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Future horizons for urban form: disruption, continuity, expansion and reverberation

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THE XXXI INTERNATIONAL SEMINAR ON URBAN FORM (ISUF 2024)

Since its consolidation as a disciplinary field throughout the twentieth century, the study of urban form has established itself as a fundamental domain for understanding cities and their processes of transformation. The XXXI International Seminar on Urban Form (ISUF 2024), titled Future Horizons for Urban Form: Disruption, Continuity, Expansion and Reverberation, was held from September 16 to 20, 2024, at Mackenzie Prebyterian University, in São Paulo, Brazil. When we decided, Denise Antonucci and I, to propose hosting this edition of ISUF, we were immediately confronted with a persistent and often uncritical narrative: the idea of Brazil as the "country of the future," widely disseminated in the popular imagination and reinforced by Brazil, Land of the Future by Stefan Zweig. While it is an evocative and problematic notion, we chose to honor the title and asked ourselves where better than Brazil, and São Paulo in particular, to interrogate the future of urban form, not as projection or promise, but as a condition already unevenly present.

Conceived as a platform for debate, exchange, and dissemination of knowledge, the conference sought to address the future of cities in a context marked by climate change, socio-spatial inequalities, and technological transformations. Its thematic structure, organized around the four tracks of Disruption, Continuity, Expansion, and Reverberation, reflected the need to engage with both emerging and persistent challenges in urban morphology. These included environmental crises such as global warming, urban heat islands and rising sea levels, as well as questions of heritage, conservation, global urbanization processes, and the circulation of knowledge across teaching, research, and professional practice.

The conference was organized by the School of Architecture and Urbanism of Mackenzie Prebyterian University, under the coordination of Heraldo Ferreira Borges and Denise Antonucci, with the support of CAPES and MackPesquisa and the contribution of an international scientific committee. It brought together approximately 200 participants from nearly thirty countries, including Afghanistan, Australia, Brazil, China, England, Germany, Italy, Poland, Portugal, Russia, Scotland, Serbia, South Africa, Spain, Sweden, Turkey, and the United States. A total of 177 papers were selected, involving 466 authors, and presented through oral sessions and posters, organized into 42 parallel sessions. The diversity of participants and the intensity of exchanges throughout the event demonstrated both the global reach of ISUF and the uneven geographies that continue to shape the field, particularly evident in the limited participation from Latin American countries beyond Brazil.

The relevance of the conference lies in its capacity to bring together different traditions, methodologies, and emerging perspectives within urban morphology at a moment of disciplinary transformation. The prominence of early-career researchers, the growing presence of participants from the Global South, and the emergence of new topics such as artificial intelligence and quantitative methods signaled a shift in the field, while also revealing

tensions with more established approaches, including the relative absence of senior scholars associated with classical morphological schools.

The program combined keynote lectures, roundtables, and parallel sessions, fostering a dense and productive environment for discussion. These exchanges were complemented by informal interactions and symbolic moments, including the tribute to Staël de Alvarenga Pereira Costa and social events such as the gala dinner at Edifício Itália and the book launch at the Brazilian Institute of Architects, which strengthened the sense of community among participants. Field visits and excursions across São Paulo further enriched the experience by engaging participants directly with the city's diverse urban landscapes, reinforcing the idea that the future of urban form is not an abstract projection but a condition already embedded in the complexities of contemporary cities.

This volume of proceedings brings together a selection of contributions presented during the conference, reflecting the diversity of approaches, scales, and contexts that characterize urban morphology today. By publishing these proceedings, we acknowledge the contributions of authors, reviewers, organizers, and participants, and reaffirm the importance of fostering international dialogue and collaboration. At a moment marked by profound environmental, social, and technological transformations, urban morphology remains a critical field for understanding and transforming cities, and the discussions initiated in São Paulo point toward new directions for its future development.

THEMATIC AXIS

The XXXI International Seminar on Urban Form consisted of four thematic axes. Each of these was associated with a keynote speaker who offered a brief summary of the findings and highlights of its researchs.

DISRUPTION

Urban form is increasingly shaped by conditions of rupture and instability. This track examines how environmental crises, public health emergencies, and socio-political conflicts disrupt established urban patterns and challenge conventional design responses. Presentations explore how phenomena such as climate change, heat islands, rising sea levels, and forced migrations reshape settlements across scales, while also addressing the role of urban design in fostering resilience, adaptation, and healthier urban environments.

KEYNOTE SPEAKER: HOWARD DAVIS

CONTINUITY

Urban form is equally defined by persistence and transformation over time. This track focuses on the historical dimensions of cities, examining how inherited structures, cultural heritage, and long-term processes inform contemporary urban design. Contributions investigate continuity through comparative and multidisciplinary approaches, addressing conservation and preservation practices while reflecting on how past urban forms condition present and future spatial configurations.

KEYNOTE SPEAKER: TERESA MARAT-MENDES

EXPANSION

Urbanization processes continue to expand in scale, speed, and geographical scope, particularly across the Global South. This track explores emerging forms of urban growth, including megamorphologies, informal settlements, and provisional urbanisms such as tent cities. Presentations address analytical and methodological approaches, including morphometrics, to understand large-scale transformations and the evolving spatial logics of rapidly expanding urban territories.

KEYNOTE SPEAKER: GABRIELA CELANI

REVERBERATION

The disciplinary field of Urban morphology resonates across education, research, and professional practice. This track investigates how knowledge is produced, transmitted, and applied within and beyond academia. Contributions reflect on pedagogical approaches, methodological innovations, and the translation of research into practice, highlighting how urban morphological thinking reverberates through different domains and scales of action.

KEYNOTE SPEAKER: OLGU ÇALISKAN

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50th years of SAAL interventions in Portugal revisiting four neighbourhoods

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ABSTRACT

The research intends to investigate revisiting 4 SAAL interventions, from a multi and interdisciplinary perspective, such as architecture, history, sociology, anthropology, among others. The objective is to question the impacts of SAAL. The study proposes a new approach to SAAL interventions, analysing 4 neighborhoods in Portugal: 1) In Lisbon, Fonsecas and Calçada, designed by Hestnes Ferreira (1931-2018), starting in October 1974; 2) In Porto, Lapa, designed by Matos Ferreira (1928-2015) starting in November 1974; 3) Also in Porto, Acácio, designed by Soutinho (1930-2013), starting in October 1974; and 4) in Sintra, Pego Longo, designed by Costa Cabral (b.1929), from August 1975. The investigation aims to reflect on the fragility of SAAL, in part this process was shorter than proposed, and to promote a new perspective about these neighborhoods, empowering populations for a more sustainable future, 50 years later. Through a historical, social, and cultural approach, the objective of this research is to analyse and illustrate the evolution of participatory architecture in Portugal and its relationship with critical thinking and international practices. The objective is to remember and celebrate SAAL's interventions, but also to repeat the strategies of this model to promote a more promising future for these inhabitants. What are SAAL interventions today? How will inhabitants organize their lives and activities? What resources will be needed and how will they be used for housing 50 years later? Will it be possible to promote participatory interventions, currently and in the future? Questions explored chronologically considering 3 times: past, present, and future. It is expected that the research results can contribute to increasing knowledge and literacy in 4 fundamental aspects: Citizenship (social relationships); Built Environment (housing and public space); Policies/Practices (participatory actions); Memory.

Keywords: Housing; Local Support Ambulatory Service (SAAL); Portugal.

INTRODUCTION

To celebrate the 50th anniversary of April 25 in Portugal, the Local Support Ambulatory Service (SAAL), created in July 1974, stands as one of the most important and disruptive experiences of the revolutionary period following the Carnation Revolution. It is in this context that architect Nuno Portas (b. 1934), a researcher at the National Laboratory of Civil Engineering (LNEC) and Secretary of State for Housing and Urbanism in the 1st Provisional Government after his appointment on May 16, 1974, emerged as one of the key figures responsible for implementing this program (d'Almeida and Marat-

Mendes, 2022). His understanding of the country's real situation (social, political, and housing) allowed him to immediately emphasize the urgent need to address the housing shortage and the lack of a theoretical/scientific basis for solving this issue. Thus, on July 31, 1974, through a joint order from the Ministry of Social Equipment and Environment and the Ministry of Internal Administration, Portas propelled the SAAL program forward.

Initially, this program envisioned a decentralized service, supported by technical teams working in collaboration with the local population to build new housing and infrastructure, thereby improving existing living conditions. The order (dated July 31, 1974) safeguarded against potential speculative operations, avoiding, whenever possible, relocating residents to more peripheral areas. Several SAAL operations began across the country under the slogan "Yes to houses, no to slums!"

Two years later, on October 27, 1976, a ministerial order transferred the management of SAAL to local municipalities. At the time, 169 operations were active across the country, involving the housing of 41,665 families. Data indicated that 2,259 housing units were under construction, with an additional 5,741 units planned for imminent development. According to Bandeirinha (2007), only 13% of the land required for these interventions was available, either ceded or expropriated.

However, no operation was completed during the period when SAAL operated as a central administration service (from August 1974 to October 1976). An administrative and procedural adaptation became necessary, which in some cases reversed or nullified the initial plans. Consequently, many operations changed their intervention sites, teams, or projects; some continued with the same projects but without the involvement of the original teams, while others simply disappeared.

Fifty years later, it is essential to understand the specific contributions of the architects' prior research experience in developing these neighborhoods projects. What are the SAAL interventions today? How have the residents organized their lives and activities? What resources will be needed, and how will they be used for housing 50 years later? Is it possible to promote participatory interventions today and in the future?

METHOD

Based on the archives of the four architects under analysis, stored at the Marques da Silva Foundation (FIMS), as well as materials archived at LNEC and the Architects' Association, we analyse the trajectory of each architect, evaluating the possible relationship between their career paths and their respective urban planning and housing projects within the scope of SAAL. This article is part of ongoing research titled "Learning from the Past: The Importance of Former Housing Participatory Production for the Coming Years."

RESULTS AND DISCUSSIONS

Housing in Portugal has undergone significant transformations, driven by economic, political, and social factors. The greatest impact was felt after the Carnation Revolution, with profound political changes, including the nationalization of many properties and businesses. This period was especially important for the most disadvantaged classes, with the Portuguese government launching various housing programs aimed at ensuring access to housing and improving living conditions.

Housing research in Portugal reflects a balance between tradition and innovation, always focusing on cultural and identity-specific aspects. Noteworthy are the studies by Portas (1969, 2004, 2007) and the pairs Portas & Silva Dias (1972) and Cabrita & Coelho (2003). These efforts aimed to develop housing solutions that respect and enrich Portuguese cultural identity while adapting to the needs of a constantly changing global society.

However, with Portugal's entry into the European Community and the country's economic growth in the 1980s and 1990s, these social policies were gradually replaced by homeownership, facilitated by the liberalization of the market. Nevertheless, this led to the relocation of the population to the outskirts of major cities, increasing the distance between housing and work. It was also during this period that fiscal incentives and financing programs emerged to promote the restoration of degraded buildings and the revitalization of urban areas.

Housing cooperatives emerged as an alternative to the traditional housing model. These cooperatives allowed groups of people to come together to collectively build and manage their homes with controlled costs. However, since the dissolution of the SAAL programs and the transfer of responsibilities to the Housing Development Fund or local municipalities, these four neighborhoods were left to their own devices. In this ongoing investigation, we can state that despite the proactive approach and the respect shown towards all participants (technicians, residents, political decision-makers), and the efforts to meet the wishes of the local population, were not enough to fully implement the developed proposals, let alone the facilities proposed by the design teams.

International critical thinking and its echoes in Portugal

Participatory social architecture became widely disseminated from the late 1950s onward. Various international architects and theorists, including Giancarlo de Carlo (1919-2005), Colin Ward (1924-2010), John F. C. Turner (b. 1927), and later N. John Habraken (b. 1928), experimented with different types of client-architect relationships to theorize new approaches and interpretations of architecture itself, focusing more on the process and shifting attention away from the results.

The Housing Policy Colloquium, held at the National Laboratory of Civil Engineering (LNEC) from June 30 to July 5, 1969, highlighted the concrete potential of evolutionary housing and urbanism as important alternatives to the models commonly practiced in public housing block developments. The main goal was to "establish a set of measures" and attempt to outline an "integrated strategy for solving the problems" of housing shortages (Bandeirinha, 2011: 70). Thus, the idea of integrated housing emerged at this congress, defined as "a set of goods and facilities that far exceeds the mere function of shelter" (Bandeirinha, 2011: 75). As stated in point 2 of Article 65 of the Constitution of the Portuguese Republic (1976), "It is the State’s duty to: a) Plan and execute a housing policy included in general territorial reorganization plans and supported by urbanization plans that guarantee the existence of an adequate network of transportation and social facilities." In early July 1974, the then Secretary of State for Housing and Urbanism, architect Nuno Portas (b. 1934), signed an order entitled Program of Priority Actions, circulated among the services under the State Secretariat for Housing and Urbanism, particularly the Housing Development Fund (FFH). But after some setbacks, on July 24, architect Nuno Teotónio Pereira (1922-2022) submitted to the FFH a first document that clearly and succinctly defined the objectives, scope of action, and functional organization of the Local Ambulatory Support Service (Teotónio Pereira, July 24, 1974). On October 24 of that same year, José Augusto

Fernandes, Minister of Social Equipment and Environment, presented the programmatic text of urban policy, titled Activity Plan, which was approved the following day by the Council of Ministers. It outlined basic intentions regarding the distribution of equipment, transport networks and infrastructures, and technical and administrative decentralization (Bandeirinha, 2011). At the invitation of Nuno Portas, architect John F. C. Turner presented his housing experience in Peru in Portugal in November 1974, based on the innovative self-construction model of barriadas, which had a great impact on those attending the SAAL Brigades Seminar. The resolution of land status issues, clarification and delimitation of intervention objects, forms of resident self-organization, and modes of construction financing emerged as the main topics of debate.

However, the SAAL program had a very limited impact as a political tool. Focused on urban housing policy programs, it was innovative in the national and international context, where social and urban equity were key goals to be achieved through deep urban reconstruction, with the populations remaining in the areas where slums existed. Nevertheless, due to the context and its short duration (during the revolutionary period, between 1974-1976, and post-revolution, after 1976), it did not achieve full implementation in all its interventions, nor was its distribution equal throughout the national territory. The international political moment, combined with the Portuguese revolutionary context, helped implement and validate the equation: Theory + Planning = Democracy. The Marxist currents of Henri Lefebvre and Manuel Castells legitimized the policy through actions where architecture, urban planning, and technical knowledge were made available to the population, particularly in their struggle to transform social, individual, and collective relations.

The evaluation of the State's role must be understood in two distinct phases. In the first phase, there was the creation of base actions for continued work, implementing a framework of values, legislation, and military support. Later, in a second phase, social dynamics emerged, bringing about bureaucracy, procedural mismatches, unequal local involvement, and the complex and unstable national political process. The contradiction of a State divided between support and abandonment of this unique social movement is evident. The role of the armed forces movement (MFA) should also be remembered as it intervened in conflict arbitration, especially during the occupation of vacant houses, acting as a force of regulation and social balance between classes.

The success of the various SAAL operations, linked to the multidisciplinary competencies of housing and urban planning technical teams (architects, engineers, sociologists, lawyers, geographers, social workers, etc.), was key to strategy definition. At the same time, alliances were established with neighbourhood committees to shape and customize housing without creating economic constraints, prioritizing low-cost technical solutions. The power of the people was undoubtedly a unique feature of the various social participation phenomena. The importance of housing cooperatives is highlighted as they brought together residents of deteriorating neighborhoods, slum areas, and rented buildings. The movement also greatly impacted and changed the social role of women, who took the most significant roles in the public sphere.

The right to housing, and more specifically the right to quality of life, was the driving force behind SAAL operations. Populations, design teams, and political decision-makers went beyond housing issues, focusing on the importance of residential space and essential infrastructure, advocating for urban equipment (sports facilities, schools, daycare facilities, health facilities, among others) and

social spaces (spaces for associations, leisure areas, green spaces, among others), not to mention adequate public transportation, all part of the broader concern for the right to the place/city.

Four SAAL Operations

In these SAAL interventions coordinated by four architects, it is important to emphasize that in all initial planes have not been fully realized, nor is the proposed schedules of the project. In this context, it is essential to highlight the professional and academic backgrounds of these architects.

Hestnes Ferreira's academic and professional path (table 1) included an internship at the Finnish Institute of Technology (Helsinki, 1958-1959), research at Yale University (New Haven, 1962), and a master's degree completed at the University of Pennsylvania (Philadelphia, 1963-1965). His work at the Technical Housing Office (GTH, 1966-1967) was a significant factor in his decisions and choices regarding this housing complex (Saraiva, 2011).

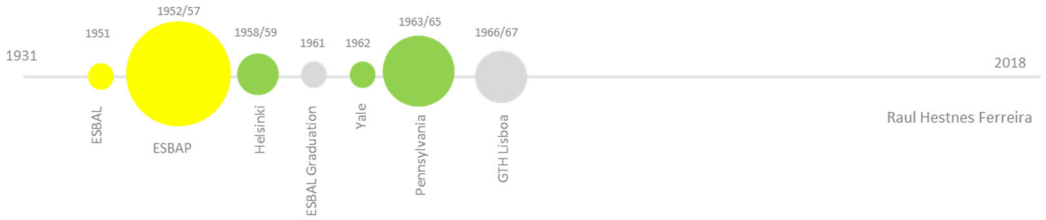

Table 1 – Hestnes Ferreira´s academic and professional path. Source: author

Matos Ferreira (table 2) attended ESBAP from 1948 to 1952 and, during the 1950s, was part of a group of students who shared Room 35 in a building in Praça da Liberdade, downtown Porto (table.2). He was the oldest member of this diverse group, which included Álvaro Siza, Alberto Neves, António Menéres, Joaquim Sampaio, Luís Botelho Dias, and Vasco Macieira Mendes. Távora's involvement in various International Congresses of Modern Architecture (CIAM, 1951-1962) and his role in the "Minho" team for the Survey on Portuguese Regional Architecture (1955-1960) (AAVV, 1961) expanded Ferreira's understanding of housing and territorial issues, deeply influencing him. His personal and professional partnership with Távora (1972-1982) further shaped his approach. Unlike Hestnes Ferreira, Soutinho, and Costa Cabral, Matos Ferreira never studied or interned abroad.

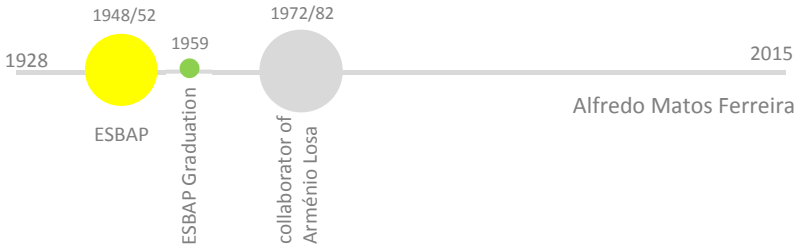

Table 2 – Matos Ferreira´s academic and professional path. Source: author

Alcino Soutinho (1930-2013) earned his architecture diploma from ESBAP in 1959. As a Calouste Gulbenkian Foundation scholar in 1961, he conducted research on museology in Italy, where he was influenced by his Italian peers. Simultaneously, he worked at the Welfare Funds Foundation, designing

numerous social housing projects in northern Portugal until 1971. From early on, he balanced his design practice with teaching (1972-1999). Soutinho was actively engaged in architectural discourse and dissemination through conferences, debates, publications, and articles, as well as holding significant public roles in institutions such as the Portuguese Design Centre (1998-2001), the Árvore Artistic Activities Cooperative (2003-2006), and the Order of Architects (1999-2002). (table 3)

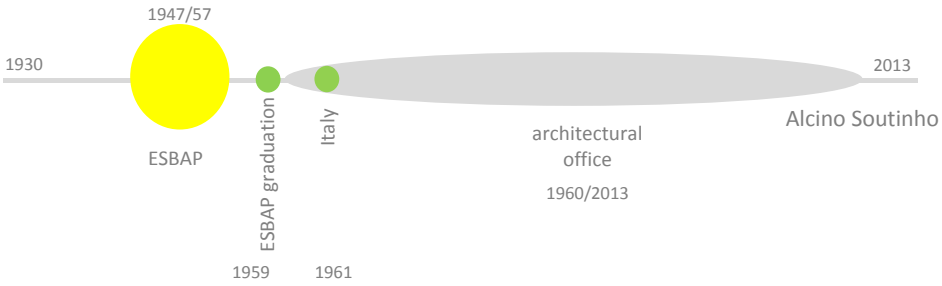

Table 3 – Alcino Soutinho´s academic and professional path. Source: author

Costa Cabral's internships at the Centre Scientifique et Technique du Bâtiment (Paris, 1962), London County Council (London, 1965), and LNEC (Lisbon, 1967) had a significant impact on his approach to research and housing design (d'Almeida et al. 2022). Under the guidance of Nuno Teotónio Pereira (1922-2022), Cabral became involved in Portugal's cooperative movement, working with the Federation of Welfare Funds (FCP) and GTH on the social housing project for Olivais. Two decades later, as part of the SAAL program, he was tasked with developing the Pego Longo neighbourhood (1975-1977) in Sintra (d'Almeida and Marat-Mendes, 2022).

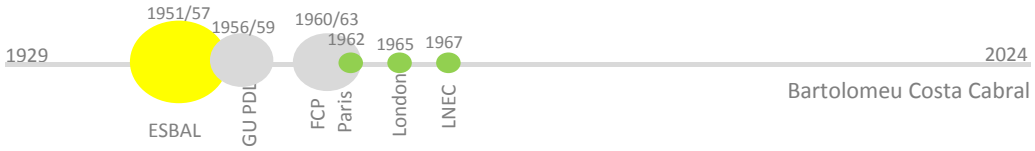

Table 4 – Bartolomeu Costa Cabral´s academic and professional path. Source: author

The professional experience gained by Soutinho and Costa Cabral at the Federation of Welfare Funds, as well as Hestnes Ferreira's experience at the Technical Housing Office of the Lisbon City Council, were decisive in realizing new housing proposals. Matos Ferreira made a significant impact in academia by proposing the graphic documentation and characterization of interior living spaces in his design courses. For this architect (Ferreira, 1995), a building must adhere to three essential principles: formal simplicity, economy, and clarity in spatial organization.

If we analyse the geographical characterization of each intervention, the Hestnes Ferreira coordinated Fonseca and Sidewalk neighbourhood is located on the outskirts of Lisbon, in an expanding area with relatively flat topography at the time. In contrast, the Proposal of Matos Ferreira for the Lapa neighbourhood is in a central area of the Port (zone 3 – central ring area of the 18th and 19th century

expansion ring), which was and is still a highly degraded area with steep topography, restricted further by the rail line (now used by the subway), representing challenges to its implementation.

The neighbourhood of Acacio, later renamed Maceda, is in the eastern part of the city, near its border, in Campanhã (zone 8 – eastern suburban sector). Implementing the project on the ground prioritized the creation of collective spaces and considered the historical, social and cultural significance of urban tissue where the operation occurred.

The neighbourhood of Pego Longo, designed by Costa Cabral, is in a peripheral area of the Sintra, which at the time had little infrastructure and steep topography, influencing the architectural proposal.

SAAL intervention	Architect	Local	Association	Population		Dwellings		Typology	Project	Construction
				families	total	Planned	Built			
Fonsecas and Calçada	Raúl Hestnes Ferreira	Lisboa	Economic Housing Cooperatives (C.H.E) 25 de Abril	310	950	1600	335	T1+(1); T2; T3; T4; T5	1974 - 1976	1976 - 1986
			Calçadas Economic Housing Cooperatives (C.H.E) Unidade do Povo	288	1000					
Lapa	Alfredo Matos Ferreira	Porto	Lapa Residents' Association	482	1700	500 (250 new+ 250 recovered)	74	T1; T2/T3; T3/T4	1975	1976 - 1977
Maceda	Alcino Soutinho	Porto	Maceda Residents' Association	52	186	43	33	T1; T2; T3; T4; T5	1975	1974 - 1977
	Andrea Soutinho						10			2016 - 2020
Pego Longo	Bartolomeu Costa Cabral	Sintra	Pego Longo Residents' Association	143	500	150 (47 new +60 recovered)	81	T1; T2; T3; T4; T5	1975	1977

Table 5. data information- 4 SAAL interventions. Source: author

The table 5 resume all data information about these four interventions, the local, the name of the association involve, the characterization of the population (no. of families and total of population), dwellings (planned and built), the typology, the year of the project and the years of construction.

All the neighborhoods are typologically different: 1) Fonsecas e Calçada is a large development of four-story multifamily buildings, with mostly left/right vertical access, and small access galleries for three housing units at building intersections; 2) Lapa is a medium-sized development of two-story terraced houses with backyards, forming blocks; 3) Maceda is a small development consisting of eight terraced housing units, of which only five were initially built; 4) Pego Longo is a large development of terraced single-story and two-story houses, with front and rear yards, forming blocks.

The rehabilitation interventions in the Fonsecas and Calçada and Pego Longo neighborhoods, promoted by the municipalities of Lisbon and Sintra in 2016 and 2017, respected the participation of the local population and allowed for the redevelopment of public spaces, the improvement of pedestrian and road accessibility, and an overall enhancement of the quality of life for these communities. In 2016, the regularization of the construction situation was finally made possible, with the legalization of all blocks through the issuance of the respective Occupancy Licenses and the creation of Identity Cards for the 355 housing units, resulting from the BIP/ZIP58 process implemented by the Lisbon City Council and endorsed by Hestnes Ferreira. In 2019, the municipality of Sintra invested around 600 million euros in an intervention area of 18,460 square meters to rehabilitate public spaces and improve pedestrian and road accessibility, thereby enhancing the quality of life for the population.

On December 9, 2019, the Porto City Council, through Councilman Pedro Baganha, announced at a council meeting the development of an Urban Study for the Lapa area. It envisioned the creation of new urban fronts, particularly residential areas, a green urban park covering 19,000 square meters (and a second one with 16,000 square meters), the redesign of access to the Lapa metro station, and the completion of the existing road network with the creation of new streets. This project for the Lapa area in Porto considers the reprofiling of Cervantes Street, from its intersection with Alves Redol Street to Antero de Quental Street. This work will have a significant impact on the Lapa neighbourhood, as Cervantes Street is the main access route to this SAAL intervention. Fifty years later, these neighborhoods and their owners, some of them second-generation, finally gained access to the habitation certificate and full ownership of their property.

CONCLUSIONS

These four SAAL interventions did not evolve in the same way, nor do they present the same results. While the intervention for the Lapa neighbourhood was never fully completed, the interventions for the Fonsecas and Calçada neighborhoods, Pego Longo, and Maceda extended over time and space. The active involvement of the architects, particularly with the residents of the latter two neighborhoods, promoted the continuity of their work and spatial ideas among the residents. Alternative approaches, such as collaborative housing and affordable rental models, are gaining ground, offering new solutions to persistent housing problems. In short, the evolution of housing in Portugal since the 1960s reflects a combination of government efforts, community initiatives, and global trends, with a growing emphasis on sustainability and social inclusion.

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A comparative study of the forms of mainstream property settlements

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ABSTRACT

As an important functional component and spatial type of cities, residential areas dominate the development and evolution of urban morphology to a certain extent. Against the backdrop of the reform of China's commoditized housing system, property developers' voice was increasing and gradually become the mainstay of China's urban construction. The construction process of large-scale residential areas led by mainstream property developers has, to a certain extent, pushed forward the evolution of China's urban morphology. Based on this, this paper uses urban morphology to extract 4 key elements of residential morphology: plot order, road network structure, residential area layout and open space, and 13 relevant morphology indicators, in order to construct a system of elements of property developers' residential morphology, and selects typical samples for comparative analyses. The study finds that the planning logic of the mainstream property developers' residential areas in China since the new century meets the needs of the era of China's incremental development and the policy orientation of local residential construction, and the existing residential construction model presents the characteristics of single land use, inward spatial connection and standardized building layout, which is the basis for the proposal of the morphology of the future residential construction: improve the complexity of the residential land, increase the correlation between the residential area and the external urban space, and enhance the continuity of the macro-morphology. The aim of paper is to guide property developers in improving the environmental quality and social benefits of residential areas and to provide valuable reference for the human residential construction.

Keywords: Chinese residential area, property developer, residential morphology, morphological typology.

INTRODUCTION

Residential area, as the basic spatial type and important functional component of urban, on the one hand, dominates the development and evolution of urban morphology. In the building typology in Italy, Caniggia distinguished all urban buildings into basic and specialized building, and regarded the residential area as “basic building” of urban tissue (Tian *et al*. 2021). Among all the common types of buildings that shape the form of cities, housing is of major importance constituting the bulk of buildings (Polyzoides et al. 1992). As a result, residential area has a high degree of unity in morphology and function, to some extent, it can embody the main characters of urban morphology. (Chen *et al*.

2014). On the other hand, in urban morphology in England, Conzen recognized the residential area as the one of the three important spatial units that make up the urban landscape, as the most important bearing of the residential function in urban, residential area occupies a huge proportion of urban land and play a decisive role in the urban morphology (Conzen and Michael P, 2009). Therefore, residential morphology is related to the quality of the urban environment, and it also dominates the development of overall urban morphology.

At the same time, along with the reform of the land use system and housing policy, in 1998, China's residential area gradually replaced the system of welfare housing allocation with the construction of commercial housing, and market interests became the main driving force in residential planning. In order to meet the real needs of rapid urban development and population expansion, property developers have gradually become the mainstay of urban housing construction, which to a certain extent affects the economic, resource and demand dynamics of residential construction and urban development (Li *et al*. 2016). The evolution of residential morphology is increasingly driven by economic interests (Zhang *et al*. 2013). Specifically, on the one hand, the spatial evolution of residential area is set against the backdrop of housing policy reform, and the characteristics of property developer-dominated residential morphology have a certain relevance to China's national development orientation and government macro-policies at the time. On the other hand, in order to reduce development cost and improve economic efficiency, efficient replication has become the basis for property developers to promote urban expansion and residential construction, and this paradigm premised on standardization has shaped the highly homogenised fabric of contemporary Chinese urban in just a few decades (Dong and Li, 2019). However, Under the influence of this "value-only" philosophy (Yao and Xu, 2020), during the evolution of residential area, new residential problems such as morphological homogeneity, spatial fragmentation, and residential segregation have emerged. This phenomenon has triggered great controversy in the academic world and has become an important issue in the research of contemporary Chinese residential planning.

In recent research, residential morphology focused on the level of residential planning and housing design, mainly concerned with the study of the dynamic and morphology of the spatial evolution of residential area (Zhang et al.2021; Gu et al.2008), the measurement and characterisation of the spatial morphology elements of residential area (Huang et al.2013; Ghosh and Vale, 2009), and the exploration of ideal models of residential area (Huang et al.2017; Braulio-Gonzalo et al.2020). The study covered a wide range of residential types, such as traditional residential area, old residential area, open residential area, mountain residential area, workers' residential area, welfare residential area, informal residential area and specific residential elements, such as boundary spaces, open spaces, and facilities and amenities. In conclusion, in China, a mature methodological system has been developed in the field of residential morphology research, but few studies regarded the residential area of property developers as an independent type. Actually, property developers, as a major participant of China's residential construction, have an increasingly obvious influence on the construction of residential environments and the evolution of urban morphology. Therefore, analysing the characteristics of the residential morphology of mainstream property developers, summarizing the achievements and mistakes and putting forward the corresponding recommendations are of great significance in guiding property developers to pay more attention to the quality of residential area while improving the efficiency of development, responding to the needs of transformation of urban development and upgrading the quality of the human environment.

METHODOLOGY

Research framework

Based on this, this paper adopts the morphological typology to construct a research framework for the residential morphology of mainstream property developers, and examines their morphological characteristics from the following four aspects: ①plot order, the general characteristics of the residential area, intensity, and boundary attributes. ②road network structure, the spatial relationship between road morphology and residential layout. ③Residential layout, the type and morphological characteristics of the layout of residential buildings. ④open space, the relationship between the location and quantity of green spaces, courtyards and other public spaces in the residential area. Based on the above four aspects, a total of 13 elements reflecting the morphological characteristics of the paradigm are set, and the database of the morphological elements of the settlement samples is constructed by collecting official data, and combining with AutoCAD software to calculate and supplement the missing data, which can be used to prove the development trend, dominant value or type of the sample, and then summarize the overall characteristics of the residential morphology of the mainstream property developers in China. Finally, the overall characteristics of residential morphology of mainstream property developers can be summarized.

Table 1.the research framework of residential morphology of mainstream property developers

Morphology Types	Extraction Elements	Influence Mechanism	Description Methods
Plot Order	Plot Area	Reflect the scale of the residential area.	Total area of the plot.
	Plot Boundary	Reflect the functional type of the residential boundary.	The main division is between physical boundaries dominated by green space and fences and functional boundaries dominated by community businesses in residential ground floor.
	Floor Area Ratio (FAR)	Reflect the intensity of the residential construction.	Ratio of gross floor area to the residential plot area.
	Building Coverage Ratio (BCR)	Reflect the compactness of the layout of building entities in residential area.	Ratio of building base area to the residential plot area.
Road Network Structure	Morphology of Road Network	Reflect the spatial correspondence between the road morphology and the building layout.	Include ringlike road, grid road, branchlike road and so on.
	Road Density	Reflect the density of road network.	Ratio of length of road network to the plot area.
Residential Layout	Architectural Layout	Reflect the overall layout of residential building.	Include row layout, courtyard layout, scattered layout, radial layout and so on.
	Average Number of Floor	Reflect the spatial average height of the residential area, focusing on vertical façade morphology.	Ratio of total number of buildings' floor to the total number of building's unit.
	Proportion of Residential Height	Reflect the composition of the residential buildings' height.	Ratio of high-rise buildings, medium-rise buildings or multilayer buildings to the total number of residential buildings.
	Proportion of Residential Unit	Reflect the composition of residential buildings' unit types.	Ratio of panel construction or tower construction to the total number of residential buildings.
Open Space	Greening Rate	Reflect the scale of green space in residential area.	Ratio of green space area to the plot area.

	Concentrated Greening Rate	Reflect the scale of main green space and public activity space in residential area.	Ratio of area of concentrated green space to the plot area.
	Structure of Green Space	Reflect the spatial distribution of the green space in residential area.	Include centralized structure, cluster- model, panel- model, knot- model and so on.

Sample Selection

In order to make the research results become more realistic, the sample selection principles of this paper are as follows: ①typical representation. The samples of residential areas can reflect the typical planning morphology in the context of the corresponding era, as well as the basic logic and planning paradigm of Chinese mainstream property developers' residential construction. In principle, the sample shouldn't include something reflecting the residential needs of minority groups, such as villa areas, and special samples with specific planning orientations, such as sheltered housing and elderly flats; ②comparability. The sample should avoid, as far as possible, the interference of special external factors, such as natural topography, and to carry out comparative analyses of settlements under more universal construction conditions.

Based on the above principles, this paper refers to the typical residential cases selected by architectural academic journals and the “National Comfortable Housing Demonstration Project”, “Shanghai Excellent Residential Community”, “Tien-yow Jeme Civil Engineering Prize” which selected by the government. The collection of these cases can, to a certain extent, serve as a representative of contemporary Chinese residential planning. Sixteen samples of residential areas represented by Chinese mainstream property developers such as Vanke, Longhu, Poly, Greentown, China Resources, Zhonghai, Jindi, and Country Garden are selected according to the construction completion time as the research object for comparative analyses.

Table 2. the residential sample selection of mainstream property developers

Name of Residential Area	Completion Time	Plot Area	FAR	BCR	Greening Rate
Guangzhou Poly Garden	2000	12.09	2.2	29.00%	38.00%
Beijing Country Garden Community	2001	8.94	1.8	16.36%	36.00%
Shanghai Vanke Wonderland Garden	2004	16.65	1.1	28.90%	42.00%
Greentown Shangyu Osmanthus Garden	2005	9.69	1.5	25.20%	40.00%
Wuhan Vanke City Garden	2006	42.03	1.2	25.08%	36.00%
Foshan Country Garden of Fengnan Garden	2007	4.51	2.3	18.45%	32.70%
Shenyang Vanke New Mileage Community	2007	5.27	2.0	21.00%	51.00%
Zhonghai Jinxiu City Community	2010	8.71	2.3	26.09%	36.00%
Wuhan Jindi Central City Community	2010	7.17	3.9	17.02%	35.24%
Nanjing Jindi Mingjing Community	2011	9.07	1.7	25.00%	30.00%
Suzhou Zhonghai Haiyue Garden	2012	5.71	2.3	15.70%	53.00%
Beijing Vanke Blue Mountain Community	2012	4.03	3.0	19.23%	30.00%
Changsha Vanke Charm City Community	2016	54.00	3.0	18.28%	40.00%
Xian Poly Xinyu Garden	2018	14.84	3.4	21.04%	35.00%
Xiangtan Evergrande Yujing Peninsula Community	2018	24.06	2.8	15.34%	42.00%
Changsha Zhonghai Longyuefu Community	2021	7.06	4.0	19.84%	40.00%

RESULTS AND DISCUSSIONS

Plot Order

The study extracted four data related to plot order from the sample group, including plot area, plot boundary, floor area ratio and building coverage ratio. The analysed sites in residential areas of mainstream property developers were found to show a differentiation in plot area, the evolutionary trend was closely linked to the reform of housing policies, and the management model of residential area was both closed and independent.

Table 3. Statistic of plot order for residential sample

Name of Residential Area	Plot Area	Plot Boundary Type	FAR	BCR
Guangzhou Poly Garden	12.09	physical boundaries	2.2	29.00%
Beijing Country Garden Community	8.94	physical boundaries	1.8	16.36%
Shanghai Vanke Wonderland Garden	16.65	physical boundaries	1.1	28.90%
Greentown Shangyu Osmanthus Garden	9.69	both physical and functional boundaries	1.5	25.20%
Wuhan Vanke City Garden	42.03	physical boundaries	1.2	25.08%
Foshan Country Garden of Fengnan Garden	4.51	functional boundaries	2.3	18.45%
Shenyang Vanke New Mileage Community	5.27	physical boundaries	2.0	21.00%
Zhonghai Jinxiu City Community	8.71	mainly physical boundaries	2.3	26.09%
Wuhan Jindi Central City Community	7.17	mainly physical boundaries	3.9	17.02%
Nanjing Jindi Mingjing Community	9.07	physical boundaries	1.7	25.00%
Suzhou Zhonghai Haiyue Garden	5.71	mainly physical boundaries	2.3	15.70%
Beijing Vanke Blue Mountain Community	4.03	physical boundaries	3.0	19.23%
Changsha Vanke Charm City Community	54.00	mainly physical boundaries	3.0	18.28%
Xian Poly Xinyu Garden	14.84	mainly functional boundaries	3.4	21.04%
Xiangtan Evergrande Yujing Peninsula Community	24.06	both physical and functional boundaries	2.8	15.34%
Changsha Zhonghai Longyuefu Community	7.06	mainly physical boundaries	4.0	19.84%

（1）The average plot area of the residential sample is 14.61hm², with a general construction of two large ends and a small middle (Figure 1), which is closely related to the development process of urbanization and the evolution of housing policies in China. At the beginning of the 21st century, in the context of increasing urban expansion and the need for land finance, large and medium-sized cities have granted land for the construction of large-scale residential areas, and even large-scale residential areas larger than 40 hectares have appeared on the outskirts of many large cities and new development zones, and a considerable portion of them are built as villas or high-grade residences, which are not included in this sample group; On the contrary, most of the new residential areas built on the fringe of urban centres in response to urban expansion are in the form of general commercial residential area, affordable residential area and welfare residential area, the areas of them are moderate. After 2011, the rate of urbanization in China exceeded 50% for the first time, and the concept of “new-type urbanization” was put forward by the government. Since then, China's urban construction and development has begun to transform from incremental expansion to high-quality development, which is reflected in the construction of residential area, with increased emphasis on

the quality of residential area and the promotion of high-rise residential buildings in order to conserve the land. In 2015, as a result of the Chinese government's efforts to promote a new residential mode of “block”, among other things, a significant number of residential plot area in this period were adapted to accommodate the neighbourhood scale of small blocks with dense road networks, and the plot area was more biased towards a smaller area than in the past. After 2017, the 19th China National Congress report proposed that all people should have a comfortable livelihood, and this new regulatory policy has led to a more diversified housing supply system and formed differentiated residential shapes (Bian, 2022).

（2）Different plots and different communities are separated by fences and the modes of management for residentials are mostly closed and independent. The external boundaries of the residential areas are mainly divided into two types: physical boundaries dominated by greenery and fences, and functional boundaries dominated by ground-floor commercial and public service facilities, with physical boundaries accounting for a significantly higher proportion of the total than functional boundaries. However, with the gradual improvement of the demand for supporting facilities in the residential area and the consideration of the convenience of life of the residents, the distribution location of various types of supporting facilities has changed from the centre of the district to the first floor of the building along the city road, and the frequency of the use of functional boundaries has gradually increased, which reflects the practical application of the idea of land use compatibility and functional mixing.

（3）The floor area ratios of the residential samples range from 1.14-4.0, with a mean of 2.41, 50% floor area ratios of residential samples range from 1.51-2.34 and 31.3% floor area ratios of residential samples are more than 3.0(Figure 2), this reflects the fact that the intensity of construction in residential areas of property developers is evenly distributed and moderately intense, and that there is a gradual tendency towards high-rise construction in residential areas of property developers.

（4）The building coverage ratios of the residential samples range from 15.34%-29%, with a mean of 21%, more than 43% building coverage ratios of the residential samples are less than 25.2% and more than 81% are less than 25.2%. According to a relevant study, the building coverage ratio range from 15% to 30% is considered as medium density.(Tang, 2022), this means that the majority of the samples are in the appropriate range of building coverage ratio (Figure 3). At the meantime, with the advancement of the construction era, the overall building coverage ratio of the sample has shown a slow decline, which can reflect the gradual increase in the requirements of property developers' residential areas on the quality of the environment, and they have been reducing the building coverage ratio by increasing the height of the buildings in order to free up more public space and green space.

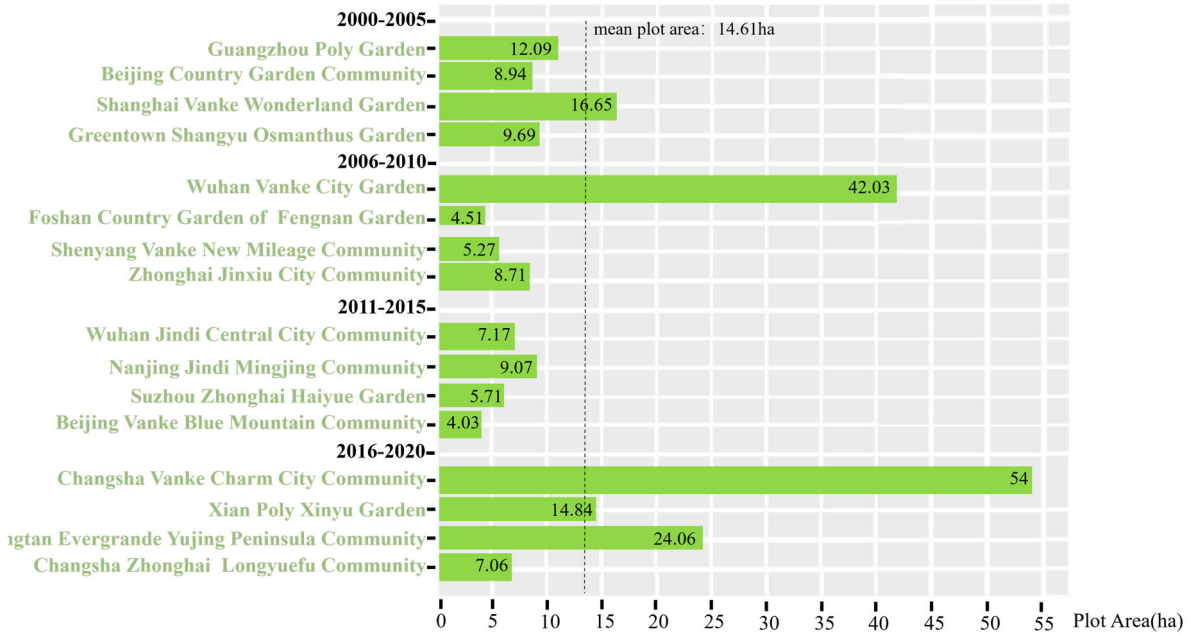


Figure 1. The plot area of residential areas, photo credit: author.

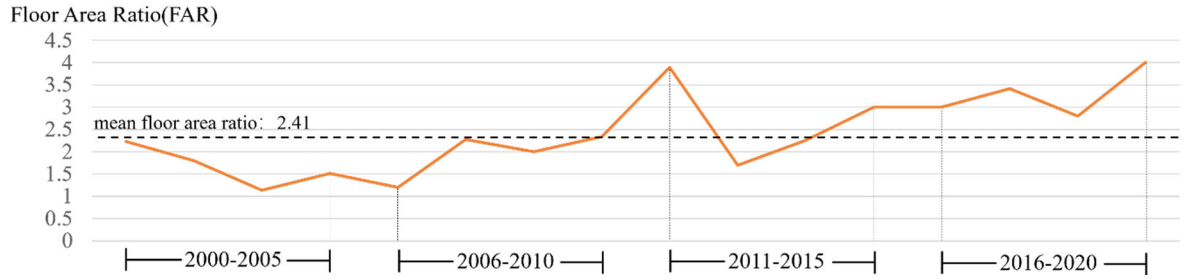


Figure 2. The floor area ratio (FAR) of residential areas, photo credit: author.

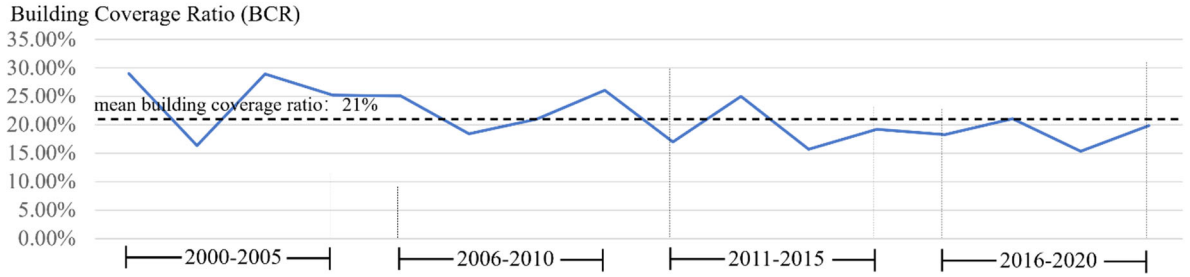


Figure 3. The building coverage ratio (BCR) of residential areas, photo credit: author.

Road Network Structure

The study extracted 2 data related to the road network structure, including road network morphology and road density. It is found that the road structure of residential areas of mainstream property developers in China, especially in the early period, is deeply influenced by the neighbourhood unit and the Radburn principle, and most of them have a clear road hierarchy with the basic goal of separating pedestrian and vehicle traffic. 87.5% of the sample residential areas have a ring-based internal road network, with the frequency of the inner ring and outer ring being basically equal, and other road network morphologies such as branch and grid are used locally to meet the needs of home flow and fire protection.

At the same time, more than 81% of the sample of residential neighbourhoods had road densities between 0.018 and 0.032, with a mean value of 0.03, which is in the moderate density range, reflecting good accessibility of roads within the residential areas.

Table 4. Statistic of road network structure for residential sample

Name of Residential Area	Road Network Morphology	Road Density(m/㎡)
Guangzhou Poly Garden	ringlike road (inner)	0.035
Beijing Country Garden Community	ringlike road (inner)	0.027
Shanghai Vanke Wonderland Garden	ringlike road (both inner and outer)	0.038
Greentown Shangyu Osmanthus Garden	ringlike road (inner)	0.026
Wuhan Vanke City Garden	ringlike road (both inner and outer)	0.024
Foshan Country Garden of Fengnan Garden	ringlike road (inner)	0.040
Shenyang Vanke New Mileage Community	ringlike road (both inner and outer)	0.020
Zhonghai Jinxiu City Community	ringlike road (inner)	0.020
Wuhan Jindi Central City Community	ringlike road (inner)	0.018
Nanjing Jindi Mingjing Community	ringlike road (outer)	0.024
Suzhou Zhonghai Haiyue Garden	ringlike road (outer)	0.018
Beijing Vanke Blue Mountain Community	ringlike road (outer)	0.022
Changsha Vanke Charm City Community	grid road	0.025
Xian Poly Xinyu Garden	branchlike road	0.022
Xiangtan Evergrande Yujing Peninsula Community	ringlike road (outer)	0.023
Changsha Zhonghai Longyuefu Community	ringlike road (outer)	0.032

In general, the traffic structure of China's residential areas of mainstream property developers is based on maximising the efficiency of connection for path organization, focusing on the diversion planning of pedestrian and vehicular traffic and the efficiency of vehicular traffic, with a greater emphasis on its own independence and completeness, and seldom considering the connection with the system of urban traffic, nor constituting a morphological counterpart to the residential building layout.

Residential Area Layout

The study extracted data on the architectural layout, the average number of floors, the proportion of residential height, and the proportion of residential unit from both the horizontal and vertical perspectives. It has been analysed that the residential planning mode of mainstream property developers in China tend to be similar, and the architectural layouts have a high degree of homogeneous characteristics to a certain extent.

Table 5. Statistic of residential area layout for residential sample

Name of Residential Area	Architectural Layout	Average Number of Floor	Proportion of Residential Height			Proportion of Residential Unit		
			Multilayer	Medium-rise	High-rise	Panel	Tower	Panel +Tower
Guangzhou Poly Garden	both row and radial layout	10.07	0.035	0.52	0.38	0.10	/	0.10
Beijing Country Garden Community	row layout	11.00	0.027	/	1.00	/	0.86	0.14
Shanghai Vanke Wonderland Garden	row layout	6.00	0.038	1.00	/	/	1.00	/
Greentown Shangyu Osmanthus Garden	both row and point layout	9.23	0.026	0.59	0.26	0.15	1.00	/
Wuhan Vanke City Garden	both row and courtyard layout	5.13	0.024	0.77	0.19	0.05	1.00	/

Foshan Country Garden of Fengnan Garden	courtyard layout	12.36	0.040	0.65	0.18	0.18	0.59	0.41
Shenyang Vanke New Mileage Community	row layout	13.41	0.020	/	/	1	1	/
Zhonghai Jinxiu City Community	row layout	10.72	0.020	/	0.56	0.44	0.91	0.09
Wuhan Jindi Central City Community	row layout	26.57	0.018	/	/	1	/	0.05
Nanjing Jindi Mingjing Community	row layout	11.00	0.024	/	1.00	/	1.00	/
Suzhou Zhonghai Haiyue Garden	row layout	14.39	0.018	/	/	1.00	0.55	/
Beijing Vanke Blue Mountain Community	courtyard layout	27.64	0.022	0.2	/	0.8	1	/
Changsha Vanke Charm City Community	row layout	17.12	0.025	0.07	0.26	0.67	0.69	0.07
Xian Poly Xinyu Garden	row layout	16.26	0.022	0.44	0.07	0.48	0.73	0.01
Xiangtan Evergrande Yujing Peninsula Community	both row and point layout	18.26	0.023	0.33	/	0.67	0.32	/
Changsha Zhonghai Longyuefu Community	row layout	25.00	0.032	/	/	1.00	/	0.09

（1）Considering the orientation of sunlight and the need for standardization, the general layout of buildings in 87.5% of the residential samples is based on the basic principle of row layout, especially the north-south row layout with the front and back rows of buildings aligned, which is the root cause of the high degree of homogeneity of the general residential layout of mainstream property developers in China, especially in the early years. As the overall spatial environment of the residential area has become more and more important, in order to change the monotonous form, some residential areas improve the richness of the architectural layout through the interlacing, enclosure, inclined and other measures.

（2）The number of floor in the residential sample ranges from 5 to 27, with multilayer buildings accounting for 41.5% , medium-rise buildings for 20%, and high-rise buildings for 38.5%, with an average number of 14.63, in accordance with the classification of types of residential heights in "*Code for Residential Design*"[①] (Figure 4). In terms of the distribution of height types, there are residential areas that are made up of a selection of multilayer, medium-rise and high-rise buildings in a single form, as well as those that are mixed in combination with each other. In general, however, with the need for intensification of land use in recently years, high-rise housing has increasingly become the dominant choice of residential height in the current era (Figure 5).

（3）The construction of residential areas in China is dominated by modular housing, including panel construction, tower construction, and construction with both panel and tower. At the beginning of the 21st Century, the main unit organization is panel construction, with a small number of tower construction laid in the core space or on the side of the main road, in order to enrich the spatial form of residential areas (Figure 6). And with the rising demand for residential product differentiation, construction with both panel and tower which offered a wide range of house types is gradually increasing.

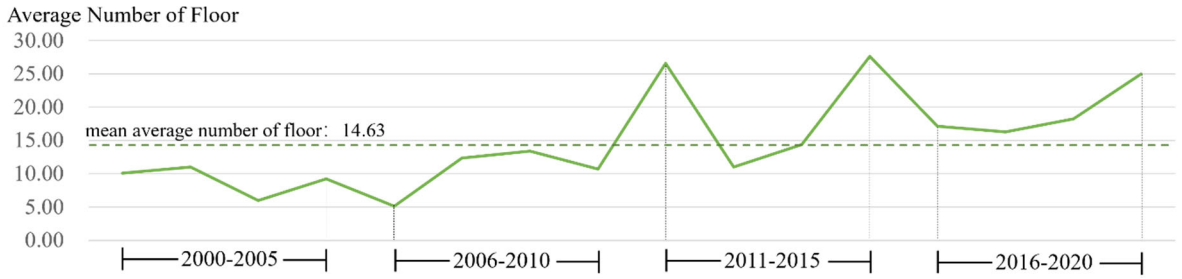


Figure 4. The average number of floors of residential areas, photo credit: author.

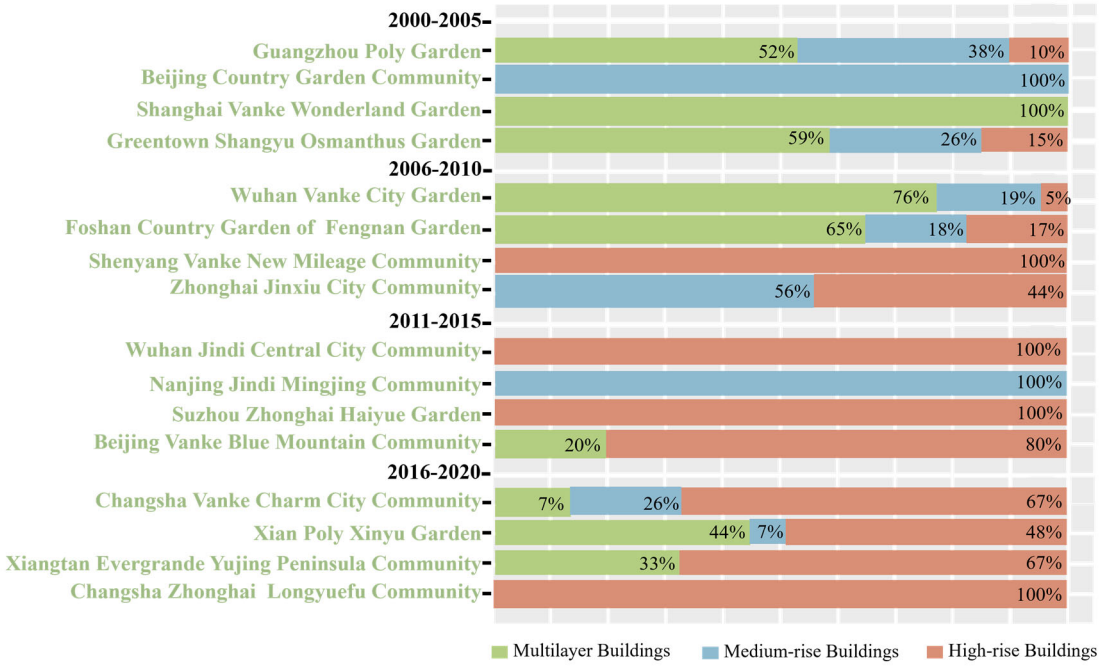


Figure 5. The height distribution of residential areas, photo credit: author.

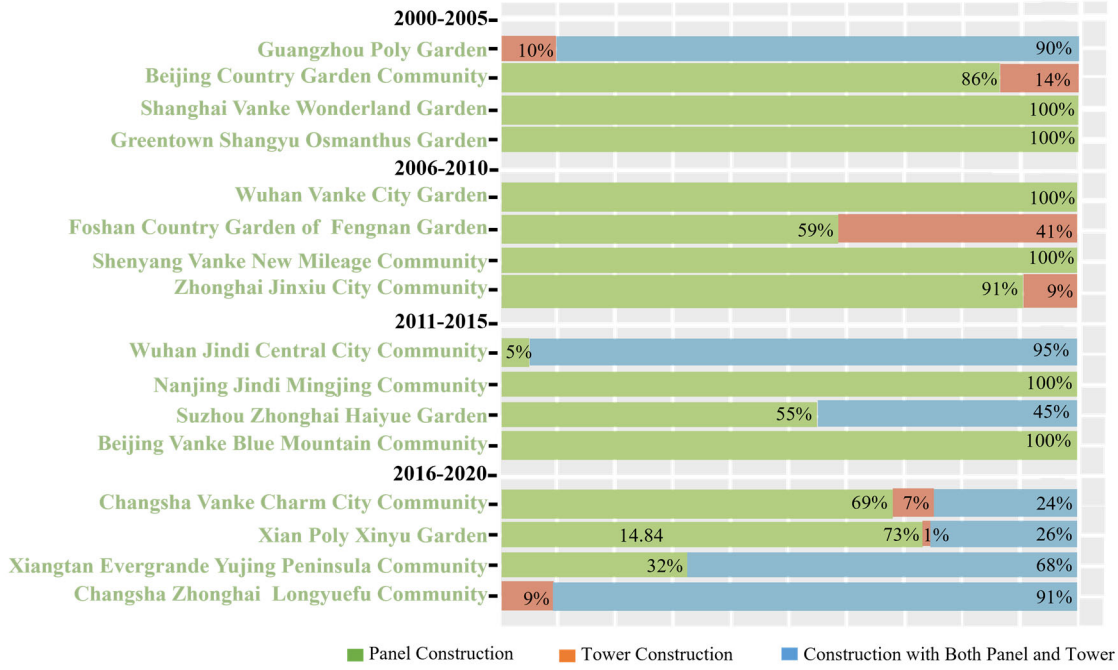


Figure 6. The unit distribution of residential areas, photo credit: author.

Open Space

The study extracted three data on greening rate, centralized greening rate and green space structure for the sample group, in which the average greening rate reached 39%, and the average centralized greening rate, which reflects the scale of open space within the residential area, reached 17.72%, which are far beyond the limit specified in the norms (Figure 7), this suggests that most of the residential samples provide large public spaces in the core space where residents can move around, reflecting that mainstream property developers attached great importance to the quality of residential environment.

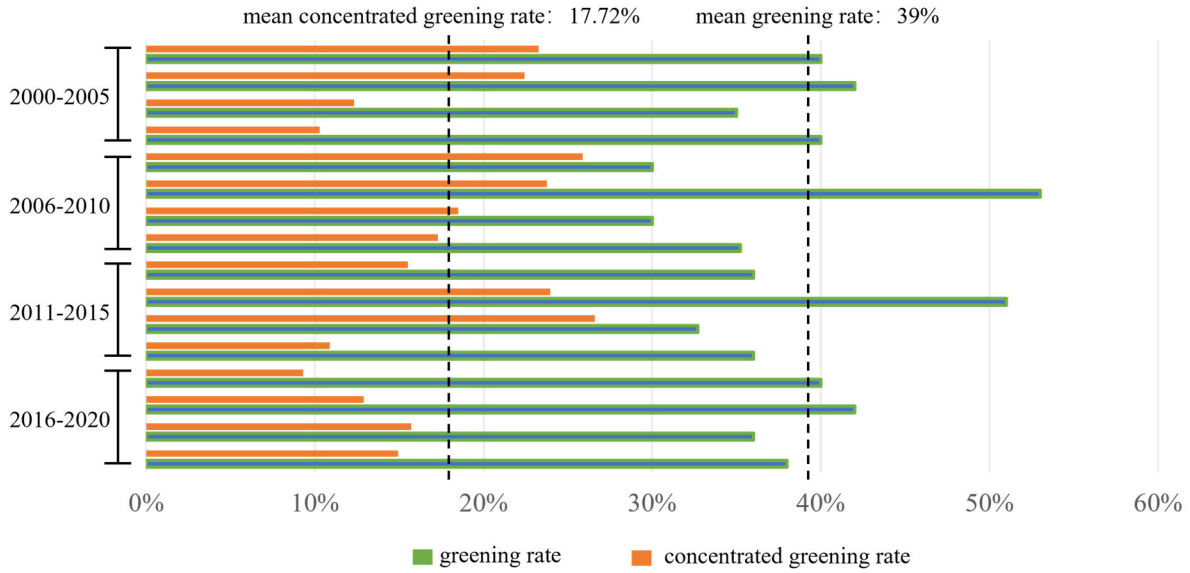
In terms of the spatial structure of green space, more than 50% of the sample group is of a centralized structure and more than 30% is of an axial structure, both of which have a significantly higher rate compared to decentralized structures, they can be more effective to utilize the scale effect of green space. Decentralised structures are presented in large neighbourhood, which shape a single homogeneous spatial layout of buildings. At the same time, in the early day, the green space system of mainstream property developers' residential areas had a more obvious hierarchical system, but as property developers pay more attention to the wholeness and evenness of the residential environment, the planning of green space system gradually tends to be holistic, and property developers are increasingly focusing on the green space system. More and more residential areas are beginning to favour a sequential spatial system rather than a strict hierarchical model, with the exception of the central green space as the main public space which still has a more prominent scale, the overall distribution of the green space system is more balanced in order to provide as much as possible a good landscape environment for each resident, and echo with the architectural layout and the surrounding environment, presenting a diversified spatial form.

Table 6. Statistic of open space for residential sample

Name of Residential Area	*Green Space Structure*	*Greening Rate*	*Centralized Greening rate*
Guangzhou Poly Garden	*centralized structure*	*38.00%*	*14.93%*
Beijing Country Garden Community	*axial structure*	*36.00%*	*5.73%*
Shanghai Vanke Wonderland Garden	*decentralized structure*	*42.00%*	*12.89%*
Greentown Shangyu Osmanthus Garden	*centralized structure*	*40.00%*	*9.31%*
Wuhan Vanke City Garden	*decentralized structure*	*36.00%*	*10.90%*
Foshan Country Garden of Fengnan Garden	*centralized structure*	*32.70%*	*26.61%*
Shenyang Vanke New Mileage Community	*centralized structure*	*51.00%*	*23.95%*
Zhonghai Jinxiu City Community	*axial structure*	*36.00%*	*15.51%*
Wuhan Jindi Central City Community	*centralized structure*	*35.24%*	*17.31%*
Nanjing Jindi Mingjing Community	*axial structure*	*30.00%*	*18.49%*
Suzhou Zhonghai Haiyue Garden	*axial structure*	*53.00%*	*23.76%*

Beijing Vanke Blue Mountain Community	*centralized structure*	*30.00%*	*25.88%*
Changsha Vanke Charm City Community	*centralized structure*	*40.00%*	*10.29%*
Xian Poly Xinyu Garden	*decentralized structure*	*35.00%*	*12.32%*
Xiangtan Evergrande Yujing Peninsula Community	*centralized structure*	*42.00%*	*22.44%*
Changsha Zhonghai Longyuefu Community	*axial structure*	*40.00%*	*23.27%*

Figure 7. The greening rate and concentrated greening rate of property residentials, photo credit: author.



CONCLUSIONS

Summary of Morphological Features

Based on the above research, the residential morphology of mainstream property developers in China has the following common characteristics: (1)plot order: the plot area in residential area is differentiated by the location of land parcels and housing policies, and at the same time, different residential areas are independent of each other in terms of spatial boundaries and management modes, which creates problems such as the blockage of the urban road system and the loss of vitality of the streets. In addition, with the increased emphasis on land-use intensification, residential areas are gradually moving towards high-rise trends. (2)structure of road network: the road network in residential areas is based on the principle of pedestrian-vehicle circulation and maximum efficiency of internal connections, and often has little relevance to the building rows and external urban space; (3)overall layout of residential building: with the general layout of north-south rows and unit-type building types as the basic principle, as the investment attributes of housing have increased after the commercialization of housing policy reform, property developers have been pursuing replicable modes of standardized designs due to the excessive concern for market efficiency, resulting in the obvious trend of solidification of residential areas in terms of the layout of buildings. (4)open space: gradually, emphasis has been placed on the wholeness and homogeneity of the environment of the settlements, presenting a structural system of centralized green space-group green space-attached

green space, and the structure of the green space and the layout of the buildings in the residential areas always contact with each other.

At the same time, the morphological typology embodied in the sample of residential area of mainstream property developers is closely related to the context of China's urban development and reform of the housing policy. At the beginning of the 21st century, Chinese urban construction in the era of incremental expansion was influenced by the ideas of new urbanism and neighbourhood units, and then large-scale neighbourhoods appeared in the suburbs and new districts of cities. In 2016, following the *"Opinions on Further Strengthening the Management of Urban Planning and Construction"*, a number of "block" have emerged in urban center that are smaller in plot area, with boundary type and road network structure that are more closely linked to the external urban space (Zeng *et al*. 2016). In 2018, the government introduced new planning standard for urban residential areas, which on the one hand adjusted the spatial organization paradigm of China's residential areas, with smaller-scale 'block' as the basic space of residential areas.(Luo *et al*. 2019). On the other hand, by regulating the height of residential buildings and the average number of storeys, it also indirectly controlled the irrational paradigm of residential morphology represented by the "combination of high-rise and low-rise buildings", thus forcing property developers to explore a residential morphology that is more suitable for urban space.

Problem Analysis and Recommendations

However, the characteristics of residential morphology of China's mainstream property developers also reflect the lack of maintenance of the public interest in China's rapid development process: (1) Homogenisation of land use. The lack of consideration of block rezoning in residential areas of property developers and the monolithic approach to land use reduces the efficiency of urban land and, in particular, weakens the spatial mix of the urban public realm. (2) Internalisation of spatial connections. Physical boundaries and enclosed management isolate different residential areas from each other, internalised residential road networks also weaken the outward linkage of residential areas to the urban space. (3) Standardization of building layouts. The standardized form of residential areas caters to the market demand for standardized management, replicated production, and mass sales, but this kind of profit-maximization oriented layout has a homogeneous landscape, which is not in harmony with the urban fabric and is not conducive to the sustainable development of the city.

In the process of transforming the space of China's large cities towards a new stage of development, the constraints imposed by established the mode of residential construction on the development of the urban public realm are becoming more and more pronounced. The following optimisation recommendations are made: (1) Improving the composability of residential land use. Improve the system of supporting facilities based on living circle, encourage the compatibility of land-use and construct mixed-use district, eliminate residential differentiation by promoting equity in the distribution of social resources and providing diverse types of residential buildings. (2) Improving the relevance of residential areas to the external urban space. Promote the integration of the structure of the residential road network into the urban road system and enhance the community character of residential street places by increasing the functional boundaries. (3) Improving the continuity of residential areas in the urban macroscopic morphology. Residential construction should be integrated into the physical character of the site and the ambience of the area, it is important to seek continuity of overall morphology by embedding the residential planning in the existing urban street network and

strengthening the nodes (Goodchild B, 1994), instead of mechanical standardized replication and the models of “profit-oriented layout”②.

Annotation

①Definition of 1.0.3 of the *"Code for Residential Design"*: multilayer buildings have 4-6 floors, medium-rise buildings have 7-9 floors, high-rise buildings have more than 10 floors.

②"Profit-oriented layout" is a unidirectional design approach based on the intention of capital, equating residential planning with a capital business product, seeking a product mix and layout that maximises profit in a short period of time, subject to the constraints of the capitalist. This layout often puts the spatial environment of residential areas on the back burner, and the resulting programmes are often characterised by a single spatial layer and low environmental quality, which is a kind of master plan that ignores the quality of the human environment, deviates from the needs of residents' lives, and focuses on the interests of the capital.

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A São Paulo for the future: the production of interstitial infrastructures based on morphological, environmental and social parameters

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ABSTRACT

The city of Sao Paulo is planned, designed, built and used from the perspective of "buildings" to the detriment of the urban void and its latent potentialities. It is hypothesized that the city, if produced from interstitial infrastructures based on morphological, environmental and social parameters, results in higher quality urban environments for people. The aim of the article is therefore to evaluate typical urban interstices selected in the existing city and to evolve, analytically, and to apply, prospectively, innovative tools and parameters for urban planning and design, seeking the construction of effective interstitial infrastructures to requalify the city, with a focus on territories with potential for urban transformation. The method is empirical, analytical and speculative in the way that articulates Fieldwork, Analytical Work and Prospective Work, theoretically based. Ultimately, against the prevailing urban regulation and practice, and from the application of the morphological-environmental- social parameters proposed by the thesis, alternative futures are speculated to the city of São Paulo, legitimating and proving the infrastructural role of urban interstices in the requalification of the city.

Keywords: Urban void, Thermal Comfort, Open space, Urban Design, Equivalent Perceived Temperature.

INTRODUCTION

As other cities living in the legacy of Modernist Urbanism, the city of Sao Paulo, in Brazil, is fundamentally planned and built following the logics of self-standing and isolated buildings, regardless to the space in-between them (Rowe and Koetter, 1978). From this panorama, it is launched the hypothesis that when urban planning and design are driven by environmentally, morphologically and socially informed interstitial infrastructures, the resulting urban space acquires higher levels of quality for people (Pizarro, 2019). Therefore, this research pro-design's objective is to analytically develop and prospectively apply simplified and replicable tools and parameters of urban planning and design with the aim of requalifying the existing city through the logics of the urban voids.

The concept of urban void

Based on the concepts of “intervals” (Smithson and Smithson, 2005), “accumulation of voids in largely unmanipulated solid” (Rowe and Koetter, 1978), and “positive spaces” (Alexander, 1977), the term “urban void” or “urban interstice” is understood as a three-dimensional instance that overlaps the term “open space”. It is fundamentally the whole space in-between buildings (Fig. 1) that supports everyday common life, besides environmental dynamics (solar radiation, daylight, wind, sound), regardless to public or private domains.

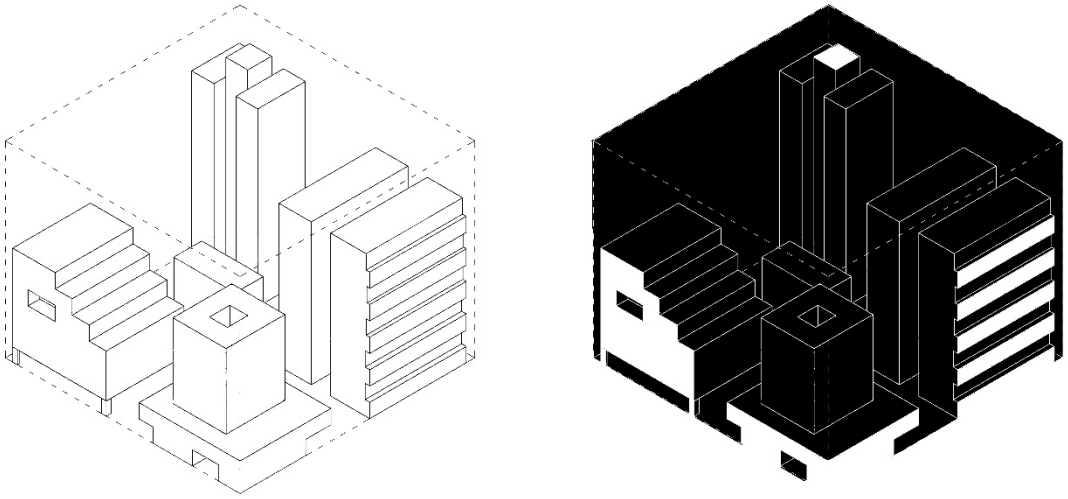


Figure 1. Diagram that illustrates the concept of urban void: self-standing buildings in white (left) and urban void in black (right). Source: Pizarro, 2019.

METHOD

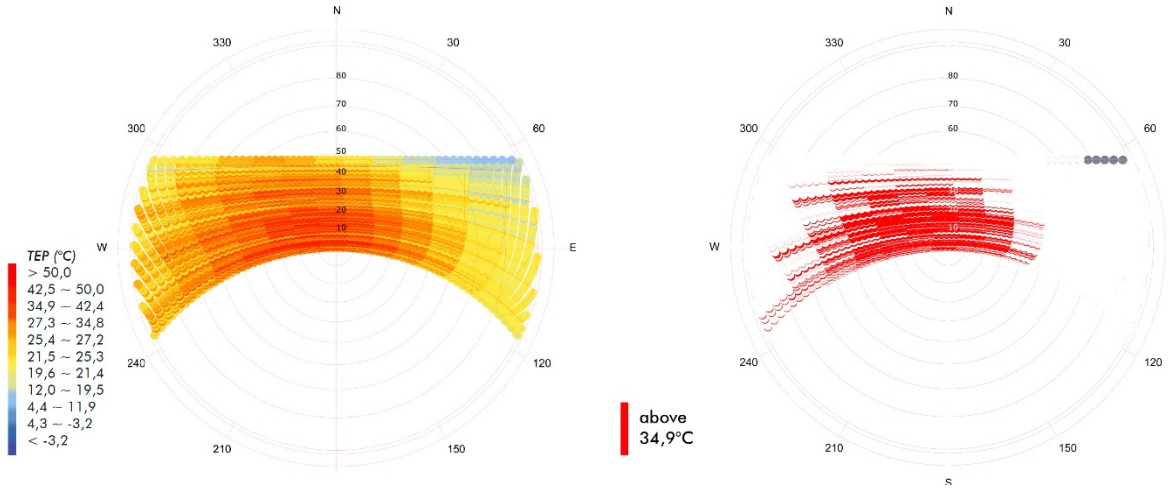
The Method is fundamentally analytical and prospective (Yannas, 2015). The Analytical phase is composed by two parts: first, the development of an innovative and simplified analytical tool that combines the sun path diagram to a thermal comfort index for outdoor spaces; second, the application of this tool to selected typical case studies of urban voids and prospected scenarios in the city of Sao Paulo, from which the assessment leads to the proposition of environmental-morphological parameters. Ultimately, the Prospective phase employs and validates the parameters found in the previous phase that provide outdoors comfort in the various configurations of open spaces through design applicabilities in existing territories under transformation in the city of Sao Paulo. In addition to that, the method is anchored in Theoretical References regarding Outdoor Thermal Comfort (Erell and Pearlmutter, 2010), Urban Morphology (Rossi, 1984) and Social Dynamics of Open Spaces (Gehl, 1980); besides Fieldwork, which is developed in three different territories in the city of Sao Paulo prior to the Analytical phase, in order to check the adopted theoretical concepts and hypothetical assumptions.

RESULTS AND DISCUSSIONS

Tool

The Interstitial Thermal Comfort Chart (ITCC), or “Carta de Desempenho Térmico Intersticial” (CDTI) in Portuguese, is an innovative tool developed with the aim of both assessing and estimating the thermal conditions in existing and proposed urban voids throughout the year for a specific climate

and latitude, in this case referring to the city of Sao Paulo. In essence, the tool is composed by the sun path diagram in which are plotted the calculated values of Equivalent Perceived Temperature (TEP) according to Monteiro's thermal comfort index for outdoor spaces (2018) and to the local climate database. The ITCC (Fig. 2) was constructed using the computer modelling software Rhinoceros 3D, Grasshopper and Ladybug.



Figures 2 and 3. (on the left) Interstitial Thermal Comfort Chart (ITCC) for the city of Sao Paulo (lat. 23°30'S) showing values of Equivalent Perceived Temperature in the scenario: Summer-fall; Global Radiation; and 0% wind. (on the right) Simplified version of ITCC highlighting the TEP range above 34,9°C in the scenario: Summer-fall; Global Radiation; and 0% wind. Tools: Rhino + Grasshopper + Ladybug Source: Rhino + Grasshopper + Ladybug. Source: Pizarro, 2019.

In order to enhance legibility and simplify the application of the ITCC for the case of the city of Sao Paulo (warm temperature, hot summer - Cfa - under the Koppen climate classification, CIBSE) it was produced a further version of it (Fig. 3), highlighting exclusively the TEP range above 34,9°C, which is related to "warm", "super warm" and "extremely warm" sensations according to Monteiro (2018). The value 34,9°C is therefore assumed as threshold for outdoors thermal comfort in this climate. To all intents and purposes, the ITCC tool is composed by an ensemble of eight sun path diagrams encompassing the combination of different scenarios regarding period of the year (summer-fall versus winter-spring), radiation (global versus diffuse), and wind (0% versus 100% of the value registered in the weather file), as shown in the Figure 4. The selection and combination of ITCCs for evaluating and estimating thermal conditions outdoors in a specific given urban void is further described in the next item.

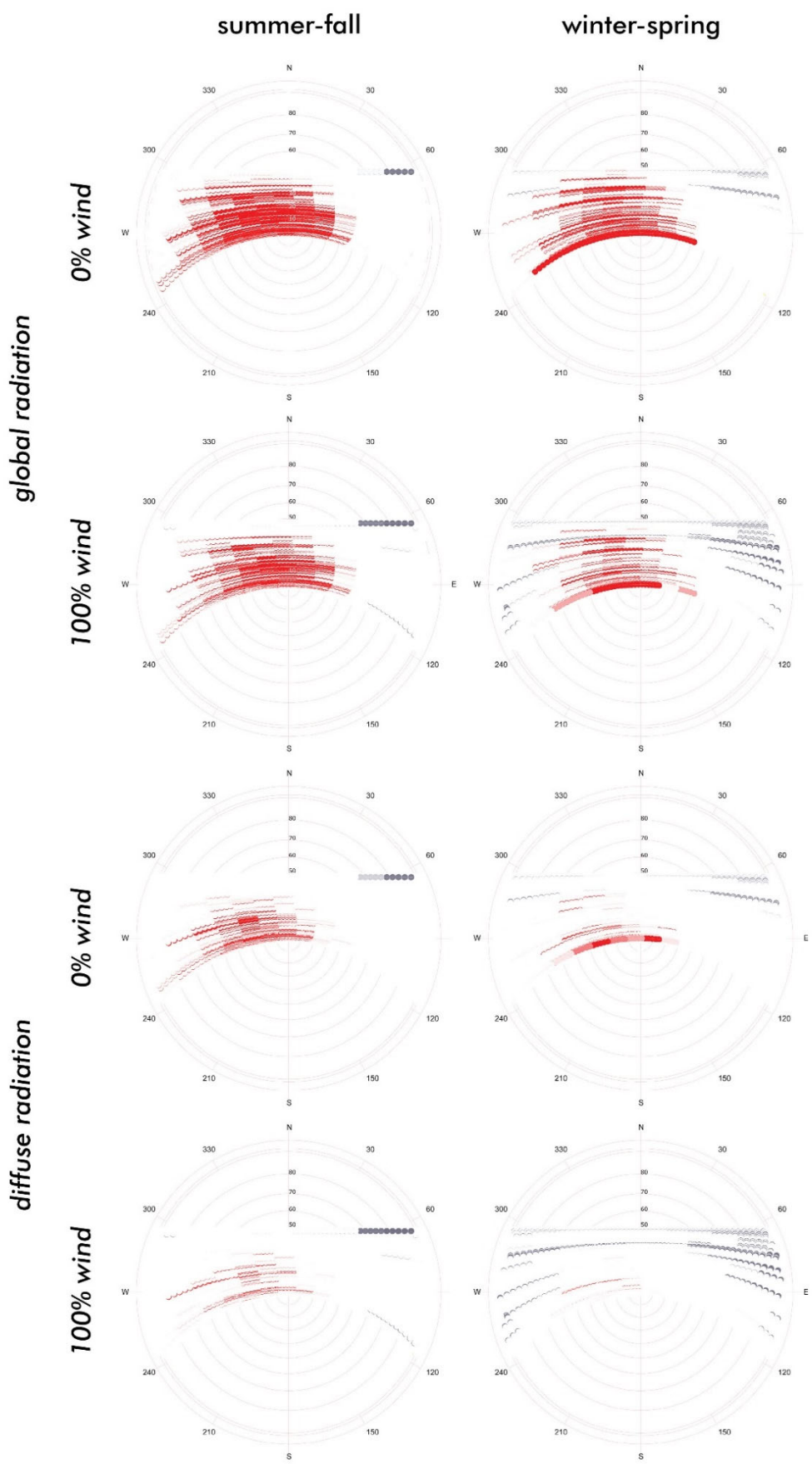


Figure 4. Ensemble of ITCCs for different scenarios regarding period of the year, radiation and wind. Source: Rhino + Grasshopper + Ladybug. Source: Pizarro, 2019.

Tool application

The ITCC tool allows the assessment and prediction of the thermal conditions of a single point (at a time) in an urban void along the day and year once combined with the respective sun mask as shown in Figure 5. It is important to highlight the combination among global and diffuse radiation's ITCCs for exposed and protected zones of the sun mask, respectively.

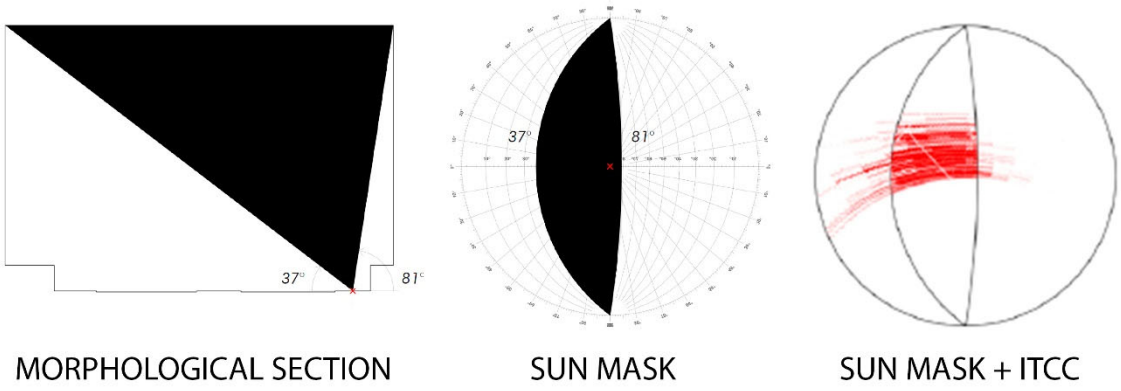


Figure 5. Diagram summarizing the analytical procedure, combining ITCC and sun mask for a single point in the void. Source: Pizarro, 2019.

Since the ITCC and the sun mask are combined, the percentage of hours in thermal discomfort (assumed as TEP above 34,9°C) or comfort is graphically determined through a comparative pixel's counting in the software Photoshop. As part of the Analytical work, the ITCC tool is applied to 87 selected case studies in the city of Sao Paulo (Fig. 6), such as the void on the ground floor the Museum of Modern Art of São Paulo – MASP (Fig. 7), with the aim of analysing the thermal performance of pre-selected existing urban voids. The case studies were selected according to the following criteria: territorial distribution; diversity of morphology, scale and function; environmental, morphological and social singularities or potentialities such as spatial connectivity and liveable edge zones. Depending on the morphology of each case study, the analysis is mainly based on the plan, or section, or both, or in an axonometric perspective.

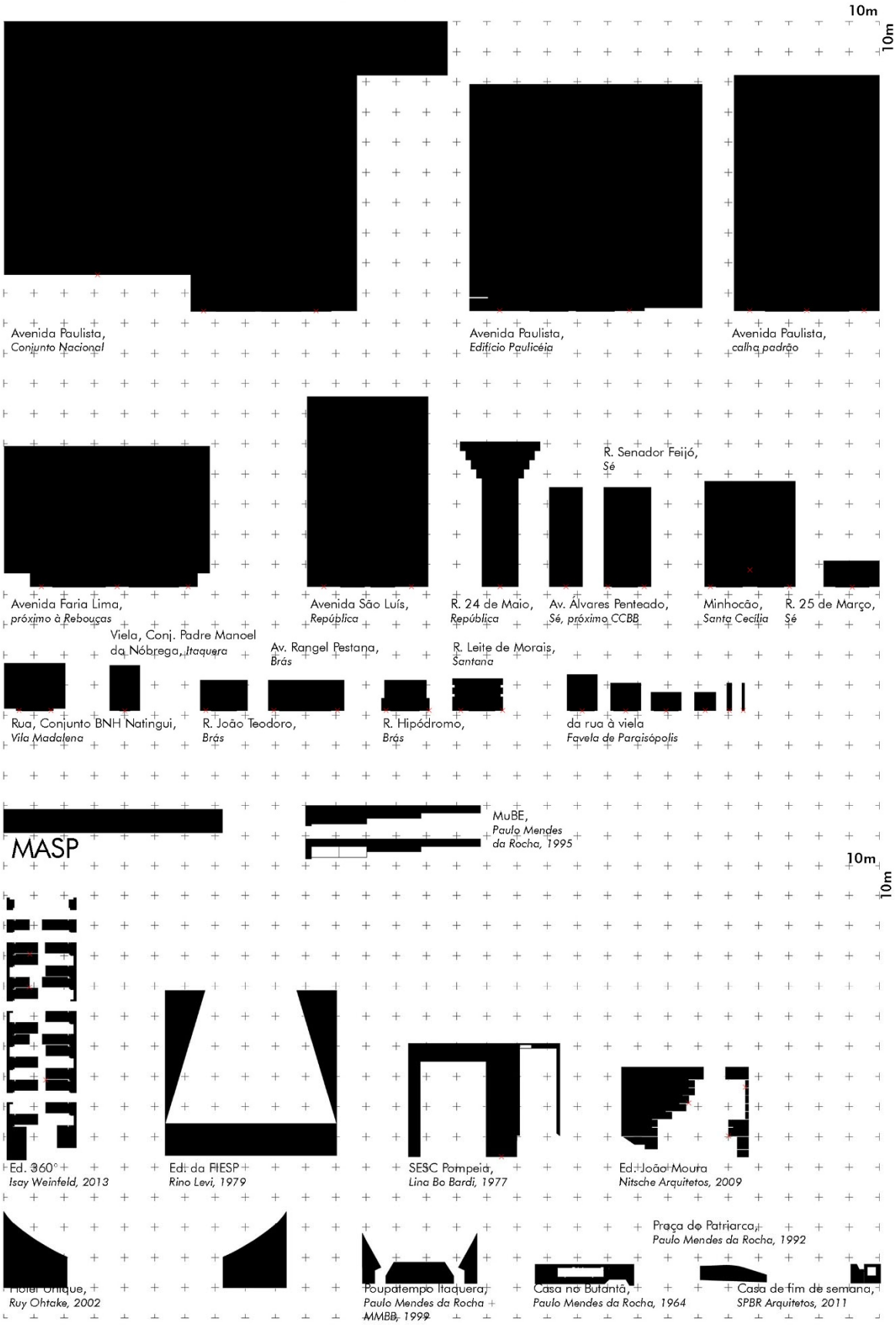


Figure 6. A sample of morphological masks of typical voids taken out of the 87 cases identified in the urban fabric of Sao Paulo, analysed in section. Black refers to urban void. The following figure illustrates one of the morphological masks. Source: Pizarro, 2019.



Figure 7. In reference to previous figure, picture of the void of the Sao Paulo Museum of Art – MASP. Source: AV Monographs, 2015.

The main results of the environmental assessment of the 87 case-studies were: the variation of hours in thermal discomfort along the year, leading to guidelines of adaptable and/or temporary interventions; the positive impact of natural ventilation on mitigating thermal conditions in warmer periods; that East-West oriented urban voids are more critical to thermal comfort; ultimately that typical voids from disparate contexts (for instance formal versus informal settlements) may embody similar thermal and social performances due to equivalent morphological proportions.

Environmental-morphological parameters

Based on the outcome of environmental assessment of the case studies, a correlation between the morphological parameters of height-to-width ratio (H/W) and sky view factor (SVF) with thermal performance. In addition to that, the research speculates other proposed parameters: A/H^2, which compares the area of projection to the void's height; and H/(A/P), which relates the height to the ratio between the area and perimeter of projection. The morphological parameters are rated according to ranges of percentage of hours in thermal comfort or discomfort in different scenarios regarding sun orientation and natural ventilation available (Fig. 8).

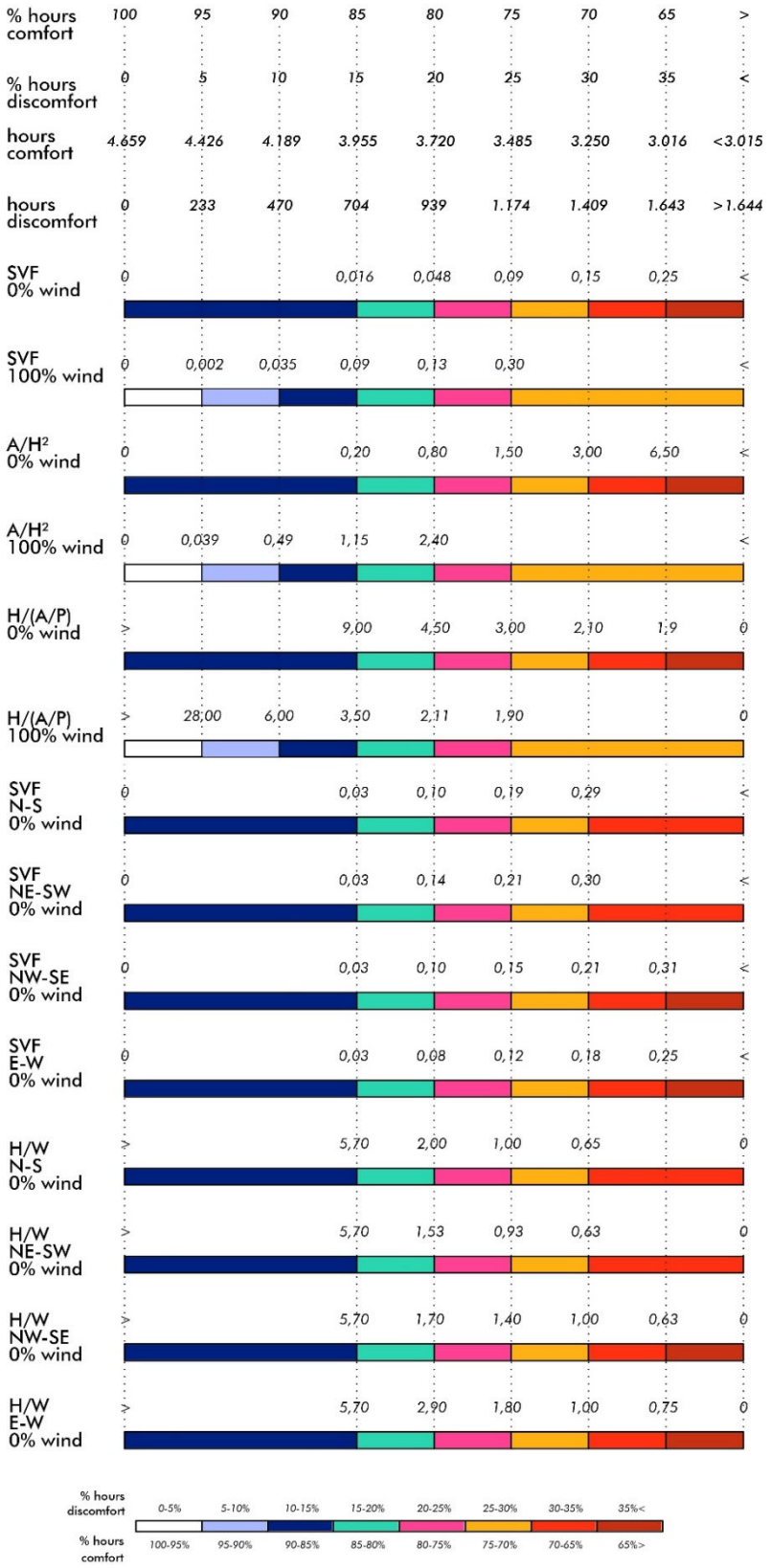
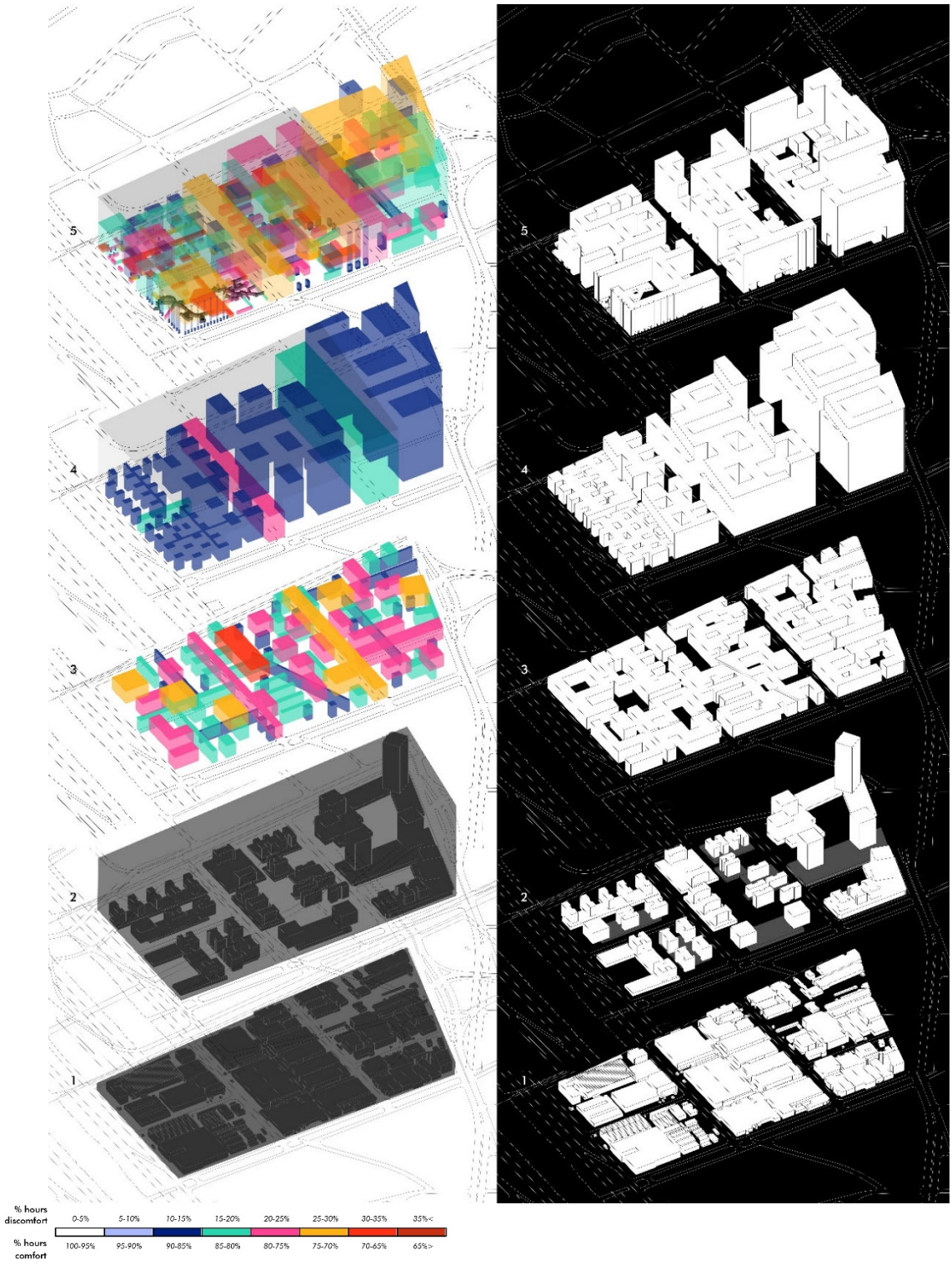


Figure 8. SVF, H/W, A/H² and H/(A/P) parameters related to percentage of hours in thermal comfort or discomfort (referring to TEP = 34,9°C as threshold for thermal comfort) along the year for the city of Sao Paulo. Each line presents a different scenario regarding sun orientation and natural ventilation availability. Source: Pizarro, 2019.

Design Applicability



Figures 9 and 10. Voids on the left and Resulting Buildings on the right. Design applicabilities developed for an ensemble of five existing urban blocks in Lapa's neighborhood. The urban void and resulting buildings are highlighted in different scenarios in Colours: 1. existing factory settlement; 2. proposed scenario according to current urban regulation; 3-5. alternative plans show proposed scenarios based on the application of the proposed performance parameters. Source: Pizarro, 2019.

The proposed parameters are ultimately applied to two different territories in current process of transformation in the city of Sao Paulo with the aim of evaluating their effectiveness and speculating/illustrating possible alternatives to the future of a subtropical city re-structured by environmentally responsive and socially liveable interstitial infrastructures. Each selected territory (five urban blocks in the neighborhood of Lapa and one single urban block along Rebouças Avenue) is re-designed by different interstitial infrastructures (scenarios), through digital and physical models (Figs. 9-15).

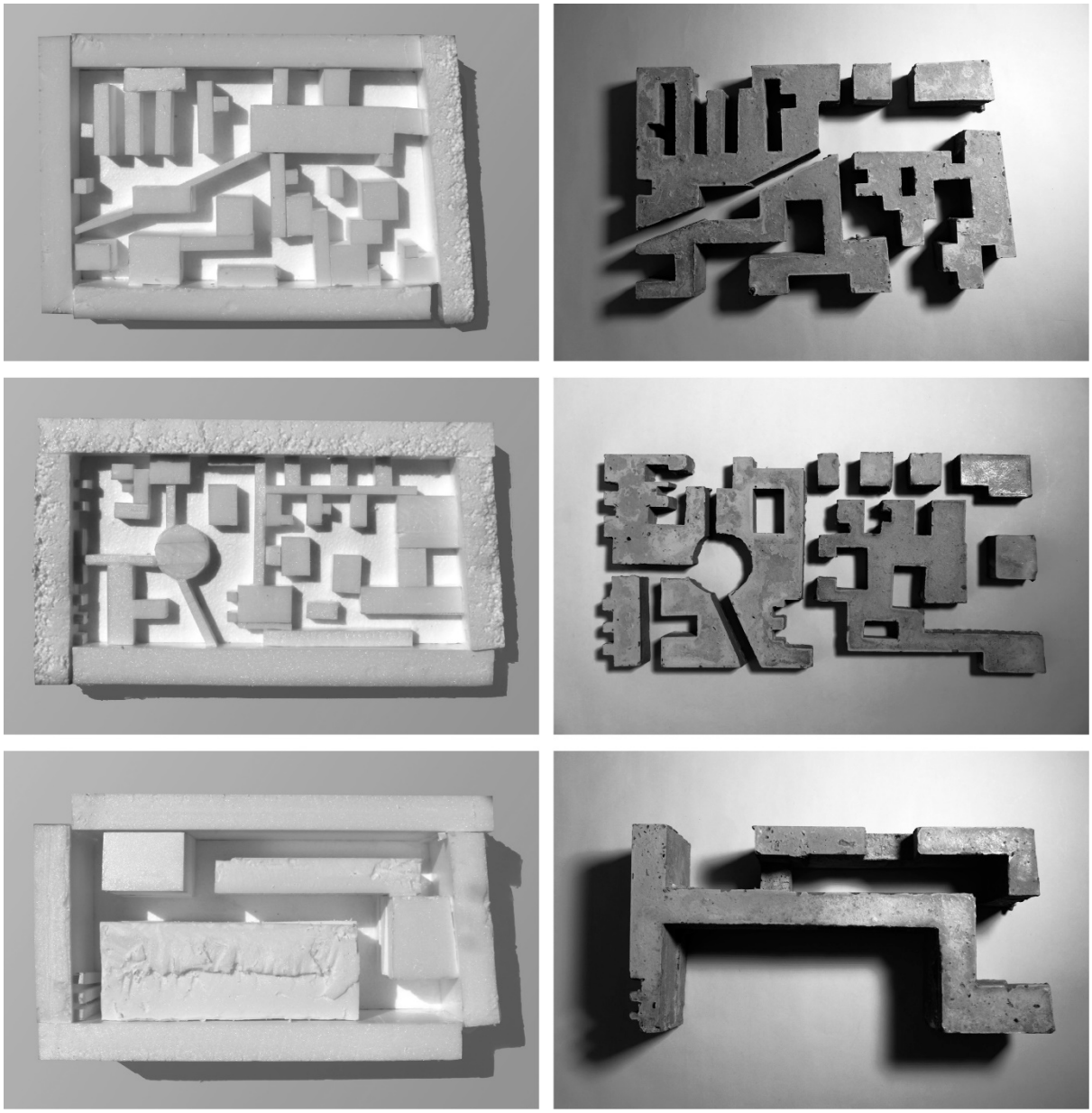


Figure 11. Physical models developed for Lapa's neighborhood: on the left the voids materialized in polystyrene; on the right the resulting buildings in concrete. Source: Pizarro, 2019.

The evaluation of the design applicabilities developed for the territory of Lapa (Figs. 9-11) brings to light important considerations. Firstly, the application of the proposed parameters results in an urban fabric marked by more diverse (regarding shape and scale) and articulated voids than the existing urban layout, emphasizing the "edge zones" as fundamental physical structure for supporting the

social structure (Gehl, 1980). Secondly, the proposal of interstitial infrastructures based on environmental, morphological and social parameters should be developed in articulated layers. In other words, the pre-requisites for urban voids on the ground floor are different to the ones above, but the whole infrastructure's performance relies on their interaction.

This consideration is further investigated in the design applicability for Rebouças Avenue, where the voids are designed in four articulated layers at different heights (Fig. 12-15).

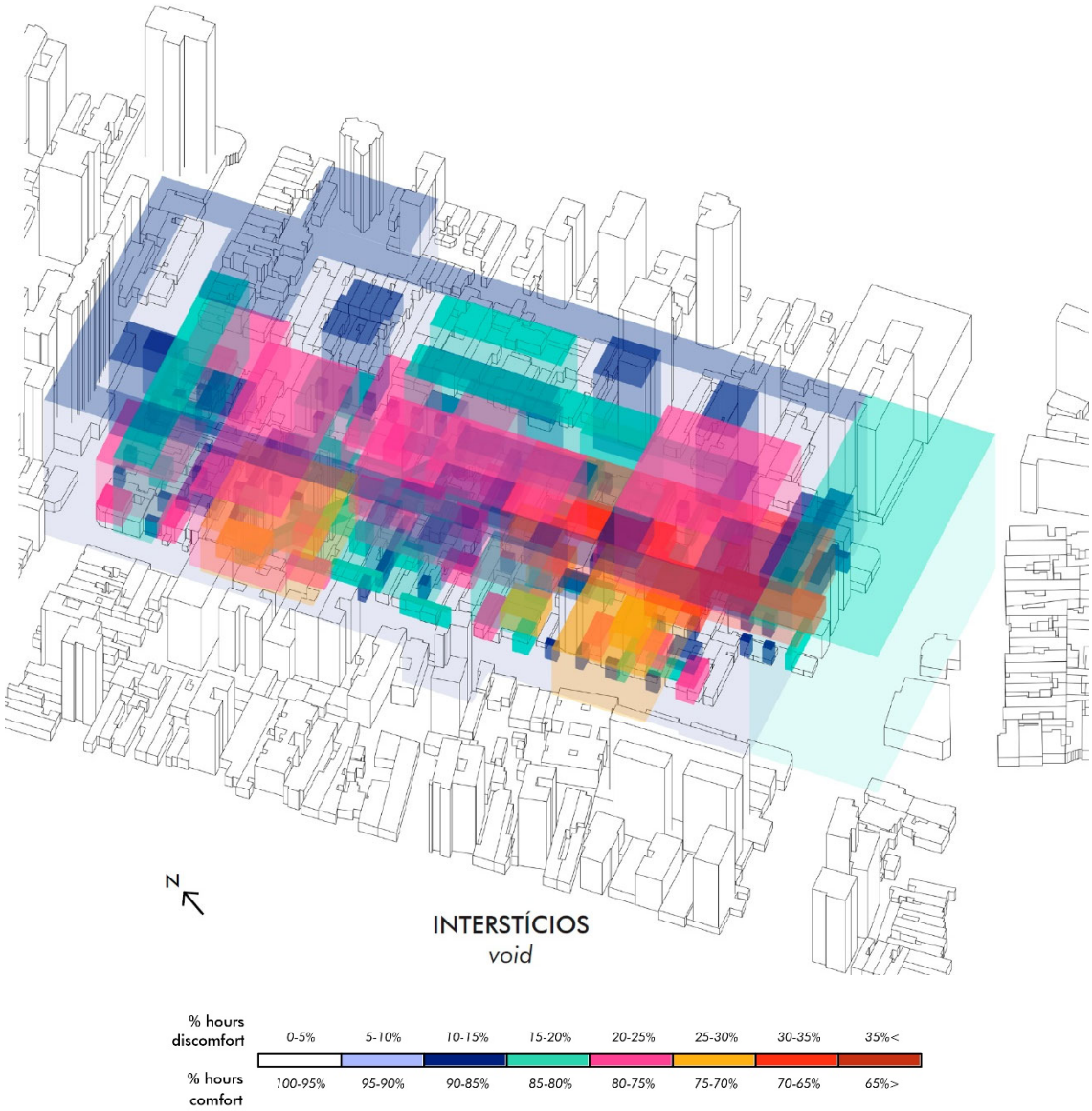


Figure 12: Design applicability in Rebouças' urban block, highlighting the proposed interstitial infrastructure in colors.

Figures 12 to 15 show how different layers address specific requirements: the ground floor layer is designed with the aim of avoiding sun overexposure and stimulating urban life along rougher edge zones; the higher layers should gradually control solar radiation without blocking access to natural light and wind.

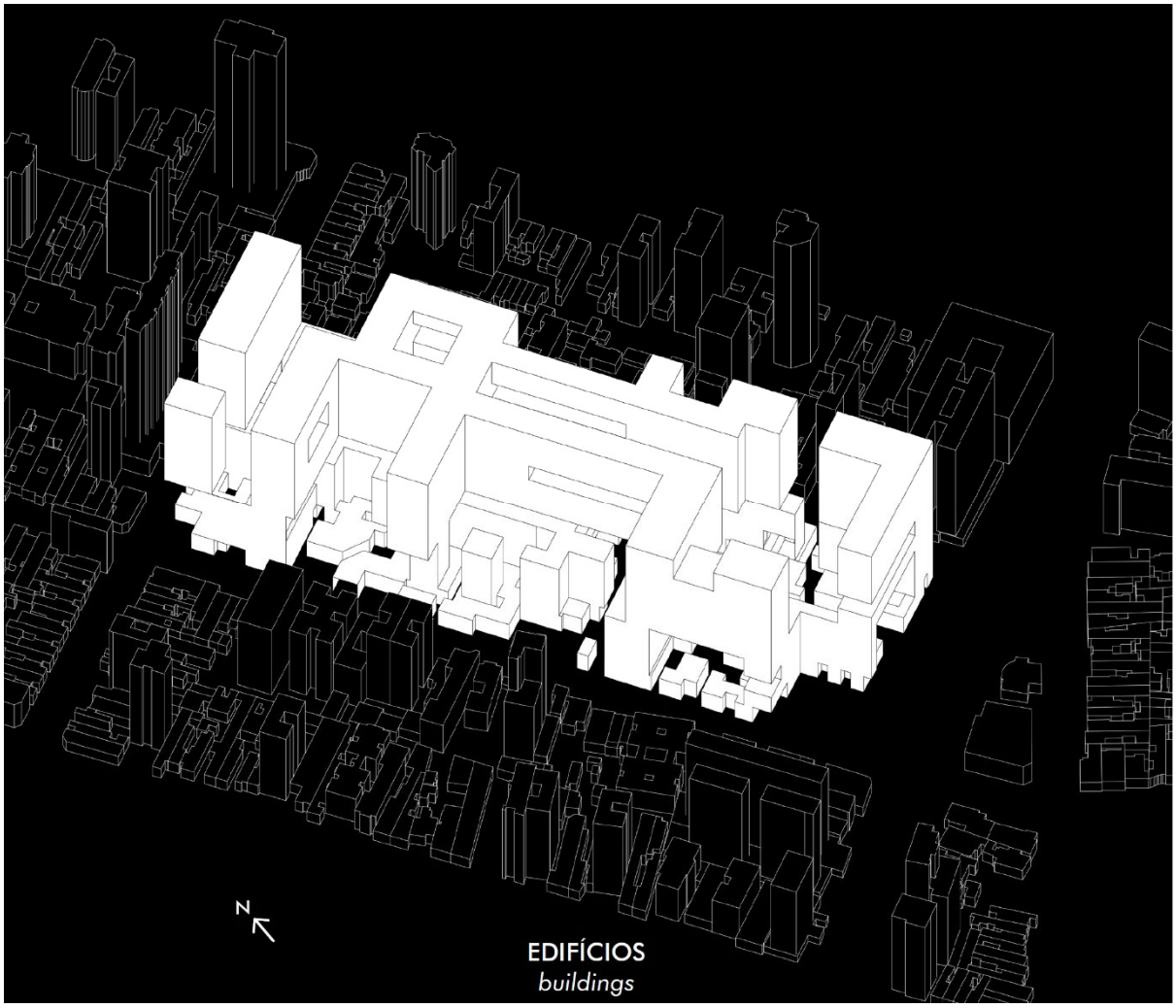


Figure 13. Design applicability in Rebouças' urban block, highlighting the resulting built mass in white. Source: Pizarro, 2019.

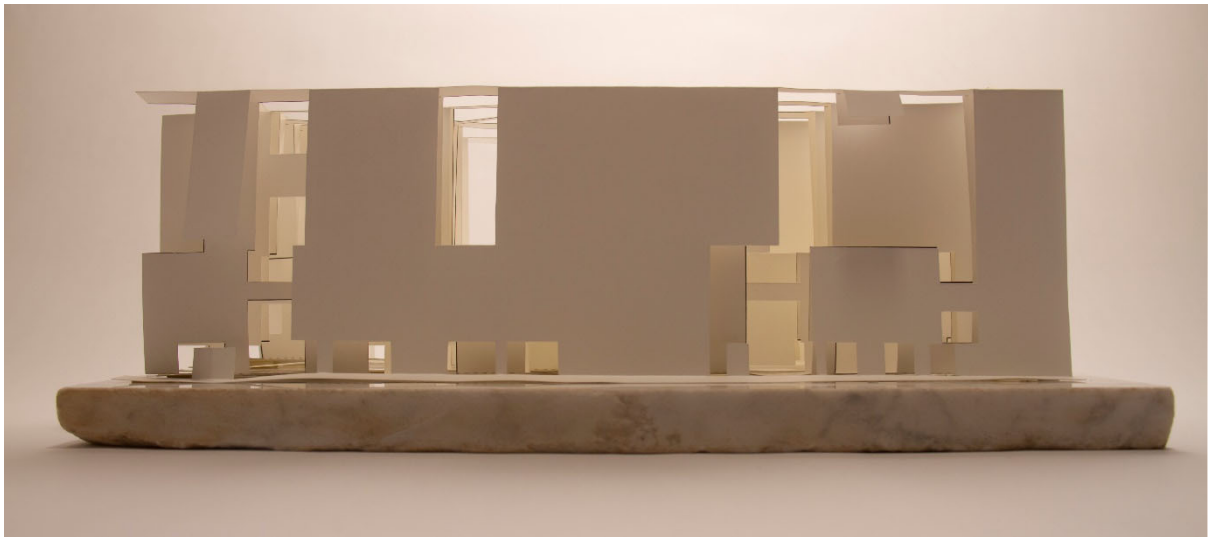


Figure 14. Physical model, in paper and stone, developed to highlight the proposed voids for an urban block in Rebouças neighborhood. Source: Pizarro, 2019.



Figure 15. Ensemble of diagrammatic sections for Rebouças neighborhood: voids in black; buildings in white. These sections follow "where to build" and "where not to build" logics (Koolhaas, 1995). Source: Pizarro, 2019.

CONCLUSIONS

The analysis of the research's results leads to four possible next steps: firstly, the application of wider ranges of natural ventilation data in the construction of the ITCC tool (instead of simply 0% versus 100%); secondly, the production of the ITCC tool for other latitudes and climates; thirdly, the development of further analysis in order to evaluate the impact of the proposed environmental-morphological parameters in the environmental quality of indoor spaces adjacent to the re-designed urban voids, stressing daylight levels; fourthly, the assessment (mainly based on the user experience) of the proposed parameters through the construction of 1:1 temporary prototypes around the city.

By all means, the investigative process proved the stated hypothesis and led to five key considerations for the environmental quality and potential social success of the urban voids, as follows. Firstly, the importance of basing the research findings in the evaluation of the existing city. Secondly, the articulation of environmental, morphological and social domains in every phase of the research increases the applicability of the proposed tools and parameters. Third, instead of the deterministic implementation of fixed rules, the combined application of quantitative and qualitative parameters leads the city to adaptive spaces and ultimately to a network of "environmental diversity" (Steemers and Steane, 2004). Fourthly, the employment of simplified tools and parameters enhances replicability and scalability levels in urban planning and design, ultimately leading to the improvement of the city's everyday life. Finally, the application of the proposed tools and parameters to the existing city should take the urban block as minimum unit of planning; and besides that, publicly and privately owned open spaces should be planned/designed together as three-dimensional masks assigning "where to build" and "where not to build" (Koolhaas, 1995), ultimately guaranteeing an articulation of scales and, most importantly, the "smallness of big cities" (Jacobs apud Whyte, 1993).

Acknowledgements

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Analysis of the features and renewal strategies of traditional street interface in urban fringe areas: a case study of Sipo Town, Yibin City

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ABSTRACT

With the full development and promotion of China's urbanization, the development of urban centers continues to heat up. Towns located in the urban fringe are facing many development dilemmas, such as hollowing out, weak industrial competitiveness and degradation of human settlements. Many traditional streets are facing decline in morphological structure and characteristic space gradually disappears. In view of the current situation that traditional streets in Sipo Town need to continue their characteristics, this paper introduces the method of morphological typology, divides the elements of street interface into four categories: street space, transition space, street wall system and building texture, and conducts characteristic induction and quantitative analysis from the aspects of morphology, scale and structure. In the implementation, combined with the status quo and design requirements, the prototype of traditional street interface with characteristics of Sipo is refined, the composition logic between various elements is clarified, and the integrated "text-chart-legend" principle is established to guide the update of traditional street interface in Sipo town, and provide new ideas and strategies for the lost traditional streets in the urban fringe, so as to protect the form and texture of the existing streets and lanes, and guide the interface style of newly built streets and lanes.

Keywords: arginal zone; Traditional street interface; Morphological typology; Protection and renewal.

INTRODUCTION

After years of practice in urban construction and exploration of urban renewal, the era of “large-scale demolition and construction” has passed. Urban construction has entered a new stage of improving the quality of existing buildings. A series of renewal activities have injected new vitality into the city. Traditional streets and lanes record history, nurture the lives of the general public, and depict the appearance of the city (Kang and Zhang, 2023). Historical blocks are a concentrated reflection of the city’s spirit and are of great significance for inheriting urban culture and shaping the city’s appearance(Wang *et al*., 2023). Therefore, their cultural and spiritual values are increasingly valued, and traditional historical blocks located in the city center are welcoming new development opportunities. However, compared with the superior geographical location and relatively clear historical development context of traditional blocks in the central city, the urban fringe is an extremely sensitive and unstable space-time complex(Zhou *et al*., 2024). The traditional blocks in the urban fringe often have disadvantages such as unclear development positioning, poor accessibility, scattered distribution, and weak

continuity of street and lane forms. They cannot be effectively protected and developed in the long-term urban and rural construction, and fall into a vicious cycle of population outflow and deterioration of the living environment. The traditional street and lane form structure is facing collapse. This paper focuses on the traditional street interface and attempts to analyze its morphological structure and constituent elements from the perspective of morphological typology. Guided by "morphology" and using "type" as a tool, this paper extracts the "metalanguage" of the traditional street interface, and combines the renewal needs to establish design criteria to control and guide the street interface morphology.

STREET INTERFACE IN URBAN FRINGE AREAS FROM THE PERSPECTIVE OF TYPO-MORPHOLOGICAL APPROACH

Research overview

Since the 1990s, K.S. Kropf and I.Samuels were the first to apply Typo-morphological approach to urban planning and management practices, among which the Mennecy region in France was the most comprehensive(Zhang *et al.*, 2024). In China, scholars Chen F et al. first applied Typo-morphological approach to the renewal of traditional blocks for the purpose of protecting urban context(Kropf, 1996); Li Jinfang et al. applied Typo-morphological approach to the planning practice of historical blocks(Chen, 2010)(Figure 1). Subsequently, more and more scholars have applied it to traditional blocks, historical and cultural ancient towns, villages and other cases, but they are mainly concentrated on the overall planning and design of the city, or the areas in the city center and residential areas where the traditional historical style is well preserved. There are few applied studies focusing on the special urban landscape elements of the urban fringe.

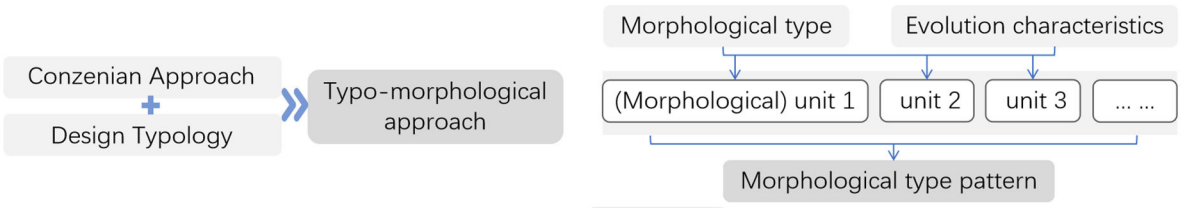


Figure 1.Theoretical development and Practical method. photo credit:Self-painted

In a narrow sense, the street interface refers to the building interface on both sides of the street (Li and Chen, 2021). In a broad sense, it refers to the street itself and the side interface. As the intersection of various components within the block, the street interface has a relatively sensitive characteristic and is the primary reflection point of changes in various elements. The combination of street space and architecture is essentially similar, both are enclosed space environments formed by the interaction of various factors, and the elements have the same constraints; the application of Typo-morphological approach can fully identify and extract the traditional characteristics of street interfaces, and use them as the basis for renewal research. Therefore, the practical method of Typo-morphological approach is relatively applicable to research in specific areas.

Characteristics of street interfaces in urban fringe areas

Sipo Town is located in the northwest of Yibin City, between the edge of the urban construction area and the airport, and faces the Minjiang River to the south(Figure 2). According to legend, the Northern Song Dynasty poet Huang Tingjian was demoted here. Because he missed Su Dongpo, he built a building here and wrote a plaque "Sipo" by hand, waiting for Dongpo to come, hence the name. The town is distributed in a strip along the river. Among them, Dashunchang Block is the street with the

best preserved traditional style in the Sipo Town area. In ancient times, there was a water wharf. It was called "Dukouchang" before the Ming Dynasty and was renamed "Dashunchang" in the late Ming Dynasty(Figure 3). Dashunchang Block has long been the center of Sipo Town's development, but behind the great improvement of the quality of the living environment by modernization, the disadvantages of regional transportation and geographical location have become increasingly prominent: the "historical inherent defects" left by the street width restrict vehicle access, and the street is located on the concave bank of the lower reaches of the Minjiang River and the flat terrain cannot resist flood disasters. In the current context of extreme emphasis on production efficiency, there is undoubtedly great resistance to the development and protection of the street. Driven by transportation and topography as the main factors, Sipo Town gradually expanded to Dongpo Street, which is located on higher ground. The development focus of the urban area also shifted to the northwest block. Traditional buildings were gradually abandoned and replaced by stereotyped modern buildings.



Figure 2. Location map of Sipo Town. Photo credit:Self-painted

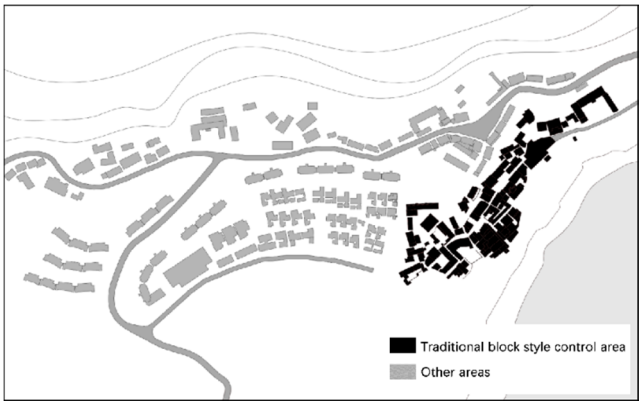


Figure 3. Location map of DaShunChang Block. Photo credit:Self-painted

The so-called Typo-morphological approach is to understand the structure and characteristics of the morphology (physical properties) with the analytical and conceptual cognitive framework of urban morphology, and to examine the logical relationship between the formation and change of these morphologies (human properties) in combination with the evolutionary perspective of typology (Chen et al., 2017). It emphasizes revealing its internal structure and characteristics through the typological study of the urban material space morphology. It focuses on the relationship between different types of buildings, streets and blocks, as well as the evolution of each element in space and time. Its research method is to decompose the entire spatial form into a number of type elements. These type elements should contain a hierarchical system from small to large. The single element should always maintain the relationship with the elements of the same level and the previous level(Li et al., 2023) .

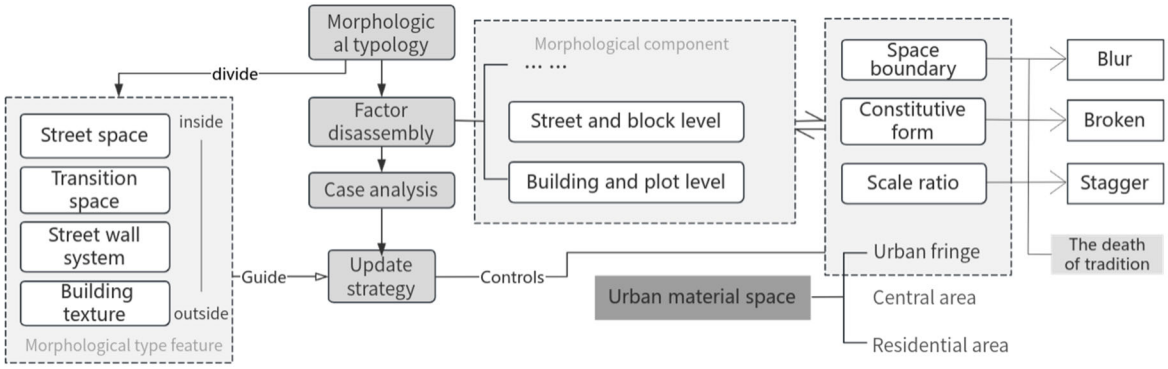


Figure 4.Technical route. photo credit:Self-painted

Typo-morphological approach believes that the morphology of urban material space can be analyzed and recognized at multiple levels, generally divided into four levels: building and plot level, street and block level, city level and regional level; among them, each level influences and restricts each other: high-level elements dominate the macro-morphological characteristics, and low-level elements dominate the meso-micro spatial composition and style. In urban material space, compared with urban central areas and residential areas, urban fringe areas have relatively isolated and highly dynamic development patterns in terms of life, production and ecology, which have accelerated the deconstruction of the traditional characteristics of the various morphological elements and the disconnection between the elements. As a traditional block in the urban fringe, the conflict between the protection of the original buildings and the progress of modern construction in Dongpo Community inevitably has a negative impact on the various element levels themselves, presenting a development dilemma different from ordinary areas, such as the increasingly fragmented rural landscape, the mixture of old and new settlement space, and the particularly prominent management deficit(Wei *et al.,* 2022). The disappearance of tradition has made the boundaries of urban material space increasingly blurred, the constituent forms tend to be fragmented, and the scale proportions are unbalanced(Figure 4).

Fuzzy spatial boundaries

The word “boundary” has different meanings. But generally speaking, boundary means “difference”. It is a mark that distinguishes things and is widely present between things (Li, 2023) . Spatial boundary refers to the boundary between different functional areas in cities, blocks, and even buildings, including natural boundaries and artificial boundaries. It can divide the form of cities or blocks and guide the spatial functional layout. Dashunchang Block is located in a special area where dense urban construction areas transition to open rural areas. Under the influence of the intersection of two different forms of human settlement, urban functions and rural functions penetrate each other, and construction land and agricultural land are intertwined. With the more active urbanization construction activities, the spatial boundary between the two has become dynamically blurred. There is no clear and fixed boundary between urban and rural areas, and traditional blocks are gradually shrinking(Figure 5). Especially in the marginal areas where traditional blocks and modern construction intersect, the functions of block plots are presented in a disordered and complex way. New residential buildings are adjacent to small-scale industrial production areas, and modern high-rise residential areas are adjacent to traditional blocks, which exacerbates the ambiguity of land use nature and

spatial hierarchy fractures between blocks. In addition, there is a contradiction between urban and rural development benefits and standardized management, and the blurred boundaries between public and private property plots have led to many informal reconstructions and expansions in the traditional blocks of Dongpo Community. These reconstructions and expansions have crossed the traditional boundaries, and behaviors such as occupying the road for business and parking have also occurred, and the building boundaries within the blocks have become increasingly blurred.

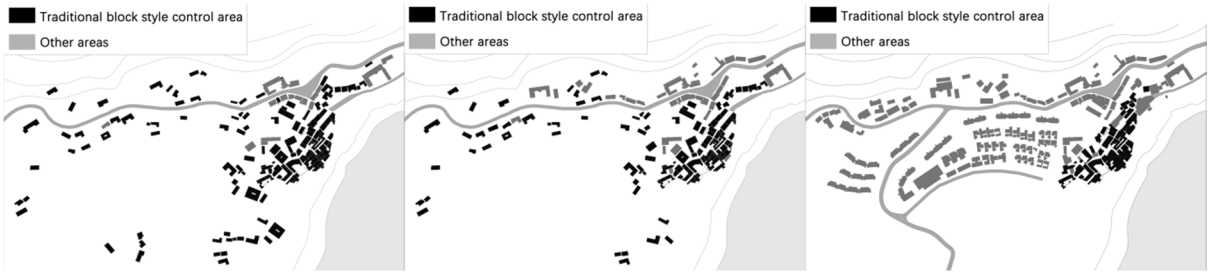


Figure 5.Distribution map of traditional buildings over the years. photo credit:Self-painted

Broken structure

Compositional form refers to the spatial and morphological characteristics of cities, blocks and buildings, including organizational structure and composition elements. As Dashunchang Block gradually expanded northward, it became the core street of the entire community. The limitation of the width of the streets in the traditional blocks resulted in the lack of direct connection between the emerging construction land and the traditional blocks. The continuity of the two was ignored, and the street network became fragmented. Driven by development benefits, some traditional buildings were ignored due to dilapidated structures and locational traffic disadvantages. In the absence of effective human intervention and maintenance, the traditional buildings in Dashunchang Block were mainly interpreted in three different ways. The first is to build new buildings around the original traditional buildings. In this way, the original traditional buildings still bear some of the main functions and can also be better maintained, but the facade style and materials of the new buildings are often incompatible with them. The large-scale use of decorative elements such as glass and tiles weakens the continuity of the traditional street wall system. The second is to extract it from the original main role and place it in auxiliary production, storage and other functions. Although it will still be maintained, due to the trade-off between input and output ratio, the quality is often low, and it can only support the basic space function and temporarily extend the service life of the building. Third, if they are left alone, many buildings with brick and wood as the main load-bearing structure will soon collapse. Under different levels of intervention, the original complete traditional street wall system has more and more fracture points, and the street space interface is presented in a "hodgepodge" style: traditional but modern, modern but dilapidated, various components are gathered in the building facades along the street, and various styles of building facades are gathered in the street wall system.

Unbalanced scale

Any three-dimensional object of any shape must have three dimensions: length, width, and height(Cai, 2016). From the overall block to the level of architectural details, scale ratio always runs through it,

involving the relative size and proportion of architectural details, facades, and street space. Reasonable scale ratio can not only enrich people's spatial experience when walking, promote the overall coordination of the block, but also play a structural role in shaping the block's form. Effective control of scale ratio can also create street spaces with diverse experiences. The traditional streets in Dashunchang Block are small in scale, which restricts vehicle access, but the scale of the family can also accommodate more daily activities, which is crucial to maintaining the traditional characteristics and vitality of the block; in contrast, Dashunchang Block has a large scale of streets and buildings on both sides. Although it strengthens the traffic function, it alienates the street from carrying daily functions to a certain extent. The buildings in Dashunchang Block are mostly one or two stories high. As the traditional buildings are dilapidated, they are replaced by new buildings that are inconsistent with the scale of the blocks. In terms of facade form, most of these buildings are above two stories and have relatively higher floor heights. Therefore, the scale of doors and windows and the scale of materials presented on the facade are different from those of traditional buildings.

ANALYSIS OF INTERFACE ELEMENTS OF TRADITIONAL STREETS IN SIPO TOWN

As part of the urban fabric, traditional streets and lanes carry rich historical memories and cultural accumulation. The continuation of street and lane space is also a guarantee for the continuation of the original social network and life network (Hu and Zhang, 2003). As the forefront and leading area of urban development, the urban fringe area needs to be effectively protected and renewed without delay. There are many traditional buildings preserved in the Dashunchang Block of Sipo Town. Most of them were built in the 1970s and 1980s, and a few are even older, dating back to the Qing Dynasty. The block is now mainly residential, with a small number of commercial and industrial functions scattered around. There are few public service facilities, and only one open cross-street market. The overall layout of the block buildings is the "fishbone" form commonly seen in traditional blocks, with compact streets and lanes and few public spaces. Buildings along the streets are mostly organized in an "introverted" arrangement, that is, the buildings are close to the streets along the street, and there are courtyards inside to form living and production spaces .

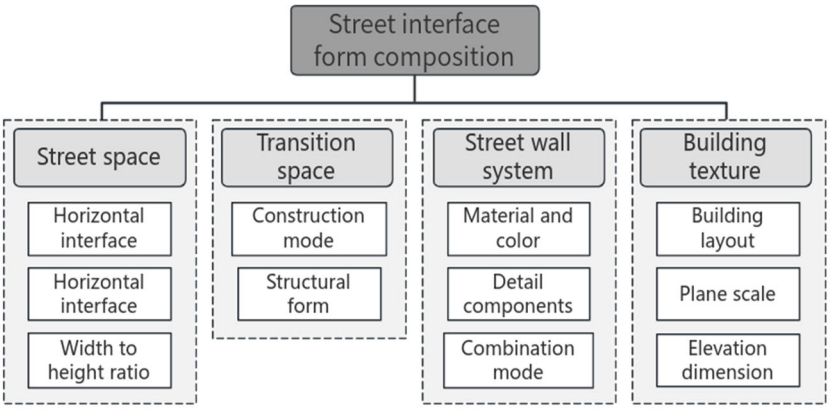


Figure 6.street interface form composition. photo credit:Self-painted

The buildings in the Dashunchang Block are very old. Under the influence of many extensive construction and informal reconstruction activities in the process of urbanization, traditional buildings and places have been destroyed. New buildings have not continued the regional style and

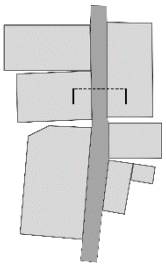
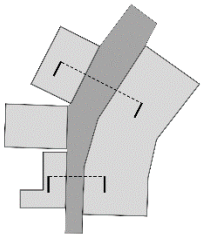
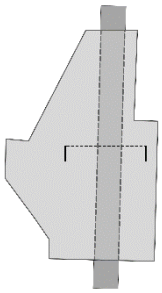
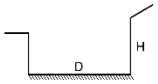
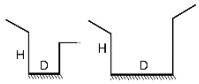
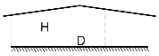
characteristics. The style of the entire block has become increasingly chaotic, and the street interface has been destroyed. Therefore, based on morphological theory, it is particularly important to understand the overall characteristics of the traditional street interface of Sipo Town from the perspective of the special urban landscape component of the urban fringe. On this basis, the street interface is disassembled from the inside to the outside into four major components: street space, transition space, street wall system, and building texture (Figure 6). The traditional characteristics of the street interface are deeply analyzed from the meso-block level and the micro-architectural and spatial levels using the typological operation method, providing a prototype that can highlight the regional characteristics for block renewal and promoting the continuation and modern translation of traditional architectural language.

Street space

Street space is the core component of the traditional street interface, which consists of horizontal and vertical interfaces. The vertical interface of the street is a side interface formed by the surrounding buildings or plants, and the horizontal interface is the street bottom interface. The two together affect the spatial scale and morphological characteristics of the street. The street bottom interface of Dashunchang Block has a rich morphology. According to the street direction and the side interface morphology, it can be roughly divided into four types: straight-through, expansion, turning and crossing. By selecting samples to calculate the aspect ratio (D/H) of the street, that is, the ratio of the street width to the height of the buildings on both sides, the spatial scale of the street is comprehensively measured. The straight-through street is the most common type, and the aspect ratio is usually small, 0.4~0.5. This small aspect ratio can bring people a closer sense of space: low buildings and narrow streets together form a street space with a strong sense of wrapping, allowing pedestrians to participate more in commercial activities in the street. The expansion street is a special form of straight-through street with a width-to-height ratio of 1.25-2. In this state, it can ensure sufficient use space without alienating people from the side interface of the street. As the intersection of two or more streets, it has more complex functions, carries more activities, and acts as a node for local buffering. The turning street has more significant spatial changes. Generally, there are transition sections of two streets of different scales. The height-to-width ratio often shows a uniform increase and decrease, avoiding the appearance of mutation points to ensure a continuous and homogeneous spatial experience. The crossing street is a street that passes through the interior of a building or under an open top. It is generally used as a market space. Compared with other types of streets, the top interface of the crossing street is closed, and the height-to-width ratio of the street is larger, but it still has a relatively close spatial feeling. There is no standardized planning and construction in the Dashunchang Block, but due to the differences in the main business functions carried by its side interface, under the guidance of spontaneous construction and transformation, the spatial comfort of traditional streets can also be just right(Table 1).

Table 1. Spatial form Scale. credit:Self-painted

type	Straight through	Expansion	Breakover	Traversal

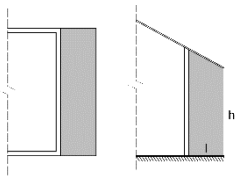
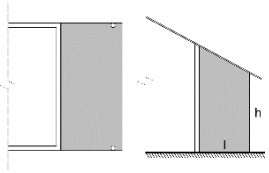
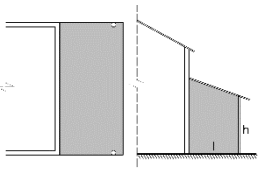
Spatial form				
Scale （mm）	 D=(2100-3200) H=(4200-5400) D/H=0.4~0.5	 D=(8000-10000) H= (4000-6400) D/H=1.25~2	 D=(2800-6100) H= (3000-5400) D/H=0.5~2	 D=(3600-5100) H= (3600-4500) D/H=1~1.6

Transition space

Transition space refers to the buffer zone between buildings and street space, usually including corridors, porches, courtyards, steps, etc. The transition space of the traditional block of Dashunchang is mainly porches and corridor spaces, which can be divided into three types according to the spatial form: extended type, indented type and additional type. They not only separate and connect the public and private domains, but also provide a rich variety of semi-public activity venues.

The extended type is the most common and original type of transition space. It is usually formed by the structure of the main building directly extending outward or diagonally extending outward to form a porch under the eaves. Due to structural limitations, the width is relatively small, generally ranging from 600-1200mm, and it mainly serves to provide shade and shelter from the rain. In order to relieve some functions to the street surface without interfering with the function of the street itself, the indented corridor space appeared, that is, the street wall of the building is retracted inward by one to three spans of purlins, and the through-beam structure is exposed. The width is usually between 1800-3000mm. It can not only serve as the outdoor area of the store, but also serve as a passage, making the interior of the building more naturally connected with the street. However, due to the wide retraction distance, it will affect the natural lighting of the building along the street. The attached type refers to the corridor space that is separated from the main structure of the building and built independently. Its width is usually more than 2000mm. Its function is similar to the indented type, but because the attached type only needs to meet the normal passage and activity functions, the height is not affected by the main structure and is generally lower than the building. Therefore, the position can be staggered to set window holes to ensure natural lighting indoors. These eaves and porch spaces are often gray spaces for residents to communicate and rest on a daily basis and for shops to carry out commercial activities. This transitional space not only enhances the social function of the street, but also enriches the layering of the street interface(Table 2).

Table 2. Spatial form Scale. credit:Self-painted

type	extension type	indent type	additional type
Spatial form			
Scale （mm）	h=3200-4500 l=600-1200	h=4200-5400 l=1800-3000	h=2800-3600 l=2000-2800

Street wall system

The street wall system refers to the continuous facades of buildings on both sides of the street. It is the vertical boundary of the street space, including the building facades, door and window components, material use and decorative details. These elements together constitute the street wall system, affecting the spatial perception and historical style of the streets. In Dashunchang Block, the street wall system is usually composed of one to two story residential and commercial building facades. It is simple and rich in regional characteristics. Local materials are mostly used, mainly bamboo, wood, brick, stone and soil. The wall decoration is simple, emphasizing functionality and practicality. According to the difference in the main materials used in the facade, it can be divided into three types: wood-based, brick-wood mixed and brick-based. The three types of facades have their own characteristics due to different material properties. The wood-based facade type is the most primitive and widely distributed. It is characterized by the exposed gable wall with a through-beam wooden frame, the enclosure structure is a lightweight rammed earth wall with bamboo strips as the skeleton, and the exterior is plastered with lime. In order to cope with the relatively humid local climate, the column pier is generally a natural stone in the shape of a truncated cone, which can avoid direct contact between the wooden structure and the ground and increase the durability of the structure. With the popularity of bricks, a mixed brick-wood facade type began to appear. Bricks are usually used as structural columns and first-floor walls, but the supporting structure of the roof is still wood. Another important reason is that the Dashunchang Block prospered because of the dock. Now that this advantage has faded, the block is built along the river, which makes it vulnerable to floods. The use of water-resistant materials on the first floor can minimize losses. There are relatively few facade types dominated by bricks, but they also retain a more complete traditional style. Although there are differences in the use of materials, the building width is two to three bays, and the bay size is not much different, which is also determined by the characteristics of the wooden roof frame(Table 3).

Table 3. Typical elevation form. credit:Self-painted

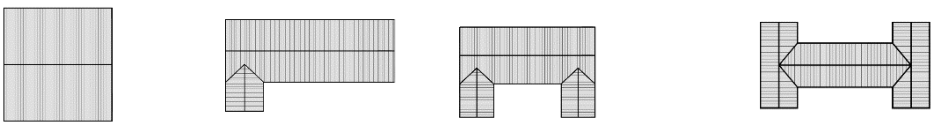
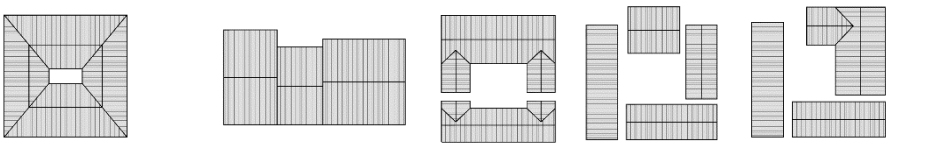
type	wood-based	Brick-wood mixture	brick-based

Typical elevation form	

Building texture

Architectural texture refers to the overall characteristics of the layout and spatial organization of buildings in streets and alleys, which affects the direction of streets and the form of street side interfaces. The layout of building monomers in Dashunchang Block mainly includes four basic types: rectangular, "L"-shaped, "U"-shaped and "I"-shaped. The building groups are mainly organized in a straight line along the street. When the population of a single household increases, the function and scale of the residential space will be expanded, and the courtyard layout will be derived from the basic type. There are mainly three types: courtyard type, single group type and composite group type. The courtyard type has a strong integrity. The various parts are generally built at the same time. The interior is relatively closed, and the middle courtyard is small and narrow, which is called a patio. The single group type is a courtyard surrounded by monomer buildings of the same basic type. Usually, the integrity is weak, but the spatial permeability is strong, the shape is relatively regular, and the spatial organization is compact. The composite group type is a courtyard surrounded by monomer buildings of different basic types. Usually there are two basic types, the spatial organization is relatively scattered, and the internal openness is strong(Table 4).

Table 4. Building texture types. credit:Self-painted

Basic type				
	rectangle	"L" shape	"U" shape	"I" shape
Derived type				
	Courtyard type	Single group type		Compound group type

UPDATE STRATEGY

Reset space boundary

In the context of urban and rural interweaving, the functional positioning within the block tends to be vague, making it difficult to achieve the best effect in the allocation of public resources. This ambiguity of spatial boundaries has led to the mutual penetration of urban and rural functions in the block, resulting in a chaotic land use pattern, which in turn affects the overall development efficiency of the block and causes the inactivation of some sections of the block. Clearly dividing the functions of the block not only helps to optimize the allocation of public resources, but also lays the foundation for the continuation of the traditional characteristics of the block. By sorting out the development context of the block, and on the premise of following the existing distribution rules of commercial and production spaces, the block is divided into four functional types, namely, characteristic industries, cultural leisure, catering services, and farmers' market sections (Figure 7). Although the transitional space enhances the spatial continuity between the street and the building, the use of the transitional space in the block does not completely follow the spatial boundary. The behaviors of occupying the road for business and spontaneous construction occur from time to time, which are often regarded as a gray area between the public and private domains. According to the construction logic and type of the transitional space, the public and private domains can be effectively distinguished, so as to determine the type and use of the transitional space (Figure 8).



Figure 7. Original business locations and functional divisions of the block. photo credit:Self-painted

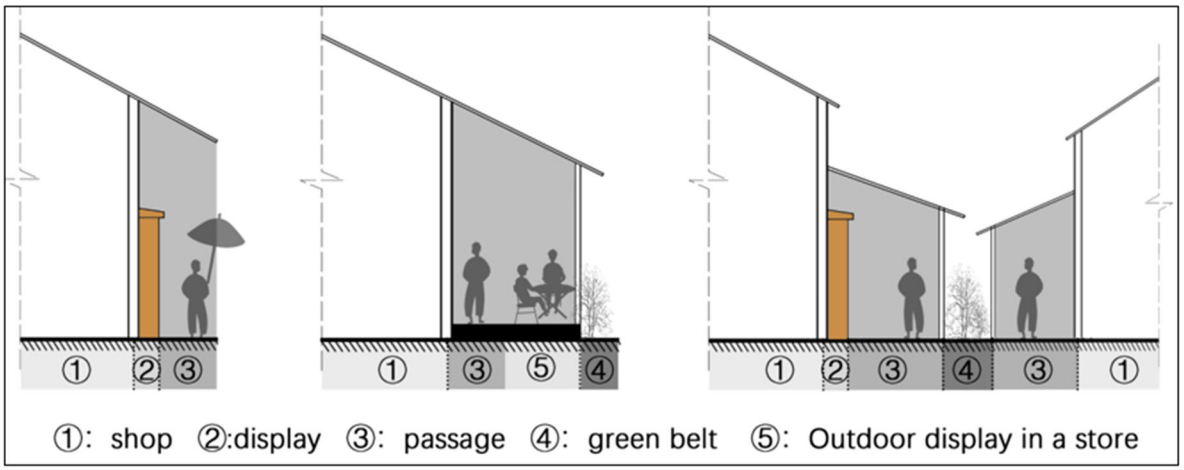


Figure 8. Transition space boundary reset. photo credit:Self-painted

Simplified composition form

Table 5. Facade form and scale control. credit:Self-painted

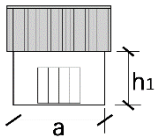
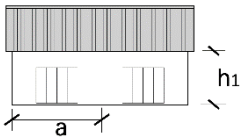
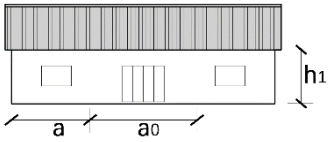
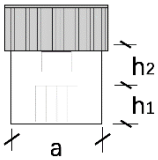
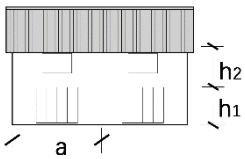
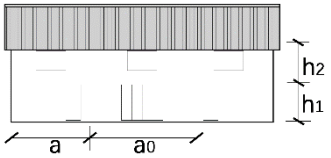
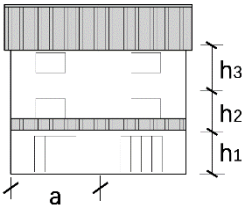
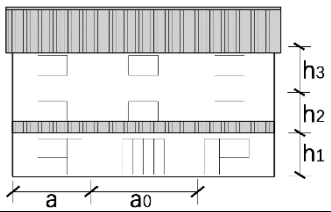
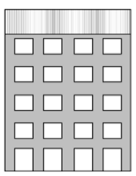
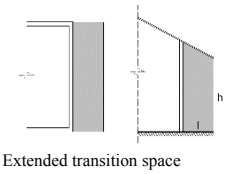
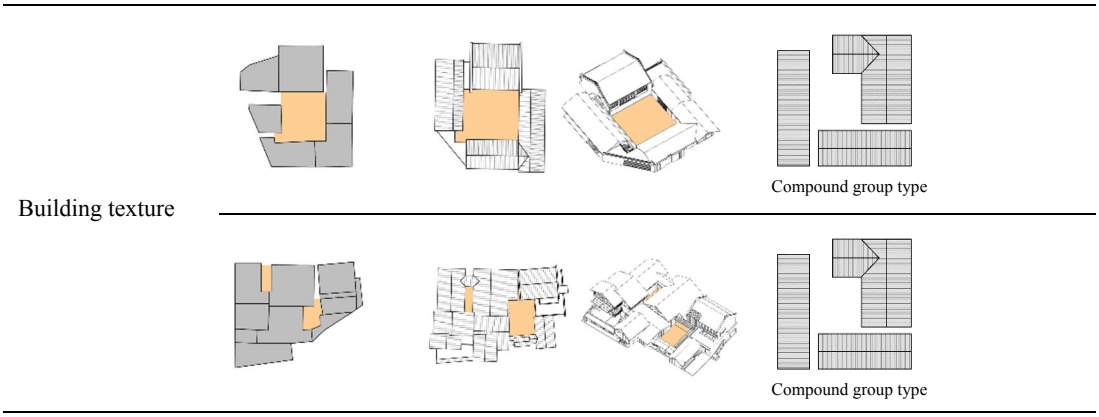
Bay width /number of storeys	**1** **a=3600-4200 (mm)**	**2** **a=2800-3600 （mm）**	**3** **a=2800-3600,a0=3600-4200 （mm）**
1 h1=3000-3600 (mm)			
2 h1=3000-3600 h2=2000-2600 （mm）			
3 h1=h2=3000-3600 h3=2000-2600 （mm）			

Table 6. Plane shape control. credit:Self-painted

	Current Situation	**simplify**	**prototype**
Elevation composition			



The simplification of the compositional form is mainly reflected in the street wall system and street texture level. In the street wall system, the control of the building facade is an important means to continue the overall style of the block. The street wall system in traditional streets and lanes usually has a clear interface relationship and rich detailed structure, and is the main defining element of the street space. In the renewal process, the facade forms of different types of buildings should be classified and controlled. For existing buildings, the original facade type should be identified and its composition and material characteristics should be inherited. For new buildings, the facade type should be selected in the legend according to different bays and storey heights. By unifying the facade order and applying facade types of different materials, the new and old buildings can visually echo each other, rather than just a stereotyped copy of the facade(Table 5). In addition, for multi-story modern buildings that violate the traditional street facade composition form, eaves can be added on the first or second floor to eliminate the single compositional form in the form of an extended transitional space. The street texture level is mainly aimed at the renovation of existing buildings, that is, to extract characteristics from the original texture of traditional streets and lanes, and to retain and strengthen these characteristics during the renewal process. By reorganizing the combination logic of the original plane, using basic types of architectural texture to regularize the building layout, strengthen the enclosure of the courtyard space, and appropriately adjust the volume and density of the building, the street texture and the overall block form are more coordinated and unified(Table 6).

Restricted scale

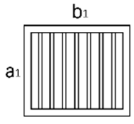
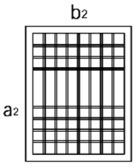
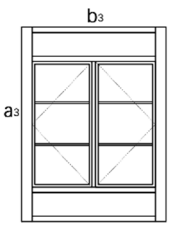
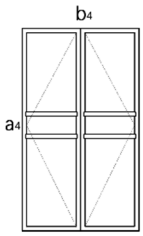
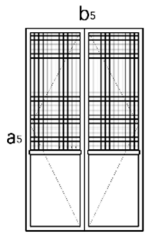
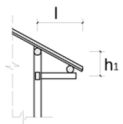
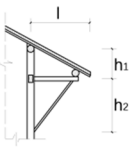
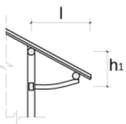
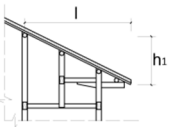
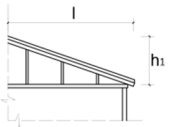
In the renewal of traditional streets and lanes, the key to maintaining the spatial order and style consistency of the block is to reasonably control the height-to-width ratio of the street space and the proportion of the street wall system and its components. Through the analysis of the proportion scale of traditional buildings, the renewal of block buildings should maintain a proportional relationship consistent with traditional buildings in terms of facade height, bay width, door and window size, etc., so as to maintain the historical style and spatial order of the block as a whole. Under the condition of ignoring the impact of new buildings in traditional blocks, by analyzing the types of existing street spaces and horizontal and vertical scales, it can be found that the width-to-height ratio of streets and lanes within the Dashunchang Block is between 0.4 and 2, and it shows a relatively homogeneous change with the change of street space type. In the process of block renewal, the original street space form should be maintained and the original height-to-width ratio should be continued(Figure 9). In addition, the proportion of the street wall system and its components should also be strictly controlled during the renewal process. The bay width and floor height of the building should be selected according to the type of street wall structure, and the top floor height should not be higher than other

floors. The components are mainly doors and windows and transition space support structures, and their universal proportion scales are as follows(Table 7).



Figure 9. Street space scale control. photo credit:Self-painted

Table 7. Door, window and component size control. credit:Self-painted

Door and window components					
	Mullion window	Lattice window	Casement window	Plank door	Grille door
Scale （mm）	a1=800-1200 b1=1000-1400 a1<b1	a2=1200-1800 b2=1200-1800 a2>b2	a3=1500-2100 b3=1200-1800 a3>b3	a4=2000-2400 b4=1200-1600	A5=2400-2800 B5=1400-1800
Transitional spatial structure					
Scale (l:Transition space width)	l/h1=2:1	l/h1=2:1 l/h2=1:1	l/h1=2:1	l/h1=2:1-3:1	l/h1=3:1

CONCLUSION

As an important part of the urban material space, the traditional streets and lanes interface of Dashunchang carries rich historical and cultural values and unique spatial characteristics. Through the

method of morphological typology, an in-depth analysis of the elements of the street and lane interface can reveal its spatial characteristics and historical evolution laws, and provide a scientific basis for the protection and renewal of the streets and lanes. Measures such as resetting spatial boundaries, streamlining composition forms, and limiting scale can effectively restore and continue the historical features of traditional streets and lanes, and enhance the cultural value and spatial quality of the blocks. In future urban development, attention should be paid to the protection and utilization of traditional streets and lanes, and explore renewal methods that adapt to modern needs to achieve an organic combination of history and modernity. Renewal that conforms to regional characteristics can not only preserve the historical context of the city, but also create a more pleasant living environment for residents, and provide strong support for the sustainable development of traditional blocks.

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Archetypes and archetypal models. The territory between form and cultural heritage

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ABSTRACT

This article describes the relationships between the product of human civilisation and geographical facts, investigating the form through the greenhouses of Sanremo, the "City of Flowers". The territory is here considered as a scientific propositional machine for the architectural project and, in this perspective, the greenhouses are re-signified as les machines du soleil, i.e. the analytical devices that allow to interpret the territorialisation process. This reading considers the urban form as the result of a decoding of geographical archetypes, revealing through cartography, painting and literature the territorial character of the site.

Geography becomes the paradigm for understanding the archetypal patterns of human forms, transcending the distinctions between rural and urban. The text explores how geography is structurally organised into archetypes, from which the archetypal models of the machines du soleil descend, and how these are able to explain the settlement logic of the city.

The aim is to recognise territorial characters as formal tools of an arché from which it is possible to orientate a reasoning aimed at identifying a formativity of the cultural heritage, identity and memory of a place, using urban and territorial facts as construction material to respond to global challenges.

The classification of anthropic forms, generated through the case-studies of the greenhouses, develops two tabelloni (boards) of the machines du soleil capable of rereading through form an order of generalisability of urban and territorial facts of promontory and hillside. The study illustrates how urban and territorial transformations at the time of Man are the outcome of a formal relationship between architecture and geography. The analysis of the greenhouses of Sanremo as machines du soleil thematises the territorialisation and geometrialisation of the earth's crust through archetypes and archetypal models and constitutes the detonating element to re-signify the greenhouses and imagine a territorial regeneration starting from the case-studies of the tabellone.

Keywords: Geography, morphology, territory, archetype, cultural heritage.

ΜΟΡΦΉ AND ΛΌΓΟΣ. LEXICAL-LOGICAL ISSUES

"The greatest danger is that not only things, but history itself, may largely be reduced to mere petrified objectivity, to an accumulation of data and objects unmediated by consciousness and unenlightened by the deciphering and contextualization of their meaning".[1]

(Bodei, 2011: 55).

Studies on form, by generalizing their scope of action, aim to theorize the relationships that exist between things (Muratori, 1960; Rossi, 1966; McHarg, 1969; Caniggia, 1976; Cataldi, 1977; Motta and Pizzigoni, 1991; Krier, 2009; Ravagnati, 2018). The extensive power of the morphological gaze on things, understood here as the relationship established between anthropic figures of different orders and scales – type, urban/rural/architectural form, etc. – in relation to geographic/territorial characters, constitutes a series of investigations that, while diverse, share a common substrate to some extent. Some of these investigations unfold through a sequential perspective (Muratori, 1960), others through a generative grammar process, a language of patterns (Alexander *et al*., 1977), or through the generation of discourse on form that explores the "processual typology" of anthropic figures (Caniggia and Maffei, 1979).

These conditions of analysis are foundational for the construction of theoretical thought and crucial in defining the meanings and formal solutions related to urban and territorial phenomena. They involve investigation through the combination of the terms "μορφή" (morphè) and "λόγος" (logos), which, in ancient Greek, mean "form" e "word, study, or discourse". The union of these terms forms the *corpus* of reasoning on the subjects to which the research on the terrestrial forms of Sanremo is directed, becoming more precise as the word rationally describes the external appearance of things.

"Morphology", as such, belongs to the sense that Deleuze and Guattari attribute to writing, by virtue of the fact that, similarly to morphology understood as the formal writing of things over time, "*n'a rien à voir avec signifier* [signifying is nonetheless a consequence, a meaningful trajectory of discourse]*, mais avec arpenter, cartographier, même des contrées à venir*" (Deleuze and Guattari, 1980: 11).

In this sense, the study conducted here aims, through the lexemes that structure its content – morphology in the strict sense analyzes the structure of things – to identify a territorial syntax aimed at examining the possibility of an interdisciplinary theoretical construction through the textual parts that contribute to the explanation of forms, partly anchored to that logical sense with which the term "morphology" reveals itself to the world in the *Versuch die Metamorphose der Pflanzen zu erklären* (1790), from which the concept of the "primordial or original leaf" (*Urblatt*) originates. This concept corresponds to the search for an archetype in which all parts – Goethe refers to the biological form of things – are variations of a single fundamental structure, the terrestrial substrate from which things are interconnected parts. This image of "morphology" as a form interconnected with space and time does not escape the laws of physics developed a year earlier by Lavoisier (1789), as the arché-type is neither created nor destroyed; rather, it is trans-formed – de-composed and re-composed.

The research tries to understand how the possibility of breaking the linearity of time introduces us to the mechanisms of an operative reading of the interconnection between past, present, and future, in

[1] The English quotations from Italian sources – see bibliography – have been translated by the author.

which the greenhouses constitute the fragments for the decoding of the archetype, since "*the past takes place in the sign but not in every sign*" (Sini, 1985: 45), connecting the forms before and after Man's time.

Territorial Memory and Geographical Condition

The form of the city is studied here through the logical interconnections that can be established over time with its material and immaterial heritage, with the identity and historical memory of the site, both of which constitute the territorial memory. Considering the crisis we are facing – industrial, economic, food, energy, social, etc. – as a point of insurgence, the opportunity emerges for the architectural project to connect the spirit of forms, finding, within the framework of urban analysis sciences, a possibility. The proposal is to reverse the perspective that formalized the idea of an expanding city, where this notion subordinated the form of the territory to the city (Samonà, 1976), reversing the perspective towards the territorialization of the city. Since "*it is not possible to fully describe or understand things... because the figures through which they can be described are already embedded in a movement of references... an unstoppable drift in which the objects of representation are carried away, in an equally unstoppable oscillation*" (Motta and Pizzigoni, 1999: 24) and it is precisely for this reason that "*the city can be described through the mountain, but the mountain, in turn, can only be described by looking at the city*" (Motta and Pizzigoni, 1999: 24).

The possibility of reading the indissoluble relationship between architecture and geography, deriving from a "fundamental" structure – a substratum that cancels and quantifies time as a propositional tool for the architectural project, readable through the forms at the time of Man, the greenhouses – opens up an interpretation focused on geo-morpho-logical characters (Figure 1). These are necessary tools for grafting possible development scenarios for architectural design, urban and territorial regeneration, and landscape, imagining possible worlds starting from the forms of time – in this context, the greenhouses of Sanremo.

With this perspective, it is possible to retrace and rediscover in form what Bergson explains in the ability to see the freezing of the becoming of things, since, in fact "*la forme n'est qu'un instantané pris sur une transition*" (Bergson, 2008: 302). This activity of transition allows for the imagination that in the treatment of the transitoriness of form – architectural, urban, rural, territorial – there exists a principle of arché of the geographical thing, and that, in anthropic transformation, when transitioning from one architectural figure to another, this potentiality of the geographical arché remains and equates to what Martí Arís (2007) refers to as the activity of the intellect that transits in architectural memory from one body to another – a passage that occurs in analogy between the forms before the time of Man and those in the time of Man.

The notes and annotations developed to imagine a possible Plan idea for the Municipality of Sanremo perform this operation: they unite apparently distant strips of time, in which territorial memory and heritage – both material and immaterial – become analysis tools for the architectural project.

In this context, the research for a possible territorial regeneration – through the system of greenhouses – which acts through the reading of geomorphological characters to formulate notes and ideas of a possible image of the city, reflects on the structural and philosophical condition of space in small-medium sized cities in relation to their geographical status.

The study of the terrestrial forms of Sanremo addresses all those fragile territories that struggle to engage constructively with territorial memory, where urban and rural factors have, over the course of time, constituted the interconnection between the characters and cultural specificities of that part of the world.

The Illatency of Form

The research focuses on the study of the micro-decommissioning of San Remo's greenhouses, explaining, through the classification of case-studies, the settlement logic of the ancient city.

Classification, as a method of analysis and theorisation (Soavi *et al*., 2013), recognises archetypes and archetypal patterns between form and cultural heritage in the geographic condition, constructing reasoning to address new global challenges. The greenhouse system, consisting of syntactic relationships – artifacts, agricultural paths, anthropic structures, forms in the time of man, etc. – represents "*the human thing... an immense repository of labours.... testimony of values, are permanence and memory*" (Rossi, 1966: 28).

The recognition of the product of human activity as cultural heritage takes place through the logical construction of the classifier and, as Brandi specifies regarding the work of art, "*it takes place in consciousness: it has to be done each time by a single individual. The human product... is there, before our eyes, but it can be classified generically among the products of human activity, until the recognition that consciousness makes of it as a work of art, exempts it definitively from the commonality of other products*" (Brandi, 1963: 32).

The human product – the greenhouses – preserve and derive from human labour, as "*memory truly seems to be about something, to be as such connected to things*" (Cacciari, 1990: 251).

The greenhouses embody ἔργον – *érgon*, meaning "work, work or action" – and are the physical object whose form, in relation to the spatial scale, does not betray but unveils the purpose and connection to the image of an arché, "*it enchants because it brings to presence, in its saying* [the arché-typical saying of the arché], *that unforgettable being, which time does not devour – because it speaks the truth, Aletheia*" (Cacciari, 1990: 236).

The greenhouses, which constitute the last morpho-logical gesture made by man on the territorial scale, where the lemma *Aletheia* (ἀλήθεια) means "truth or revelation", unveil the geographical nature embodied in the body of architecture – the greenhouses explain themselves and the city (Figure 2). In their constructive simplicity and essentiality of form, they stand in contrast to "lēthē" (oblivion), clinging to the particle "a", turning their gaze to non-forgetfulness, as they not only manifest the memory of forms before Man's time, but also correspond to the manifestation of the essence of things, effectively breaking the linearity of time.

The greenhouse system constitutes the research tool of the archetypes and uses the greenhouse device insofar as "*memory reveals all the power of its timé when it is Memory of the beginning... yes, it addresses the illatence of the beginning... but precisely because Beginning and not beginning-of... already belongs to the series to which it begins, this arché does not exclude anything from itself*" (Cacciari, 1990: 235-36).

In this research, the geographical condition is a detonating condition. Through the logical procedure by which the city is investigated – cartographies, travellers' descriptions, representations, etc. – different ways of seeing and describing the forms of the city of Sanremo intertwine.

In continuity with the studies of Motta-Pizzigoni and Ravagnati, a dual reading is established on which it was possible to construct a Plan idea for the Foce Valley from the analytical image of the form of invisible cities, in which "*the two cities that emerge... are co-present cities, not always and not necessarily collaborating, but certainly not in conflict with each other. ... the most hidden city... is not yet aware of its architectural and settlement vocation. It is the city in which the energy of work accumulated over the centuries has remained there, still, waiting to develop positively. It is the city whose structure can be grasped by looking at it in reverse. ... a city that has disappeared... that never was or, more simply, still is not. To see this city it is necessary to look where architecture seems to be absent or denied*" (Ravagnati, 2018: 41-43).

Micro-decommissioning represents a widespread phenomenon in all those small and medium-sized European municipalities and, together with the theme of territorial regeneration, is the subject of this study. The progressive abandonment of these areas leads to the oblivion of heritage – cultural, landscape, etc. – and leads to loss of identity, economic opportunities, resources, knowledge, degradation and destruction of heritage, as well as a lack of historical and cultural awareness.

The questions this research raises are: is it possible to define a paradigm of regeneration – urban and territorial – capable of counteracting the oblivion to which these places are destined? How can we educate, i.e. "nurture" (from the Latin *educĕre*, composed of *e-* [out] and *ducĕre* [to lead, guide]), the architectural project with the aim of "bringing out" the intrinsic capacities of the territory, developing a model that looks to the substance and geomorphological potential to guide society to grasp the bare potential of these places?

The vertigo of this theme is articulated on two substantial points: a) "The *tabellone*. A Question of Method: Classify, theorize, Signify", in which classification as a theoretical and cognitive paradigm of forms – cultural, historical, landscape, literary, etc. – becomes a tool for the construction and unveiling of urban and territorial facts, which in its formal construction projects interdisciplinary bridges in/for research, demonstrating the strength of language as a stratified process of signification and interpretation of things; b) "Results and Discussion: The case-study of the Foce Valley": defining/recognising problems to generate a plausible response to the new global challenges, orienting the project towards a horizon capable of spatialising between disciplines, interconnecting the regeneration model with the need to plan the future of the territory, with the demands of social, economic and environmental development to ensure the survival and well-being of present and future generations.

The *tabellone*. A Question of Method: Classify, Theorize, Signify

The *tabellone* is an ordering geometric grid that allows for the classification of elements belonging to and/or deriving from the underlying geographical structure. The grid functions as a regulatory system, organizing the samples of the typical fabrics of Sanremo.

This method is employed to address the relationships between terrestrial forms, allowing for an understanding, through study and redesign, of the fragments that characterize the history of urban and territorial transformations, by hierarchizing their logical structure and recognizing their syntax.

The classificatory process required to construct the grid triggers modalities that allow the territory to be read through the formal relationships that the elements present establish with the geographical status of the places and their parts, highlighting characters of generalisability and specificity.

The grid aims to reveal the typical relationships of the preaching concepts of territorial syntax in their complexity and origin.

The arrangement of figures within the *tabellone* generates interpolations between objects, identifying matrices and possible connections between the parts. The *tabellone* is a tool applied by Saverio Muratori to investigate and understand the nature of places, the characters and history of the territory, allowing the study from criteria based on the aspects of the figures present.

The first phase of this study was to articulate the literature on the history of greenhouses, urban and territorial transformations of the Sanremo Gulf theatre, focusing on the partly descriptive textual forms necessary for the construction of the city's image, i.e. the discourse around the forms to which the greenhouses, henceforth referred to as *les machines du soleil* when they operate as analytical devices, anchor the signification of transformations.

This classificatory machine allows for understanding how the form of anthropic structures is related to the characters of the territory. The latter are the result of a slow process of erosion of the orographic structure, in which the water system collaborates in the formal definition of promontory and hillside figures before the time of Man. The hydrographic resources that characterize the valley structure of Sanremo are composed of 14 main watercourses, plus an additional 6 minor courses. The hydrographic network of the valleys of Sanremo, incising the earth's crust, contributes, together with the promontory orographic structure, to define the triangular shape of the theater of the Gulf of Sanremo, whose vertices correspond to the monumental figure of Monte Bignone to the north, Capo Nero to the west, and Capo Verde to the east. The orographic structure, together with the watercourses, constitutes the underlying system of forms in the time of Man.

The analytical relationship that is established between geographical and anthropic forms is enriched by the combination of literary sources, offering a fundamental perspective for the construction of meanings and interdisciplinary correlations. These meanings and correlations derive from the intertwining of descriptions by travellers who, starting from the 17th century, relate to the image of the city and its geographical character. These descriptions, together with the climatic conditions of Sanremo, constituted a highly appreciated attraction for aristocrats and tourists – French, English, German, and Russian – who, in the 19th century, decided to settle during the winter months – the so-called *hivernantes*.

The literary apparatus intertwined with the construction of the cartographic *corpus* – 436 representations from approximately the 16th century onward – chronologically reading the urban and territorial transformations. Together, these documents make it possible to generate the cognitive value of the formative nature of the syntactic relationships between anthropic structures, landforms and textual forms, before and after the time of Man. The chronological arrangement of historical thresholds in the cartographies enables the reading of the cultural significance of what *les machines du soleil* represent, producing knowledge of urban and territorial facts, showing on one side the

geographical character of the site and on the other the political/administrative aspect of a territory in continuous transformation.

The grid of the *tabellone* is composed of cells that organize the systemic reading of the typical samples of the territorial structure. The cells are defined by the intersection of columns (ordinates) and rows (abscissas). The number of columns is determined by the number of case-studies, which establish the extent of the *tabellone*, while the rows are three, each analyzing the territory according to three founding principles of Sanremo's settlement logic: acclivity, exposure, and terrestrial paths. The adjacent arrangement of the cells belonging to the same row constitutes the series of case-studies of the same type, while the reading of a single column analyzes the same case-study according to three different themes.

This scientific machine renders the geographical figures legible, allowing for the construction of reasoning on the relationships of meaning that cultural heritage has instilled between the territorial type and the advent of the city. These syntactic and semantic relationships articulate and determine the settlement logic through two main morphological aspects: the promontory system and the hillside system, necessitating the construction of two *tabelloni* (Figures 3-4).

The first row of each *tabellone* is a "bookmark" row, or the archetype column, and constitutes the matrix of the ancient city, operating an analytical interconnection with *les machines du soleil*. The promontory matrix/archetype is represented by La Pigna, while the hillside archetype is identified with the Rocca district, located on the southwest hillside of La Pigna.

La Pigna, located on a promontory between two valleys, not only preserves in the toponym etymological issues that clarify the indissoluble geomorphological relationship between architecture and geography (Ferrari, 1963; Petracco Sicardi, 1962), but also highlights, through *les machines du soleil*, the interconnections of continuity with the territorial characters derived from the relationships with the monumental figure of the promontory.

The urban and territorial architectural structure of the *machines du soleil* conquers the territory by following a logic that repeats the form of the archetypes over time, giving back a reading that, through the greenhouses, unveils the formativity of the city of ancient foundation. This process manifests the functioning of an orographic and topological model that shows the relationship between city and territory, starting with the phenomenon of the greenhouses.

Les machiens du solieil explain the formativity of the archetypes and vice versa, they become archetypal models in a dual relationship that contributes both to defining the archetype and unveiling the arché of territorial facts.

Acclivity. Going into the merits of the three themes of the *tabellone*, acclivity explains the morphological aspect of the territory and the intelligibility of the forms resulting from the relationship between the slope of the land and the topological condition of the greenhouses. The topographical surface of the greenhouses is illustrated by the technical device of the "plate", which investigates the slope of the terrain and analyses the organisation and distribution of the relationships between the forms of the greenhouses and the geomorphological characters of the site. Acclivity highlights the orographic and plano-altimetric arrangement of the *machines du soleil* concerning the geographical figures of promontory and hillside (Figure 5).

The acclivity series highlights, through the device of the plate, the total adherence to the orographic structure of the territory, analytically producing the leap in time and logically linking the archaeological fragments of the *vicos et castella*. *Les machines du soleil* relate the settlement form of La Pigna with the pre-Roman castellars and in continuity with the work of the terracing extended by the Benedictine monks, where the greenhouses constitute the architectural gesture that exalts and crystallises the geometry of the geographical theatre of Sanremo.

The visible operation, which in the castellari was a strategic issue, operates as “paving”. Paving is the repetitive operation of the plates through the use of the greenhouse bodies. This architectural action shows the geographic characters of the place and becomes the instrumental means for the realisation and/or intensification of the infrastructural system, making the terraced structure and the edges of the transit system intelligible.

The image of the city is, in fact, the result of a paving operation, where the greenhouse plates replace the stone slabs used to pave a street. This repetitive operation levels the orographic structure and positions the greenhouses. Paving defines the relationship with the ground and the size of the slabs – plates – according to the body of the greenhouses, taking on different geometries and measurements. Paving produces a new image of the city, the “Crystal Hill,” which is formalized through the succession of rectangular figures that are the most recurrent form and, depending on the topological conditions, deforms and specifies whether we are in the presence of the promontory or the hillside. The physical operation of paving makes the image of the “Crystal Hill” visible through two founding operations of Sanremo’s architecture: a) the hillside paving is an operation that occurs through the use of narrow and long geometric figures, parallel to the contour lines, and that, from the valley floor to the ridge, shows a fragmented system of stairways; b) the promontory paving follows the orography and covers the “Crystal Hill” with concentric rings towards the summit.

Exposure. Exposure is a determining factor for the specific characters of architecture and its arrangement, as it, together with acclivity and terrestrial paths, establishes the proximity relationships between the anthropic structures of the Sanremo territory and the forms of the geographical system. To study exposure, a specific analytical tool is necessary: the “wall.” The wall, like the plate for acclivity, becomes the analytical object that reveals and measures the architectures and their parts, positioned to optimize their relationship to the sun (Figure 6). This principle explains the strategic placement of the first hotels and how the process of real estate speculation, highlighted by Calvino (Calvino, 1963), follows this constructional aspect. The same criterion is adopted by the greenhouses, which, in the transition from a culture of cut flowers *en plein air* to the floriculture industry, are positioned according to this logic to optimize profits. The selection of these differences has highlighted, in the *tabelloni*, only the external surfaces of the walls of the greenhouses and the buildings subject to irradiation, revealing the logical principle by which the greenhouses – and even earlier, the archetype – relate to the geomorphological characters of the site, defining the most privileged positions for realization – becoming crystal, an icon of the forms of the earth.

Through the analysis of the *machines du soleil* by studying the walls of the greenhouses, we can identify and reveal the geo-architectural works necessary to explain the functioning of the geomorphological characters of an overall design of the greenhouses. This analysis allows us to formulate the importance of the exposure factor and understand how the wall can: a) determine the

choice of location for settlement; b) identify the tectonic structure of the "Crystal Hill"; c) define the height of the plate; d) select the most exposed areas of the territory; e) contribute to the prevention of hydrogeological instability; f) configure the geometry and capturing surface of the greenhouses.

Terrestrial Paths. Terrestrial paths are generated by the persistent and incessant walking of man. The study of walkways reveals the logic of connections between geographical structure and geoarchitectural figures. These paths delineate man's passage from one place to another and decipher the human-territory relationship over time.

The pathways constitute the infrastructure of the geographical figures, materializing human transit and the need to connect the architecture of the Earth through a topological and topographic space, with the goal of linking the greenhouses and the city via roads. In the terrestrial paths of the greenhouses, the layout of the routes reflects the close relationship between anthropic spatialization and the geographical characteristics of the Gulf of Sanremo (Figure 7).

The relationships with the territorial organism develop through three key stages: a) the terrestrial paths of the promontory case-studies originate from the terrestrial figures of the ridge system; b) the terrestrial paths of promontory and hillside follow the logic of counter-ridge paths; c) the terrestrial paths of the hillside derive from the territorial syntax of half-cost paths.

These paths constitute a link with the past, an infrastructure that, during the phases of formation of the territorial syntax, has stratified and deposited in the paths the relations between land use and the geomorphological characters of the Gulf of Sanremo.

Finally, the *tabellone* method becomes, through the grid, a cognitive tool of cultural heritage that, by classifying, theorizing, and signifying the terrestrial figures of the Sanremo territory, allows the decoding of the "City of Flowers," recognizing a posteriori, in the context of the micro-decommissioning crisis, a new image of the city characterized by the system of the *machines du soleil*: the "Crystal Hill."

RESULTS AND DISCUSSION: THE CASE-STUDY OF THE FOCE VALLEY

The results of this study serve to formulate a critical reflection on the interconnected relationships established between forms before and after the time of Man. In describing the fragments of the territory, *les machines du soleil* operate as "*membrane cérébrale où s'affrontent immédiatement, directement, le passé et le futur, l'intérieur et l'extérieur, sans distance assignable, indépendamment de tout point fixe*" as the operating image of *les machines du soleil* "*n'a plus pour caractères premiers l'espace et le mouvement, mais la topologie et le temps*" (Deleuze, 1985: 164).

The *tabellone* produces the possibility of staging, all on the same plane, the thresholds of time and their interconnections, making these abandoned, non-productive and disused figures accessible. They become the logical statement for architectural design, territorial regeneration and landscape restoration in the widest possible sense.

Les machines du soleil operate in continuity with the logic of settlement in the past, in the present and for the future. The result is to rediscover the relations between the formativity of the facts of Man, through the identification and recognition of cultural heritage, in which the geographical condition aims to establish a connection with the image of the arché, spatialising the geomorphological relations

through the process of classification, theorisation and signification, with the aim of structuring the reasoning of the city's emergence through the word.

This passage is fundamental in order to understand how architectural design can intervene at the scale of the territory, staging the ancient relationship with the land and time, understood as a reinterpretation of a memory of things that "*n'est certes plus la faculté d'avoir des souvenirs: elle est la membrane qui, sur les modes les plus divers (continuité, mais aussi discontinuité, enveloppement, etc.), fait correspondre les nappes de passé et les couches de réalité, les unes émanant d'un dedans toujours déjà là, les autres advenant d'un dehors toujours à venir, toutes deux rongeant le présent qui n'est plus que leur rencontre*" (Deleuze, 1985: 269-270).

The notes for a Plan idea for the Foce Valley start from these assumptions. The discussion revolves around how it is possible to establish a model of territorial regeneration applicable to small and medium-sized cities, which rescues the places of micro-decommissioning from oblivion, where cultural heritage allows us to imagine and formulate responses to global challenges through architectural project. The case-study of the Foce Valley is interpreted through the experience of the *tabellone*, in which the analytical devices of *les machines du soleil* become the chosen places for formulating responses that operate in line with the logic of settlement concerning three themes: acclivity, exposure, and terrestrial paths (Figure 8).

The construction of the *tabellone* served to capture the cognitive aspect inherent in the devices, highlighting the permanence of the territorial characters already described in the travellers' accounts, generating further knowledge and awareness of the facts of Man and the territory.

The analysis investigates terrestrial forms through the *tabellone*, elaborating *les machines du soleil* as mnemonic devices that activate modes by which the territorial system and its formative processes can formalize responses to current, concrete, and contemporary problems. The definition of the notes for an idea of a Plan for the Foce Valley is rooted in the thematisation of the display *tabellone* and traces the forms in a path of signification between cartographic *corpus* and site descriptions, in which the places of the micro-decommissioning within the valley become intelligible, making it possible to imagine a regeneration project on a territorial scale in continuity with the becoming of the city.

The Foce Valley, originating from the confluence of the Massei and Gozzo streams, defines the Fallita coast upstream. The rio Massei, located in the upper west valley, originates at 650 m a.s.l. near the Poggi spring, while the rio Gozzo, located to the east of the valley, originates from Mount Carparo (910 m a.s.l.) and joins the rio Massei, giving rise to the Foce river. This conformation recalls the founding theme of the Pigna, reproducing the analogy with the figure of the archetype that lies between two valley systems, where the Pigna constitutes the confrontation with the figure that projects the arché of territorial facts. The Fallita coast ridge, between the Solaro and San Bartolomeo coasts, shows the typical characters of buildings in the hillside areas, exposed to the south-west and characterised by the presence of greenhouses. In the Foce Valley, the greenhouses present similar solutions to those found in the geomorphological relations of the hillside archetype, the ancient Rocca region, facing south-west of Pigna, known as the Borgo.

From the case-study of the Foce Valley, it is possible to deduce an operative retrospective that re-reads the site's transformations over time through its fragmentation, from the ancient "*Lemon Valley*"

described by Hassall in the 19th century (Hassall, 1883: 270), to the continuous fragmentation that is configured over time through the *hortus*, the garden, the house and the greenhouse. This scenario brings us back to the first aspect of the analysis of this study, in which the valley enunciates the founding role of an architecture that begins with the interplay between the orography and the architecture of water, bringing us back to the theme of "paving", the geometry of the earth's crust and, consequently, the terracing system.

This passage occurs through those territorialising and deterritorialising factors of which the territory has always been the geographical theatre. The figures – geographical and anthropic – present in the cartographies activate the outflow of territorial characters through *les machines du solieil*, bringing a new content and semantic impulse, where fragments of time – past, present and future – persist and insist in the architectural body of the greenhouses.

The construction of the three themes makes it possible to analyse the Foce Valley from a new perspective: the gaze rests on the greenhouses, aware of a new reading, where the construction of the grid starts from the phenomenon/epilogue of the crisis of the flower industry, enriched by the analysis matured on the ancient city.

When the architecture of Man collides with or lays on the architecture of the Earth, what Deleuze and Guattari call the process of *"déterritorialisation et de reterritorialisation"* (1980: 70), that is, the genomic passage in which fragments of archetypes – the type of promontory and the type of hillside, predating Man's time, prior to a signification that constitutes them as archetypes in Man's time, the segments of the wasp-orchid-wasp (Deleuze and Guattari, 1983) – re-emerge for parts in habitation, in greenhouses, in artefacts.

The results of this double reading produce an image with a strong semantic content, capable of further specifying the city through *les machines du soleil*. The figure of the promontory is signified through its relationship with the site – reinterpreting the relations of continuity with the first settlements – and becomes the *locus*. Thus, the process of deterritorialisation initiated by the greenhouse phenomenon re-establishes the encounter between the geographical machine and the reinvention of a critical reading of the territorial type – the promontory type – from which Man extracts and abstracts those segments/fragments, the latency of the archetype, in line with the Deleuzian relationship.

This relationship makes it possible to rediscover, in the case-study of the Foce Valley, the type of hillside as well as that of promontory, as autonomous and complementary elements that structure, exercise and show the continuous and unceasing relationship between geographical form and water system.

CONCLUSIONS

The conclusions of this text, like the research itself, are becoming, they do not conclude; the end represents the plausible beginning of something else. They are intended to image the possibility of seeing in the geographical form a timeless myth through which new scenarios can be unveiled/formulated (Figure 9).

The work described here has the opportunity to further formalise and specify the multiplicity of interconnected fields of investigation. The case-study of the Foce Velly shows, through the system of

greenhouses, how anthropic structures are located within a geographical grammar that is a structuring part – formal and cultural – of becoming a city.

From the textual and formal analysis emerges a reflection on the relations between territory, urban form and cultural heritage, in which the interpreting system of the territorial syntax is given by the analytical reading of the phenomenon of the micro-decommissions of Sanremo, or *les machines du soleil*.

The central concept of this argument is the reading of geography as semantic transfer from one body to another. The arché becomes transeunte – in the time of Man – in the sense that, in *transire*, it becomes the subject of becoming. Its destiny is realised in the incarnation of the architectural body, in the proposition -*trans*, which goes beyond, passes through and, as passing through, releases and crystallises, remaining part of the principle of things in the act of settlement/construction. This occurs in the illatency of those fragments derived from Man's interpretation of them when he has to relate to the archetypes of promontory and hillside.

Through the classification of landforms, two *tabelloni* of *machines du soleil* are established, representing a general order of the interconnections between urban and territorial facts. This method of analysis makes it possible to rethink urban and territorial transformations as the result of a formal relationship between architecture and geography, arranging these places – the Foce Valley and, in the future, the entire Sanremo district – as propositions for the architectural project.

This gaze is articulated and defined through the analysis of expositional, pedological, panoramic, connecting, controlling, etc. conditions, the nodes of the interconnection between things, between being and being, in that ancient sense of the discourse on becoming, in which "*from nothing comes nothing...* [and as such] *the generation of something is but transformation or, according to others, composition and separation*" (Aristoteles and Severino 1995: 40-41).

The process of urbanisation is, in this case, seen as the decoding of pre-existing geographical and geomorphological elements. *Les machines du soleil* become hinges between urban and rural; the greenhouses represent the places of the periphery, the critical, neuralgic, unresolved situations that are located in the *transurban* and reinterpret the face of the Earth as a new opportunity.

Through the study of the transformations that led to the formalisation of the culture of cut flowers, it is possible to investigate an economic and social model that, over time, has reinvented itself through the constant transformation of land use.

The notes and drafts for the idea of the Foce Valley Plan are oriented towards building paradigms of sustainable development to counter and mitigate climate change. Through the re-signification of the image of the "Crystal Hill" and the analytical devices of the *machines du soleil*, places are identified to shape a strategy of territorial, energetic, social and economic regeneration: a model of a sustainable valley that starts from the study of the shape of heritage.

Greenhouses, representing the last stage of a continuous reinvention and interpretation of the Earth's forms, hold the cyclical memory of this exaggerated use of the soil and constitute the manifesto of Man's fatigue. From the unsustainable profitability of olive groves and vineyards to their progressive uprooting, part of the Mediterranean beauty has been wiped out to make room for the more

convenient production of flowers and plants, fragmenting and geometrizing the soil and giving rise to a new image.

In line with the objectives of the Green Deal, the COP28 scenarios and the Net-Zero Emissions 2050 (NZE) scenario, the Foce Valley case-study aims to unite agriculture with the production of energy from renewable sources, imagining a model not only for the renewable energy sector, but also capable of creating jobs and new opportunities.

It is possible to start from the founding values of cultural heritage to imagine future transformations. In this perspective, advanced agri-voltaics would become part of a system of design actions aimed at combating climate change, giving rise to interventions involving the environmental resources (soil, water, biodiversity, ecosystem services) and cultural heritage (material and immaterial) of rural and peri-urban areas. These rural areas, if not properly governed, studied and designed according to ambitious European regulations and strategies (Perpiña Castillo et al., 2024; OECD, 2012; OECD, 2006; IRENA, 2024; IEA, 2024), risk damaging the economic, human, social, physical and natural capital specific to these territories.

Liguria is the last region in terms of investment in and consumption of renewables (Italy for Climate, 2022: 16). It has the lowest national motorisation rate (Italy for Climate, 2022: 14). The risk status of ecosystems is classified as vulnerable, with highly endangered areas (ISPRA, 2023: 73). In addition, the region shows a national trend of increasing soil consumption (Munafò, 2023; SNPA, 2023: 78-79), occupying the penultimate place nationwide for agricultural areas with organic production methods (SNPA, 2023: 72-73). Agronomic practices should ensure levels of environmental quality and biodiversity, as well as the wholesomeness of food and the welfare of farm animals, in line with the structural objectives of the *Farm to Fork Strategy* (European Commission, 2020), a central initiative of the Green Deal.

In this scenario, the study transforms the analytical devices into design tools: the ‘wall’ -the exposure- becomes the investigative tool to understand where and how to install renewable energy production plants; the earth paths provide the syntax for the design of the energy management and distribution system, while the system of ‘plates’ enshrines the topological space intended for the project - monitoring, storage, etc. These elements are the material for analysis to unite agricultural and food production in parallel with energy production, monitoring and counteracting the loss of biodiversity, improving soil water retention, orienting these places towards new possible futures.

The new image of the sustainable valley, the “Silicon Valley”, can through advanced agri-voltaics establish a scientific and holistic reading of the territorial system, helping citizens of rural and peri-urban areas to build an equitable society, based on a clean and accessible energy system, consistent with settlement logic and heritage.

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Illustrations and tables

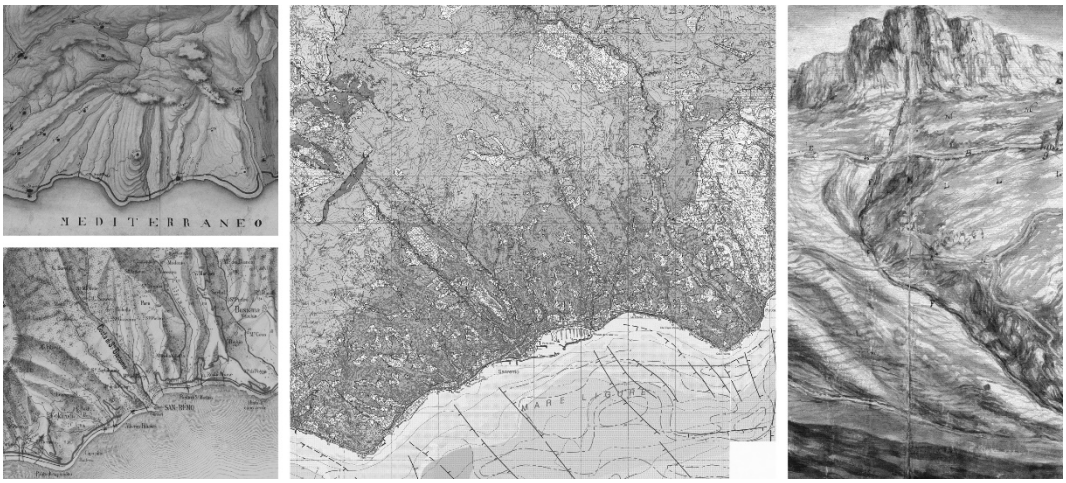


Figure 1. From left to right, top to bottom: Pietro Cometti, Topographical plan of the Province of San Remo divided into mandaments, 1843. (C.A.D.A.M. Archives départementales des Alpes-Maritimes, 01FI 0094); General Staff of the 15th Army Corps, San-Remo, 1897. (C.A.D.A.M. Archives départementales des Alpes-Maritimes, 01FI 1727); Clipping of the territory of Sanremo extracted from Geological Maps sc. 1:25.000 referred to Sheet 258 San Remo, sc. 1:50.000. (https://srvcarto.regione.liguria.it/geoservices/apps/viewer/pages/apps/download/index.html?id=1443); Anonymous, View of Mount Bignone and the bordering territories of Sanremo, Ceriana, Apricale, Baiardo, 17th cent. (State Archives of Genoa)



Figure 2. From left to right, top to bottom: The urban architectural structure of Cape Green promontory greenhouses as seen from Duke of Aosta Street in the direction of Cape Black. (Photo by author, 2022); The greenhouse structure and planting of promontory terraces in Cape Green. (Photo by author, 2022); The terraced structure of the town of Sanremo seen from the south pier of the old port. (Photo by author, 2022)

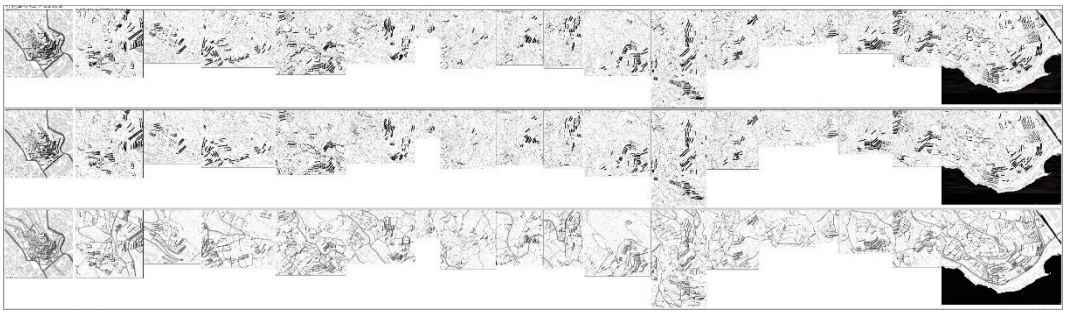


Figure 3. "The tabellone". Archetypes and archetypal patterns of promontory of the Sanremo earth crust. The spatial type in the logical construction of machines du soleil, scale 1:2.000, 468.0x134.3 cm. (Author's drawing, 2022)

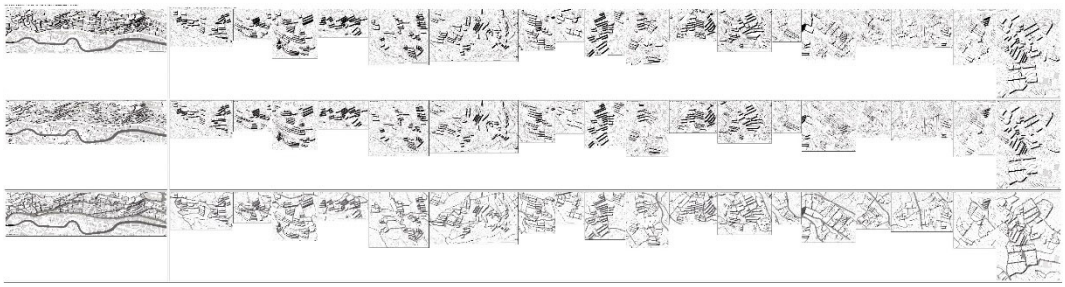
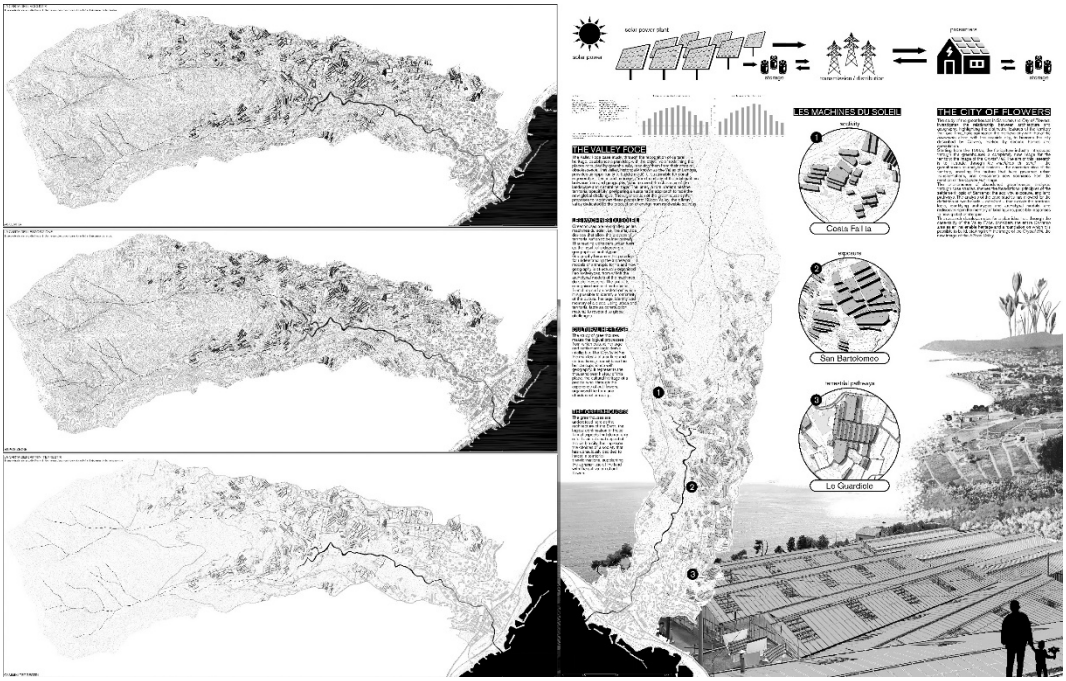


Figure 4. "The tabellone". Archetypes and archetypal hillside patterns of the earth's crust of Sanremo. The spatial type in the logical construction of machines du soleil, scale 1:2.000, 360.1x95.0 cm. (Author's drawing, 2022)



Figures 5-7. From left to right: The greenhouses and acclivity of the hillside orographic structure at Solaro. (Photo by author, 2022); The exposure of greenhouses in the promontory structure at Monteolivo. (Photo by author, 2022); The ridge system along the ascent of Mount of Ravens. (Photo by author, 2022)



Figures 8-9. From left to right: The case-study of the Foce Valley of San Remo: The map of acclivity, exposure and terrestrial paths. Les machines du soleil and the system of plates, walls and paths, scale 1:5.000, 283.8x317.7 cm. (Author's drawing, 2022); Plan idea for the regeneration of the Foce Valley in Sanremo. (Author's drawing, 2022)

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Between the plateau and the plain: the phenomenology of the system Anchieta-Imigrantes

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ABSTRACT

The route between the Planalto Paulistano (plateau at 700 to 800 metres high) and the Baixada Santista (plain at the level sea), composed by two motorways (Via Anchieta, the 'old' one, and Rodovia dos Imigrantes, the 'new' one) constitutes the link between the largest urban concentration (Metropolitan Region of São Paulo) and the main port region in Latin America (Santos), and can be seen as an outstanding element in the history of global urbanization. In addition to this, it also stands out for sitting on a natural landscape – a section of the Serra do Mar– endowed with significant Brazilian physical-geographical references. In this sense, this system (both paths) lies at the heart of decisive processes for architecture and urbanism in the country: original peoples tracks, Portuguese colonization on the seafront, urban sanitation plans, the emergence of the industrial park, the constitution of the metropolis, the formation of the financial centre, rail and road transport connections, irregular occupation and the preservation of natural reserves. Delving into this understanding, we move on to two specific analyses of our object of study, understood as a sign full of meanings that expand, from the high to the low and vice-versa, to these two urban territories. The first analysis focuses on the description of the territory on which it was built (physical-geographical character) and the main movements of its own construction (historical-urban character); while the second is composed by the perception, from a phenomenological point of view, of this constructed scenario. Based on a semiotic structure of understanding, in its syntactic, semantic and pragmatic character, we then identify values, absences and presences that reverberate in the current double path (Anchieta and Imigrantes) since before the formation of the current urban centres, fundamental to appreciation of the still preserved natural landscape and its importance for the cultural landscape of Brazil.

Keywords: Environmental perception, Via Anchieta, Rodovia dos Imigrantes, semiotics, phenomenology.

INTRODUCTION

The system of roads between the Planalto Paulistano (Paulistano Plateau) and the Baixada Santista (Santista Lowlands)[2] is the link between the largest urban concentration and the main port region in Latin America, two relevant areas of the world urbanization. Besides that, is located on a stretch of the Serra do Mar (Sea Mountain Range) - a significant Brazilian natural landscape.

[2] The most important names are kept as original in Portuguese and translated at first time they appear in the text. Paulistano is related to someone or something from São Paulo city, while Santista from Santos city. In the case of Baixada Santista, it is related not only to Santos but all metropolitan area where this city is the main one.

Composed by the Via Anchieta (Anchieta Road) and the Rodovia dos Imigrantes (Immigrants Road) the Anchieta-Imigrantes System is at the heart of decisive processes for architecture and urbanism in Brazil since the beginning to now, such as Portuguese colonization by the sea, urban sanitation plans, the emergence of the industrial park, the establishment of the metropolis, the formation of the financial centre, rail and road transport connections, irregular occupation and the preservation of nature reserves. Since this route is a production of these processes, could we also understand and conceptualize it as an architectural-urbanistic object?

In 'The Aesthetics of Architecture', Roger Scruton[3] (Scruton, 1979) identifies *function* as the first distinctive feature of architecture. In this context, there is no greater utility than the plateau-plain route, which, from the 16th century to the present day and under various designs, indispensably connects the country's largest metropolitan region and the Santos lowlands, its presence being directly linked to the founding of the city of São Paulo, one of the biggest cities of the world.

As another distinctive feature, the author emphasizes the quality of *place* and the intrinsic relationship between the object and the environment in which it is inserted - which presupposes primary concepts such as nature versus culture and tradition versus modernity. The influence of a sui generis geography such as the Serra do Mar on the design of the connections between Santos and São Paulo, including the current System, is undoubted.

A third trait pointed out by Scruton is the presence of *technique*, the 'extension of human competence', and nothing is more representative of this than the evolution of the paths, and the power of the engineering, to permit one to reach the highlands across the huge mountain covered by the Atlantic Forest.

The author also points to the *public character* of the architectural object, responsible for its imposition on the built landscape and its consequent exposure, clearly differentiating it from other arts. Allied to this, he highlights its political nature and human and social representation, which no one can avoid experiencing in some way. Considering this specific scenario, who would be indifferent to what is imposed between the sea level and the almost 800 meters of altitude of the plateau?

METHOD

By considering the hypothesis that the Santos-São Paulo plateau-plain route system can be included in the field of architecture and urbanism as a very significant sign, two specific analyses are defined for this study: while the first one focuses on the description of the territory on which it was built (physical-geographical character) and the main movements of its own construction (historical-urban character); the second is composed by the perception, from a phenomenological point of view, of this constructed scenario. This double analyse is related to a methodological path already indicated in my master and doctorate degree, completed in 2002 and 2010, respectively, at the Faculty of Architecture and Urbanism of the University of São Paulo (FAUUSP). Both research considerer environmental perception theories to understand important elements of the urban form of Vitória (Espírito Santo) and São Paulo[4]. Based on a semiotic structure of understanding, in its syntactic, semantic and pragmatic character, this study aims to identify values, absences and presences that reverberate in

[3] Scruton, 1979.
[4] Monteiro, 2008 and Monteiro, 2010.

the Anchieta-Imigrantes System, fundamental to appreciation of the still preserved natural landscape and its importance for the cultural landscape of Brazil.

These studies culminated in the following key representation, which understands the architectural object (and also the city) as Gestalt[5], but extends the concept beyond the figure-ground relationship only on a special level: {[(figure/ground) x subject] x verb}

Besides that, it considers the understanding of the sign in its simplest character (the compositional structure itself) to the most complex (the use of space), recognizing the value of form as a signifier through the historical apprehension of use.use → meaning → form ← meaning ← use

The Anchieta-Imigrantes system, then, is understood as a sign, to be observed in two stages:

- History (on Geography): understanding the historical construction of the sign, in its most relevant characteristics.

- Geography (on History): understanding the current configuration of the sign - at the three levels of the semiotic approach - taking into account the values assigned historically.

RESULTS AND DISCUSSIONS

The natural territory

The Serra do Mar, a transitional territory between the Metropolitan Region of São Paulo and the Metropolitan Region of Baixada Santista, is a territory classified as a plateau in an orogenic belt, whose formation refers to intense folding followed by erosion processes. It is a mountain range linked to the so-called Atlantic belt, and to the set of plateaus of the eastern Atlantic, the most complex in the country. In general, it consists of a crystalline bedrock with heights of between 800 and 2,000m (highest points), forming an imposing barrier, with a predominant direction almost parallel to the sea coast, on which it sometimes leans. It stretches for more than 1,000km from the north of Santa Catarina to the north of Rio de Janeiro State[6].

Below the Serra do Mar is the Baixada Santista, a typical Brazilian plain, whose design is basically characterized by a flat relief generated by the deposition of recent sediments of marine, lacustrine or fluvial origin. It was in this lowland that the first Brazilian town - São Vicente - was officially founded in 1532, next to the island of the same name. Thirteen years later, the town of Santos was founded, nearby, and afterwards became more important. By including Santos as its economic centre, the Baixada Santista urban agglomeration includes nowadays the cities of Bertioga, Cubatão, Guarujá, Itanhaém. Mongaguá, Peruíbe, Praia Grande and São Vicente, set over islands, rocky outcrops and mangroves, representative elements of the southeast Atlantic coast

[5] Pallamin, 1996.
[6] Ross, 1996.



Figure 1. Brazil urbanization and natural landscapte between São Paulo and Santos. Map credit: IBGE. Drawing credit: Vallandro Keating.

Above, as a backdrop to this flat region, the Planalto Paulistano is located, at an average height of 800 meters, forming a veritable natural wall drawn by escarpments on which various connecting paths were drawn between one territory and another. By using original peoples routes as a reference, the new European inhabitants were able to overcome the steep slopes of the Serra do Mar as early as the 16th century, which led to the foundation of a number of towns on the plateau, including São Paulo. Founded in 1555 on a plateau between the Anhangabaú stream and the Tamanduateí river, the city became the most advanced boca-de-sertão at the beginning of Brazilian colonization. From its urban nucleus, known as the Triângulo - an interfluvial plateau situated between 700 and 800 meters above sea level, already detached from the Paulistano Plateau complex - it was possible to access the interior of São Paulo state via the Tietê River, the main route into the region.

The former tracks and the Calçada de Lorena (1792)

There are indications that the original peoples who lived on the Planalto Paulistano, at certain times of the year, went up and down the Serra do Mar, between the plateau and the plain, to fish in rivers and in the ocean, bringing sun-dried fish back to their villages. To do this, they used narrow trails that started and ended at various points. One of these trails was the old Guaianases trail (Piaçaguera Road), which was used by Martim Afonso de Souza and João Ramalho on their first ascent to the Piratininga fields in 1532. The route, on the plain, went from São Vicente to the so-called port of Piaçaguera de Cima on the Cubatão river, by canoe. From there, the Ururaí river valley was crossed overland to the plateau.

A new route - considered safer - was opened by the Portuguese. One version suggests that the opening of this was ordered by Governor-General Mem de Sá in 1553, in order to avoid harassment by the original peoples. Because it was supervised by José de Anchieta, this road was known as the Caminho do Padre José (Padre José Way). During its activity, important events in the Brazilian colonial period were linked to this road, such as the foundation of Santo André (1532) and the foundation of São Paulo (1553).

In the middle of the 17th century, the governor of the Captaincy[7] of São Vicente ordered the construction of a new road, which several bridges over watercourses along the way to allow better passage for carts and carriages. The route reduced considerably the steep stretch along one of the

[7] Division of regions at Colonial time (1500-1822).

hillsides, although required a considerable zigzag design on the slope. Used for a century, this road was then restored by Governor Bernardo José de Lorena and it became the Calçada do Lorena (Lorena´s Sidewalk). The renovation, designed by Portuguese military engineers, included work on the entire sidewalk, the installation of parapets in the most dangerous places and a monument on the peak of the mountain. The paving of this road with stone slabs became a landmark and consolidated the connection between the highlands and the lowlands by assigning a defined place. By the government decision, the territory then demarcated became the official route connecting the sea and the hinterland and allowed the permanent transit of mules[8].

By bringing Santos closer to São Paulo, the Calçada do Lorena became a symbol of a new dynamic in the state, consolidating the link between the internal world (the Brazilian hinterland) and the external world (the Portuguese metropolis). Although "smaller" compared to the Royal Road, the plain-to-plain link was part of a larger network of roads (river and land) that had been gradually developing in the captaincy of São Paulo, geared towards an economy of internal markets, based on commercial activity. While Santos developed as an export centre, São Paulo took on its role as the "radiating centre of roads" and was no longer isolated from the rest of the country.

At the same time as the royal roads connecting the ports of Rio de Janeiro to the captaincy of Minas Gerais, Brazil's gold region, began to decline, the Calçada do Lorena became the "most notable" road in colonial Brazil, consolidating the sugar cycle in São Paulo and commercial interests.

The Estrada da Maioridade (1841) / Caminho do Mar (1922)

In 1841, a new route is created, reinforcing the junction between the plateau and the plain. With a width ranging from four to seven meters, the road was inaugurated by Emperor Dom Pedro II in 1844. In his tribute, it was named the Estrada da Maioridade (Majority Road). The road is filled with curves, laid out alongside one of the slopes of the Serra do Mar, from the current Henry Borden Valve House to the base near the Presidente Bernardes refinery. At times, it crosses the Calçada do Lorena, whose use is then practically abandoned. Some years later, after improvements, the road changed the name to Estrada do Vergueiro (Vergueiro Road). The construction of the railway from Santos to Jundiaí (1867) gradually led to the decline of road usage during the late 19th century. With the emerging automotive era, the first car journey took place in 1908, when the road already showed visible signs of deterioration.

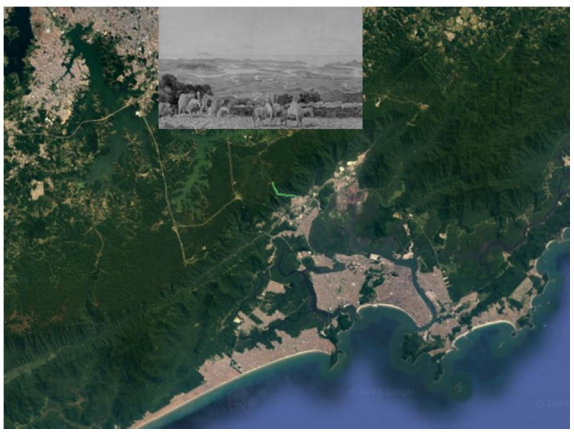
After a period of neglect, a new action by the state government, initiated in 1912, brings the road back to life with new improvements and slight changes to its layout. The road, then called the Caminho do Mar (Sea Way), is paved with macadam, a new drainage system is implemented, retaining walls and supports against landslides are built, as well as a new bridge over the Cubatão River. It becomes the first concrete-paved road in Brazil.

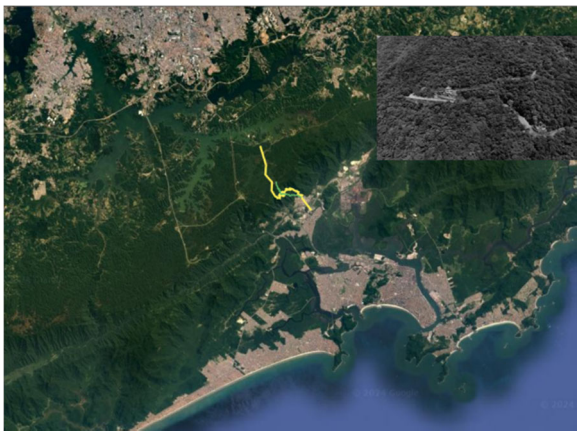
A quite significant moment occurs in 1922, when a series of monuments is inaugurated along the road. To celebrate the 100th anniversary of the country's independence, the governor of the State, Washington Luís, invites the architect Victor Dubugras[9] to design a series of works along the path,

[8] Mendes, 1994.

[9] The architect Victor Dubugras (1868-1933) was born in France but raised in Argentina and based in Brazil, where achieved prestige for designing works such as the redevelopment of Ladeira da Memória in 1921, in São Paulo, and the inss and monuments of the Caminho do Mar (1921/1922), in neocolonial style.

harmoniously aligned with the geography of the place. Such monuments, designed in Neocolonial style, stand out not only for their historical value but also for the way they rest upon the landscape, marking specific places within this setting. The road, monuments and landscape come together in a unique way[10].





Figures 2,3 and 4, 5. Calçada do Lorena (in green) and Caminho do Mar (in yellow). Map credit: Google Earth (edited by the author). Painting credit: Oscar Pereira da Silv. Photo credit: www.turismodenatureza.com

Beyond the integration with the physical geography of the area, the group holds great historical value, constituting an important architectural and landscape heritage. In its Neocolonial architecture, the use of granite with the Portuguese paving technique stands out, along with tile cladding highlighting architectural elements (pediments, friezes, murals, and bases), the use of clay tiles in exposed roofs, and the presence of balconies and porches. The drawings of the artist Wasth Rodrigues[11] reinforce the artistic value of the works, which aim to recover a genuinely Brazilian aesthetic, even though it is connected to the baroque of Portuguese origin. The strategic location along the route creates a harmonious relationship with the surrounding landscape, by allowing impressive views.

At the highest point of the Serra, the Pouso de Paranapiacaba (Paranapiacaba Inn) is located, still in São Bernardo do Campo city. From the balconies, it is possible to have an exceptional view of the landscape and the sea. The program includes a central hall, sheltered, with a fireplace, and balconies, arcades, and external landings. Next, along the path to the plains, you will find the Belvedere Circular, which, in addition to offering another privileged view of the landscape, stands out as the first intersection of the Calçada do Lorena – the previous route – and the Caminho do Mar. From this point, it is possible to enter the sidewalk and then exit at the next intersection further down. Following the road, the next monument is the Rancho da Maioridade (Majority Ranch), which was also built to serve as a resting place for tourists, and was named in honour of the road's name before it became the Caminho do Mar. In the unique implementation, the architectural elements are presented: a semicircular balcony along the curve with tiles that evoke the Portuguese baroque. Right after that, there is the Padrão de Lorena (Lorena´s Standard), which marks the third and final meeting between the sidewalk and the road. It is named in honour of the man who ordered the construction of the Calçada do Lorena. At the plain, there are two monuments: the Raiz da Serra Bridge - which was built

[10] Toledo, 1966.
[11] José Wasth Rodrigues (1891-1957) was a Brazilian painter, draughtsman, illustrator, ceramist, teacher and historian.

to mark the end of the asphalt paving on the road – completed in 1926- and the 16th-century Cross, which stands out for marking the intersection between this path and the Caminho do Padre José.

Despite the advantages, the rapid increase in vehicle traffic soon makes the road inadequate for the growing flow of vehicles and the constant landslides during the rainy season. In 1947, after the inauguration of the Via Anchieta, the Caminho do Mar became a secondary route and was renamed Estrada Velha (Old Road). In 1985, the road was decommissioned. Between 1992 and 2004, it was renovated and became an ecotourism hub. Nowadays, the road is open to visitors on foot or by bicycle, maintenance vehicles, or minibuses from the São Paulo Historical Energy Heritage Foundation, which manages the Ecotourism Hub Caminhos do Mar. Part of the Calçada do Lorena is also reached inside the park.

The parallel paths: Estradas-de-Ferro Santos-Jundiaí (1867) and Mairinque-Santos (1937)

Still at the mid of the 19th century, a new road connects the plateau to the plain, but without replacing the Estrada da Maioridade motorway. The expansion of coffee culture in the interior of São Paulo state necessitaded a more effective route for transporting the product to the port of Santos for export. The Estrada-de-Ferro Santos-Jundiaí (Santos-Jundiaí Railway) is then designed and built.

The railway was inaugurated in 1867, along with urban centres in the plateau, crossing São Paulo at Luz Station and starting the descending from the Alto da Serra station, in the new village of Paranapiacaba. On one side of the track, the English designed and built a very complex funicular system just after the village, an entire neighborhood called Vila Martin Smith, to house engineers and staff in wooden residences with slate roofs. Important buildings stand out in the ensemble, such as the Castelinho (residence of the chief engineer), the Lira Paulistano club, etc. The station, in turn, drew attention for its English-origin design, a clock tower, and the machinery system. The development stands out for the quality of its buildings and streets, turning this area into a historical heritage site[12].

For many years, passengers and goods traveled down the Serra do Mar by train. In 1946, with the end of the São Paulo Railway concession, the process of decline for the village and the railway system begins. In 1970, the funicular system was partially deactivated to make way for a new transportation system, the rack-and-pinion. The Valongo Station in Santos, the last one in the system on the plain, remained active until 1995, when passenger use was discontinued.

Running parallel to the two existing routes - the Caminho do Mar and the Santos-Jundiaí railroad - the Estrada-de-Ferro Mairinque-Santos (Mairinque-Santos Railway)[13] was also planned in the 19th century but inaugurated only in 1937. With a length of 155 km, it was designed to break the monopoly of the São Paulo Railway (“the English”) on the descent from the mountains to the port of Santos, constituting a branch of the Sorocabana railroad, built by the American Brazil Railway Company, which already connected São Paulo (Júlio Prestes Station) to Sorocaba and the western part of São Paulo state. This railroad was built with a maximum gradient of 2%, which allows for a maximum speed of 64 km/h. The descent of the Serra do Mar begins at an altitude of 740 meters at the Evangelista de Souza Station, in São Paulo, and ends near sea level at the railway yard of Paraitinga, in São Vicente.

[12] Iphan, 2024.
[13] Estações Ferroviárias do Brasil, 2024.

This rugged stretch of mountain features 27 tunnels, already built with dimensions to accommodate the future duplication of the railway line.



Figures 6,7 and 8, 9. Estrada-de-Ferro Santos-Jundiaí (in light blue) and Estrada-de-Ferro Mairinque-Santos (in dark blue). Map credit: Google Earth (edited by the author). Photos credit: RFFSA; www.ampfmairinque.org

In 1957, the Evangelista de Souza station, in the highlands, became the junction point for the Jurubatuba branch, directly connecting the city centre of São Paulo to Mairinque-Santos. After the creation of FEPASA in 1971, the branch became part of the Araguari-Santos Export Corridor, undergoing several improvements. However, while cargo transport was encouraged, passenger traffic was decreasing, first limited to the Embu-Guaçu to Santos stretch in 1975, until it completely ceased to exist in 1997, when the branch was granted to the private sector.

Nowadays, this stretch is managed by Rumo Logística, which fully doubled the route in 2015 as part of the works for the main export corridor of Brazilian agribusiness. In the same year, the Santos-Paratinga stretch (Praia Grande) began to be used as the track for the VLT for intermunicipal passenger transport in the Baixada Santista.

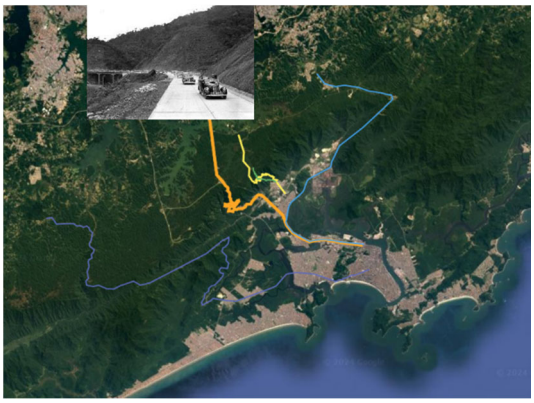
The Anchieta-Imigrantes System (1947, 1976)

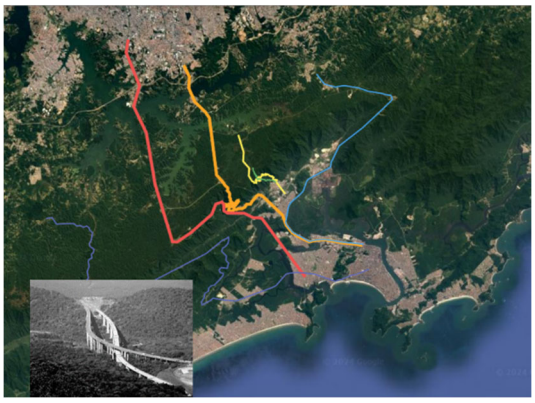
Despite the effectiveness of railways, with rapid urban growth and increased use of motor vehicles, the Sea Road soon becomes limited. A new road is then built, going to be used parallel to the two railways and the (now) Old Road of Santos. For several decades, connections between Santos and São Paulo could be made in various ways.

Father Anchieta, a prominent figure in the colonial history of São Paulo and, indeed, of Brazil, is once again honoured in the 20th century with the new motorway connecting the plain and the plateau, introduced in 1929 as part of the Prestes Maia Avenue Plan. The Via Anchieta, as it is known, employs more advanced techniques than those used on the Caminho do Mar, which soon becomes underutilized and starts to be referred to as the Old Road of Santos. The inauguration of the north runway takes place in 1947, while the south runway is established in 1953, both with two lanes each.

The new road starts, at its highest point, in the city of São Paulo, in the Sacomã neighborhood, passing through São Bernardo, Cubatão, and Santos, providing access to the other cities (São Caetano, Santo André, and Diadema) as well as to the old Caminho do Mar. Like this, it features in its design – over its 72 kilometers – many curves, on a route that often follows the very outline of the mountain range, whose proximity is still very evident. On the other hand, it is innovative in presenting some tunnels

and overpasses that either discreetly penetrate the massif or subtly leap over small valleys. Its use has been explored since 1969 by Dersa, a state-owned company. In 1972, tolls were installed. In 1998, the highway was then privatized, and a consortium of private companies was granted concession until 2018 for the operation and maintenance of the entire Anchieta-Imigrantes system.





Figures 10,11 and 12, 13. Via Anchieta (in orange) and Rodovida dos Imigrantes (in red). Map credit: Google Earth (edited by the author) / Photo credit: www.saobernardodocampo.info; public domain.

Thirty years after the inauguration of the Via Anchieta, a new and more moder road was created to connect plateau and plain. The Immigrant Highway, or SP 160, was planned and built with the aim of serving as a broad export corridor between the largest industrial complex and the largest port in Latin America, carried out by the Department of Highways of São Paulo (DER-SP), with about 100 engineers and 13,000 workers. At that time, it was considered the largest road engineering project in Latin America and one of the five largest roads ever built in the world. Nowadays, it is the main access route from the city of São Paulo to the Baixada Santista and the southern coast of São Paulo.

It was built in two phases, with the first phase starting in 1974 and inaugurated in 1976. The North Track was initially designed for ascending traffic only, and then it was reversed according to the flow of vehicles. Started in 1998, the South Track was inaugurated in 2002. The work was carried out by Ecovias, which was granted the concession for the highway for 20 years. Unlike the North Track, it featured more modern overpasses, as well as longer tunnels - totaling 8,200 meters in length across four sections. The first one, at 3.2 km, was considered at the time the largest road tunnel in Brazil. It is also noteworthy in the construction of this track the use of new technologies for maintenance, such as ventilation jets, sensors for noise reduction, heat detection and wind measurement, and smart accident cameras. Extensive tunnels and viaducts were necessary to ensure that the environmental impact on the Serra do Mar was minimal during the construction of the South Track[14].

The Rodovia dos Imigrantes has an incline of about 6%, which prevents buses and trucks from traveling safely on its lanes. The main users of these highways are, therefore, private cars. Despite the generous number of lanes, for years the Anchieta-Imigrantes System has been unable to handle the enormous flow of vehicles using the motorways to reach the beaches of Baixada Santista and the South Coast, especially on festive dates, especially in summer. A prominent engineering work on the national scene, these two tracks consist of impressive viaducts, bridges, and tunnels, by reducing considerably the time to cross the range.

[14] Ecovias, 2024.

Nowadays, the connection between the plateau and the plain is primarily made through the Anchieta-Imigrantes System, via motor transport, since the Caminho do Mar has become a tourist park while the railways only transport goods. Meanwhile, we understand all the former paths still reverberate on this one, historical and geographically.

The syntax

From a syntactic point of view, it is possible to see that, as time goes by, the route between the plateau and the plain becomes longer - from Calçada do Lorena to Rodovia dos Imigrantes - but also increasingly direct. At the same time as it grows, on the uphill stretch, the route becomes increasingly distant from the territory, aided by artificial elements that fly over (bridges) or penetrate (tunnels) the natural landscape. The zigzags and sharp curves of the Calçada do Lorena and the Caminho do Mar give way to the straights and open curves of the railroads, and within the system itself, the Rodovia dos Imigrantes increasingly expands to speed up the route in relation to the Via Anchieta. New means of transportation allow for greater speed and São Paulo and Santos, with the passage of time, become closer and closer. Nowadays, on a normal traffic, it's possible to go from the city centre of São Paulo to the city centre of Santos in one hour, something impossible to imagine at the colonial time. Time after time, the plain and the plateau get closer. At the same time, direct contact with the territory, solidified by the stones of the Calçada de Lorena and, later, by the concrete of the Caminho do Mar, will increasingly demand devices to traverse over (bridges) and under (tunnels) nature. These elements - already necessary for the railroads - are then emphasized in the Anchieta-Imigrantes System.



Figures 14 to 21. The sintax of the System: then and today. Photo credits (black & white): public domain / Theodor Presing / MSR / public domain // Photo credits (color): Ecovias / Jornal da Orla / Ecovias / Ecovias

From the outset, the challenge of overcoming the 800-meter height in its irregular shape required a great deal of effort and economic and political resources to make significant engineering works possible. The stones of the Calçada do Lorena, the concrete of the Caminho do Mar, the special structures of the bridges and tunnels of the railroads and their improvement in the Anchieta-Imigrantes system, bring to light the gradual technical strength in the historical path of the design of roads between plateau and plain. Increasingly, São Paulo - the radiating hub to the interior of the country - and Santos - the radiating hub to the exterior - have come closer together, in a process of increasingly faster, albeit longer, design. To this end, it is made up of a system recognized as one of the most important engineering works in the world, just as the Caminho do Mar, the railways and even the Calçada do Lorena were at the time. the best engineering works of their time: motorways, railroads and roads.

Technique is present not only in the construction of the design but also in the evolution of means of transportation, from mules to trains, cars, buses and trucks. It is also responsible for the elements that will allow greater protection against natural accidents and "equalize" the route, making its irregularity less and less noticeable. Bridges cross rivers and valleys while tunnels pierce mountains.

The semantics

Because it crosses such a special area, there are many meanings present in the Anchieta-Imigrantes system. Starting with the names: Anchieta in honour of the founding priest of São Paulo, recovering the name of one of the primitive roads; and Imigrantes in honour of those who helped the region's economic growth. Just as the Caminho do Mar was named after its main investor, Vergueiro, and the Barão de Lorena gave his name to the Calçada. Inland and coastal areas are also named after the railways (from Santos to Jundiaí and from Mairinque to Santos). History is present in the naming of the roads, although the original peoples - responsible for the first trails - have been forgotten.



Figures 22 to 29. The semanthics of the System: then and today. Photo credits (black & white): CATV / public domain / Ricardo Koracsony / Anderson Bianchi // Photo credits (color): Ecovias / Urbana / Ecovias / Eduardo Knapp

In the history of the meanings of its design, one can also see how economic periods are reflected in the roads. At the same time that the paving of the Calçada do Lorena symbolizes the commercial function between the plateau and the plain linked to the sugar economy, and the Santos-Jundiaí railway symbolizes the function related to the coffee economy, the Way of the Sea demonstrates the supremacy of the road system, then framed by monuments that honour one hundred years of Brazil's independence, seeking a new aesthetic in its colonial past.

In addition to the route itself, other architectural objects also demonstrate public significance, such as the train stations built below and above the Serra do Mar. With the end of passenger transportation, many were abandoned, such as Marsilac Station, in the south of the São Paulo capital, and Valongo Station, the most important in Santos which, thanks to its aesthetic and historical value, was later restored and today houses a museum. Others ended up adapting to other railway systems, on an inter-city scale - whether on the plains or the plateau - as is the case with Luz Station in São Paulo.

The Anchieta-Imigrantes system speaks to us about the pride of São Paulo's labor, names the Catholic catechization and the immigration of the workforce, all those responsible for the progress of the richest city in the country. In this gradual eloquence, it distances itself from the paths of original peoples, from the colonial stone road, from nationalist monuments, and from imported railways. At

the same time, it owes its existence to all the other paths. Acting on the great wall of mountains, it interferes and modifies.

The pragmatics

In terms of use, it is undoubtedly possible to identify the importance of the Caminho do Mar for the sense of place. Here, the road was not only considered a connection, but also an opportunity to access spaces for viewing the landscape. The inns and stops were spaces to value history and contemplate the Serra do Mar and the Baixada Santista. This character is strengthened by the set of works of inestimable aesthetic value created by Dubugras. Although it is more heavily trafficked than Calçada do Lorena, the highway takes advantage of the rugged topography, featuring a design full of curves. Embracing this harmonious relationship with nature, the Path of the Sea incorporates architectural elements that will serve as moments for resting and appreciating the landscape. Allied to an aesthetic that seeks a national reference – even if it is rooted in the Portuguese colonial past – reinforces the idea of place. Once again, a landscape scenario "in between" is drawn - neither a plain nor a plateau, the Caminho do Mar enhances the identity of São Paulo and becomes a national heritage. Unused for a long time, it became in 2004 not just a park, but an open-air museum, where it is possible to identify a harmonious relationship between architectural objects and the territory. Like in the old colonial cities of Brazil – where the interrelation between built objects and elements of the natural landscape is visibly present – it constructs an identified cultural landscape.



Figures 30 to 37. The pragmatics of the System: then and today. Photo credits (black & white): Google Earth / Caminhos do Mar Park / ATP Cultural / Pulsar Imagens // Photo credits (color): Google Earth / Cobrape / Google Earth / Eduardo Knapp

On the Anchieta-Imigrantes system, there are no terraces to contemplate the landscape, no buildings or monuments that pay tribute to the history of the country and its geography. On the long and fast Imigrantes journey, there is no time to appreciate the landscape. There is no place to rest or to contemplate the delicate (and monumental) poetry of the connection between plain and plateau. Delays only occur on foggy days, when visibility is lost, or in undesirable traffic jams. Despite the complementary views (flying and diving), the Anchieta-Imigrantes complex is still just a passageway. There are only a few glimpses (stops for safety, maintenance and eventual accidents), whose main purpose is not to rest and admire the scenery.

Meanwhile, as contact with nature is lost in the new routes, poor neighbourhoods have sprung up in the environmental protection area, revealing the social differences that are still present in the country. Without proper planning, neighbourhoods occupy the plain and climb the slopes, in precarious constructions. They reveal the social inequality of the country and the precarious life in delicate

natural areas. For some of these places, even direct access from the Anchieta-Imigrantes system is not permitted.

CONCLUSIONS

A territory of large dimensions, Brazil offers considerable diversity in its relief, that, combined with other common natural factors - climate, hydrographic system, vegetation – shape significant specific areas within the context of the Brazilian landscape, such as the numerous mountains and valleys amidst the Atlantic Forest of the Southeast, where the Planalto Paulistano and the Baixada Santista are located. In the appreciation of Brazil's physical and natural landscape, the coastline stands out not only for its geographical formation but also for the fundamental role it has always played in the social structuring of Brazil; its analysis, therefore, raises numerous questions related to the understanding of both Brazilian geography and history.

In this context, the connection between Santos and São Paulo, which required a significant effort of transposition since the 16th century, became a key point in the structuring of the largest economic centre in the country. While the Northeast and, later, Rio de Janeiro and Minas Gerais profited from the first major economic cycles linked to colonial Brazil (sugar and gold), São Paulo region was preparing for rapid development starting in the 19th century, reinforcing its role as a gateway to the hinterlands and a radiating centre. In fact, the building of the connections between the plateau and the plain contributed significantly to make São Paulo the richest city of Brazil. In this sense, it can be said that the Anchieta-Imigrantes complex is an expressive visual communication system, a truly integrated visual message[15], full of meanings constructed by its design: interrelated natural and artificial landscapes.

From the analysis carried out, it can be seen that Anchieta and Imigrantes, in their geographical and historical context, in fact reveal the characteristics pointed out by Scruton to be understood as architecture - or urban form - but with different weights. In the syntactic approach, the presence of *technique* is strong, both in the current design - huge tunnels and viaducts - and in the historical route - the Calçada do Lorena as one of the best roads in colonial Brazil, for example. Without adequate technological resources, it would have been unthinkable to cross the mountains. The semantic approach to *function* and *public character*, on the other hand, is ambiguous, since, while notable works were built on the previous routes - such as the railway stations - the use of the roads is currently prioritized only as a place to pass through. In turn, the sense of *place*, visibly represented in the Camino do Mar and its ensemble of architectural elements, is obscured in the current system. Millions of vehicles travel the Anchieta-imigrantes[16] system every year, going from the highlands to the lowlands and vice-versa, viewing the natural landscape - without, however, ever stopping to feel it phenomenologically. In addition, the precarious neighborhoods in naturally preserved territories on the banks of the Anchieta and Imigrantes motorways are still a big challenge.

In addition to the question *Can we understand the Anchieta-Imigrantes System as architecture?,* one has also to ask: *For whom is this architecture intend?* As an urban form, the Anchieta-Imigrantes System visibly connects the plains and the plateau, at a time not even imagined when the first road

[15] Monzeglio, 1993.
[16] Nowadays Santos and São Paulo house 22 million people, concentrating almost 10% of the population of Brazil.

was consolidated. As a rapid passage, it transports not only goods, but mainly people, for the most diverse reasons. It brings the sea closer to the highlands and vice-versa. It connects lives.

This rapid connection, however, reduces not only time, but also the space between, also formed by a complex natural system of life. As one of the largest natural biodiversity landscapes on the planet, the Atlantic forest between the plateau and the plain remains preserved, despite historical interference: the planned paths and the unforeseen neighborhoods.

For the native peoples - who have always respected this place, while at the same time experiencing it - its name is Nhe'ẽry, the basis of their life experience and resistance[17], the place where the spririts bathe. The place that we have to feel as the same phenomenon. Because to take care of it is to take care of oourselves.

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[17] Krenak, 2022.

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Between tiles and concrete: a dialogue among tradition and modernism in São Luís

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ABSTRACT

São Luís is a city renowned for its colonial Portuguese architectural and urban influences. With its tiled mansions and primitive colonial layout dating back to 1612, still preserved, the area was recognized as a UNESCO World Cultural Heritage Site in 1977. However, like elsewhere, São Luís has also been influenced by modern thought, resulting in city expansion and the pursuit of new ways of living and developing, making the analysis of this coexistence intriguing. This study aims to examine the possible continuities or discontinuities generated by modernism in the urban structure of São Luís' historic center. The objective is to discuss how modernist ideas relate to the city's historical urban landscape, evaluating whether there is integration or conflict between modernist elements and traditional architecture. A literature review will be conducted on the impact of modernism on historical heritage, with a specific focus on cases where São Luís' Historic Center resists and coexists with modernist ideals that often promoted the "abandonment" of the old. In light of this, it is noted that modernism, as an artistic, architectural, and cultural movement, was often associated with the valorization of the new, innovation, and the breaking of old traditions. This may have resulted in architectural and urban interventions that neglected the preservation of historical heritage in the name of progress and modernity. Faced with these nuances and dualities within the movement itself, one observes the reasons behind the choices of preservation or transformation of historical heritage in São Luís and how these decisions were influenced by political, economic, and social factors. Ultimately, a critical and comprehensive approach could offer valuable insights into the complex interactions between modernism and historical heritage in São Luís and other historic cities worldwide.

Keywords: Modernism; historical heritage; urban integration.

INTRODUCTION

São Luís is a city recognized for its Portuguese colonial architectural and urban influences. With its tiled mansions and colonial layout dating back to 1612 still preserved, the area was designated a UNESCO World Cultural Heritage site in 1997. Like other historic cities, São Luís has undergone urban transformations in pursuit of modernization, resulting in an interesting coexistence between the old and the new. Separated by the Anil River, on one side lies the old city, the city of Portuguese heritage,

with its mansions, belvederes, and tiles; on the other side, the modern city with its concrete towers and gated communities.

Although modernism, as an architectural and urban movement, is often associated with the appreciation of the new and a break from the past, in São Luís, this condition of two cities facing each other seems to affirm a dialogue, a harmonious coexistence between the construction of the new and the appreciation of the past. This article aims to examine the continuities and discontinuities generated by modernism and the modernization process in the urban structure of São Luís. More specifically, it discusses how modernist conceptions and the modernizing impulse influenced the preservation of heritage and urban development.

Ultimately, it seeks to critically discuss whether this relationship between the old and the modern in São Luís was one of integration or a symbolic and physical separation, and what the implications of these decisions were for the city.

Considering the modernization movement that shaped the concrete city on the other side of the Anil River in the 1970s, it is possible to state that, in the same movement, within the same plan that guided modernizing urbanization, were the guidelines for the conservation of historical heritage, with the old city being treated as a historic city.

SÃO LUÍS: FROM CITY TO HISTORIC CENTER

To address the complex interactions between modernism and the preservation of São Luís' historical heritage, a qualitative approach was adopted, focusing on a critical analysis of the processes that shaped the city's urban configuration. In this context, different methodological strategies were articulated to account for the complexity of the topic investigated. On one hand, there was a focus on the analysis of urban plans, projects, and conservation policies for ancient structures; on the other hand, the observation and recording of the current dynamics of the historic center were emphasized. Portuguese colonial consolidation and the beginning of an urban design in São Luís occurred around 1615, after the definitive conquest by the Portuguese metropolis.

The initial plan was attributed to chief engineer Francisco Frias da Mesquita and can be identified in the city's map drawn by the Dutch during their occupation between 1641 and 1644. This layout revealed orthogonal streets with right angles, making São Luís the first Brazilian city to follow an organized urban plan, oriented by the cardinal points (ANDRÉS, 2016).

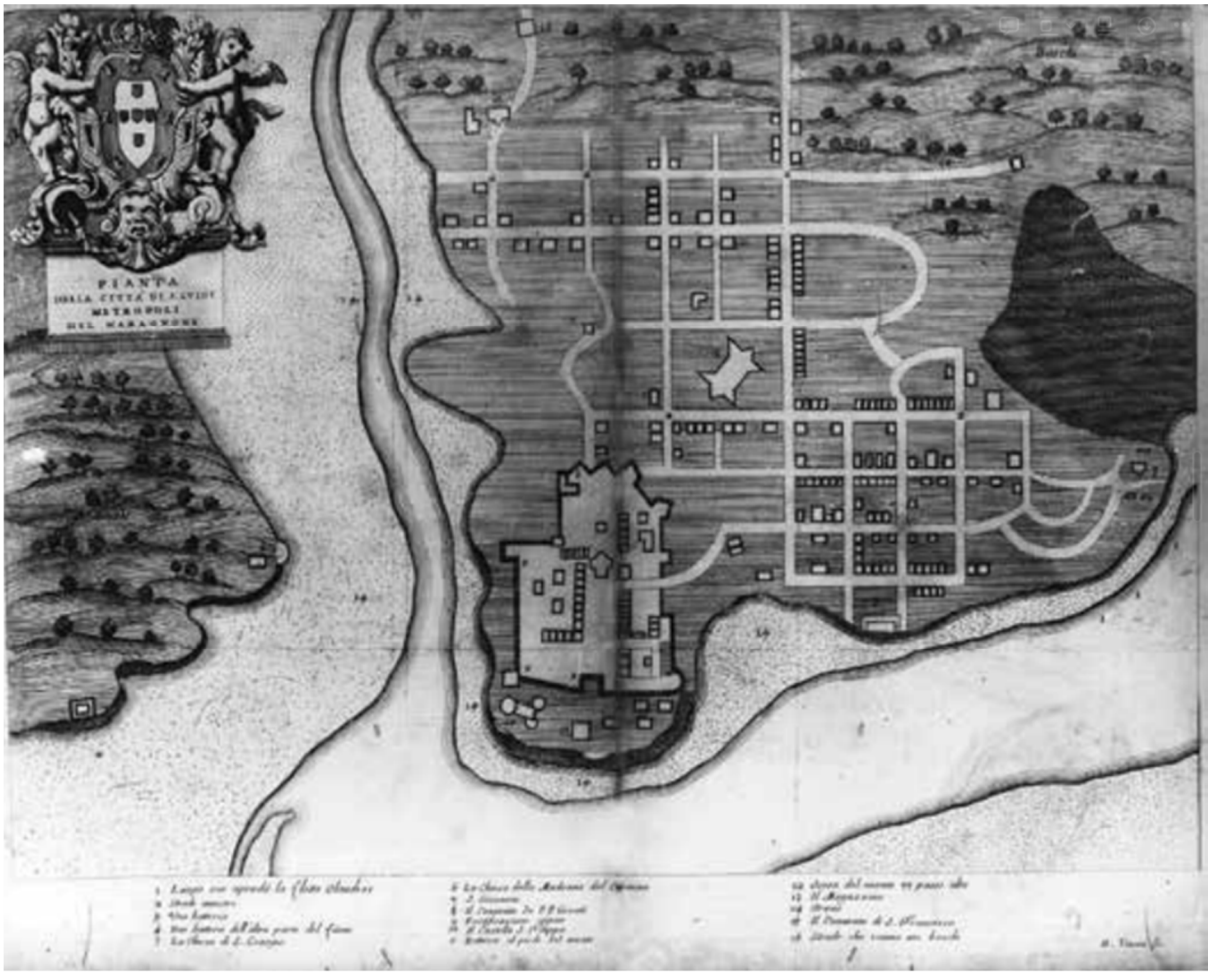

Figure 1. View of the city of São Luís, photo credit: National Library, RJ, 1698.

This urban design endured for centuries, shaping the city's development from this region and leading to São Luís being included on the UNESCO list.

For the purpose of this study, the urban analysis in this region will begin around the 1930s, when a major economic crisis emerged in Maranhão. The decline in agricultural exports resulted in population displacements and impacted urban occupation. However, the changes were guided by the axis defined by the original urban layout, moving towards the interior of the island, following the so-called Caminho Grande, already present on the aforementioned Dutch map. The attempt at recovery through industrialization, with textile factories, brought some prosperity and hope for recovery, until even the factories could not withstand the pressure, entering a state of bankruptcy in the second half of the 20th century. In the old city, the Praia Grande area, near the port and home to a concentration of mansions that had housed the wealthy trade for some time, felt the weight of the bankruptcy and faced a process of abandonment of the factories that existed there. The region remained vibrant due to the presence of residents from Desterro, a popular neighborhood near Praia Grande, along with the Mercado das Tulhas and a distinctive, popular trade.

Near Praia Grande, after Largo do Carmo, Rua Grande concentrated on elite commerce, resisting the crisis. The residences of this elite surrounding Rua Grande in the center coexisted with colonial

mansions, eclectic houses, and even some modern incursions built in the 1960s, following modernist principles in the form of three ten-story buildings, two of which housed public institutions and a third designated for commerce and services. A fourth building, also ten stories high, constituted an initial attempt at modernizing housing: the Caiçara building, a residential structure with four apartments per floor, symbolizing a new way of living.

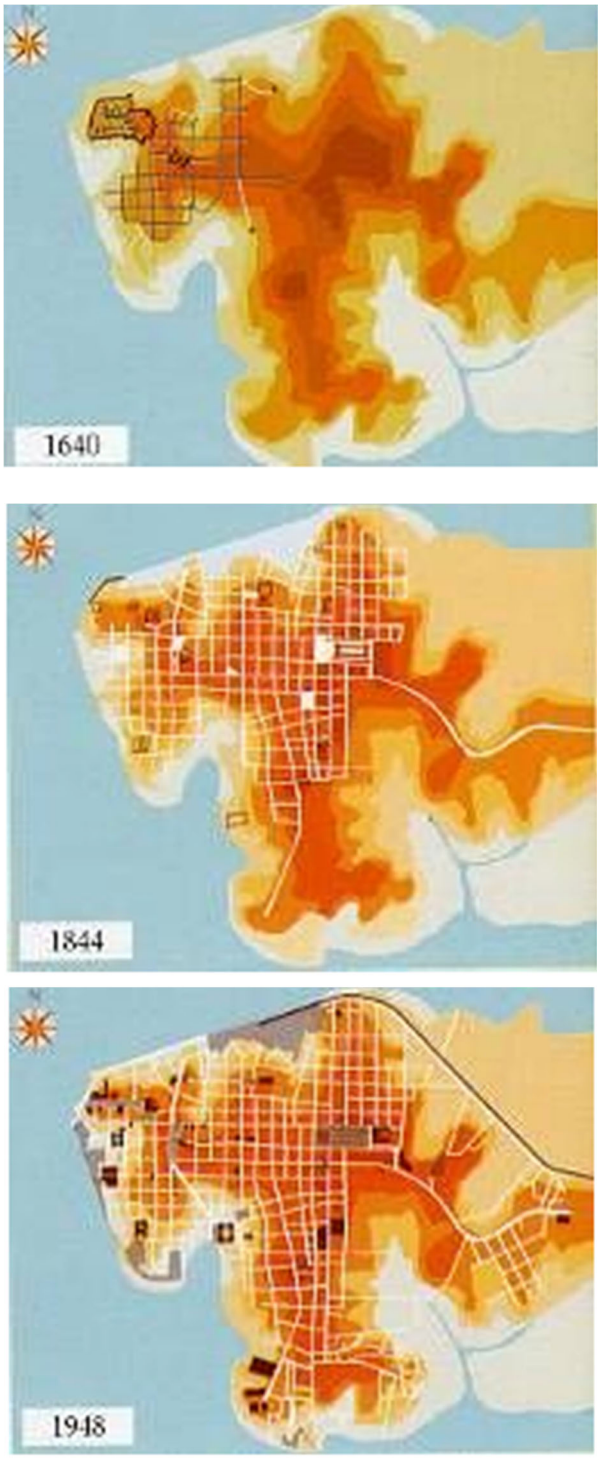

Figure 2. Maps with relief and urban evolution of São Luís. São Luís, photo credit: Andres, 2006

> A hope emerges. The dream of an industrial São Luís would once again be nurtured. A new wave of population growth. São Luís was blatantly swollen, now with five-star hotels, department stores, ALUMAR, Vale do Rio Doce Company, the Port of Itaqui, the enhancement of the coastal area, and the erection of buildings with modern lines in fine contrast to the old, tiled mansions, now decaying, that helped it earn the title of the fourth most important city in Brazil at the beginning of the century (Ribeiro Júnior ,P.26, 1999).

This is a vision of modern São Luís, which was being constructed and transformed through the modernizing expansion guided by the Master Plan (1975), developed under the direction of Wit Olaf Prochinik[18]. A plan that followed the paradigm of modernist urbanism and functionalist urban planning: zoning by function with the consequent creation of homogeneous zones, prioritizing the movement of individual motor vehicles, materialized in the construction of many roads and high-speed thoroughfares, created to meet the needs of modern life: new high-speed avenues, bridges over both rivers, connected, that would quickly integrate the new areas with the old ones (WALL, 201). And, above all, the occupation of the entire territory of the municipality, even if this meant, in practice, the creation of new residential zones in areas that had not yet been urbanized.

It can be stated that starting from the 1960s, several factors would drive the construction of the modern city. First, the developmentalist impetus of the authoritarian government that took power in the country in 1964 favored the construction of a new port that would replace, with many advantages, the old one in Praia Grande, as the construction of the Port was treated as a special project, the Grande Carajás Project, in the National Development Plan (PND), which included the National Urban Development Policy (PNDU) and contemplated medium-sized cities as decentralization poles of development, with São Luís included in this plan. In fact, the construction of the Port of Itaqui, envisioned for decades, finally materialized, and the export of iron ore extracted from the Serra dos Carajás in Pará began to fuel hopes for economic recovery through the industrialization that would follow this export, which was expected to provoke enormous economic growth.

Secondly, the city, founded in 1612, maintained its original 17th-century layout of regular blocks in a reticulated grid, a pattern that created a compact and continuous urban fabric. This logic prevailed until the urbanization process in the 1970s, which made the city spread across unurbanized lands, creating large areas of residential production as well as a port and industrial area. Since then, the logic of producing new urban space has been guided and dominated by a modern network of high-speed avenues, with the new residential areas dispersed along this extensive road network. From this moment on, urban expansion adopted the pattern of a dispersed city.

[18] Development Plan (PND), which included the National Urban Development Policy (PNDU) in the Brazilian context. São Luís was aligned with the proposal to create new development poles in the country, especially in the North and Northeast, aiming to decentralize the population and economic activities by creating new jobs and seeking to reduce income disparities. It was characterized as an area promoting urbanization and as one of the cities that would receive development and industrialization poles led by the establishment of the Port of Itaqui. Wit-Olaf Prochinik's office was responsible for expansion plans for several of these cities, particularly in the Northeast, which were to receive special projects such as the Grande Carajás Project.

To accommodate the expected growth, around 12,500 housing units were built from 1967 to 1980, just to illustrate the strength of this housing policy, financed by the National Housing Bank, accompanied by the construction of developments or subdivisions for the middle class of São Luís, all very well guided by the 1974 Master Plan, following a logic of socio-spatial segregation characteristic of the modern urban planning paradigm.

Although reality did not exactly match these hopes, the city transformed. The displaced growth axis resulted in a fragmented city, with residential areas isolated from one another, connected by large high-speed avenues, and many empty spaces between them.

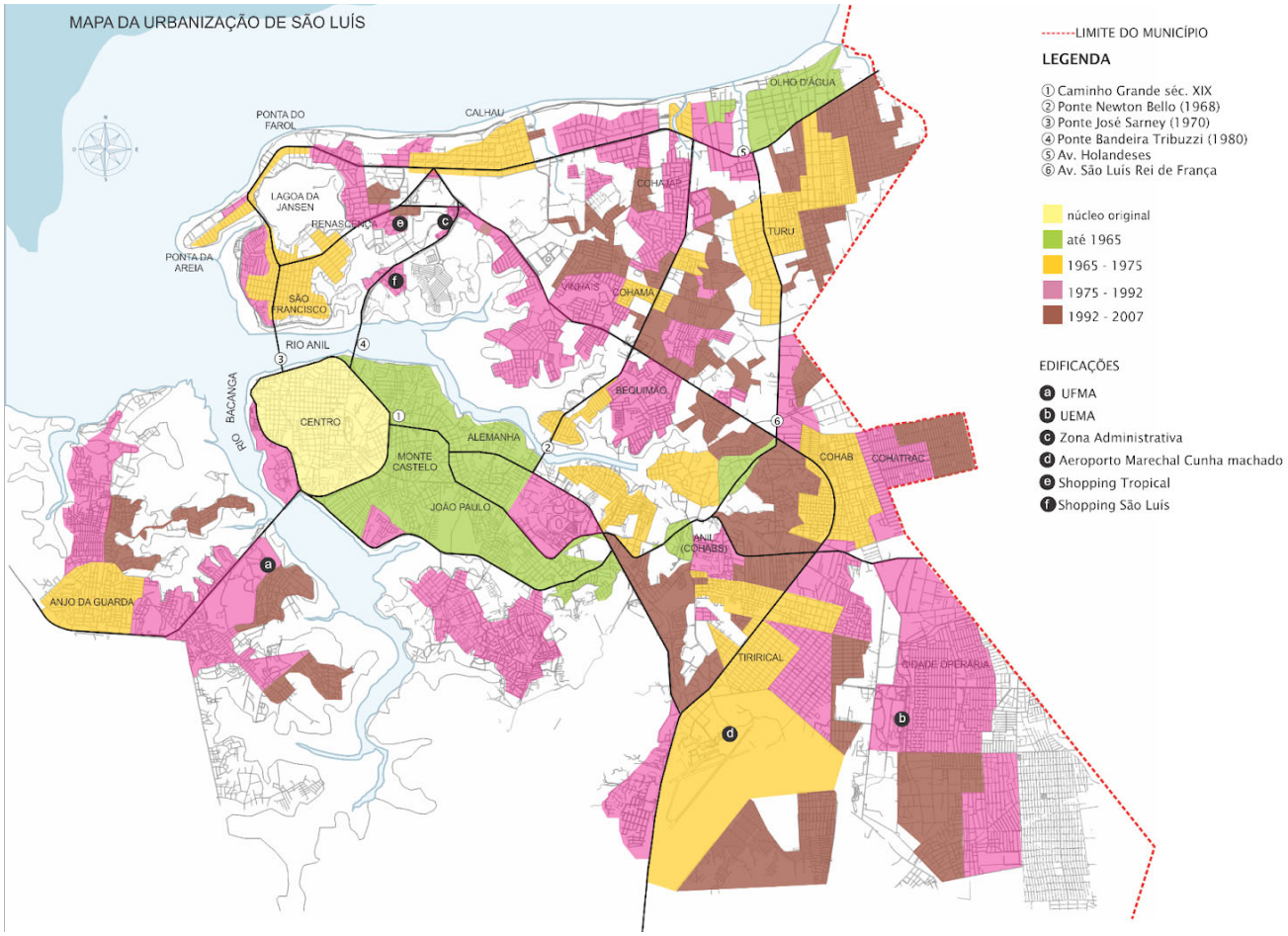

Figure 3. Map of the dispersion of São Luís, photo credit: Wall, 2011

In this context, the proposal to reconcile the existing city with the modern city, the city of tiles with the city of concrete and asphalt, materializes through the enhancement of historical heritage, preserving the colonial urban environment. From that moment on, the colonial city, which was where people lived, became the administrative, institutional, and civic center, also aligning with modernist urbanism's functional zoning, a CBD (Central Business District). The proposal to value the existing historical and cultural heritage included the primary objective of developing art tourism, seeking to integrate this highly valued heritage into the proposed urban and economic development process at that time.

This seemed to be a conciliatory, or even natural, solution capable of pleasing all sectors. A modern city was being constructed while the old one was preserved. Indeed, it is impossible to imagine the center as it remains today, or even the inclusion of this center in the UNESCO World Heritage List, without this process of modernizing expansion that, while embarking on the conquest of new territories, proposed the conservation of the old city. The modernization that had begun in the center, which even included verticalization, was halted. The modern city moved to the other side of the rivers surrounding the original nucleus. To a large extent, this situation preserved the architectural ensemble.

The Center, which once represented the entire city, began to take on new contours around 1970. Now carrying the title of "historical city," it started to be experienced differently by the rest of the city. As Wall (2011) clarifies, urban dynamics transformed the relationship between the center and the other neighborhoods, all of which were distant from the old city.

However, before delving deeper into this aspect, it is important to note that one of the valued areas in the new regions was precisely the waterfront, the beaches. Previously distant from the existing city and difficult to access, the modernization process ensured, if not proximity, at least greater ease of access, with the construction of new high-speed avenues.

In seeking this proximity to the beaches or the possibility of purchasing their own homes as a new way of living, the relationship with the existing city, now transformed into a center, changed.

> For some, the distance was welcome because it kept the turbulence, noise, and pollution of concentration at bay (living modes in coastal neighborhoods); for others, the distance was a necessary evil (residential complexes for the middle classes) to be able to live in their own homes in a more individualized manner; or it was a terrible burden to be endured to get to work (more distant residential complexes and marginalized periphery) (Wall, p. 246, 2011).

The conservation of the old city benefited from the collaboration of UNESCO technicians. In the 1960s, through the French architect Michel Parent, and later with the visit and subsequent preparation of a technical report by architect Alfredo Viana de Lima, who conducted a detailed photographic and cartographic survey of the historic center. This work underpinned the diagnosis and recovery plan for the area, which was even materialized in a chapter of the 1974 Master Plan, and served as a reference for future studies.

It is worth noting that the study conducted by the Portuguese architect not only embraced the idea of modernity but also outlined guidelines for urban expansion aligned with the nationalistic optimism of the "economic miracle," as Lopes and Viana (2018) point out. However, this diagnosis brought an important distinction: based on the Venice Charter, Viana de Lima emphasized the value of built cultural heritage and the importance of its management, in accordance with Article 16 of the Charter:

> Conservation, restoration, and excavation work should always be accompanied by the preparation of precise documentation, in the form of analytical and critical reports, illustrated with drawings and photographs [...] this documentation will be

> deposited in the archives of a public body and made available to researchers; its publication is recommended (BRASIL, 2004, p. 95).

The reverence for the urban ensemble is expressed when the architect emphasizes the importance of adapting the city's expansion process:

> If Brasília is a landmark in contemporary urbanism, the city of São Luís do Maranhão plays an important role in the study of the formation of cities in Colonial Brazil. It must be preserved, cherished, and correctly integrated into the planned expansion (VIANA DE LIMA, 1973, p. 39).

Prior to Viana de Lima's diagnosis, Michel Parent—also a consultant for UNESCO—produced a report entitled "Protection et mise en valeur du patrimoine culturel brésilien dans le cadre du développement touristique et économique" (Protection and Valuation of Brazilian Cultural Heritage within the Scope of Tourist and Economic Development) (Leal, 2008). The central ensemble of São Luís held value and was particularly seen as an opportunity for tourism, specifically art tourism.

Both reports highlighted the liveliness of the existing city, and while proposing the use of its structures for art tourism, they warned of the need to integrate the space, now elevated to historic city status, with the development of the modern city. They suggested the establishment of a university, the Federal University, which was being developed at the same time, and cautioned about which uses could be more detrimental to conservation.

In the ongoing dialectic between expansion and conservation, and with the clear need to preserve monuments, sites, and historic centers, various approaches emerged regarding how to achieve this preservation. Some advocated treating these locations as museum pieces, primarily serving an educational function, while others viewed them as works of art, valued as commodities within the cultural tourism industry. The necessity for innovation, the dialectic of destruction, and the replacement of the old with the new were also discussed.

In this context, the field of conservation gained a chapter, already mentioned, in the 1974 Master Plan, which closely followed the guidance of Viana de Lima and was under the charge of technical teams from conservation agencies (at both federal and state levels, the newly created Department of Historical, Artistic, and Landscape Heritage, DPHAP—established in 1973). They determined a Historic Protection Zone and a Support Zone for historic protection.

Simultaneously, the Government of the State of Maranhão embraced the idea of conservation and supported the implementation of recovery plans for Praia Grande, still in the 1970s. From then on, considering the extent of the existing city, an area was designated as the Historic Center, roughly corresponding to the original nucleus, following Frias de Mesquita's design.

In the 1980s, the largest and most comprehensive program aimed at attracting attention to the area and consolidating its tourist potential was created. Cultural venues such as the Odylo Costa Filho Creativity Center, Morada das Artes, and the Domingos Vieira Filho Popular Culture Center demonstrated this commitment to culture. Furthermore, cultural groups and manifestations found in these revitalized spaces and the accompanying discussions an opportunity to express themselves and strengthen their identities. The phenomenon of appropriation of this space by popular culture

intensified over the years, driven by the construction and consolidation of a vibrant cultural scene in the city center.

On the other hand, the representation of modern living, the perspective of modern ways of living in the new areas, played a decisive role in the devaluation of the old space, of the historic center as a place to live. The modern city developed in a segregated space, presenting closed residential enclaves. The new neighborhoods attracted commerce and services. Following the typology of gated communities came the typology of closed commercial and leisure spaces, such as shopping centers.

Meanwhile, in the historic center, contrary to this representation and against conservation policies that did not demonstrate concern for creating programs to incentivize residents to stay in the center, residential niches remained, and popular culture persisted, challenging desires for the gentrification of the heritage space.

FROM CENTER TO COMMODITY?

In experiencing and witnessing the local scenario, the commitment to culture is sometimes only safeguarded in discourse. The region has been promoted as a large open-air museum, aimed at attracting tourists, many of whom come to the city to visit the Lençóis Maranhenses but take the opportunity to enjoy São Luís's rich cultural heritage, including popular manifestations, traditional games, and the unique local cuisine, which has also had its moment of appreciation, suggesting that the focus on cultural tourism has also been incorporated.

The state government is restoring buildings for the State University to house Law, International Relations, and Music courses, while simultaneously moving out of the city center to other areas, a trend that has been intensifying for some time. In the same process, it abandons important cultural centers, such as the Odylo Costa Filho Creativity Center and the Popular Culture Center, along with other spaces that once hosted special tourism delegations, all undergoing significant degradation and becoming easy targets for theft and vandalism.

The moment is paradoxical: on one side, many new programs and intervention projects are being actively developed, promoted by federal, state, and municipal public authorities. With significant funding, including from international organizations, large cultural projects, economic development, and cultural tourism promotion are underway. On the other hand, there is neglect.

Various actions have been and are being carried out over the years that provide the urban experience described by Mogin (2009), emphasizing encounter and diversity. Weekly events, such as the Feirinha (Little Fair), organized by the Municipal Secretariat of Agriculture, Fisheries, and Supply (SEMAPA) on R. do Giz, promote not only leisure but also the economy through local entrepreneurs and artists.

However, there are also visible signs of promoting rehabilitation aimed at private initiative and the predatory exploitation of cultural resources, including the devaluation of local and popular culture during festive times, such as the June festivities, and the major symbolic act: the dismantling of the Casa do Maranhão. This mansion, which in the 19th century housed the old State Treasury and functioned for decades as the State Department of Finance, served as a reference center for

Maranhão's popular culture, including Black and Indigenous culture, local handicrafts, and was used for cultural group presentations and lectures.

The replacement of the Casa do Maranhão, a center for promoting this culture, supporting local handicrafts, and promoting cultural activities, with a luxury hotel, for example, may aim to attract more tourists who appreciate (undeniably) good accommodations. Still, it risks bringing them in without being able to offer exactly what is currently available in the historic center of São Luís: local culture, handicraft products, and the works of local artists. Similarly, heritage needs to be lived. Wouldn't it be time to allow culture to appropriate and take care of this heritage as it always has?

By implementing incentives for the use and permanence of cultural activities and manifestations in the Historic Center, we would not only be revitalizing the spaces but also the heart of the city. After all, a living heritage is one that pulses, breathes, and transforms alongside the community that inhabits it.

CONCLUSIONS

The historic center of São Luís, as a space of living culture, faces a crucial challenge: how to reconcile tourism, heritage preservation, and the daily life of the community? On one hand, it is evident that government programs have sought to encourage urban rehabilitation, promoting São Luís as a culturally significant tourist destination. However, at the same time, contradictory actions, such as the abandonment of essential public spaces and the replacement of centers for popular culture with private enterprises, point to a devaluation of local culture. Culture, which has always been the soul of the historic center, risks being sidelined in favor of a development model that prioritizes immediate profit.

The transformation of the Casa do Maranhão into a luxury hotel is a symbolic example of this dilemma. By replacing a space dedicated to promoting popular culture with a venture focused on luxury tourism, there is a risk of disconnecting the historic center from its cultural identity. Local culture, expressed in June festivals, traditional games, handicrafts, and community spaces, needs to remain the guiding thread of urban revitalization. A historic heritage cannot be treated as a static object; it is a living organism that breathes and evolves with the community.

For the revitalization of the historic center of São Luís, it would be important to place the permanence of cultural manifestations and residential niches, of current residents, at the heart of rehabilitation policies. Incentives for the continuation of these activities, for the appreciation of handicrafts and local cultural expressions, are essential to ensure that the heritage continues to pulse with the life of the community that inhabits it.

The true success of any intervention in the historic center depends, above all, on authentic and continuous cultural appropriation and an understanding of the place as a space for living, as this experience keeps the heart of the city vibrant and relevant.

The sustainability of the historic center of São Luís, therefore, depends on an approach that values local culture and the traditions that define it. Revitalization policies must go beyond mere restoration of buildings, incorporating strategies that promote social inclusion and the strengthening of cultural

identity. Community participation in decision-making processes is fundamental to ensure that interventions respect the history and experiences of the residents. Only through open and collaborative dialogue will it be possible to build a future that celebrates the cultural diversity and historical heritage of the city.

Moreover, it is imperative that revitalization actions are accompanied by urban planning that prioritizes the well-being of local inhabitants. This involves creating accessible public spaces that encourage interaction and the exchange of experiences among diverse social groups. Strengthening initiatives that promote popular culture, such as craft fairs and cultural events, can contribute to the recovery of the identity of the historic center, attracting not only tourists but also the local population, who should feel part of the process of valuing their heritage.

Finally, the revitalization of the historic center of São Luís should be seen as a long-term project that requires ongoing commitment and investment. Public policies must be supported by partnerships with civil society organizations, the private sector, and universities, aiming for the implementation of integrated and effective actions. The future of the historic center is closely linked to the ability to transform challenges into opportunities, allowing local culture to flourish and ensuring that the city maintains its vibrant essence, in tune with the needs and aspirations of its population.

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Co-housing design strategies for neighbourhood socio-environmental sustainability: a morphological analysis of patterns

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ABSTRACT

To promote the development of Sustainable Cities and Communities, as recommended by one of the United Nations Sustainable Development Goals, this paper addresses design strategies with the potential to promote socio-environmental sustainability in urban spaces from a neighbourhood scale. Co-housing, functioning as a sustainable housing typology, emerges as an intermediary between utopian ideals, experimentation, and social transformation. This paper examines the morphological patterns of Co-housing design, highlighting humanizing attributes to promote socio-environmental sustainability in urban spaces. To achieve this, the study examines the case of the Beddington Zero Energy Development (BedZED) project in the United Kingdom, a pioneering example of experimental urban sustainable housing design. The method adopted uses a design reading of morphological patterns identified in architectural and urban spatial forms incorporating a humanizing approach. Design patterns are identified based on Christopher Alexander's patterns at the neighbourhood and building scales, and analysed graphically in architectural design, and photographs recorded on-site during a technical visit. The outcomes of this analysis contribute to the discussion of existing design strategies in Co-housing typology, fostering socio-environmental sustainability in urban spaces.

Keywords: Co-housing, socio-environmental sustainability, humanization, patterns.

INTRODUCTION

According to the World Cities Report (UN-Habitat, 2022), the global urban population is projected to increase by approximately 2.2 billion people by 2050, rising from 56% in 2021 to 68% of the total population. This rapid growth poses the risk of exacerbating unsustainable urban expansion patterns. In response to this challenge, it is crucial to rethink urbanization through alternative housing and community design approaches that align with sustainable urban development. Both the New Urban

Agenda (UN, 2017) and the Sustainable Development Goals (SDGs) highlight this need, with a particular emphasis on promoting Sustainable Cities and Communities (UN, n.d.).

Within this framework, the focus of this paper is on the seventh target of SDG 11, which aims to ensure the creation of safe, inclusive, accessible, and sustainable public spaces by 2030. To contribute to this objective, the paper proposes a morphological analysis of Co-housing design strategies, exploring their potential to promote socio-environmental sustainability in urban spaces from neighbourhood scales. In this context, socio-environmental sustainability is understood as a strategy for achieving SDG 11, integrating sustainability's social and environmental dimensions. The social dimension addresses human well-being, focusing on equitable access to essential services and fostering social cohesion. In contrast, the environmental dimension addresses the responsible management of ecosystems, encouraging pro-environmental human actions and behaviors (Robert, Parris, and Leiserowitz, 2005; Demantova and Rutkowski, 2007). By balancing these two dimensions, urban spaces can better support sustainable development.

Co-housing, as explored in this study, offers a housing typology that aligns with these sustainability objectives. Widely discussed in the literature, Co-housing is positioned between utopian ideals of social experimentation and practical responses to living in neoliberal contexts, particularly in culturally diverse societies with increasingly limited state support (Sargisson, 2012; Tummers, 2015; Droste, 2015; Boyer, 2018). According to Beck (2020), Co-housing consists of clusters of independent single-family homes with access to communal facilities, integrating open areas and shared spaces within the neighborhood. Since its origins in Denmark, the Co-housing typology has evolved significantly. As Rolando (2022) notes, it now represents an alternative to the traditional model of predefined-function housing, offering more flexible spatial configurations. These configurations challenge conventional privacy boundaries and encourage new forms of social interaction, particularly at the neighborhood scale, making Co-housing a compelling approach to sustainable urban design.

The term "Co-housing" was translated by Vedel-Petersen, Jantzen, and Ranten (1988) from the Danish term Bofællesskab. This concept emerged in Denmark during the 1960s and 1970s as an alternative to conventional single-family suburban residences, aiming to restore a sense of community in modern society. The literature also includes the term "Cohousing," coined by American architects Charles Durrett and Kathryn McCamant, who regarded Danish Bofællesskab experiences as foundational to this housing typology. According to McCamant and Durrett (1988), Cohousing communities are defined by participatory design processes. These strategies promote community living, extensive common facilities, resident-managed spaces, non-hierarchical structures, and independent income sources.

Although there is no consensus in the literature regarding the distinct use of "Co-housing" and "Cohousing," with both terms often used as English translations of Bofællesskab, Babos et al. (2020) suggest that "Co-housing" be understood as a broader concept of collaborative housing. The prefix "co-" encompasses various forms of collective living arrangements, such as cooperative, community, and communal housing, each with different levels of social interaction and distinct spatial configurations. Therefore, examples of the Co-housing typology include Bofællesskab, Cohousing communities, ecovillages, communes, housing cooperatives, co-living, collective self-help housing, community-led housing, and other formats that prioritize collective and collaborative living. While

these arrangements differ in social dynamics and spatial structures, they share a common goal of fostering integrated and socially engaged living environments.

This paper proposes an analysis of Co-housing design strategies through a morphological analysis of patterns, using the Beddington Zero Energy Development (BedZED) as a case study. BedZED, widely recognized as a pioneering experimental sustainable community, was developed in the United Kingdom by the British sustainability charity Bioregional and architect Bill Dunster in the 1990s, in collaboration with the Peabody Trust housing association, which served as the project developer. The central vision behind BedZED was the creation of a community that operates without relying on fossil fuels. To realize this vision, an available site was identified in Beddington Farmlands, a suburban area of London (Figure 1) that had previously served as a sludge disposal site. In 1998, the London Borough of Sutton, which owned the site and acted as the local planning authority, endorsed the project by selling the land to Peabody at a below-market rate. Construction of the project began in 2000 and was completed in 2002. BedZED's residential units range from studios to four-bedroom flats, with 25% allocated for subsidized rental, 25% for affordable private ownership, and 50% for market sale. In addition to residential spaces, the project includes offices, a nursery school, and communal facilities designed to function as extensions of the private living spaces (Bioregional, 2016).

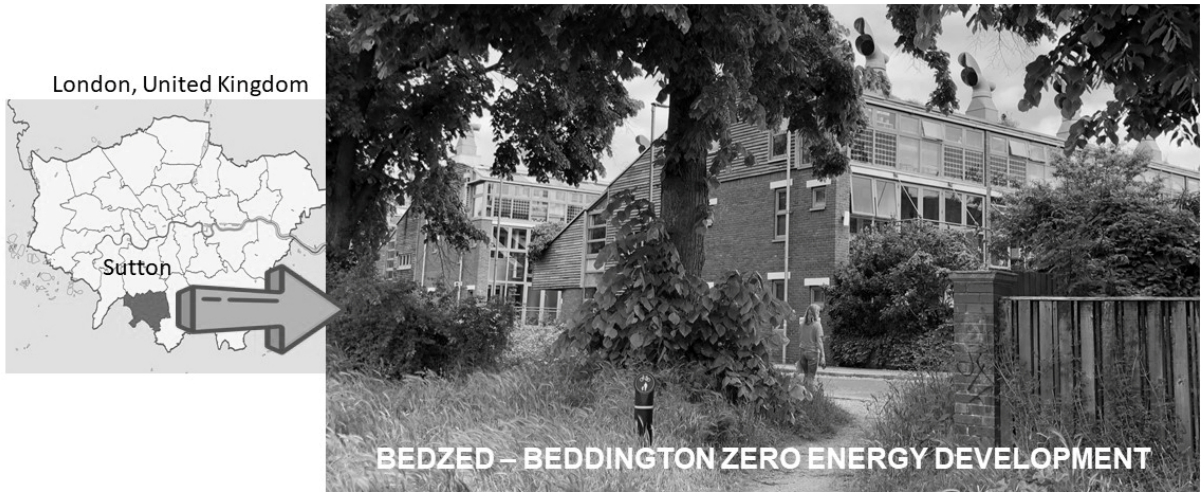


Figure 1. BedZED project location. Source: Authors.

The choice of BedZED as a case study is justified by its status as a consolidated experimental sustainable community, aligning with the objectives of Goal 11 of the SDGs: Sustainable Cities and Communities. While most literature on BedZED focuses on its technical strategies to reduce carbon dioxide emissions, such as the use of renewable energy sources like photovoltaic and wind energy, passive thermal comfort technologies, solar orientation for heating, water-saving systems, and recycled materials (Smith & Butler, 2008; Chance, 2009; Puma et al., 2024), there is limited analysis of its design strategies from an urban morphology perspective. For instance, Sdei (2005) conducted a comparative analysis of the morphological impact of passive solar systems in domestic architecture using BedZED as a case study to identify its energy performance. Another study by Deakin, Reid, and Campbell (2014) does not specifically analyze BedZED but examines its neighborhood through a morphological lens, highlighting issues of energy performance and carbon emission reductions aimed at mitigating climate change. In this context, there is limited exploration of these strategies through a

humanizing design approach and within the framework of Co-housing typology, which functions as an umbrella concept for collective and collaborative contemporary housing arrangements.

In response, this research aims to address that gap by examining how the design strategies adopted in BedZED, as a Co-housing typology with humanizing morphological attributes, can potentially contribute to socio-environmental sustainability in urban spaces. These humanizing attributes are framed through Christopher Alexander's concept of patterns, which encapsulate sensory and affective dimensions into design parameters. While these dimensions are difficult to quantify, they address essential human aspirations and needs in the built environment, such as enhancing social interaction in urban spaces and strengthening human connection with nature (Alexander et al., 1977; Alexander, 1979).

The paper is organized into five sections, starting with this introduction. The following section explores humanization as a design approach, focusing on Christopher Alexander's theory and methodology, particularly his concept of patterns. The third section outlines the design analysis method, explaining the steps of the protocol that applies Alexander et al.'s (1977) patterns as the key parameters. In the fourth section, the results of the BedZED analysis are presented, covering the selection, examination, and articulation of patterns, culminating in the highlighting of humanizing attributes. Finally, the fifth section provides the conclusions drawn from the analysis of the identified morphological patterns and their potential to promote socio-environmental sustainability in urban spaces.

Humanization design approach through patterns

In the field of Architecture and Urban Design, the concept of humanization has evolved, incorporating knowledge from various disciplines to fill stylistic and theoretical gaps (Kowaltowski, 1980). Originally, this evolution stemmed in the history of humanity from movements aimed at preventing physical cruelty against humans and animals and became popular during the 1970s with the countercultural, ecological and human potential-valuing movements, mostly in the USA. This study considers the development of humanization as a design approach, particularly through the research activities and publications of the Design Methods Movement between the 1960s and 1970s, especially by members of the second and third generations. According to Van Der Voordt and Van Wegen (2005), during this period, design methods emerged that focused on addressing human aspirations and needs in the built environment, emphasizing user participation and the validation of interdisciplinary knowledge from fields such as environmental psychology and sociology. Among the main figures of this movement, Christopher Alexander stands out, whose theoretical and methodological work, especially in A Pattern Language and The Timeless Way of Building, introduced the principles of humanization into the design field. The first volume (Alexander et al., 1977) is related to the participatory design method approach with patterns as its major tools, functioning as design parameters in the design process and construction of buildings and towns. The second (Alexander, 1979) is the design philosophy Alexander aimed to propose as a basis for a new paradigm for the design discipline.

Alexander (1979) developed the concept of patterns translating the patterns of human interactions with spaces into design parameters with humanizing attributes that add "life" to the environmental and social dimensions of places, which he associated with "the quality without a name". In this study, these attributes are understood as sensory and affective aspects, difficult to measure, but accepted by the common human sense – such as human needs for social interaction and connection with nature – that are associated with the quality of the built environment and consequently with human health

and well-being. The idea of humanizing attributes is linked to many theories in Architecture and Urban Design fields nowadays – but not necessarily using this designation – indicating that certain spatial arrangements may be beneficial to the built environment as well as to human well-being socially and psychologically (Hillier and Hanson, 1984; Kaplan, Kaplan and Ryan, 1998; Nasar, 1998; Helleur, 2001; Thwaites, Helleur and Simkins, 2005).

Despite being a product of the 1970s, Barros and Kowaltowski (2013) acknowledge Alexander's attempt to translate the patterns of human interactions with environments as design parameters value a more sensitive human connection with place, people's well-being and socio-environmental diversity; since Alexander anticipates concerns about the socio-environmental impact of construction and urban design, as well as issues related to the sustainable use of materials and the creation of healthy environments from a holistic perspective. For Salingaros (2005), the knowledge produced by Alexander et al. (1977) derived from observations and subjective experiences within specific physical and social environments, requires interdisciplinary knowledge to understand them. Thus, understanding Alexander's patterns demands a dialogue between different disciplines and a mental effort to establish their connections.

In A Pattern Language (Alexander et al., 1977), Alexander introduces the concept of pattern as design parameters that translate the patterns of human interactions with places, in a participatory design approach focused on the users' aspirations and needs in the built environment. Organized into a language structure, the patterns replace words with design parameters that combine to essentially support the process design. To facilitate use by participants in the design process, each pattern is presented in a chapter following a consistent structure (Figure 2) for all the 253 patterns identified at scales ranging from cities and communities, progressing to medium themes like buildings, and moving to more specific details such as construction and landscaping: 1) A figure representing the archetypal nature of the pattern. 2) An introductory paragraph discussing the pattern's context and its relationship with larger-scale patterns. 3) A set of three diamonds (⋄⋄⋄) marking the beginning of the problem addressed by the pattern. 4) A bold paragraph summarizing the design problem in one or two sentences. 5) A descriptive text, accompanied by figures or graphs, that provides empirical evidence of the pattern's validity and its various manifestations. 6) Bold text offering the solution to the problem, highlighting the necessary physical and social relationships in the design. 7) Diagrams or drawings illustrating the design strategies proposed. 8) A set of three diamonds (⋄⋄⋄) marking the conclusion of the main design strategy proposed. 9) A final paragraph linking the pattern to smaller, more specific patterns that complete the language structure.

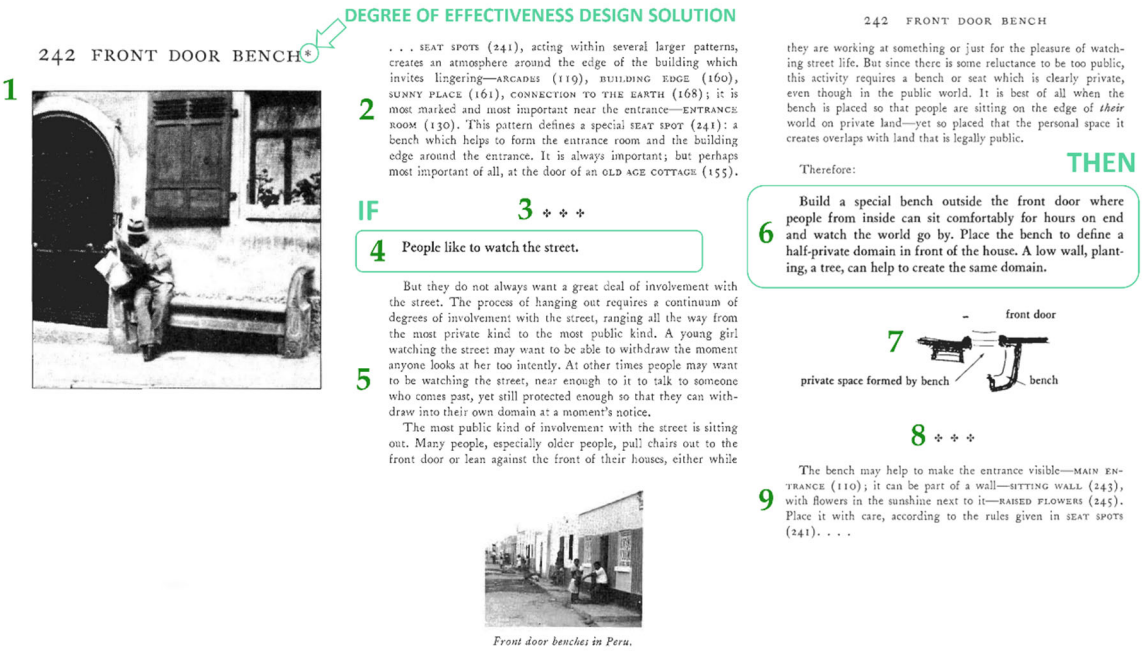


Figure 2. The standard structure presentation of all patterns. Source: Adapted from Alexander et al. (1977).

According to Kowaltowski (1980), this structure reflects a cause-and-effect mindset, characterized by "if... then..." statements rooted in architectural determinism. Authors such as Dovey (1990), Dawes and Ostwald (2017), and Kowaltowski, Gonçalves, and Cleveland (2024) point out that the absence of scientific validation in some hypotheses presented in the patterns reduces the credibility of Alexander's theory. However, this criticism is acknowledged by Alexander et al. (1977), who caution about the lack of guarantees regarding the degree of effectiveness design solutions listed. To address this uncertainty, the titles of the patterns are marked with asterisks to indicate different levels of confidence. Two asterisks (**) signal patterns with design solutions are considered invariant by the authors. One asterisk (*) indicates patterns whose effectiveness is uncertain, suggesting that users approach these solutions with scepticism and explore alternatives. Patterns without asterisks indicate that the authors were unable to identify a plausible solution, admitting that other approaches may be more appropriate.

This study suggests that adopting a probabilistic approach, now commonly used in Urban Design, is more suitable for applying Alexander's design theory. The earlier notion of environmental determinism, once prevalent in Environmental Psychology, is no longer accepted as it neglects human agency by assuming a unidirectional interaction between the environment and people. In reality, the person-environment relationship is bidirectional. As Carmona et al. (2003) state, people are not passive; they actively shape and modify the built environment, which, in turn, influences and alters them. While some of Alexander's pattern design strategies lack scientific rigor, suggesting that certain environmental and social structures may better address human aspirations and needs in the built environment, recent neuroscience studies might confirm these propositions. According to Zeisel (2006), this emerging research niche is classified as Environment/Behavior/Neuroscience.

This study adopts a distinct approach to Alexander's patterns by applying morphological analysis to Co-housing design strategies, focusing on the relationship between the environment and human behavior within the visual dimension of Urban Design. This approach explores the patterns' potential to foster socio-environmental sustainability in urban spaces, mostly from neighbourhood scales.

METHOD

This study analyzes the design of BedZED, focusing on identifying morphological patterns. According to Yin (2009), the case study method requires understanding the complex dynamics that both shape and are shaped by the case. BedZED is examined to explore Co-housing design strategies with humanizing attributes that promote socio-environmental sustainability in urban spaces. The analysis uses Alexander's patterns to identify design strategies, incorporating sensory and affective dimensions into design parameters. The materials include publicly available architectural drawings and photographs taken during a guided site visit on May 25, 2023. The analysis follows a four-stage protocol outlined below.

1st Stage. Patterns' Selection: In this phase, a probabilistic sample of patterns from Alexander et al. (1977) is selected to be identified in the Co-housing design strategy. This selection follows the author's guidelines, considering the hypothesis of developing a design similar to the case study. In this scenario, the goal is to choose patterns whose design strategies are most coherent with the BedZED.

2nd Stage. Pattern Scanning: Here, the patterns from Alexander et al. (1977) are identified as the main evidence in the design analysis. The scanning design analysis strategy involves mapping morphological patterns present in the case study and comparing them with Alexander's patterns. To facilitate identification, the architectural design is hand-redrawn, highlighting the contour of built and open spaces. Subsequently, markings are made on the morphological patterns' locations, and numbering them according to Alexander's patterns using AutoCAD software as a tool. This process is applied to both the drawings and the photographs taken on-site.

3rd Stage. Design Reading Based on Pattern Articulation: Parallel to the scanning, this stage involves a design reading based on the patterns identified and their articulations. The relationships between the patterns help interpret the design strategies adopted, according to their numerical sequence.

4th Stage. Patterns' Humanizing Attributes: In this stage, the humanizing attributes of each identified pattern are summarized in a framework which highlights the humanizing attributes in patterns with the potential to promote socio-environmental sustainability in urban spaces. These attributes are transcribed based on the content from the chapters in Alexander et al. (1977).

RESULTS AND DISCUSSIONS

The results and discussions are organized according to the protocol stages described above. These stages are 1) Patterns' Selection, 2) 3) Pattern Scanning with Design Reading Based on Pattern Articulation, and 4) Patterns' Humanizing Attributes.

Patterns' Selection

Initially, 21 patterns from Alexander et al. (1977) were selected as a sample, described as follows: 15 (neighborhood boundary); 21 (four-story limit); 37 (house cluster); 38 (row houses); 39 (housing hill); 48 (housing in between); 51 (green streets); 52 (network of paths and cars); 53 (main gateways); 59 (quiet backs); 60 (accessible green); 61 (small public square); 67 (common land); 100 (pedestrian street); 103 (small parking lots); 112 (entrance transition); 118 (roof garden); 140 (private terrace on the street); 158 (open stairs); 164 (street windows); and 177 (vegetable garden). From this selection,

the analysis involved scanning architectural drawings and photographs to identify patterns applied as Co-housing design strategies. The goal was to select patterns whose design strategies align most coherently with BedZED.

Pattern Scanning with Design Reading Based on Pattern Articulation

Figure 3 identifies eleven patterns on the BedZED site plan, illustrating how they are articulated as design strategies.



Figure 3. Pattern scans – BedZED schematic site plan. Source: Redesign by the Authors.

Pattern 15 (neighborhood boundary) defines the limits of the housing complex in relation to the surrounding neighborhood. Pattern 37 (house cluster) organizes the overall buildings on site, grouping housing units around circulation realms and interacting with pattern 38 (row houses), which structures the houses in row. Pattern 52 (network of paths and cars) connects circulation routes, forming a network between open spaces and previous patterns. Pattern 59 (quiet backs) establishes a calm environment behind the buildings' spaces, enhancing integration with nature, complemented by pattern 60 (accessible green), which provides accessible green spaces for leisure and food cultivation, further supported by pattern 177 (vegetable garden). Pattern 61 (small public square) creates spaces for social interaction, functioning as a small public square, while pattern 67 (common land) integrates the broader social system neighborhood. Pattern 100 (pedestrian street) connects communal spaces, serving as circulation, uses and appropriations of people, directly interacting with the other patterns. Lastly, pattern 103 (small parking lots) is positioned on the housing complex periphery, reinforcing its boundaries and protecting neighborhood spaces in conjunction with pattern 15. The articulation of these patterns shapes BedZED's design morphology, which challenges the conventional urban

subdivision typically seen in residential neighborhoods. This approach to Urban Design aligns with several New Urbanism design principles, emphasizing sustainable, pedestrian-oriented spaces, energy-efficient design, and environmentally sensitive planning. According to Carmona et al. (2003), these principles prioritize the integration of architectural forms with public places, reflecting a broader commitment to creating functional, human-centered, and ecologically responsible urban spaces.

In Figure 4, four additional patterns from Alexander et al. (1977) are identified in the section of the BedZED housing units.

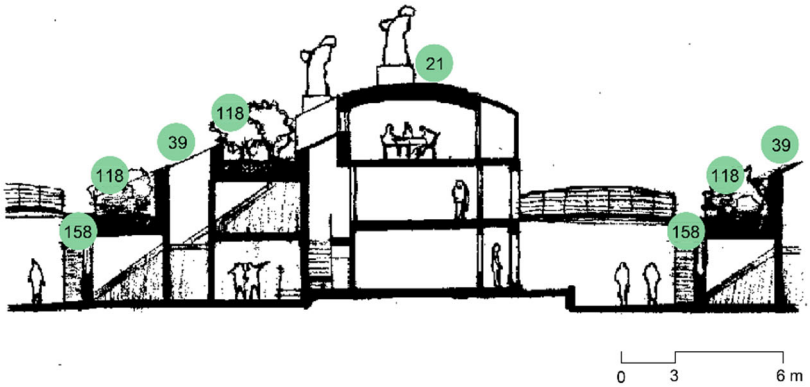


Figure 4. Pattern scans – BedZED schematic section. Source: Redesign by the Authors.

Pattern 21 (four-story limit) limits the building's height to three floors, maintaining a scale compatible with human dimensions. Pattern 39 (housing hill) proposes an alternative flats' layout, breaking with the traditional configuration and creating spatial variations vertically, such as outdoor balconies with different views. Pattern 118 (roof garden) integrates green spaces on the roofs, adding functional and visual value to the building, in addition to strengthening the connection with nature. Finally, pattern 158 (open stairs) suggests open stairs as vertical circulation realms that also act as extensions of community spaces, facilitating integration between buildings and neighborhood spaces. Compared to conventional housing in vertical buildings, BedZED creates more vibrant neighborhood spaces. The integration of green spaces on terraces and the hill-like arrangement of housing units fosters a sense of community and liveliness. According to Day (2002), this design strategy generates an ambiance that communicates: "People are truly living here", enhancing the connection between residents and their surroundings.

As for the facades, the photographs taken on site reveal the presence of three patterns, illustrated in Figure 5, which are articulated with other patterns identified in the BedZED common spaces. To access the pedestrian-only streets, pedestrians pass through a portal corresponding to pattern 53 (main gateways) (Photo 1), which delimits the entrance to the interior of the complex. Within this complex, there are platforms aligned with pattern 140 (private terrace on the street) (Photo 2), which connect the pattern 100 (pedestrian street) to the terraces and bridges for private use, linked to other flats on higher levels, facilitating both social interaction and connection with nature. On the upper levels, pattern 118 (roof garden) (Photo 3) performs a function similar to that of the terraces, offering more privacy and a wider view of the public spaces. These design strategies help to creating a safer atmosphere in neighborhood spaces, particularly for children and youth, as the building facades provide numerous visual contact zones over public spaces, enabling informal surveillance. Jacobs

(1961) described this phenomenon as vital to urban spaces, coining the expression “eyes on the street” to emphasize the role of informal surveillance in enhancing the quality of public places.



Figure 5. Pattern scans - photographs taken on site. Source: Authors.

In Figure 6, additional patterns are identified through photographs of the BedZED housing complex, offering a more comprehensive spatial understanding of its design strategies.



Figure 6. Pattern scans - photographs taken on site. Source: Authors.

Pattern 158 (open stairs) (Photo 4) illustrates a design strategy that fosters spontaneous encounters by connecting different levels of the building. This pattern is complemented by pattern 160 (building edge) and pattern 164 (street windows) (Photo 5), which enhance the social function of the space. Together, these patterns transform an ordinary corner into a social hub, encouraging people to linger while facilitating visual and physical integration between private interiors and neighborhood spaces. In Photo 6, patterns 59 (quiet backs) and 60 (accessible green) are visible, promoting human interaction with nature. Additionally, pattern 177 (vegetable garden) supports the planting and consumption of organic food. The integration of these patterns underscores the significance of an ecological approach to urban planning. This design approach seems vital for advancing the SDGs,

particularly the goal of promoting Sustainable Cities and Communities, by creating urban spaces that are both environmentally sustainable and conducive to social cohesion.

Patterns' Humanizing Attributes

Based on the identification and analysis of the articulations between Alexander's patterns (Alexander et al., 1977) in the BedZED Co-housing design strategies, the framework (Figure 7) highlights the humanizing attributes presented in each pattern, organized into seven thematic subsets of design strategies with similar and complementary contents. These humanizing attributes in Co-housing design typology demonstrate the potential to improve the quality of the built environment, positively impacting human health and wellbeing. However, these proposed attributes need further testing to validate their effectiveness regarding their potential to promote socio-environmental sustainability in urban spaces.

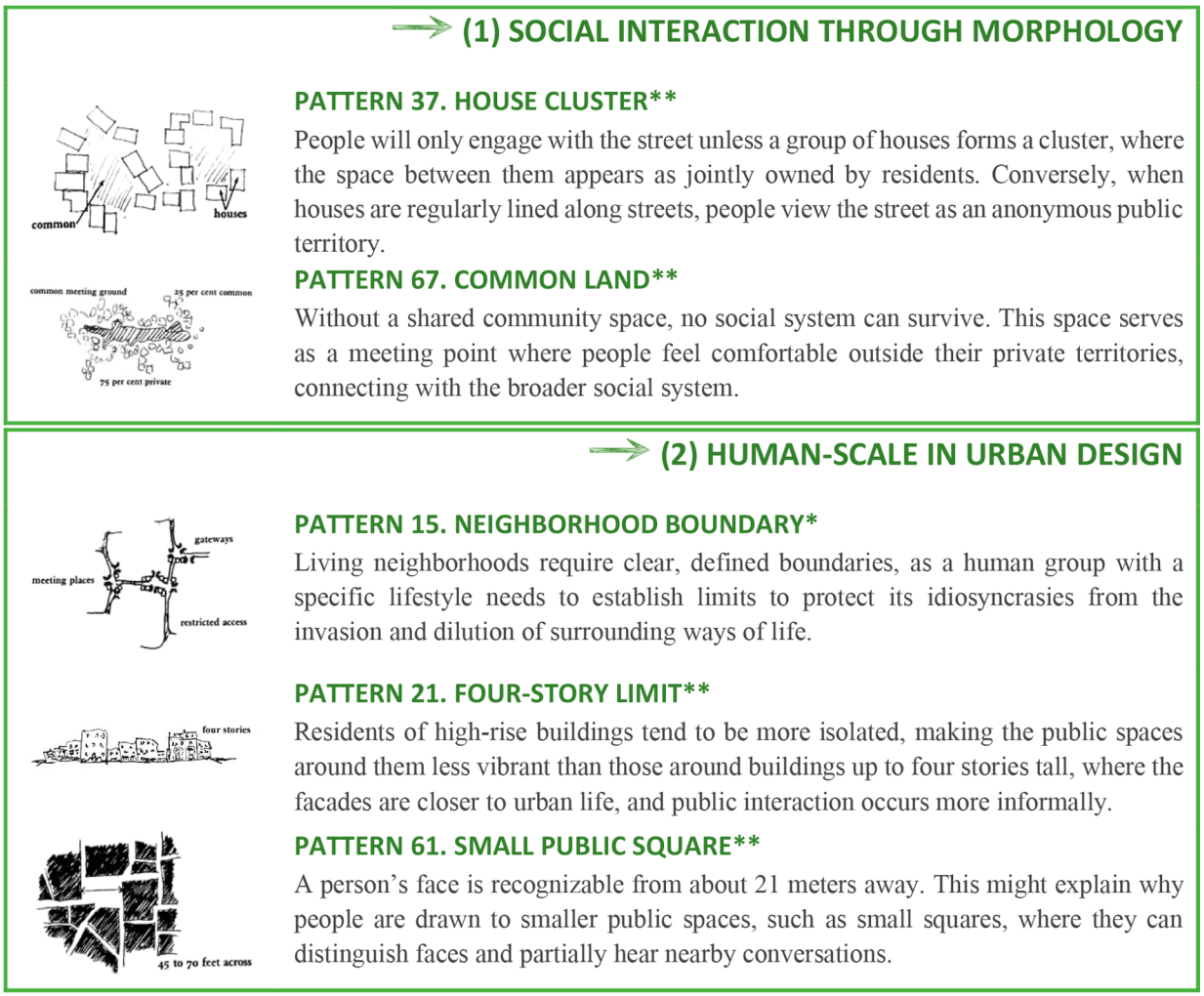


Figure 7. Thematic subsets of Patterns' Humanizing Attributes. Source: Adapted from Alexander et al. (1977).

Figure 7. Thematic subsets of Patterns' Humanizing Attributes. Source: Adapted from Alexander et al. (1977).

→ (6) BUILDINGS LINKING PEOPLE AND LANDSCAPE



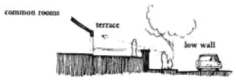
PATTERN 39. HOUSING HILL

Homes built on hills allow upper-floor residents to cultivate outdoor spaces like gardens or yards, meeting the human need for contact with nature and neighbors while creating territoriality in housing unit spaces.



PATTERN 118. ROOF GARDEN*

Buildings with green rooftops allow people to enjoy more sunlight and fresh air, maintaining closer contact with nature. These rooftops meet psychological needs, offering pleasant views and enhancing the quality of urban life.



PATTERN 140. PRIVATE TERRACE ON THE STREET**

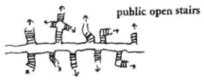
The relationship between domestic spaces and the street is often ambiguous: people need privacy in their private spaces but also wish to participate in public life. Human nature includes both communal and individual inclinations.

→ (7) PEDESTRIAN-ONLY WALKWAYS



PATTERN 100. PEDESTRIAN STREET**

Pedestrian streets serve as circulation routes leading people from cars, buses, or trains to their destinations while also being places of social interaction and permanence. The social interactions occurring in these spaces are one of the essential "social glue" elements in society.



PATTERN 158. OPEN STAIRS*

Open stairs function as social structures that provide freedom of movement, allowing people to move without the feeling of being under authority. They serve as extensions of public space, facilitating free and unrestricted flow.

Figure 7. Thematic subsets of Patterns' Humanizing Attributes. Source: Adapted from Alexander et al. (1977).

CONCLUSIONS

Examining how Co-housing design strategies can foster socio-environmental sustainability through morphological patterns, using the BedZED project as a case study, provided valuable insights into how design strategies in Architecture and Urban Design can improve urban space quality and contribute to human health and well-being. This approach, grounded in the environment behavior methods for design, involved a scanning design analysis strategy to map morphological patterns. Alexander's patterns were applied as key design parameters to identify and highlight Co-housing strategies with potential humanizing attributes. In this study, the focus shifted away from the traditional emphasis on the aesthetic values of Alexander's patterns, directing attention instead to their sensory and affective morphological values. Though difficult to measure, these aspects address fundamental human aspirations and needs in the built environment, such as social contact and connection with nature, which are universally recognized. This methodological approach requires further graphical and visual refinement in its protocol to be fully operational in future studies to create a more objective design analysis framework. Such a framework could then be used to identify morphological patterns within architectural and urban designs as well as photographs of built environments.

The BedZED project, with its innovative architectural features, is particularly relevant to this study, offering a novel application of Alexander's patterns in urban morphology. BedZED challenges the traditional association of Alexander's patterns with traditional construction methods, demonstrating their relevance in contemporary housing design. The framework of humanizing attributes, organized into seven thematic design strategy subsets, requires further testing to validate its effectiveness. The Co-housing strategies identified through these patterns show potential for promoting socio-environmental sustainability, especially when adopting a bidirectional, probabilistic approach to the person-environment relationship. This involves fostering social interaction, a connection with nature, pro-environmental behavior, and a sense of community, which could be key strategies in developing Sustainable Cities and Communities.

Acknowledgements

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Comparative analysis of COVID-19 pandemic responses: urban dynamics, governance strategies, and socio-spatial inequalities in Brazil and South Korea

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ABSTRACT

The pandemic caused by the new coronavirus responsible for COVID-19 has had a profound impact on urban environments' daily life and the way people interact with their surroundings. Different countries have responded differently to this challenge resulting in a plethora of outcomes, some even changing the way we experience urban spaces. This study compares the situations in both Brazil and South Korea, which have had significantly different paths and policies during the pandemic but arrived at a similar number of confirmed cases. The research shows that the virus outbreaks in the countries were very different, and that proactive governance and unified efforts were crucial in mitigating the pandemic's impact. South Korea's approach, which included comprehensive health measures, mass testing, contact tracing, and strict quarantine protocols, resulted in lower mortality rates and effective control of the virus, all of those aspects were also supported by the culture of vigilance and monitoring that was used to enforce sanitary policies. However, Brazil faced challenges due to a delayed and disjointed response, leading to devastating consequences, especially in its unequal urban landscape, at the same time that privacy was a concerning matter in the country, having many refuse to be tracked for monitoring the pandemic. The study highlights the importance of unified leadership in a complex socio-political context, establishing policies, and having public trust in navigating pandemics. Additionally, the research explores the dynamics of urban spaces during quarantine and the difference they experienced as Korea never had a lockdown, emphasizing the need for resilient urban planning strategies to address socio-spatial inequalities. Overall, this research provides insights into pandemic preparedness and urban resilience and strategies, emphasizing the lessons learned from different national approaches.

Keywords: Urban Planning; South Korea; Brazilian Perspective; Spatial Policies; Regional Development.

INTRODUCTION

The COVID-19 pandemic, caused by the novel coronavirus SARS-CoV-2, has profoundly disrupted urban environments worldwide, reshaping urban planning and public health systems. The rapid spread of the virus, first identified in Wuhan, China, led the World Health Organization (WHO) to declare it a pandemic within 100 days of its discovery (Spiteri et al., 2020). This unprecedented global

health crisis has highlighted the critical role of urban governance and planning in managing public health emergencies. Urban spaces have been reconfigured to accommodate social distancing, and public health strategies have evolved to address the challenges posed by high-density living and the need for accessible healthcare (Zhang et al., 2021).

Brazil and South Korea present compelling case studies for examining diverse responses to the COVID-19 pandemic. Despite both countries experiencing rapid urbanization and facing similar public health challenges, their approaches to managing the pandemic diverged significantly. South Korea's response was characterized by proactive governance, comprehensive health measures, and the use of technology for mass testing and contact tracing, which effectively controlled the virus's spread and resulted in lower mortality rates (Yang et al., 2021b). The country's success was underpinned by its extensive infrastructure of healthcare units, supported by a competitive and subsidized national healthcare security plan that ensured healthcare accessibility across urban areas.

In contrast, Brazil faced challenges with a delayed and fragmented response, exacerbated by a lacking healthcare infrastructure with uneven distribution across its vast territory. During the pandemic, Brazil had to rapidly create new healthcare units to meet the high demand, particularly in its socio-economically diverse urban areas, highlighting the challenges of managing public health in a federal system with significant regional disparities (Santos, 2021).



Figure 1. Left Image: Baseball fans cheer their teams during a popular match during COVID-19 pandemic in Seoul, South Korea, November of 2021 (Source: Yonhap). Right image: Brazil buries COVID-19 victims and reaches over 1 million deaths from the disease, October of 2021 (Source: Brasil de Fato).

This study aims to analyze the urban dynamics, governance strategies, and socio-spatial inequalities that shaped the pandemic responses in Brazil and South Korea. By comparing these two nations, the research seeks to uncover the factors contributing to effective pandemic management and the lessons that can be drawn for future public health crises. The study emphasizes the importance of unified leadership, public trust, and resilient urban planning in mitigating the impacts of pandemics. Furthermore, it contributes to the broader discourse on urban resilience and preparedness, offering insights into how emerging economies can adapt global best practices to their specific contexts, thereby enhancing their capacity to address future health emergencies (Romanillos et al., 2021; Akatsuka & Toyoda, 2023).

COVID-19 and its relation to urban dynamics

The COVID-19 pandemic has significantly altered urban dynamics worldwide, reshaping how cities function and how people interact within them. Urban areas, characterized by high population densities and extensive public transportation networks, were initially perceived as potential hotspots for virus transmission due to the ease of movement and close human interactions (Akatsuka & Toyoda, 2023). The pandemic prompted unprecedented public health measures, including lockdowns and

social distancing, which transformed urban spaces from bustling centers of activity to quieter, more isolated environments. This shift highlighted existing socio-economic disparities, as access to resources and healthcare varied widely across different urban populations (Romanillos et al., 2021). The pandemic also accelerated the adoption of digital technologies, as remote work and education and online services became essential, further emphasizing the digital divide between different socio-economic groups (Santos, 2021). In response to these challenges, cities have had to rethink urban planning and public space usage, emphasizing the need for resilient and adaptable urban environments that can withstand future public health crises (Semantics Scholar, 2023). The experience of cities during COVID-19 underscores the importance of integrating health considerations into urban planning and the need for policies that address socio-spatial inequalities to ensure equitable access to urban benefits for all residents.

Socio Economics or Politics, what determines the impact of the pandemic?

The impact of the COVID-19 pandemic has been profoundly shaped by both socio-economic and political factors, which have influenced the effectiveness of responses and the severity of outcomes across different countries. In Brazil, socio-economic disparities played a significant role in the pandemic's trajectory, as highlighted by the uneven distribution of COVID-19-related deaths across municipalities. Studies have shown that lower socio-economic status, limited access to healthcare, and inadequate infrastructure exacerbated the spread and mortality rates of COVID-19, particularly in vulnerable communities (Coelho et al., 2020). The Brazilian government's response was further complicated by political factors, including a lack of cohesive leadership and mixed messages from federal authorities, which undermined public health measures and contributed to widespread misinformation (Ventura, 2021).

In contrast, South Korea's response was characterized by strong state capacity and effective governance, which mitigated the impact of socio-economic disparities. The country's experience with previous outbreaks, such as MERS, informed a rapid and coordinated response that included widespread testing, contact tracing, and public compliance with health measures (Yang et al., 2021b). Despite initial successes, South Korea faced challenges related to vaccine procurement and public fatigue with ongoing restrictions, which highlighted the complex interplay between socio-economic factors and political decision-making (Hong & Lim, 2023).

The comparison between Brazil and South Korea underscores the critical role of political leadership and state capacity in managing the pandemic. While socio-economic factors undeniably influenced the spread and impact of COVID-19, the effectiveness of governmental responses was pivotal in shaping outcomes. In Brazil, political fragmentation and populist leadership weakened state capacity, leading to a disjointed response that exacerbated socio-economic inequalities.

Conversely, South Korea's cohesive governance and high state capacity facilitated a more effective management of the crisis, despite socio-economic challenges. This analysis highlights the need for integrated approaches that address both socio-economic vulnerabilities and political dynamics to enhance resilience against future pandemics.

South Korea’s starting success in dealing with the virus

South Korea was recognized world-wide for its effective response to the starting phases of the COVID-19 and through the first years of the pandemic. They employed many policies and strategies for testing and quarantines responsible for controlling access and spread of the virus considering also the very strong adoption of sanitary measures from the population as a whole.

The foundation of South Korea's success lay in its preparedness and robust governance framework. The country had already established a comprehensive legal and institutional framework for pandemic response due to the previous MERS outbreak, including the Infectious Disease Control and Prevention Act, which empowered the Korea Centers for Disease Control and Prevention (KCDC) with the authority and resources necessary to manage outbreaks effectively (Lee, 2020). This framework facilitated the rapid deployment of the Three T's strategy (Testing[19], Tracking[20] and Treatment[21]) supported by the healthcare infrastructure installed in the country and technological answers and integration of systems (Choi, 2020); A key factor in South Korea's initial success was the high level of public cooperation and trust in government measures. The government maintained transparent and consistent communication with the public, providing daily updates on the pandemic's status and guidelines for safety measures. This transparency helped build public trust and encouraged compliance with health directives (Noh et al., 2020).

Despite its early achievements, South Korea faced challenges in maintaining the effectiveness of its response as the pandemic evolved. The initial success led to complacency among the public, and the government struggled to adapt its strategies to the changing dynamics of the pandemic. A rise in daily cases highlighted the need for continuous adaptation and engagement with the public to address emerging challenges and sustain public trust (Hong and Lim, 2023).South Korea's experience underscores the importance of preparedness, robust governance, and public cooperation in managing pandemics. It also highlights the need for adaptive strategies that evolve with the crisis and the importance of balancing public health measures with individual rights. As the world moves toward normalcy, the lessons from South Korea's response emphasize the need for international cooperation and the sharing of best practices to effectively tackle future global health crises.

METHOD

This study employs a comparative analysis to examine the COVID-19 pandemic responses of Brazil and South Korea, focusing on governance, public health strategies, and socio-political contexts. The research covers the period from January 2020 to October 2023, providing a comprehensive overview of the pandemic's progression in both countries. Data were collected from a variety of sources,

[19] South Korea prioritized widespread and rapid testing from the onset of the pandemic. The government collaborated with private companies to develop and mass-produce RT-PCR test kits, enabling the country to conduct tens of thousands of tests daily by March 2020. This extensive testing capacity allowed for the early detection and isolation of cases, preventing widespread transmission (Kim, 2020).

[20] The use of advanced information and communication technologies (ICT) played a crucial role in South Korea's contact tracing efforts. The government implemented a robust system that utilized GPS data, credit card transactions, and CCTV footage to trace the movements of confirmed cases. This approach, while raising privacy concerns, was instrumental in quickly identifying and notifying individuals who had been exposed to the virus (Lee et al., 2021).

[21] South Korea's healthcare system, characterized by universal health coverage, ensured that all COVID-19 patients received necessary medical care without financial barriers. The government designated specific hospitals for COVID-19 treatment, effectively managing healthcare resources and preventing system overload (Ministry of Health of the Republic of Korea, 2020).

including official government reports, publications from health agencies such as the World Health Organization (WHO) and the Korea Disease Control and Prevention Agency (KDCA), as well as academic studies and media reports. These sources provided detailed information on public health measures, vaccination rates, and socio-political factors influencing each country's response.

The analysis focuses on several key variables, including the number of confirmed COVID-19 cases, mortality rates, testing and vaccination efforts, and the implementation of public health measures. The study also examines the socio-political context, exploring how governance and public compliance influenced pandemic management. This includes an analysis of leadership decisions, communication strategies, and the impact of misinformation on public perception and behavior.

A comparative analytical framework was employed to assess the pandemic trajectories in Brazil and South Korea. This framework considers governance models, health system capacity, and public health strategies, providing insights into the effectiveness of each country's response. Additionally, the Complex Adaptive Systems (CAS) framework was applied to understand the dynamic interactions between government policies, public behaviour, and health outcomes, highlighting the adaptability and resilience of each country's response to the evolving pandemic context (Hong & Lim, 2023).

The study acknowledges limitations related to data availability and reporting discrepancies between sources. Efforts were made to cross-verify data from multiple sources to ensure accuracy and reliability. Despite these challenges, the research provides valuable insights into the pandemic responses of Brazil and South Korea, offering lessons for future public health preparedness and crisis management.

RESULTS AND DISCUSSIONS

Two countries and two different scenarios

The COVID-19 pandemic has highlighted the diverse responses and impacts experienced by different countries, as illustrated by the cases of South Korea and Brazil.

Table 1. Comparative Overview of Socioeconomic and COVID-19 Indicators: South Korea vs. Brazil

	South Korea	Brazil
Location	Leste da Ásia	América do Sul
Total area	100.378 km² (2010)	8.510.417.771 km² (2022)
Population	51.692.272 (2022)	203.062.512 (2022)
Population Density	Densidade Demográfica 514.6 p/km²	Densidade Demográfica 23.86 p/km²
GDP (PIB)	USD$ 1.67 trilhões (2022)	US$ 1.92 trilhões (2022)
GDP per capita	US$ 32.254.6 (2022)	US$ 8.917.7 (2022)
Average income ($USD)	USD$ 1.542,64[22] (2023)	USD$ 286,32[23] (2023)
Cases of COVID-19	34.571.873[24] (até Setembro, 2023)	38.130.675[25] (até Dezembro, 2023)
Deaths by COVID-19	35.934	708.237

[22] https://www.minimumwage.go.kr/english/main.do

[23]https://agenciabrasil.ebc.com.br/economia/noticia/2023-12/salario-minimo-de-r-1412-entra-em-vigor-nesta-segunda-feira#:~:text=O%20projeto%20de%20lei%20do,Nacional%20em%2022%20de%20dezembro.

[24] https://ncov.kdca.go.kr/en/bdBoardList.do

[25] https://covid.saude.gov.br/

	(até Setembro, 2023)	(até Dezembro, 2023)

The substantial difference in GDP per capita between South Korea (US$ 32,254.6 in 2022) and Brazil (US$ 8,917.7 in 2022) reveals a stark divergence in economic development and standards of living. While South Korea's robust economy supports a strong social safety net, evidenced by its adjusted minimum wage and comprehensive welfare state, Brazil grapples with prevalent sub-employment and low wages, indicating deeper structural inequalities. This discrepancy underscores the interplay between economic strength and social well-being, with implications for pandemic resilience and recovery (WORLD BANK, 2022).

The table 1 provides a comparative overview of key socioeconomic and COVID-19 indicators for both nations, revealing stark contrasts in population density, GDP per capita, and pandemic outcomes. South Korea, with its high population density and robust healthcare infrastructure, managed to maintain relatively low COVID-19 mortality rates. In contrast, Brazil faced significant challenges, including a higher number of cases and deaths, exacerbated by socio-economic disparities and governance issues. This comparison underscores the critical role of effective governance, healthcare accessibility, and socio-political context in shaping pandemic responses and outcomes.

The underreporting of COVID-19 cases in Brazil was a significant challenge during the pandemic, particularly in remote and underserved areas where access to testing and healthcare was limited (Coelho et al., 2020). This resulted in many infections going undetected, obscuring the true scale of the pandemic's impact. At the same time, the lack of a centralized data collection system further exacerbated this issue, leading to inconsistencies and delays in reporting and underreporting, that not only hampered effective public health interventions but also fueled misinformation and complacency, undermining efforts to control the virus's spread. In stark contrast, South Korea implemented a robust testing and reporting system that facilitated early detection and containment of COVID-19 (Shin, 2020). The country's well-developed healthcare infrastructure and widespread access to testing enabled rapid identification and isolation of infected individuals. The government's proactive approach to testing and contact tracing, supported by advanced technology and public cooperation, ensured that a high proportion of cases were identified and reported.

This transparency fostered public trust and facilitated targeted interventions. South Korea's urban landscape, with its high population density and well-connected transportation networks, further facilitated access to testing facilities.

Another important factor was the concentration of healthcare resources in urban centers and the efficient public transportation system enabled individuals to readily access testing sites. The government's strategic placement of testing centers in easily accessible locations further enhanced this accessibility (Kim et al., 2020). Also, the COVID-19 pandemic also prompted notable shifts in transportation patterns.

Specially in South Korea, many cities saw a significant increase in bicycle use, driven by concerns about virus transmission on public transport and a desire for outdoor exercise during lockdowns. In response, several cities expanded their cycling infrastructure. This shift towards cycling not only helped reduce strain on public transport but also contributed to improved air quality and public health. Conversely, in Brazil, the pandemic led to a marked decrease in public transport use,

particularly in densely populated areas. Fear of infection in crowded buses and trains prompted many to seek alternative modes of transport, such as motorcycles and used cars. This shift exacerbated traffic congestion and air pollution, highlighting the challenges of maintaining sustainable urban mobility during a public health crisis. The decline in ridership also had economic implications for transport operators, further complicating recovery efforts.

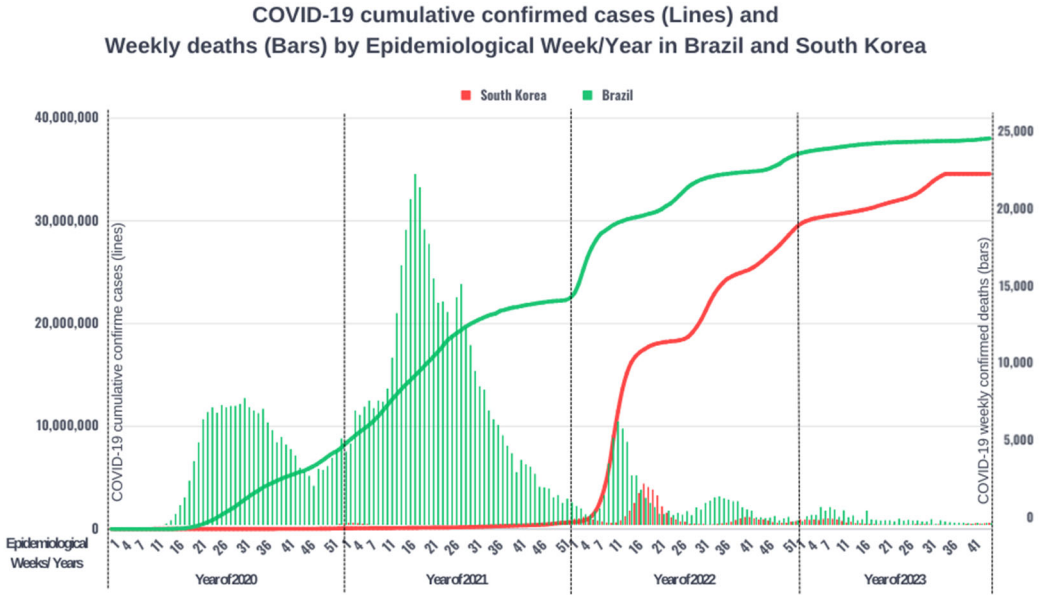

Figure 2. Cumulative Confirmed COVID-19 Cases by Epidemiological Week/Year in Brazil and South Korea from 2020 to the 43rd Epidemiological Week of 2023 (in September). Source: Prepared by the authors, data from official government communication channels for COVID-19 cases.

The graph (figure 1) depicts COVID-19 cumulative confirmed cases and weekly deaths from 2020 to 2024 illustrates the distinct trajectories of Brazil and South Korea during the pandemic. South Korea's early implementation of the "Three Ts" strategy—Testing, Tracking, and Treatment—helped maintain a relatively flat curve initially, reflecting effective containment measures. However, the emergence of new variants like Delta and Omicron led to subsequent increases, highlighting the ongoing challenges of pandemic management. In contrast, Brazil experienced significant spikes in both cases and deaths, particularly during the early stages, due to delayed public health responses and socio-political challenges. The graph underscores the importance of robust healthcare systems and timely interventions in mitigating the pandemic's impact. These insights lead into a detailed examination of South Korea's response strategies and developments over the course of the pandemic.

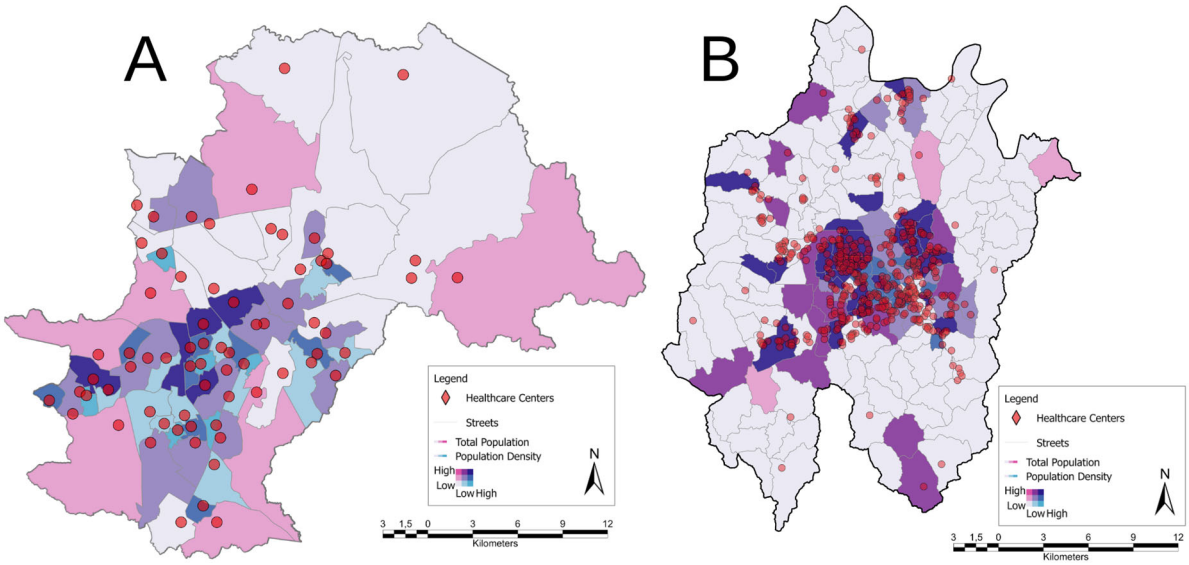

Figure 3. Comparative Spatial Distribution of Healthcare Centers, Population, and Population Density in A - City of Campinas (Brazil) and B - City of Daejeon (South Korea)

The map provides a comparative spatial analysis of healthcare accessibility, population density, and total population in two distinct urban environments: Campinas, Brazil (A) and Daejeon, South Korea (B). Both maps utilize a bivariate choropleth scale to represent population and population density, with darker shades indicating higher values. Healthcare centers are represented by distinct point symbols. This visual comparison serves to highlight potential disparities in healthcare access and resource distribution in relation to population dynamics, particularly relevant in the context of understanding the varied impacts of the COVID-19 pandemic on different urban areas.

Different approaches for political and sanitary measures and their outcomes for each country

South Korea's COVID-19 response and developments

Early Response and Initial Success (2020-2021)

South Korea's initial response to the COVID-19 pandemic was characterized by rapid and effective measures that set a global example in pandemic management. The country was among the first to be affected due to its proximity to China, with the first confirmed case reported on January 20, 2020 (Cha, 2020). Drawing from its experience with the MERS outbreak in 2015, South Korea swiftly implemented a comprehensive strategy known as the "Three Ts": Testing, Tracking, and Treatment. This approach was supported by robust healthcare infrastructure and extensive use of information and communication technologies (ICT) for contact tracing (Choi, 2020; Lee et al., 2021). The government established a special task force under the Korea Centers for Disease Control and Prevention (KCDC) to coordinate the national response, which included real-time public information dissemination and strict quarantine measures for travelers (Yoo et al., 2021).

Challenges and Adaptations (2021-2022)

Despite the initial success, South Korea faced significant challenges as the pandemic progressed. By the end of 2020, the global rollout of vaccines marked a new phase in the pandemic response. However, South Korea experienced delays in securing vaccine supplies, which led to public dissatisfaction and a decrease in trust in government measures (Hong & Lim, 2023). The government accelerated the approval and distribution of vaccines, with the Oxford-AstraZeneca and Pfizer-

BioNTech vaccines becoming available in early 2021 (Nham et al., 2022). Despite these efforts, the emergence of the highly transmissible Omicron variant in late 2021 posed new challenges, leading to a surge in cases and necessitating adjustments in public health strategies (Kwon & Yang, 2022).

Vaccination and Variants (2022-2023)

By early 2022, South Korea had achieved high vaccination coverage, with 85% of the population receiving two doses and booster campaigns underway. However, the Omicron variant led to a significant increase in cases, highlighting the need for ongoing vigilance and adaptation of public health measures (Park et al., 2021). The government responded by implementing winter vaccination programs targeting vulnerable populations and adjusting social distancing measures to balance public health needs with economic and social pressures (Ministry of Health and Welfare, 2022). Despite the challenges, South Korea maintained relatively low fatality rates compared to global averages, demonstrating the effectiveness of its healthcare system and public health policies (Our World in Data, 2023).

Transition back to normal (2023-2024)

In 2023, as global health authorities, including the World Health Organization, began to declare the end of the COVID-19 pandemic as a public health emergency, South Korea started transitioning towards normalcy. The government gradually eased restrictions, including lifting mask mandates in outdoor settings, while continuing to monitor infection rates and adjust policies as needed (MOHW, 2022). By mid-2023, the country had reported over 31 million cases and maintained a low fatality rate of 0.11%, underscoring the success of its comprehensive response strategy (KDCA, 2024). The experience of South Korea during the pandemic highlights the importance of preparedness, adaptability, and effective communication in managing public health crises, providing valuable lessons for future global health challenges.

Brazil’s COVID-19 desperate situation and struggles

Initial Response and Challenges (2020-2021)

In early 2020, Brazil, like the rest of the world, faced an unprecedented public health crisis with the onset of the COVID-19 pandemic. The country had a history of dealing with infectious diseases, but the discontinuation of its Severe Acute Respiratory Syndrome (SARS) surveillance system in 2019 left it somewhat unprepared for the rapid spread of COVID-19. The first confirmed case was reported in February 2020, before the World Health Organization declared COVID-19 a global pandemic on March 11, 2020 (The Lancet, 2020). Despite the establishment of Law No. 13,979/2020 to address the pandemic, the federal government's response, led by President Jair Bolsonaro, was marked by skepticism and downplaying of the virus's severity. This stance influenced public behaviour, leading to widespread disregard for health measures and contributing to the rapid spread of the virus across the country (G1, 2023).

Escalation and Media Intervention (2020)

By March 2020, all Brazilian states had issued alerts due to the presence of COVID-19 cases, and the situation quickly escalated. By June, Brazil had become the second country with the highest number of confirmed cases globally, following the United States. The federal government's attempts to withhold and delay crucial COVID-19 data prompted the formation of the "Consortium of Press Vehicles," a collaboration among major Brazilian media outlets to ensure the public received accurate

and timely information. This initiative was crucial in maintaining transparency and public awareness during a period of significant uncertainty and misinformation (G1, 2023).

Healthcare System Strain and Socioeconomic Impact (2020-2021)

The Brazilian healthcare system faced immense pressure as hospitals reached capacity and healthcare workers experienced significant stress. In response, the government distributed rapid tests and expanded the "More Doctors" program to bolster healthcare services. Public awareness campaigns emphasized the importance of social distancing, mask-wearing, and hand hygiene. The pandemic also had profound economic and social impacts, disproportionately affecting vulnerable populations. The federal government introduced emergency financial aid to support millions of Brazilians facing economic hardships (Ministério da Saúde, 2020).

Vaccination Efforts and Political Challenges (2021-2022)

In 2021, Brazil launched a massive vaccination campaign, marking a significant milestone in its COVID-19 response. The emergency approval of CoronaVac[26] and AstraZeneca vaccines by the National Health Surveillance Agency (Anvisa) in January were pivotal. Despite logistical challenges and political disputes, the campaign achieved notable progress, with over 80% of the population receiving at least one vaccine dose by the end of the year. However, the emergence of new variants like P.1 in Manaus and the oxygen crisis in hospitals underscored the ongoing challenges faced by the healthcare system (Oliveira et al., 2021).

Adapting to New Variants and Socioeconomic Disparities (2022-2023)

The emergence of the Omicron variant in late 2021 led to a surge in cases, prompting renewed public health measures. By early 2022, Brazil had achieved high vaccination coverage, significantly reducing severe cases and mortality rates. The country began easing restrictions, allowing for a gradual return to normalcy. However, the pandemic highlighted persistent socioeconomic disparities, with vulnerable communities continuing to face challenges in accessing healthcare and vaccines. Efforts to address these inequities were crucial in ensuring a more equitable public health response (De Menezes et al., 2023).

Transition to Normal and Lessons Learned (2023-2024)

In 2023, as the World Health Organization declared the end of COVID-19 as a public health emergency, Brazil reflected on its pandemic journey. The country's experience highlighted the importance of coordinated public health strategies, transparent communication, and international cooperation in managing global health crises. Despite the challenges, Brazil's vaccination campaign and public health initiatives played a crucial role in mitigating the pandemic's impact. The lessons learned emphasize the need for ongoing vigilance, preparedness, and equitable access to healthcare to navigate future public health emergencies (Ministério da Saúde, 2023).

Comparative Analysis of both countries scenarios

South Korea's response to the COVID-19 pandemic was marked by proactive governance and effective leadership, which were instrumental in controlling the virus's spread. The country leveraged its experience from the MERS outbreak to establish a robust framework for managing infectious diseases,

[26] The CoronaVac vaccine played a important role during the COVID-19 pandemic, it was produced and distributed locally by the Butantan institute, a public institution of Sao Paulo State, through a partnership with Sinovac, this vaccine enabled a swift and massive immunization campaign, reaching most of the brazilian population amid the global vaccine shortages.

characterized by clear communication, rapid decision-making, and extensive use of technology for contact tracing and testing (Choi, 2020; Lee et al., 2021). In contrast, Brazil's response was hindered by political discord and inconsistent leadership. President Jair Bolsonaro downplaying of the virus and resistance to implementing strict public health measures led to a fragmented response, with state and local governments often acting independently to fill the void left by the federal government (G1, 2023; BBC, 2021).

South Korea's "Three Ts" strategy—Testing, Tracking, and Treatment—was central to its success in managing the pandemic. The government implemented widespread testing and contact tracing, supported by digital technologies, which allowed for early detection and isolation of cases without resorting to lockdowns (Shin, 2020). This approach helped maintain low mortality rates and prevent healthcare system overload. Conversely, Brazil struggled with delayed testing and insufficient contact tracing, exacerbating the spread of the virus. The lack of a coordinated national strategy and the politicization of health measures further complicated efforts to control the pandemic (Ministério da Saúde, 2020).

The socio-political context played a significant role in shaping the pandemic responses in both countries. In South Korea, high levels of public trust in government and compliance with health measures were crucial in curbing the virus's spread. The government's transparent communication and effective use of ICT fostered public cooperation and adherence to guidelines (Noh et al., 2020). In contrast, Brazil faced challenges with public compliance, partly due to mixed messages from political leaders and widespread misinformation. The federal government's inconsistent communication and undermining of scientific advice contributed to public skepticism and resistance to health measures (Ventura, 2021).

CONCLUSIONS

The outcomes of the pandemic in South Korea and Brazil highlight the importance of coordinated public health strategies and effective governance. By August 2023, South Korea had reported approximately 34.5 million cases with a relatively low mortality rate, reflecting the success of its comprehensive response (OECD, 2023). In contrast, Brazil recorded 38 million cases and over 700,000 deaths, underscoring the severe impact of its fragmented response (Ministério da Saúde, 2023). These contrasting trajectories emphasize the need for unified leadership, transparent communication, and public trust in managing health crises. The experiences of both countries provide valuable lessons for future pandemic preparedness, highlighting the critical role of adaptability and cooperation in mitigating the impact of global health emergencies.

The divergent outcomes in South Korea and Brazil during the COVID-19 pandemic underscore the critical role that governance and public health strategies play in managing global health crises. South Korea's success in maintaining a low mortality rate despite a high number of cases highlights the effectiveness of its data-driven decision-making and comprehensive public health measures, such as mass testing, contact tracing, and strict quarantine protocols. This approach was supported by the public's trust and compliance, which were pivotal in controlling the spread of the virus. The country's experience with previous epidemics, such as MERS, provided a valuable framework for its COVID-19

response, proving that preparedness and adaptability are essential components of effective crisis management.

In contrast, Brazil's fragmented response resulted in a higher mortality rate, demonstrating the consequences of delayed and disjointed public health measures. The lack of unified leadership and the spread of misinformation contributed to the public's distrust and non-compliance with health guidelines, exacerbating the pandemic's impact. The Brazilian experience highlights the importance of consistent and transparent communication from government authorities to build public trust and ensure adherence to health measures. As both countries move forward, their experiences offer valuable lessons for enhancing pandemic preparedness, emphasizing the need for robust health infrastructure, clear communication strategies, and the integration of public health policies with socioeconomic considerations to mitigate the effects of future health emergencies.

The experiences that both countries went through offer invaluable lessons for enhancing pandemic preparedness on a global scale. The need for robust health infrastructure, clear communication strategies, and the integration of public health policies with socioeconomic considerations is paramount. The pandemic has demonstrated the interconnectedness of our world and the importance of international cooperation and knowledge-sharing in mitigating the effects of future health emergencies.

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Comparative study on TOD built environment forms of core commercial circles in chinese mountainous and plain cities

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ABSTRACT

The development of Chinese cities is facing the dilemma of more people and less land. Therefore, in the planning and construction of core commercial circles, China vigorously promote the development by the TOD model. In order to better achieve the integration development benefits of TOD model in multiple aspects such as land appreciation, pedestrian flow aggregation, and public transportation. This paper consider the complex geographical environment of Chinese cities, selecting the Chongqing Guan Yinqiao Station and Chengdu Chun Xilu Station with TOD built environment forms of mountainous and plain areas to research. From the perspective of transportation systems, the spatial boundaries of accessibility are comparable between the two stations. However, due to the influence of mountainous environments, the walking range of Chongqing Guan Yinqiao Station is smaller than that of Chengdu Chun Xilu Station. In addition, this also leads to poor transfer efficiency between the "subway-bus" at Chongqing Guanyinqiao Station; From the perspective of land use system, the proportion of land functions is relatively similar, but there is still a gap in development intensity and directional diversification of mixed land functions, and the development intensity of Chongqing Guan Yinqiao Station is greater. These results show that the similarity in the TOD built environment forms between the core commercial circles of mountainous and plain cities in China is specifically manifested in the distance effect of functional proportion and development intensity, which has a "fluctuating" trend; the difference lies in the differences in directional diversification of mixed land functions and public transportation. Therefore, The development of TOD in mountainous cities requires a high-density vertical development and construction model, as well as convenient pedestrian space creation. The development of TOD in plain cities requires attention to the coordination of land use functions with a certain accessibility to ensure gradient construction of development intensity.

Keywords Transit-Oriented development (TOD), built environment forms, transportation systems, land use system

INTRODUCTION

The development of Chinese cities is facing the dilemma of more people and less land, this is even more evident in China's commercial circles. So Both the Chinese government and developers are considering how to leverage limited land use to not only increase local land capital and drive economic development, but also better serve a large number of surrounding populations. In response to this situation, the National Development and Reform Commission has issued the "14th Five Year Plan for

the Implementation of New Urbanization (2021-25)", which proposes to promote the Transit-Oriented Development (TOD) model and create integrated station city complexes. Therefore, utilizing TOD model to analyze its built environment forms for guide urban development, especially the development of core commercial circles, has important practical significance.

At present, research on the built environment forms of TOD is mainly conducted based on the 5D indicators (density, diversity, design, transportation transfer distance, and destination accessibility) summarized by Cervero in terms of research objects (Cervero and Kara Kockelman, 1997; Cervero et al., 2009). In terms of research methods, Chinese scholars mainly rely on qualitative judgments in analyzing the built environment forms (Wei and Xu, 2021); foreign scholars mainly focus on quantitative analysis, using multi criteria analysis (MCA) that utilize 5D dimensional indicators as benchmarks and assigning weights to each indicator to evaluate the built environment forms (Singh et al., 2012). In terms of research content, some scholars evaluate the built environment forms of each TOD rail station to form a TOD index (TODness) from overall perspective, which not only determines the overall development direction of TOD model, but also gives development suggestions for different TOD rail stations based on individual differences (Singh et al., 2017; Motieyan and Mesgari, 2018); some scholars also classify and grade the TOD built environment characteristics according to the current situation, indicating that land use and transportation system in the built environment forms are key factors in TOD development (Motieyan and Mesgari, 2018). And corresponding optimization suggestions are put forward for the development intensity, functional formats, and public spaces in the built environment forms from individual perspective (Al-Harami and Furlan, 2020).

Overall, most studies on the TOD built environment forms start from the overall region, and lack discussion on specific types such as commercial districts, residential areas, transportation hubs and other areas. In addition, China has more than two-thirds of mountain resources, and its complex geographical environment also puts forward different requirements for TOD development and construction. In this regard, this paper combines the terrain differences between China's plains and mountains, takes the TOD core commercial circles - Chongqing Guan Yinqiao Station and Chengdu Chun Xilu Station as an example, determines the this circles through the differences in walking accessibility caused by the terrain slope and analyzes the built environment forms within the circles, so as to provide a reference for the optimization of the built environment and subsequent development of the TOD area in the core commercial circles.

Transportation system and land use system of TOD built environment forms

Although some scholars have divided the TOD built environment forms into relevant indicators of 5D , these indicators cannot be separated from the material environment formed by the combination of transportation system and land use system (Huang et al., 2023).

The transportation system is the skeleton of the TOD built environment forms. Since the transportation system emphasizes a pedestrian-oriented environment and strengthens the use of public transportation (Liu, 2017), current research is mainly carried out from two aspects: walking accessibility and public transportation. Therefore, American scholar Peter Calthorpe once pointed out in the TOD concept that a "pedestrian-friendly" environment is the core content of the TOD concept, which focuses the research content on the walking scale of the TOD built environment forms (Calthorpe et al., 2014; Liu, 2019). This scale represents the convenient and efficient circles of the

current TOD built environment forms. At the same time, the walking accessibility circles formed by TOD built environment forms often complement public transportation, constructing an overall travel connection system of "walking-bus-subway" to achieve rapid speed of people' travel (Liu, 2019).The TOD land use system is the carrier of the TOD built environment forms. As the transportation system brings a huge flow of people, high-density development and construction are required to ensure the business needs of people within a certain time and space range. Therefore, relevant research focuses on two aspects: land functions and development intensity. Due to the location differences of urban space, different TOD types form different land use development models, resulting in different levels of functional circles in the walking accessibility circles formed by TOD built environment forms. And in terms of development intensity, government and developers pay attention to the relationship between development intensity and development profit, ensure reasonable economic input-output with a reasonable plot ratio, and create a good urban environment for residents (Wang et al., 2011; Zhang et al., 2017).

Overall, the built environment forms of TOD requires the coordination of the transportation system and the land use system, that is, good walking accessibility circles promote the spatial concentration of population and socio-economic activities, and is conducive to the emergence of complex land functions, thereby stimulating appropriate development intensity and ensuring development benefits, which in turn promotes the establishment of a convenient travel connection system and strengthens the pedestrian environment (Figure 1).

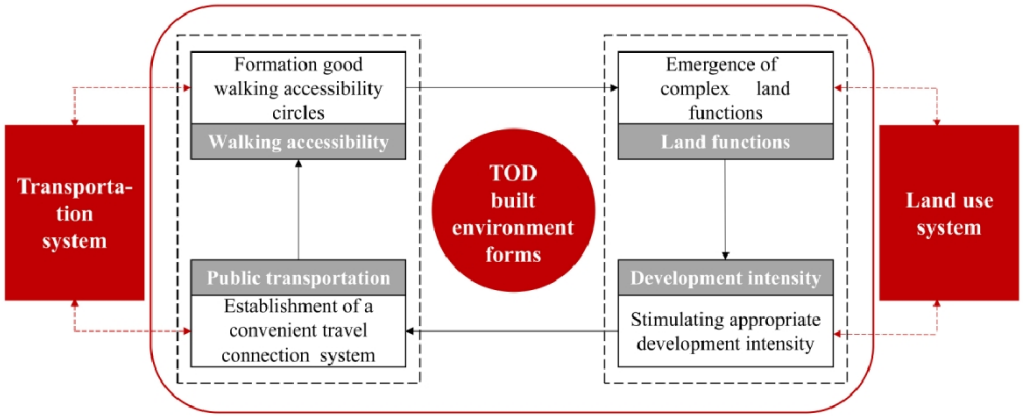

Figure 1. Coordination between TOD transportation system and land use system. Photo credit: Author's own drawing.

TOD built environment forms of core commercial circles with complex geographical environment

At present, there are few single studies on TOD built environment forms of core commercial circles. Related studies focus more on the overall characteristics of TOD built environment forms , that is to understand the TOD development model from the perspective of the spatial layout of the city. Some scholars distinguish the TOD built environment forms of based on urban spatial distance and divide them into three types of town, neighborhood and precinct (Niu et al., 2019).Some scholars also focus on the differences in development with land use to distinguish the TOD built environment forms, which can be generally divided into types such as commercial development, community residence, public transportation, and facility services (Pan and Huang, 2024).

It should be pointed out that the TOD built environment forms dominated by commercial development is often located in the core areas of the city and is extremely sensitive to the control of development intensity. Therefore, relevant scholars have conducted research on the built environment development of this type of TOD. For example, the lower limit of the floor area ratio of the TOD circle is controlled, and the upper limit of the floor area ratio of the urban area outside the TOD circle is controlled (Liu and Shi, 2020). At the same time, great attention is paid to the sustainable operation. For this reason, most cities encourage the development and construction within the TOD circle to be mainly carried out by the rail construction and operation units, while the development and construction outside the circle, in addition to independent development by construction and operation units, also needs to be jointly developed with social investment entities. In the subsequent profit distribution, it is clear that the economic benefits of their development and construction should be used first for TOD rail construction and operation to make up for losses, so as to achieve the TOD sustainable development in the core commercial circles (Liang, 2023). This aspect is inseparable from the complex geographical environment with the development and construction process. Compared with the plain environment, the available development and construction area in the mountainous environment is limited. In order to ensure the income, the vertical development requirements are urgent (Zhang, 2020; Chen et al., 2023). Taking the mountainous TOD commercial complex in Shapingba District, Chongqing, China as an example, its underground space development has currently reached 7 floors.

However, in addition to considering the economic capital brought by land use, the development and construction of the TOD model should not ignore its own purpose - to create a public environment dominated by pedestrian friendliness, so that TOD development and construction also has important public policy value (Liang, 2023). Therefore, it is necessary to explore the TOD built environment forms of core commercial circles in plains and mountains, so as to provide reference for the subsequent coordination of transportation system and land use system.

METHOD

Based on the basic composition of TOD built environment forms, this paper finally analyzes the transportation system and land use system of TOD built environment forms in the core commercial circles. Among them, in the transportation system analysis, the first is to explore the temporal and spatial heterogeneity of the walking accessibility circles; the second is to analyze the efficiency with transportation connection system under the accessibility circles. In the land use system analysis, attention is paid to the proportion and spatial differences of land functions within the circles; the second is to identify the floor area ratio and dominant development direction within the circles. This forms the technical route of Figure 2.

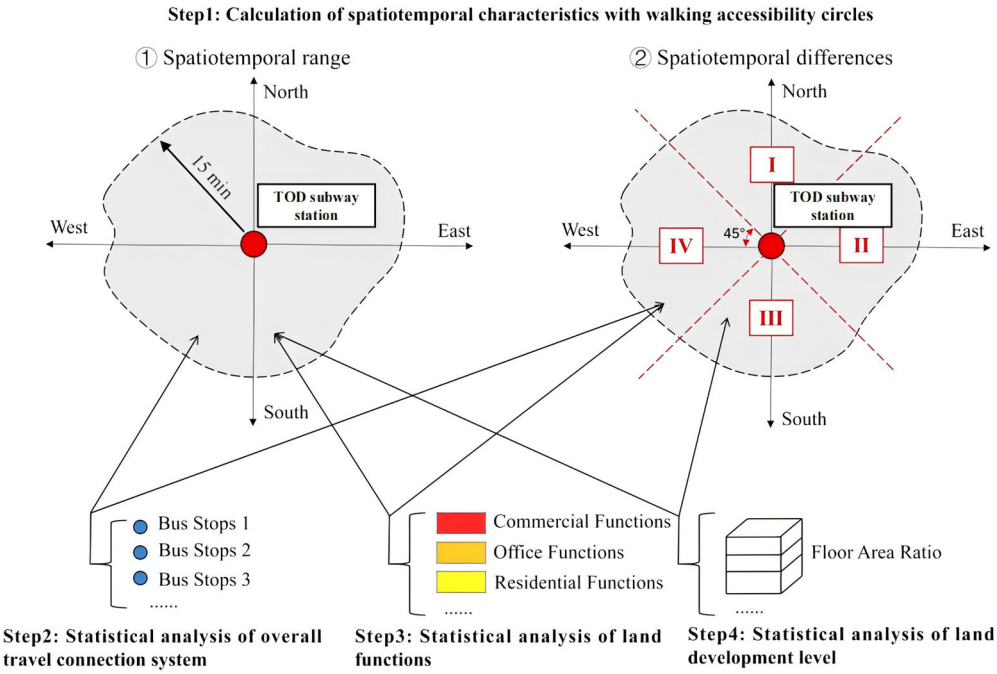

Figure 2. Technical route of this research. Photo credit: Author's own drawing.

Related calculation methods for transportation system

According to step1 and step2 of the technical route, the TOD rail station travel model is established with the help of ArcGIS network analyst module for determining walking accessibility circles. That is, this module in the rail station and road network database - centers, links, nodes and resistances are used to reflect the influence range of people at the TOD rail station (center) along the accessible roads under a certain resistance value (time, distance, cost, etc.). Compared with the traditional 400m, 800m and other regular circles, this irregular time and space range can better express the real travel scenario. Therefore, in order to reflect the complex geographical environment and show the built environment of mountains and plains, according to the relevant literature on exercise physiology (Chen et al., 2014), the pedestrian speed is combined with the slope to assign values (Table 1).

Table 1. Pedestrian speed at different slopes

Slope (%)	Pedestrian speed (m/min)
0-3	60
3-5	54
5-10	42
10-15	36
15-20	30
20-25	24
>25	18

Based on the above database, the spatial resistance model of network analysis is constructed using the "New Network Dataset" function in ArcGIS, and then the service area analysis layer is established. By setting the road time resistance value (road length / pedestrian speed), the accessible area enclosed by the source point along the road network is generated, and the spatiotemporal range of walking accessibility circles is obtained. This article uses the community life circle as an analogy. A

total of 15 time levels of accessible areas of 1-15min were determined. At the same time, in order to better reflect the physical space form under walking accessibility circles. Since area and perimeter are the basic measurement characteristics of studying spatial forms, the boundary dimension is used to calculate the overall accessible balance. The formula is:

$$D = \frac{2\ln\left(\frac{p}{4}\right)}{lnA}$$

In the formula: D is the boundary dimension; A is the accessible surface area; p is the perimeter of the accessible contour. The fractal dimension value is between 1 and 2. When D < 1.5, it means that the accessible boundary tends to be regular, and it has good walking accessibility in any direction; when D > 1.5, it means that the accessible range tends to be complex. The larger the value, the worse the stability, indicating that the accessibility of some directions is stronger or weaker than other directions.

After calculating the accessible area and overall accessible balance, the walking distance is calculated based on the differences in the east, south, north and south directions. Then based on the above accessible areas, the bus stops within the area are counted, and the walking practice from the rail station to the bus stop is counted to express the efficiency of transportation connection. The bus stop statistics are interpreted using satellite images such as Google Maps and on-site investigations. After the Ⅰ to Ⅳ are generated within 90 degrees, 45 degrees on both sides of the four directions of east, west, south and north, the transportation connections in each quadrant are further counted.

Related calculation methods for land use system

According to step3 and step4 of the technical route, This paper's exploration of land functions involves considerations for TOD development and construction. Therefore, it is not simply about the land area occupied by land functions, but rather a comprehensive consideration of the building area of various buildings, and the land area occupied by squares and green spaces. So the land functions are divided into five categories (commercial functions, office functions, residential functions, public service functions and green space functions), and classification and identification adopts a combination of satellite images such as Google Maps, on-site investigations, and planning drawings, so that the proportion of each function in the 15min accessible areas is calculated. And the functional utilization mixing degree of each area is paid attention to. The formula is:

$$M = \frac{S_n}{S_{sum}}$$

$$LU_d(i) = \frac{-\sum_i M * \ln M}{ln(n)}$$

In the formula: M is the proportion of a certain function; $LU_d(i)$ is the mixed degree of land functions; n is the five major functions; S_n is the building area or land area of each function from 1min to 15min accessible area; S_{sum} is the total area of the five major functions from 1min to 15min accessible area.

Then calculate the floor area ratio within the 15min accessible areas, The formula is:

$$R(i) = \frac{\sum_i S_n}{A_{sum}}$$

In the formula: $R(i)$ is the floor area ratio within the accessible area; S_n is the building area or land area of each function from 1min to 15min accessible area; A_{sum} is the acreage from 1min to 15min accessible area.

The data collection of the number of building floors of each function for building area calculation is based on the 2023 China Building Outline Height Data Technology Service. After calculating overall land use functional ratio and floor area ratio, further explore the dominant direction of land functions and development with the specific conditions in the Ⅰ to Ⅳ quadrants.

RESULTS AND DISCUSSIONS

This paper selects Chongqing Guanyinqiao Station and Chengdu Chun Xilu Station as the research objects with the TOD built environment forms of the core business circles in the mountains and plains (Figure 3). Chongqing and Chengdu are both located in the southwest of China. The former is located in the hilly area between the Yangtze River and the Jialing River, surrounded by rolling mountains and is recognized as a typical mountain city in China. Chongqing Guanyinqiao Station is located in the Guan yinqiao core commercial circle of Jiangbei District, Chongqing. It is the transfer station for Chongqing Rail Transit Line 3 and Line 9. In the ranking of the average daily passenger flow of Chongqing rail stations, it has always been in the top three. The average daily passenger flow was 120,000, and the highest daily passenger volume reached 262,000 in 2024; the latter is located in the Chengdu Plain with a flat terrain and typical plain city characteristics. Chengdu Chun Xilu Station is located in the Chun Xilu core commercial circle of Jinjiang District, Chengdu. It is the transfer station for Chengdu Rail Transit Line 2 and Line 3. Its average daily passenger flow has always set new highs, and the highest daily passenger volume in 2024 reached 493,000.

Figure 3. Location with Chongqing Guanyinqiao Station and Chengdu Chun Xilu Station. Photo credit: Author's own drawing.

Analysis results of the transportation system

There are large differences in the accessible areas between Chongqing Guan Yinqiao Station and Chengdu Chun Xilu Station. The 15min accessible areas of Chongqing Guan Yinqiao Station are limited by terrain constraints and are all smaller than Chengdu Chun Xilu Station (Figure 4, Table 2). From the perspective of accessibility balance, the pedestrian accessible spatial boundaries of Chongqing Guan

Yinqiao Station and Chengdu Chun Xilu Station are relatively regular, with little difference between the two and they can meet pedestrian needs in different directions, reflecting that although Chongqing Guan Yinqiao Station is restricted by the mountainous environment, the walking efficiency of the crowd has not been reduced. However, from the perspective of walking distances with differences in the east, south, north and south directions, the walking distances of every minute in Chongqing Guan Yinqiao Station is vary significantly, which is reflected in the data such as the range, mean and standard deviation, showing the complexity of the walking environment of Chongqing Guan Yinqiao Station (Table 2).

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Figure 4. Accessible areas of Chongqing Guan Yinqiao Station and Chengdu Chun Xilu Station. Photo credit: Author's own drawing.

Table 2. Accessible areas features and walking distances with different directions in Chongqing Guan Yinqiao Station and Chengdu Chun Xilu Station

name	Accessible area features		Walking distances with differences in the east, south, north and south directions				
	15min area (m^2)	overall accessible balance: boundary dimension	Maximum value (m)	Minimum value (m)	Range (m)	Mean (m)	Standard deviation (m)
Chongqing Guan Yinqiao Station	210633.98	1.26	60	13.37	46.63	36.10	11.23
Chengdu Chun Xilu Station	268065.50	1.26	60	32.39	27.01	44.04	7.70

Then through the statistics of bus stops within the accessible areas of Chongqing Guan Yinqiao Station and Chengdu Chun Xilu Station, it was found that Chengdu Chun Xilu Station has a total of 24 bus stops within the 1-15 minute reachable area, while Chongqing Guan Yinqiao Station has a total of 16 stops. At the same time, the former only needs 4 minutes to walk to transfer to the bus, while the latter needs 6 minutes to walk to transfer to the bus (Figure 5). Therefore, the subway-bus transfer system is significantly better than Chongqing Guan Yinqiao Station. This connection advantage is even more obvious in the Ⅰ to Ⅳ quadrants. The connection efficiency of Chengdu Chun Xilu Station in all directions is faster than that of Chongqing Guan Yinqiao. The Ⅰ quadrant on the north side only takes

4 minutes to transfer, while in the Ⅱ quadrant on the west side, Chongqing Guan Yinqiao Station takes up to 10 minutes to transfer, making it the least efficient area (Table 3).

Figure 5. Statistics of bus stops of Chongqing Guan Yinqiao Station and Chengdu Chun Xilu Station. Photo credit: Author's own drawing.

Table 3. Statistics of bus stops with each quadrant based on different directions in Chongqing Guan Yinqiao Station and Chengdu Chun Xilu Station

name	Ⅰ quadrant on the north side		Ⅱ quadrant on the east side		Ⅲ quadrant on the south side		Ⅳ quadrant on the west side	
	Number of bus stops	Transfer time (min)	Number of bus stops	Transfer time (min)	Number of bus stops	Transfer time (min)	Number of bus stops	Transfer time (min)
Chongqing Guan Yinqiao Station	5	6min	2	9min	4	6min	5	10min
Chengdu Chun Xilu Station	7	4min	6	5min	9	6min	2	6min

Analysis results of the land use system

After identifying and dividing categories of the land functions within the accessible area of Chongqing Guan Yinqiao Station and Chengdu Chun Xilu Station, it can be found that the two stations have basically formed the land dominant functions of commerce, office and residence. And functional proportion of each land use at the two stations change similarly with the accessible distance (Figure 6). For example, the commercial and office functions show a fluctuating trend of increasing first and then decreasing with the increase of walking time, while the residential functions are just the opposite. The public service functions basically increase with the increase of walking time, while the green space functions decrease with the increase of walking time. However, from the perspective of indicator with the mixed degree of land functions, this indicator with the 5min accessible areas of Chongqing Guan Yinqiao Station is significantly lower than that of Chengdu Chun Xilu Station, only beyond this range, this indicator of the two stations tend to be similar (Figure 7).

Figure 6. Land functions of Chongqing Guan Yinqiao Station and Chengdu Chun Xilu Station. Photo credit: Author's own drawing.

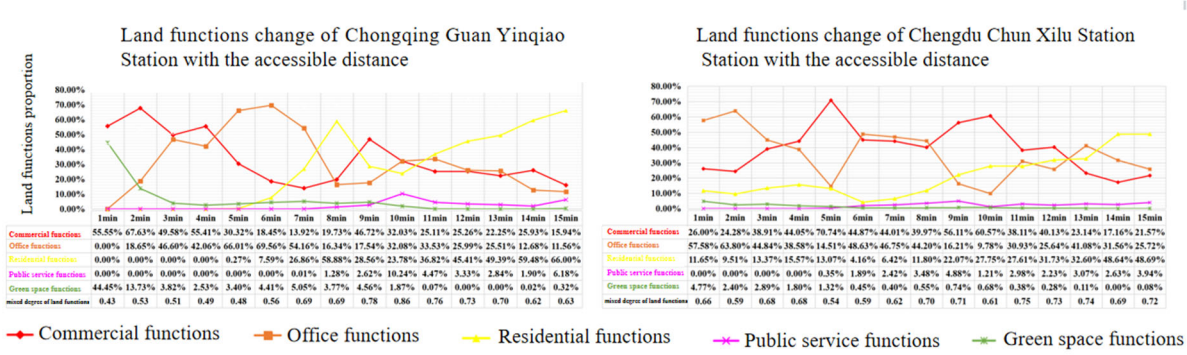

Figure 7. Land functions change with Chongqing Guan Yinqiao Station and Chengdu Chun Xilu Station. Photo credit: Author's own drawing.

Further exploration of the land functions of each quadrant generated from walking different directions shows that except for the Ⅰ quadrant on the north side where Chongqing Guan Yinqiao Station focuses on the integration of commercial, office and residential functions. The other quadrants are dominated by residential functions, with the proportion of residential functions in each quadrant exceeding 40% and the land dominant functions are relatively single. Due to the large proportion of residential functions, the supporting public service functions and green space functions in these areas are significantly higher than those of Chengdu Chun Xilu Station. In contrast, only the Ⅲ quadrant on the south side of Chengdu Chun Xilu Station is dominated by residence, while other quadrants focus on the combination of commercial and office functions, or on the integration of commercial, office and residential functions (Figure 8).

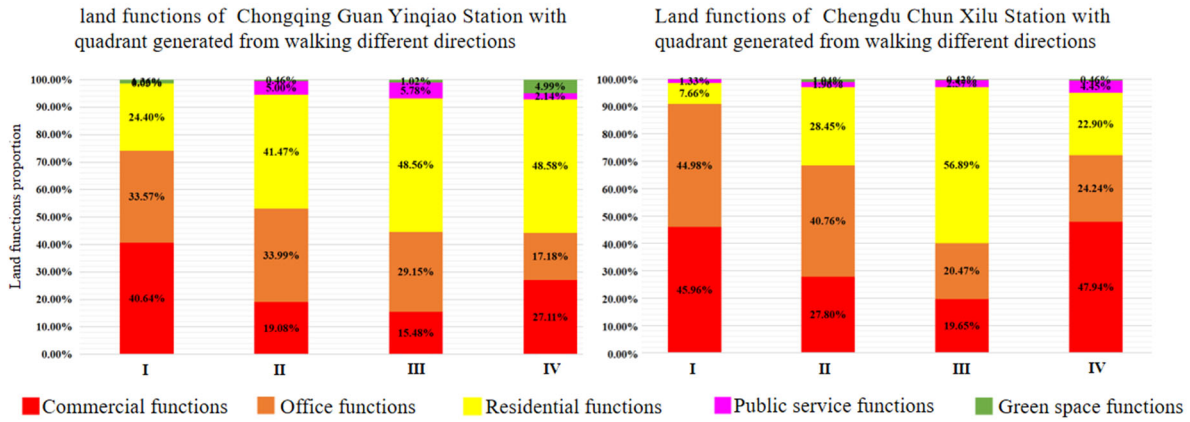

Figure 8. Land functions with each quadrant based on different directions in Chongqing Guan Yinqiao Station and Chengdu Chun Xilu Station. *Photo credit: Author's own drawing.*

Finally, from the analysis of development intensity, we can see that the changes in the floor area ratio of the two stations also show a fluctuating trend of increasing first and then decreasing with the change in walking time, but after 2 minutes, the development intensity with floor area ratio of Chongqing Guan Yinqiao Station is significantly greater than that of Chengdu Chun Xilu Station (Figure 9). Further from the perspective of the dominant development direction, the Ⅱ quadrant on the east side and the Ⅰ quadrant on the north side are the dominant directions of Chongqing Guan Yinqiao Station and Chengdu Chunxi Road Station respectively. At the same time, regardless of which quadrant, the development intensity of Chongqing Guan Yinqiao Station is greater than that of Chengdu Chun Xilu Station. Moreover, compared with the homogeneity of the latter's development and construction in different directions, the development intensity of Chongqing Guan Yinqiao Station in the Ⅰ and Ⅱ quadrants is significantly higher than that of other areas, indicating the necessity of its mountainous built environment to carry out high-intensity development and construction in a limited geographical environment (Table 4).

Figure 9. The floor area ratio of Chongqing Guan Yinqiao Station and Chengdu Chun Xilu Station. Photo credit: Author's own drawing.

Table 4. The floor area ratio with each quadrant based on different directions in Chongqing Guan Yinqiao Station and Chengdu Chun Xilu Station

Name	Ⅰ quadrant on the north side	Ⅱ quadrant on the east side	Ⅲ quadrant on the south side	Ⅳ quadrant on the west side
Chongqing Guan Yinqiao Station	4.42	5.35	3.51	3.24
Chengdu Chun Xilu Station	3.71	3.66	3.13	3.62

Discussion of similarity and difference

The above research results show that the similarity with the TOD built environment forms of the core commercial circles in mountainous and plain areas lies in the distance attenuation or increasing effect of functional proportion and development intensity. This effect has a "fluctuating" trend. From the perspective of functional proportion, commercial and office functions show a trend of first rising and then falling with the increase of walking time. The bottom of the decline is the Multifunctional core area. After walking for a certain period of time, it continues to show a trend of first rising and then falling, but the functional proportion is not as large as the former. This is because the attraction of commercial and office functions is the greatest around rail stations, which can quickly gather people to increase sales opportunities, improve transportation convenience to ensure work convenience, and promote the appreciation of commercial and office real estate. After walking for a certain period of time, certain commercial and office functions are still needed to meet the living and work opportunities of the surrounding people, so the functional proportion of the two increases again, and then decreases again as the walking time continues to increase; the trend of residential functions is just the opposite. This is because residential functions are not the main purpose of people around rail stations in the core commercial circles. From the perspective of development intensity, it also shows a trend of first rising and then falling. After walking for a certain period of time, it continues to show a trend of first rising and then falling. This is also due to the advantage of the flow of people around the rail station, and after a certain walking time, the living and working security of the surrounding people needs to be guaranteed (Figure 10).



Figure 10. "Fluctuating" trend of functional proportion and development intensity. Photo credit: Author's own drawing.

The difference between the TOD built environment forms of the core commercial circles in mountainous and plain areas lies in the differences with directional diversification of mixed land functions and public transportation. Due to the restrictions of mountainous terrain, the accessible

areas of residents in mountainous environments is obviously smaller than that of residents in plains with the same period of time. At the same time, the walking comfort in each direction varies greatly due to the geographical barriers of mountains compared with plain environment. Therefore, for mixed land functions in each direction can be promoting urban development such as commerce , office and residence, Mountain built environment mainly brings them to concentrate in a certain convenient walking convenient area to reduce the travel costs of residents, this makes the development direction of the mixed land functions more singular. While the walking environment in the plains is more superior, and the above functions can be arranged according to development needs. So they are scattered in different directions to meet the use needs of residents from different directions. Similarly, the walking restrictions in the mountainous environment further cause the high time cost of the overall travel connection system and poor transfer efficiency, and it takes more time to reach the corresponding public transportation station; while the smaller terrain differences in the plain environment and the homogeneity of walking allow residents to meet their own transportation transfer needs in a shorter time.

CONCLUSIONS

This research focuses on the TOD build environment forms of core commercial circles, providing a analysis method with the transportation system and land system. In general, the geographical limitations of the mountainous built environment make the walking environment of TOD rail stations more complex, and also make the overall operation efficiency of public transportation weaker than that of plain areas. In this regard, the TOD build environment forms of core commercial circles in the mountainous areas should pay more attention to gathering the dominant functions such as commercial and office in a good walking environment, and advocates higher density development and construction. Therefore, in the future, the TOD build environment forms of core commercial circles in the mountainous areas not only needs to expand the development area of rail stations, build transportation facilities to connect the surrounding commercial and office buildings, and add more entrances and exits to accommodate people's walking scale in the underground space of the rail stations, but also needs to further strengthen the development of land around rail stations, the high-intensity development plans in the periphery areas can be transferred to the vicinity of the rail stations, and the vertical function of the building can be used to establish a rapid connection between the ground and underground space, and corridors can be set up to connect other buildings. In the above way, the geographical barriers of the mountain can be reduced and the walking time cost can be optimized. In contrast, the TOD build environment forms of core commercial circles in the plain areas should consider the value of mixed land use in the future, especially in the face of the law of the "fluctuating" trend of functional proportion and development intensity, handle the connection between functional proportion and development intensity in the core and secondary core areas, and strengthen the gradient development around and outside the TOD rail stations.

At present, relevant research only focuses on TOD rail stations with Chinese mountainous and plain cities, and the number of samples needs to be further increased in subsequent studies to provide a richer research foundation for subsequent research law verification and development guidance.

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Comparison of Workers' Villages in the North and South of China: taking Shenyang and Shanghai in 1950s as examples

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ABSTRACT

Technology transfer, especially the transnational dissemination of urban planning concepts has become an important topic in the development of global cities. This study explores the dual influence of American and Soviet urban planning models on the spatial form of Chinese workers' villages in the 1950s, with a focus on case studies from Shanghai and Shenyang. The research aims to understand how these foreign planning principles were adapted to China's unique socio-economic and cultural contexts. Through comparative analysis, it was found that Soviet influence dominated in areas such as architectural standardization and industrial-focused urban layouts, while American planning concepts were evident in the neighborhood design of Shanghai. The study draws three main conclusions: First, socialist ideology, through national policies, shaped residential patterns, leading China in the 1950s to follow the Soviet model more closely. Second, planners exhibited flexibility in local adaptation, as seen in Shanghai, where certain American planning principles emerged. Lastly, local adaptation was central to the process of technology transfer, with workers' villages in different regions reflecting diverse and flexible planning approaches. This research provides valuable theoretical insights into the processes of technology transfer and localization in urban planning.

Keywords: workers' villages, technology transfer, local adaptation, spatial forms, regional comparison.

INTRODUCTION

The process of globalization has accelerated the flow of economic, cultural, and technological elements between countries. Urban planning, as a key field that drives urban development, has also been profoundly influenced by globalization. In this process, technology transfer, especially the transnational dissemination of urban planning concepts has become an important topic in the development of global cities. Among the existing studies, Hall (1996) examined the mutual influences of planning ideas among cities in the UK, the US, and continental Europe; Ward (1999) explored how countries such as the UK, the US, and France impacted urban planning in Canada through the spread

of policies and technologies; Healey (2012) further revealed the fluidity of planning practices between Western countries in the context of globalization.

However, current research on technology transfer largely focuses on interactions between Western countries, with relatively little attention paid to the transfer and interaction of technologies between the East and the West. In particular, studies on the transfer of technology from the West to China and other Eastern countries are relatively scarce, and this academic gap hinders our comprehensive understanding of technological trajectories and the sharing of experiences in the context of globalization. As the largest developing country in the world, China’s urban planning concepts and technological practices in the process of globalization have a significant impact on the global urban development landscape. Therefore, conducting an in-depth study of the technology transfer process from the West to China is of great academic and practical significance.

The 1950s was a pivotal period for technological introduction in China, marking the first large-scale incorporation of Western planning concepts into urban planning in the newly founded People's Republic. During this period of time, urban planning became a critical tool for national modernization when the Chinese government rapidly initiated extensive urban construction and industrial developments. Under the "leaning to one side" foreign policy diplomatic strategy and the domestic agenda of "comprehensive learning from the Soviet Union," China was exposed to Soviet planning concepts, exemplified by the "superblock model" (Sviridov, 1955), particularly in the construction of workers' villages affiliated with the Soviet-aided "156 Projects." At the same time, American planning concepts were introduced by returning Chinese planners and architects who had studied in the United States. Many of these designers, having been educated at American institutions, were subtly influenced by the "neighborhood unit" (Perry, 1929). For instance, Wang Dingzeng studied at the University of Illinois at Urbana-Champaign, Chen Shiwu at Cornell University, and Zhong Yaohua at Harvard University. This led to a dual technology transfer situation in which China adopted both Soviet and American planning ideas. Beyond planning concepts, Western technology transfers to China also included construction techniques, material technology, and other areas.

Workers' villages were a prominent example of urban residential planning in 1950s China. (Yang, C., 2017) As social welfare projects aimed at addressing the housing needs of the working class, their large-scale construction reflected not only the demands of urban development and industrialization but also the practical application of urban planning concepts in China. Overall, these workers' villages embody the specific utilization of technology transfer in the urban construction of the time.

Given China's vast territory, significant differences in climate, geography, culture, and economic foundations between the northern and southern regions influenced the localization and adaptation process of these transferred technologies, as well as the effectiveness of urban planning implementation. Moreover, the construction of workers' villages exhibited regional variations. One type was the independently built workers' village, exemplified by the Caoyang Workers’ Village in the southern region. The other type was the workers' villages integrated into large-scale construction projects, primarily located in northern regions and tied to the "156 Projects." (Luo, G., 2010) Therefore, conducting a comparative study between the northern and southern regions holds valuable insights for understanding the dynamics of technology transfer and its local adaptation.

This study aims to explore the differing impacts of the dual technology transfer from the United States and the Soviet Union on China's residential forms, by comparing workers' villages in northern and southern China during the 1950s. It also seeks to analyze how China localized and adapted these foreign influences in the context of globalization. The research aspires to fill the academic gap in studies on west-east technology transfer and provide a new perspective on technology transfer and local adaptation in the context of globalization, thereby enriching the theoretical framework of global urban planning and technology exchange.

The following sections are included in the study: the Method section outlines the case selection, classification at various spatial levels, and research methods. The Results and Discussion section analyzes the similarities and differences in the forms of workers' villages in northern and southern China through case studies, and further compares them with those in the U.S. and the Soviet Union to examine the dynamics of technology transfer and local adaptation. The Conclusion section summarizes the morphological characteristics of workers' villages under the influence of technology transfer and localization, and offers insights for modern urban planning.

METHOD

This study primarily adopts a case study approach. Utilizing regional urban theory, the research classifies the residential forms of workers' villages into three levels: city, neighborhood, and housing. Through morphological analysis, it examines the spatial forms and layout patterns and further compares them with those of the United States and the Soviet Union to analyze the specific manifestations of technology transfer and local adaptation.

In terms of case selection, the study first identifies the representative cities in northern and southern China as Shenyang and Shanghai. Both cities share similar industrial development histories and large-scale construction of workers' villages, and their existing workers' villages are well-preserved, making them suitable for comparative research. Subsequently, representative workers' villages were selected from these cities: the Caoyang Workers’ Village and the Hudong Residential Area (comprising Changbai, Kongjiang, Fengcheng, and Anshan workers’ Villages) in Shanghai, and Tiexi, Santazi, and Hemulu Workers' Villages in Shenyang. These representative cases span the early, mid, and late 1950s in terms of construction periods and are geographically distributed across different parts of the cities, covering almost all types and development models of workers' villages in both locations. This study combines literature review and field research, using horizontal comparisons and summaries to provide data support for the case studies.

In the course of the discussion, this study primarily employs regional urban theory to conduct a multi-layered analysis of the spatial forms of workers' villages across three scales: city, neighborhood, and housing. Specific methods include the creation of comparative morphological diagrams to visually analyze the similarities and differences between workers' villages in northern and southern China, in conjunction with a comparative study of planning concepts from the United States and the Soviet Union.

At the city scale, the study explores the relationship between the location of workers' villages and the urban spatial structure. This section first analyzes the connection between the workers' villages and

their associated industrial areas and then examines the spatial relationship between the workers' villages and the city center, thus revealing the characteristics of site selection and layout.

At the neighborhood scale, the study investigates the internal planning structure of workers' villages. This part compares four aspects: road Layout, building layout, green space system, and public facilities system. It discusses both the external openness and the internal cohesiveness of the workers' villages.

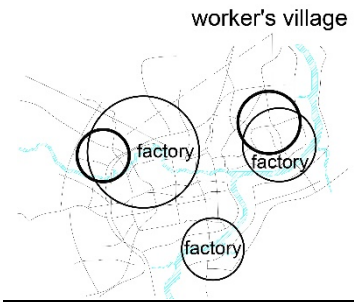
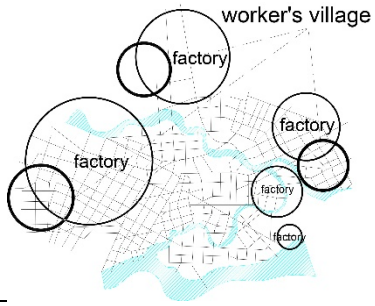
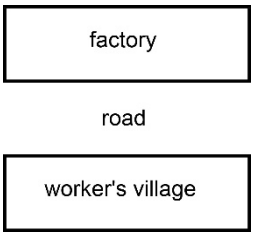
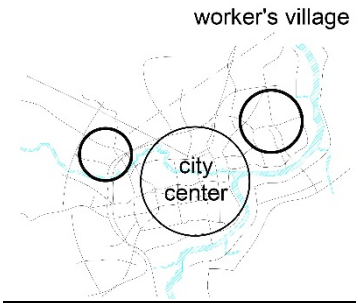
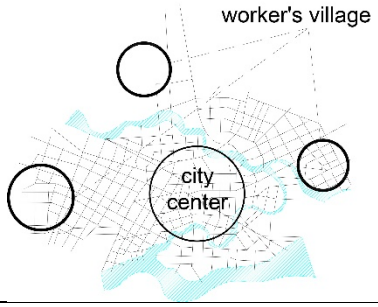
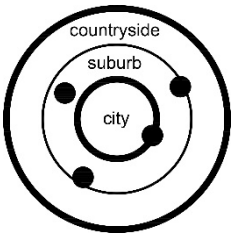
At the housing scale, the study examines the residential building design within the workers' villages, including building floor plans and façade designs. By comparing the internal structures and standardized construction techniques of residential buildings in northern and southern workers' villages, the research further reveals the influence of Soviet and American technology on Chinese housing design.

RESULTS AND DISCUSSIONS

Urban scale

This section analyzes the siting and layout of workers' villages in Shanghai and Shenyang from the urban scale. The primary purpose of planning workers' villages was to provide residential facilities supporting industrial production, addressing the housing needs of workers. As a result, the spatial relationship between workers' villages and industrial zones was a critical issue in urban planning during that era.

Table 1. Distribution of workers' village in relation to industrial zone and city center

Shanghai	Shenyang	Conclusion
		
		

The study found that workers' villages in both cities were closely tied to industrial zones and located in the suburb (Figure 1). This proximity to industrial zones reduced commuting times for workers and facilitated unified factory management. At the same time, siting these villages in suburban areas aligned with the economic conditions of the time, avoiding large-scale demolition in city centers and effectively utilizing the vast available land and existing industrial infrastructure in the suburbs. This

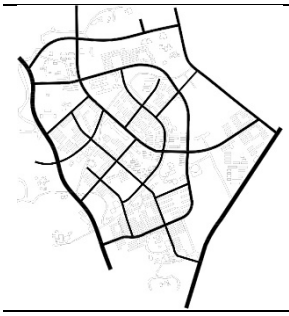
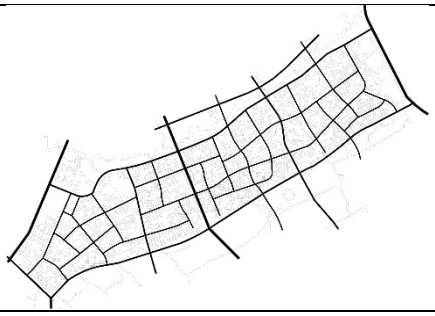
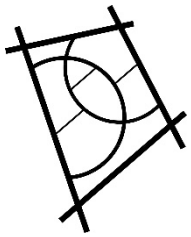
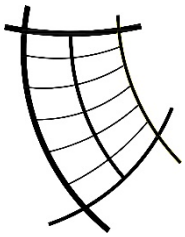
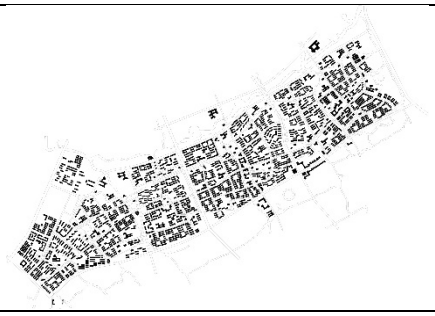
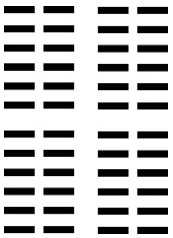
layout reflects the policy orientation of "production first, living second," embodying the spatial strategies of rapid industrialization.

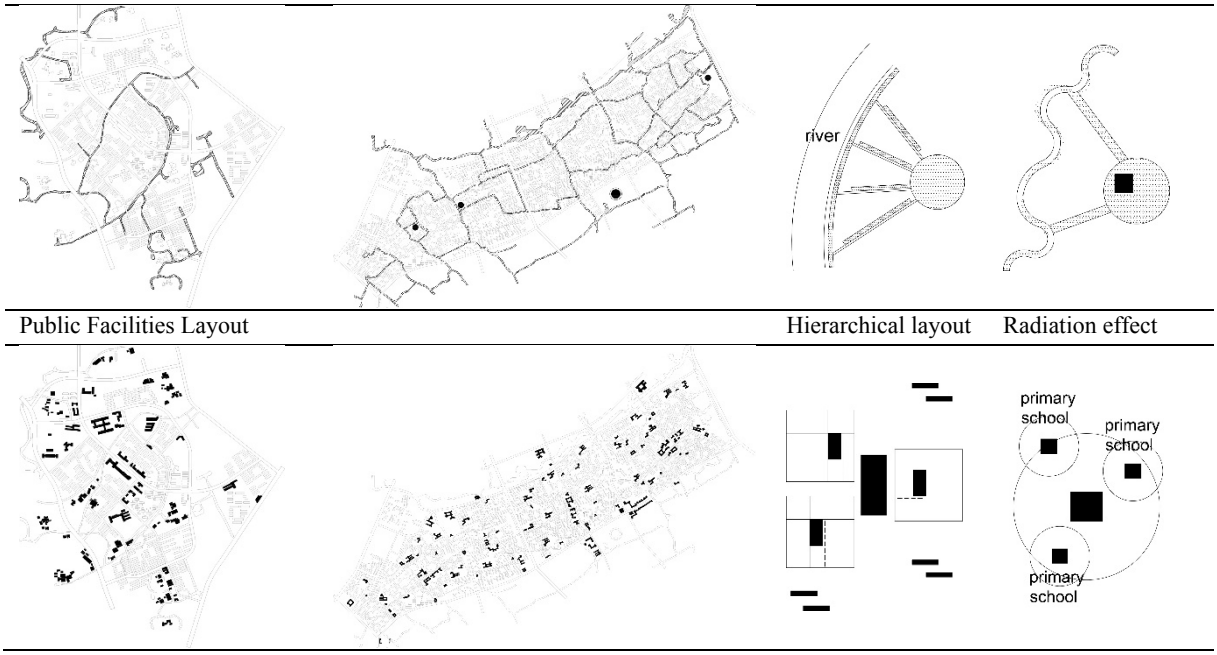
This approach closely resembles the Soviet superblock model, which emphasized the prioritization of industrial production. Soviet planning concepts focused on establishing a clear functional relationship between residential areas and industrial zones, with most industrial residential districts maintaining close spatial ties to industrial areas. In contrast, American urban planning ideas placed more emphasis on functional zoning and the comfort of residential environments, with strict separation between residential and industrial areas, highlighting the division between living and working spaces.

From the perspective of contemporary urban planning, the strategy of avoiding large-scale demolition in city centers and instead developing suburban areas shows continuity with current trends in urban renewal. However, this approach also raises concerns about the difficulties in extending urban infrastructure and public services to suburban locations. Additionally, with the growth of the tertiary sector, the need to continue planning residential areas in close proximity to industrial zones requires re-evaluation, and further in-depth analysis should be conducted based on specific cases.

Neighborhood scale

Table 2. Spatial form analysis of Shanghai. The original base map data of Caoyang workers' village is sourced from Wang, D. ,1956, data of Hudong workers' village is sourced from Xu, J. and Fang, R.,1958.

Caoyang workers' village	**Hudong workers' village**	**Drawing of analyses**	
Road Layout		Planning	Cluster
			
Building Layout		Planning	Cluster
			
Green Space Layout		Hierarchical layout	Radiation effect



Public Facilities Layout | Hierarchical layout | Radiation effect

Figure 2 compares and summarizes the representative residential areas in Shanghai based on four spatial elements: roads, buildings, greening, and facilities. The study reveals the following findings:

1)Road Layout: The road network in Shanghai's workers' villages demonstrates high flexibility and adaptability, following natural waterways and existing road patterns to create a free-form, fishbone-shaped network. At the neighborhood scale, the road organization presents a circular-radial layout, while at the cluster level, the layout is primarily fishbone-shaped.

2) Building Layout: The building structure in Shanghai’s workers' villages is predominantly organized in rows, with the buildings generally aligned parallel to the roads. At the neighborhood level, the layout is flexible, forming irregular patterns in response to roads and waterways. However, within clusters, the layout is more regular, adopting a grid-like structure.

3) Green Space Layout: The green space layout in Shanghai makes full use of the natural waterways and resources, combining strip-shaped and planar configurations. The types of green spaces can be categorized into three main groups based on their location: central gardens, front-yard greenery, and riverside parks. The distribution of green spaces is flexible and highly integrated with the natural environment. Central green spaces are often combined with community public facilities, forming a vibrant public space system.

4) Public Facilities Layout: The layout of public facilities in Shanghai's workers' villages exhibits both flexibility and a multi-core structure. Facilities are arranged along roads or rivers, blending organically with the natural landscape, demonstrating strong spatial adaptability. Additionally, the villages feature a clear multi-core structure with a hierarchical radial system. At the neighborhood scale, the community center serves as the core, concentrating various public service facilities. At the cluster level, primary schools form the core, ensuring that basic needs are met within a 7-8 minutes walking distance for residents.

In summary, when linking these findings to the planning concepts of the United States and the Soviet Union, it becomes evident that Shanghai's planning shares a high degree of alignment with the American "neighborhood unit" concept, while also partially aligning with Soviet planning principles.

In terms of road layout, the "neighborhood unit" emphasizes a "connected but not through" design to reduce through-traffic and enhance community safety and livability. Similarly, Shanghai's circular-radial and fishbone road layouts, while following natural waterways and existing road patterns, also avoid excessive through-traffic.

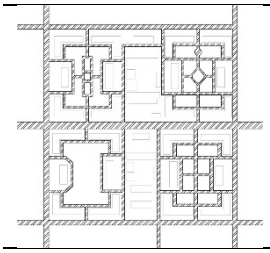
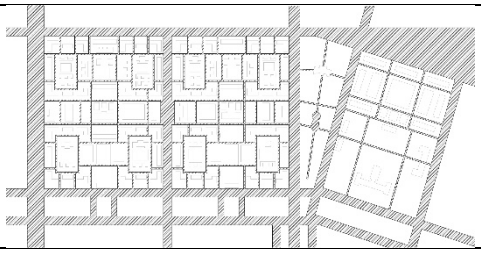
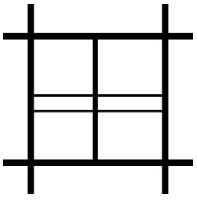
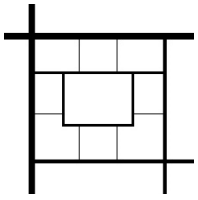
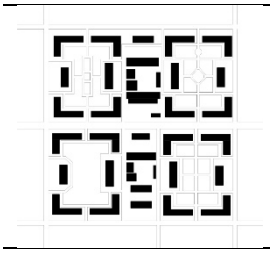
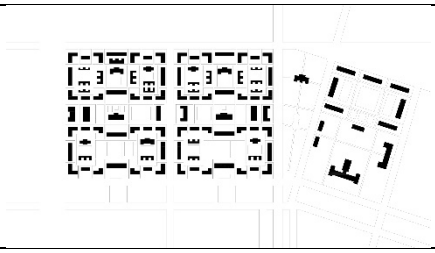
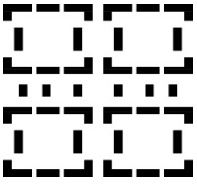
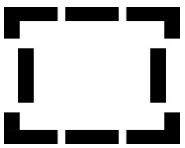
In terms of building layout, Shanghai's flexible response to the natural environment aligns with the "neighborhood unit" principle of integrating community design with natural landscapes.

In terms of green space, the flexible design of strip-shaped and planar green spaces in Shanghai, which maximizes natural resources and waterways, aligns with the "neighborhood unit" objective of creating more public activity spaces to foster community interaction and cohesion.

In terms of public facilities, the multi-core and hierarchical radial structure in Shanghai is also consistent with the multi-center service structure of the "neighborhood unit," ensuring that residents can access basic services within a walkable radius centered around primary schools.

At the same time, Shanghai's cluster-level building layout and the concentration of certain public facilities reflect Soviet planning principles, particularly in their emphasis on centralized planning and functionality within residential areas.

Table 3. Spatial form analysis of Shenyang. The original base map data of Hemulu workers' village is sourced from Xu, M. and Zhao, X.,2012, data of Hemulu workers' village is sourced from Li, S.2015.

Hemulu workers' village	**Tiexi workers' village**	**Drawing of analyses**	
Road Layout		Planning	Cluster
			
Building Layout		Planning	Cluster
			
Green Space Layout		Hierarchical layout	Radiation effect

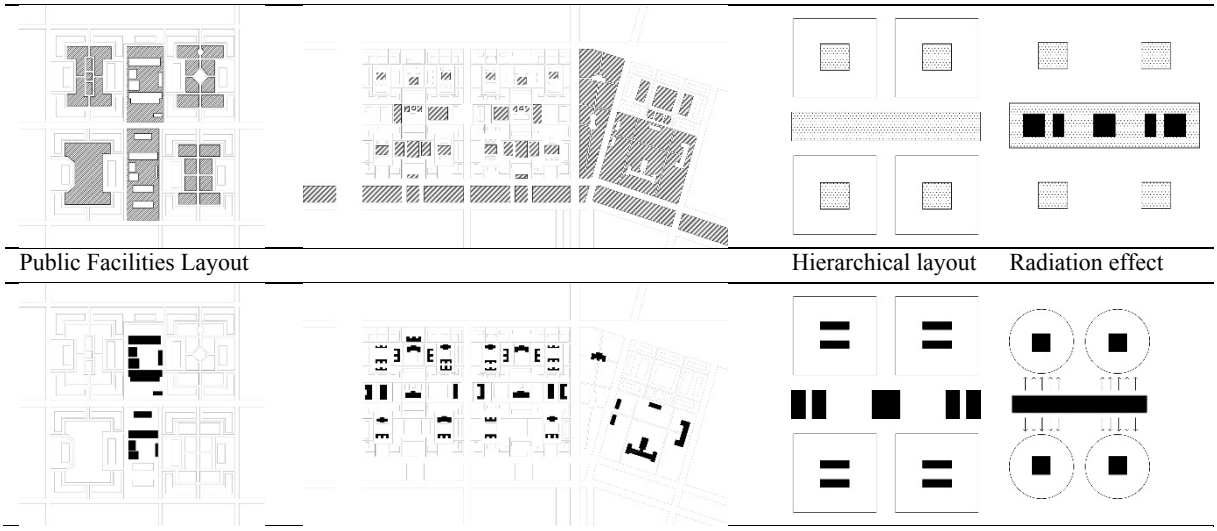


Figure 3 compares and summarizes the representative residential areas in Shenyang based on four spatial elements: roads, buildings, greening, and facilities. The study reveals the following findings:

1) Road Layout: The road structure in Shenyang's workers' villages demonstrates strong orderliness and enclosure. The road organization features a geometric grid layout, emphasizing symmetry and structure. At the neighborhood level, the roads are arranged in a symmetrical grid pattern, while at the cluster level, Shenyang' s road layout shows clear enclosure characteristics.

2) Building Layout: Shenyang's building structure reflects symmetry and enclosure. At the neighborhood level, residential clusters are arranged symmetrically along an axis centered on a public building complex. At the cluster level, corner buildings are often "L"-shaped, forming an enclosed layout with other surrounding buildings.

3) Green Space Layout: Shenyang's green space layout mainly adopts a planar distribution that complements the enclosed building arrangement. Green spaces can be divided into those within and between clusters, with the greenery between clusters closely integrated with public facilities.

4) Public Facilities Layout: The layout of public facilities in Shenyang's workers' villages is centralized and symmetrical. At the neighborhood level, large-scale public facilities are concentrated in the center of the residential area, distributed evenly along the main arterial roads, forming a distinct strip-like core zone. At the cluster level, facilities are integrated with the enclosed buildings, further emphasizing the symmetrical and radial nature of the planning.

In summary, when linking these findings to American and Soviet planning concepts, it becomes evident that Shenyang's planning is highly consistent with the Soviet "superblock model," while also partially aligning with American planning principles.

In terms of road layout and building organization, both Shenyang and the Soviet model emphasize geometric symmetry, with clearly defined axes and buildings aligned along roads. This arrangement creates a clear boundary between internal and external spaces, giving the urban form a strong centripetal character. Furthermore, the layout of public facilities and green spaces in Shenyang reflects the Soviet planning ideals of centralization, symmetry, and the creation of a core zone.

Overall, Shenyang's alignment with the Soviet superblock model can be attributed to the influence of the "Learn from the Soviet Union" campaign and the direct involvement of Soviet planners and architects. However, traces of American influence are also evident, such as in Shenyang's road system, which, while following the superblock model, incorporates the American "neighborhood unit" principle of "connected but not through" roads to reduce cross-traffic.

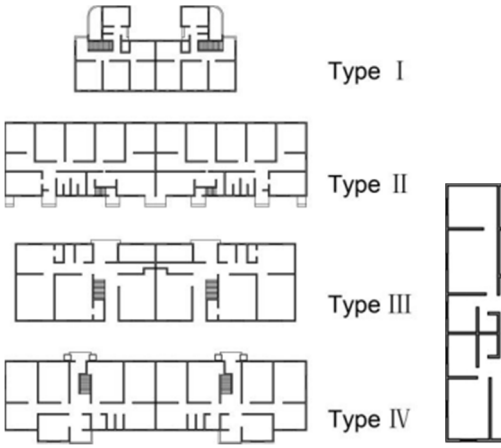
Table 4. Summary and comparison of spatial elements.

	Shanghai	**Shenyang**	**Commonality**
Road Layout	Fishbone-shaped	Grid	Connected but not through
Building Layout	Determinant	Enclosed	Ignoring orientation
Green Space Layout	Linear and area-based combined	Area-based	Integration of greening and facilities
Public Facilities Layout	Decentralized, point core	Concentrated, strip core	

The comparison between the spatial forms of Shanghai and Shenyang highlights the distinct impacts of American and Soviet technology transfers on these two cities. (table 4) First, the primary line of influence is evident: American planning concepts influenced Shanghai, while Soviet planning concepts shaped Shenyang. While there were some instances where Soviet ideas influenced Shanghai and American ideas affected Shenyang, these secondary influences were relatively limited compared to the dominant forms of technology transfer. Second, despite the limited influence of secondary ideas, there is evidence of local adaptation in the technology transfer process, demonstrating that the transfer was not a direct application of foreign concepts but involved localized adjustments to suit regional needs.

Building scale

At the residential scale, the influence of American and Soviet technology transfers on the spatial form of workers' housing can be observed from a more human-centered perspective, focusing on the design of apartment layouts and façades.



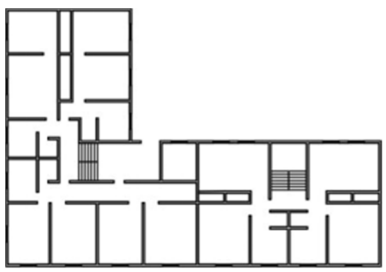


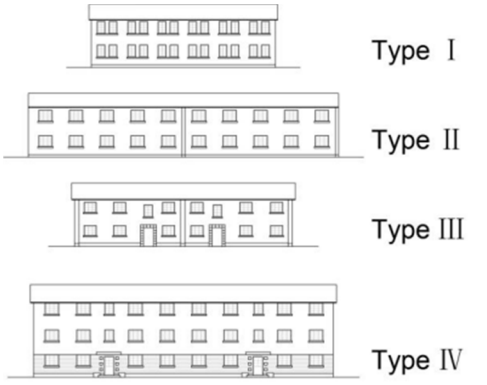


Figure 1. Four plan types in Caoyang Workers' Village. Figure 2. "L" plane type of Tiexi Workers' Village.Figure 3. High-rise residences in Hudong Workers' Village,drawing credit: Huangying Li.

In terms of floor plans, one of the key features of 1950s workers' villages was the diversity and compactness of housing unit designs. For example, in the Caoyang Workers' Village, the single-story floor plan offered four different apartment types (Figure 1). Similarly, the Tiexi Workers' Village

included L-shaped corner layouts (Figure 2), and the Hudong Workers' Village introduced high-rise residential designs (Figure 3). The variety in apartment layouts reflected the designers' consideration of different family structures and living needs. Moreover, compactness was another significant feature of workers' housing. For instance, in the Caoyang Workers' Village, internal corridors separated the living areas from the kitchen and bathroom spaces, with communal kitchen and bathroom facilities provided for multiple households to share.

In terms of façades, workers' housing from the 1950s displayed a blend of Western and Chinese architectural styles alongside a trend toward simplification. Specifically, the façade design of Tiexi Workers' Village had clear classical elements, though these were simplified for practical purposes. Additionally, some buildings featured traditional Chinese decorative patterns, such as the "hui" motif at the entrances, reflecting an effort to integrate local cultural elements. In contrast, the façades of the Caoyang Workers' Village were much more minimalist, with almost no decorative features. The design was purely functional, with flat walls and minimal articulation, focusing on necessary functional elements like staircases and balconies. This pared-down approach not only minimized ornamental considerations but also reflected the emphasis on building functionality in a resource-constrained context.



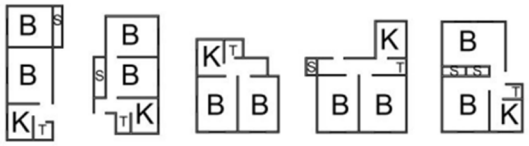




Figure 4. Four elevations in Caoyang Workers' Village. Figure 5. Composition of Tiexi Workers' Village,drawing credit: Huangying Li.

In addition to the previously discussed features, another significant characteristic of the workers' villages of the 1950s is standardized construction. The residential units in the Tiexi Workers' Village, for example, strictly adhered to standardization principles (Figure 4). The use of uniform floor plans and standardized components significantly improved construction efficiency. In terms of façade design, standardization was also evident in the uniformity of elements such as doors and windows (Figure 5), which further reinforced the uniformity and controllability of the social structure within the housing developments.

These three characteristics—diverse and compact floor plans, architectural style design, and standardized construction—are all closely linked to the Soviet technological transfer.

The diversity of floor plans addressed the varied needs of working-class families during rapid urbanization, exemplifying the Soviet housing system's principle of "standardization combined with adaptability." The focus on compact design also echoed the Soviet emphasis on functionality and efficiency in collective housing, where shared spaces like kitchens and bathrooms were central to reducing resource waste and construction costs while fostering a communal atmosphere. The

architectural style reveals China's imitation and simplification of Soviet classical aesthetics, while the widespread adoption of standardized construction techniques reflects the Soviet influence on mass housing construction, an approach that China implemented during the "156 Projects" to support its rapid industrialization.

In summary, the design of 1950s workers' villages—whether in the diversity and compactness of apartment layouts, the façade styles, or the standardization of construction—demonstrates the profound impact of Soviet technological transfer. These influences were centered on the functionality, efficiency, and adaptability of large-scale workers' housing, aligning with China's needs during its period of rapid industrialization and urbanization. At the same time, this process of technology transfer also incorporated local adaptations, particularly in consideration of China's economic conditions and the preservation of traditional cultural elements. This balance between foreign influence and local adaptation shaped the unique architectural and social functions of the workers' villages.

CONCLUSIONS

By comparing the Shanghai and Shenyang workers' villages, this study reveals the unique influence of American and Soviet urban planning models on Chinese residential spatial forms in the 1950s. The dual technical transfer from these two global powers played a crucial role in the design and construction of these workers' residential areas, while China's local adaptation was key in integrating these foreign concepts into its specific socio-economic and cultural contexts.

The results show that, at the urban scale, the siting and layout of Chinese workers' villages were deeply influenced by Soviet planning principles. These villages were typically attached to industrial zones and located on the city's outskirts, reflecting China's alignment with the Soviet industrialization strategy. At the residential scale, the interweaving of both American and Soviet influences is evident. In Shanghai, the organization of roads and public spaces was significantly influenced by the American "neighborhood unit" model, emphasizing community autonomy and integration with the natural environment. In contrast, Shenyang's residential areas followed the Soviet "superblock" model, characterized by centralized and geometrically symmetrical layouts. At the architectural scale, the Soviet influence was more pronounced, manifesting in compact floor plans, simplified architectural styles, and highly standardized construction methods, all of which closely resembled Soviet residential design models of that period.

In conclusion, this study draws the following key points:

1) During China's early industrialization phase, Soviet technical transfers played a dominant role, particularly in urban siting and the standardization of buildings, profoundly impacting Chinese workers' villages. This was largely driven by socialist ideology, which influenced national policy and, in turn, shaped residential forms. In the 1950s, as China explored its path toward socialism, it leaned heavily toward the Soviet Union, a fellow socialist state.

2) American influence primarily surfaced through the flexible application of planning concepts by individual planners. Although China's political alignment tilted towards the Soviet Union during this

period, Shanghai still demonstrated elements of American planning principles, indicating the agency of planners in adapting foreign ideas within the constraints of state policies.

3) Local adaptation was central to the process of technical transfer. By adjusting foreign concepts to address China's varying economic, cultural, and climatic conditions, workers' villages in different regions demonstrated the diversity and flexibility of planning concepts.

The limitations of this study lie in its focus on design concepts, with less exploration of technical adjustments made during the construction process. Due to factors such as resource limitations and changes in technical conditions, the final form of the residential areas may have deviated from the initial designs. Future research should more deeply explore the full process of technical transfer across the design, implementation, and operational stages. Furthermore, the geographic scope of this study is relatively limited. Expanding the research to more regions would provide a broader understanding of the varied responses to technical transfers in different cultural and economic contexts, helping to build a more comprehensive theoretical framework on technical transfer and local adaptation.

Overall, this study offers a fresh perspective on the technical transfer and local adaptation in Chinese workers' villages of the 1950s. It not only deepens our understanding of China's urban planning history but also provides theoretical insights and practical references for modern urban planning in the context of globalization.

Acknowledgements

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Density and urban form in Porto Alegre´s Historic Centre rehabilitation

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ABSTRACT

The urban centre rehabilitation process involves the proper correlation and compatibility of different factors. Among these factors, predicting population growth is crucial for the adequate use of the installed infrastructure, respecting the morphologic type configuration of existing structures. In this scenario, the incompatibility of conventional urban rules with the construction of new structures emerges as a challenge to be overcome. This is the case of Porto Alegre, Brazil. Porto Alegre´s urban rules are based upon a conceptual model that attached typologies to ideal lots to achieve the plan's goals. In this context, methods to correlate density and form in order to identify different typologies emerge in the scientific literature. This research applies GIS technology to employ these methods in examining Porto Alegre´s block DNA, guiding alternative rules for urban design that can more efficiently execute the strategies envisioned in Porto Alegre´s Historic Centre Rehabilitation.

Keywords: urban center; center rehabilitation; urban morphology.

INTRODUCTION

The urban centre rehabilitation process is a challenge as it involves the proper correlation and compatibility of different factors. Social, natural and economic issues must be addressed in order to provide the best suited environment aiming at the best use of the installed infrastructure. Among these factors, the prediction of population growth, essential for the adequate use of the installed infrastructure, must be made possible while respecting the morphological type and configuration of the existing structures. In this scenario, the incompatibility of conventional urban rules with the construction of new structures emerges as a challenge to be overcome. Leinberger (2005), when listing the fundamental steps for carrying out revitalization processes in central areas, highlights that "often well-intended setback and floor-area ratio rules mean that new construction cannot maintain consistency with older historic structures".

This is the case of Porto Alegre, Brazil. Porto Alegre´s urban rules are based upon a conceptual model that attached typologies to ideal lots in order to achieve the plan's goals. Berghausen Pont and Haupt (2009) in Spacemate present a method to correlate density and form in order to identify different

typologies through four parameters: GSI, FSI, OSR, and Height. This research applies GIS technology in order to use Spacemate to examine Porto Alegre´s block DNA, guiding alternative rules for urban design that can more efficiently execute the strategies envisioned in Porto Alegre´s Historic Center Rehabilitation.

METHOD

Case study: Porto Alegre, RS, Brazil

Porto Alegre, the capital of the southern Brazilian state of Rio Grande do Sul, is a significant urban centre with a rich history and dynamic socio-economic landscape. Founded in 1772, the city has evolved from a modest colonial settlement into a bustling metropolitan area, currently housing over 1.5 million residents. Porto Alegre is strategically positioned at the confluence of the Guaíba River and the Lagoa dos Patos estuary, making it a crucial hub for trade, industry, and cultural exchange in the region.

Throughout the city's development over its 252 years since its founding, the Historical Center has been losing its prominence. This phenomenon is not exclusive to Porto Alegre; major metropolitan areas around the world have been undergoing the same process.

According to studies conducted by the Urban Planning Coordination team of the Municipal Department of Environment, Urbanism, and Sustainability (PORTO ALEGRE, 2021), the Historical Center has been under study since the 1970s and 1980s. Based on the information obtained, urban rehabilitation studies for this area began in the 1980s and 1990s, which included the establishment of the Historical and Cultural Heritage Team, among other initiatives.

The Porto Alegre Historical Center Rehabilitation Program was conceived within this context with the initial goal of enabling the overall rehabilitation of the Historical Center area. The program aims to restore residential functions, recover public spaces, and revitalise economic activities, taking into account the new scenarios brought about by the pandemic, which have caused profound transformations in the general relationship between society and cities.

Typological description of pre-existences

The territory under analysis for the Porto Alegre Historic Centre Rehabilitation Program can be examined from four (4) levels of aggregation: city, urban structuring units, sector, and block (Figure 1). Considering the level of consolidation of the existing built fabric, with limited space for the renewal of the built environment and the need to define a local strategy, the typological description was chosen based on the smallest level of aggregation, the block.

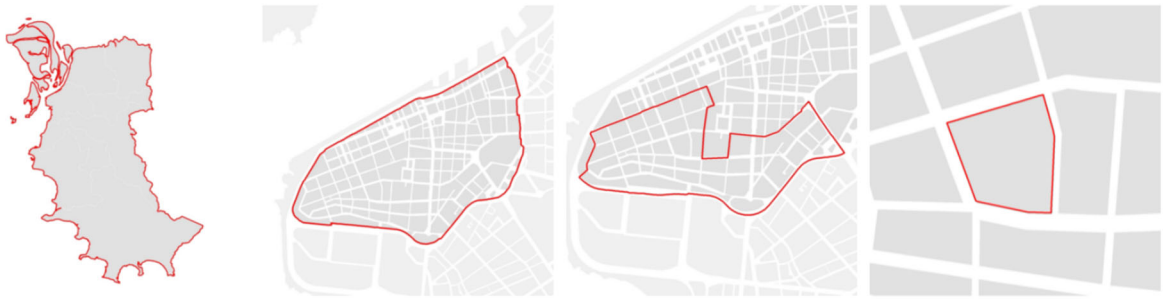

Figure 1. Possible levels of aggregation for analyzing the study area: city, urban structuring units, sector, and block. PORTO ALEGRE, 2021.

Pont and Haupt (2009) propose a model for the morphological classification of urban occupation patterns based on four (4) basic measures: floor area ratio, occupancy rate, height, and open space ratio. Henrique and Turkienicz (2021) test the application of this model as a way to establish occupation patterns on the built fabric of Porto Alegre. Through tests aimed at consolidating existing morphological type patterns, the authors demonstrate the direct relationship between this consolidation and improved performance in terms of habitability, particularly sunlight exposure and illuminance.

The model proposed by the authors was reproduced and applied to 113 selected blocks in the Historic Centre of Porto Alegre, resulting in the description of typological patterns presented in the following figures:

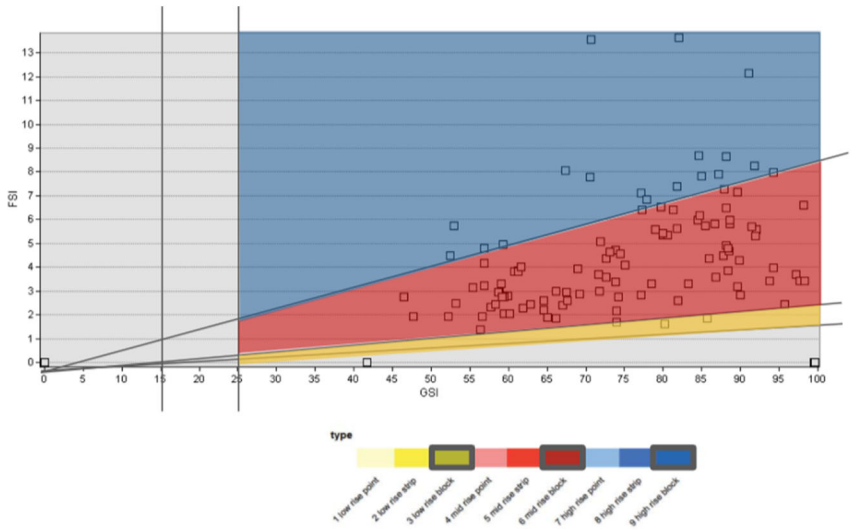

Figure 2. Morphological type patterns for the selected blocks. Source: Adapted from HENRIQUE and TURKIENICZ, 2021.

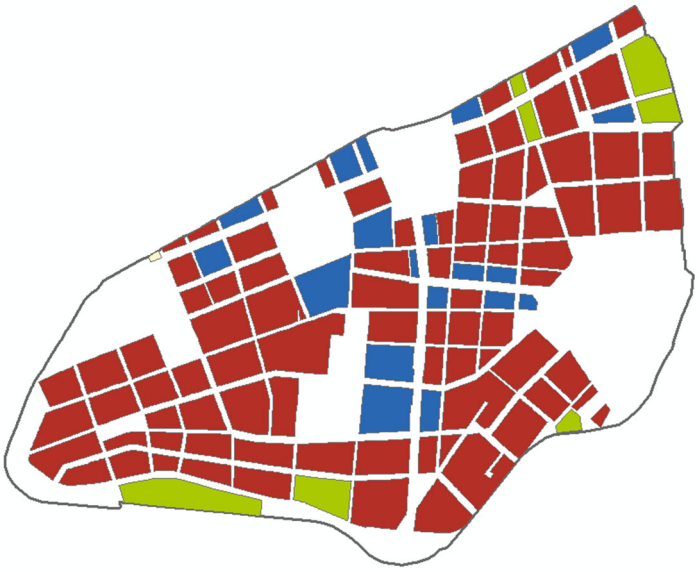

Figure 3. Spatialized morphological type patterns for the selected blocks. PORTO ALEGRE, 2021.

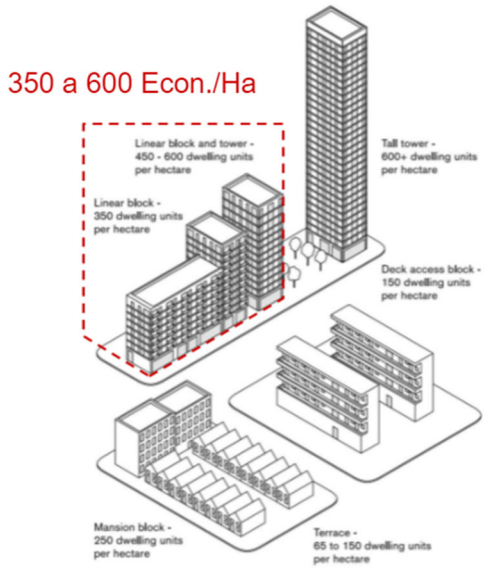

Figure 4. Most frequent morphological type patterns in the area under analysis. Source: Adapted from APA, 2012.

Regarding the most frequent morphological type pattern occurring in the analysed blocks of Porto Alegre's Historic Centre, the mid-rise block (medium height block) is notable. This typology is already recognized in the literature as highly compatible with urban qualities such as high urbanity and vitality of adjacent public spaces (SIM, 2019). In blocks with a medium to high level of consolidation, the need to preserve this pattern is emphasised, as it consolidates the identity and contributes to local habitability.

Viewsheds

The concept of a visual basin refers to a specific geographic area that is visible from a particular point in space. In the Urban Environmental Development Master Plan of Porto Alegre, this concept is related to the preservation of visual interests connected to the natural environment in the so-called "visual emergency points." For the Rehabilitation Program of the Historic Center of Porto Alegre, the idea is to extend this concept to points of interest within the built heritage, particularly in constructing visual

basins of reference elements in the landscape of the Center. The proposed concept is aligned with the strategy adopted in the conception of urban planning regimes in other cities around the world, such as in the case of London (Figure 5).

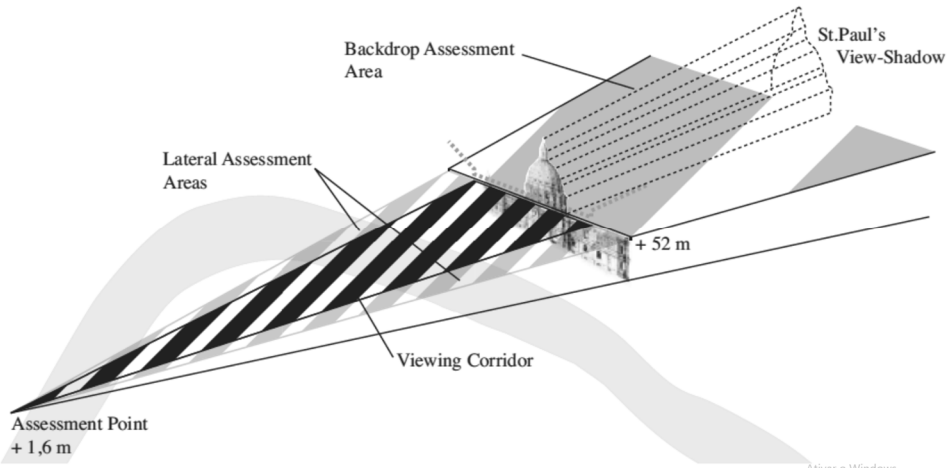

Figure 5: Views protected by geometric definition from observation points and target elements in the urban landscape. Example: the surroundings of the dome of Saint Paul's Cathedral, London. Source: Adapted from LEHNERER, 2010.

The first step for the analysis of the territory based on the visual points of interest in the Historic Centre involved establishing observation points at the intersections of the road axes within the area of analysis (Figure 6).

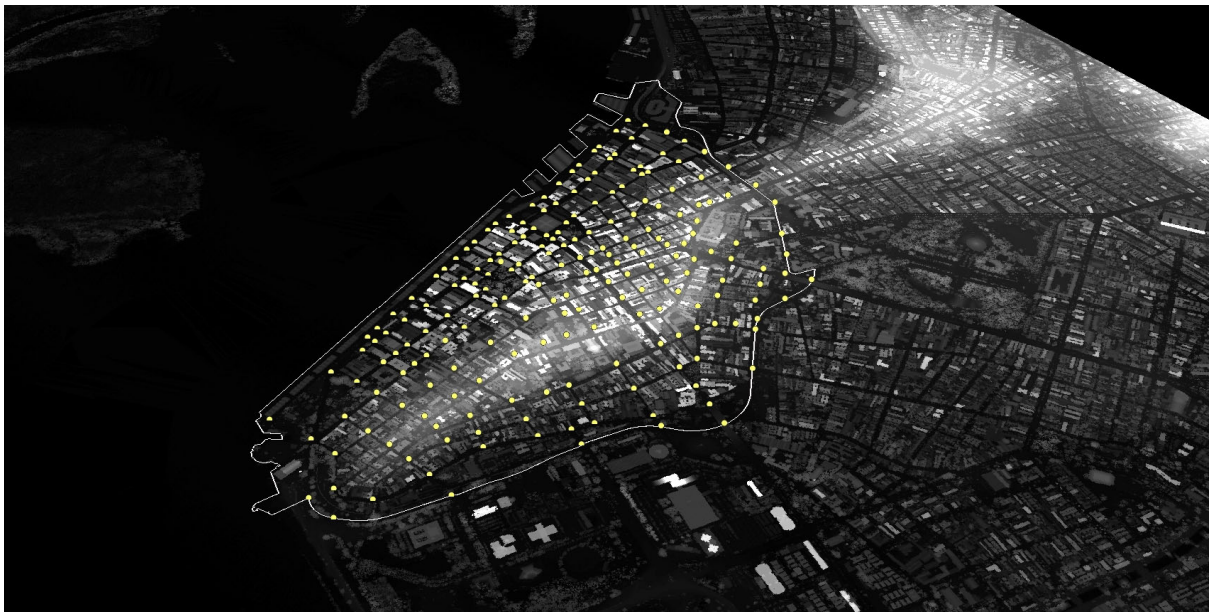

Figure 6: Observers positioned along the street network in Porto Alegre´s Historic Centre. PORTO ALEGRE, 2021.

From these points, the visibility analysis of the adjacent fabric was conducted. Figure 7 shows a point cloud over the area under analysis within the limits of the Historic Centre, classified according to the frequency of observation. The map highlights buildings and areas of interest, particularly the surroundings of the Public Market and the cluster of buildings near the waterfront. At the interface

between the Historic Centre and the adjacent neighbourhoods, taller buildings and a set of viaducts are evident.

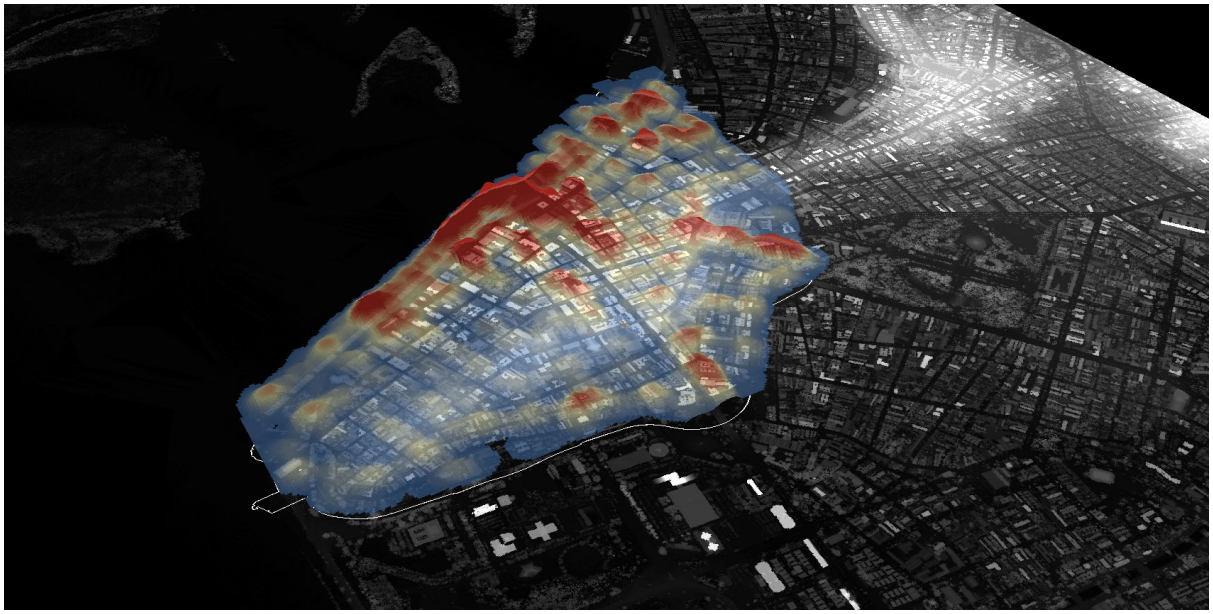

Figure 7: Point cloud classified according to the spaces observed with the highest frequency in relation to the positioned observers. PORTO ALEGRE, 2021.

Figure 8 shows the buildings observed most frequently within the point cloud. In Figure 9, the same buildings are classified to isolate those related to elements of historical and cultural interest, specifically: 41 listed properties and 92 structuring properties.



Figure 8: Highlight of the buildings seen with the highest frequency. PORTO ALEGRE, 2021.

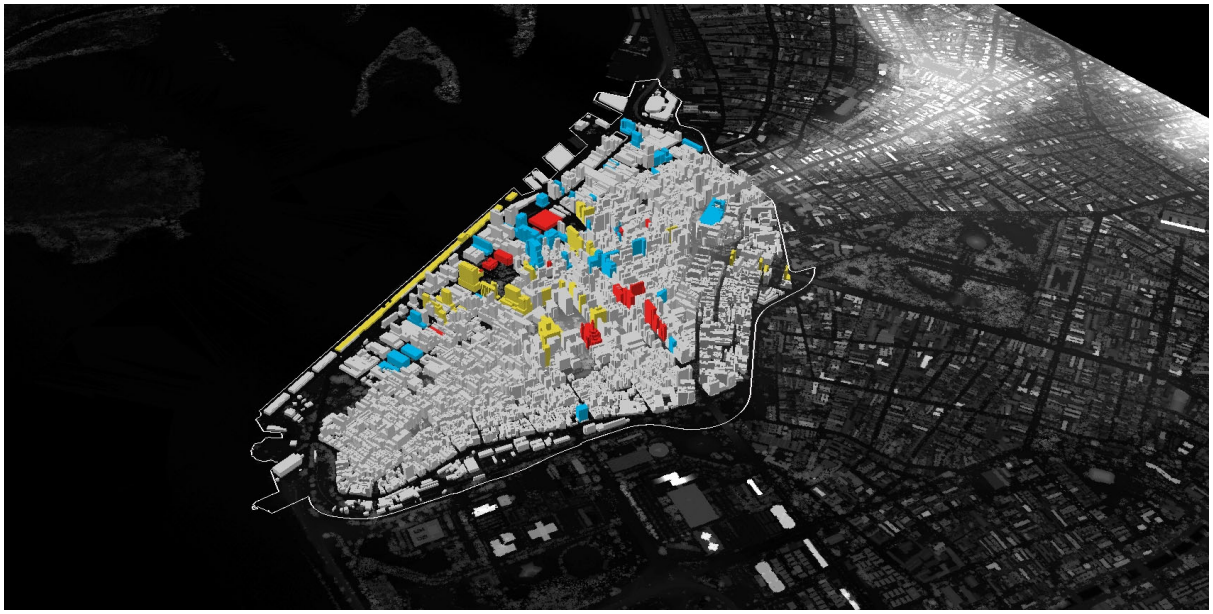

Figure 9: Buildings of interest observed with the highest frequency: listed properties (in red); properties in the vicinity of listed buildings (in yellow); and structuring properties (in blue). PORTO ALEGRE, 2021.

Figure 10 presents the visibility analysis for one of the points of interest: the dome of the Metropolitan Cathedral. In the model, it is possible to highlight road axes of interest for observing the building from the public spaces of the Center: Caldas Júnior Street and General Câmara Street.

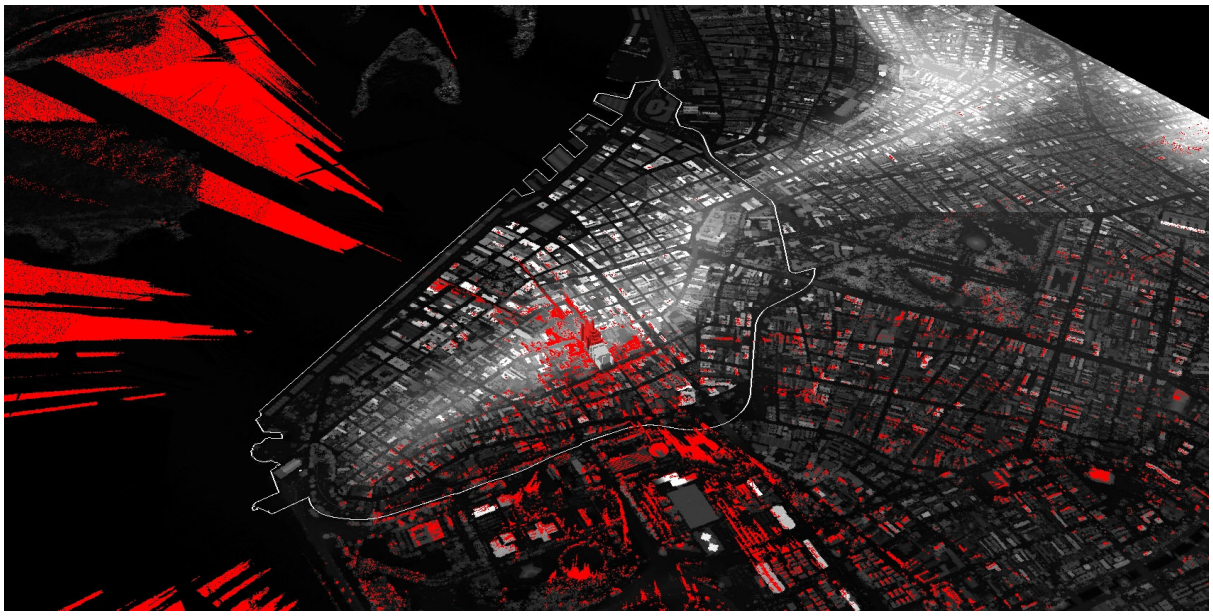

Figure 10: Spaces from which the dome of the Metropolitan Cathedral is observed. PORTO ALEGRE, 2021.

Habitability

The performance of urban form concerning habitability reference parameters, particularly in relation to ventilation, solar exposure, and illuminance, is directly related to the volumetry of buildings. The construction of scenarios to test the parameters for densification of the Historic Center of Porto Alegre considered two typical situations: (i) the construction of the maximum possible volumetry on the lots according to the current urban planning rules; and (ii) the projection of maximum volumetry according to performance criteria. For initial testing, a block on Washington Luiz Street was selected. The

automatic generation of buildings according to the current urban planning regime and proposed modifications was carried out in the CityZoom environment (TURKIENICZ, XXXX).

The evaluation of the generated forms concerning sunlight considered the simulation of impact for the winter solstice, June 21, 2021, with maximum sunlight exposure at 10:13 AM (sunrise at 7:20 AM and sunset at 5:33 PM), performed using the same software. The following images highlight in red the faces of the buildings with less than two hours of daily sunlight exposure for each scenario. The graph illustrated in Figure 14 presents a comparison of the building faces in each of the scenarios according to the hours of solar incidence for the analysis period.

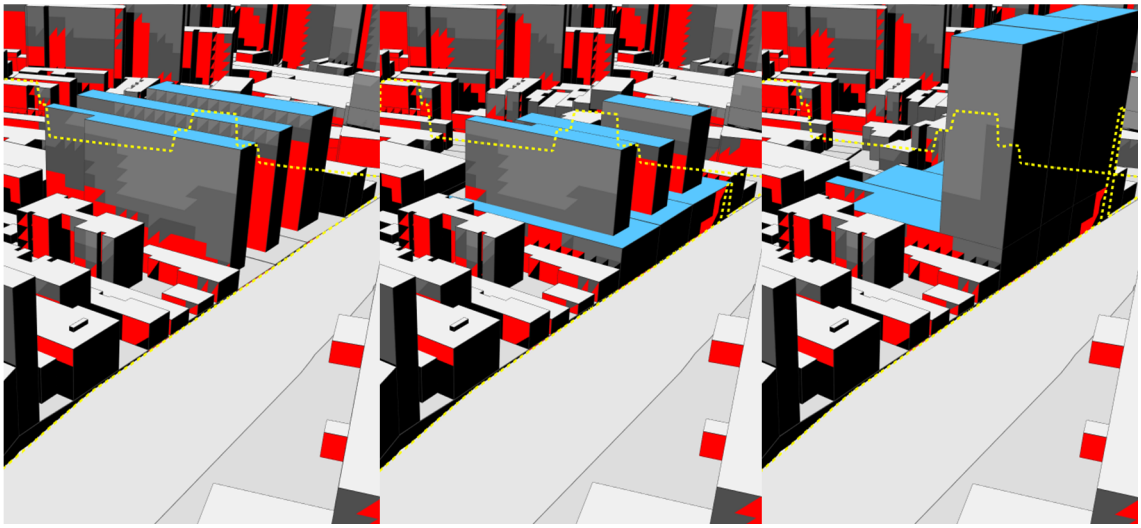

Figure 11: Scenario A-B-C, in red highlighting for faces with solar exposure < 2h/day. PORTO ALEGRE, 2021.

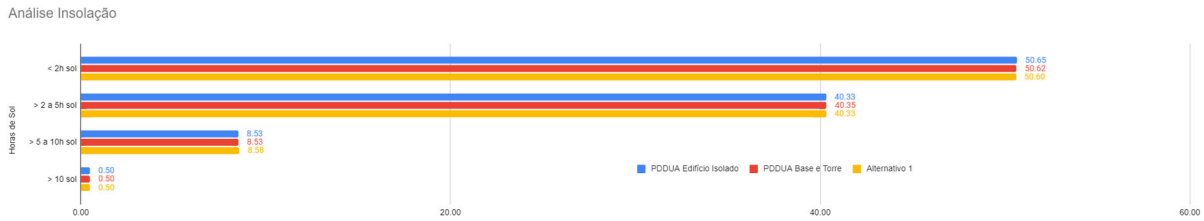

Figure 14: Sun hours for the three analysed scenarios. PORTO ALEGRE, 2021.

Regarding the presented scenarios, with tests on the compatibility of typologies in the Historic Centre, preservation of visual basins of built and natural elements of interest, and reference parameters for the habitability of buildings, it is important to note that these are tests aimed at highlighting potential approaches for developing alternative urban planning regulations for the territory. Based on this concept, the following section presents estimates for the construction potential of the territory, as well as the definition of construction stocks compatible with the proposed densities.

Building potential

For detailing the construction potential suitable for the proposed densities in the Historic Center of Porto Alegre, the blocks were classified according to their renewal potential considering three factors: (a) the level of consolidation of the blocks, low, medium, or high; (b) the current land structure pattern, with small, medium, and large lots; and (c) the level of impact according to visual basins, with low, medium, and high impact.



Figure 16: Blocks classified according to the scale of renewal potential and examples: (A) Very High; (B) Very High; (C) Low; and (D) Medium. PORTO ALEGRE, 2021.

For detailing the lots and simulating the additional construction potential, the following criteria were considered: (i) the executed utilisation rate: calculated based on data from the Municipal Department of Finance; and (ii) the preservation of historically significant buildings and urban facilities, with no increase in built area for the purposes of this estimate.

According to the results, the data were normalised according to the value scale identified below:

- 0 (zero) for lots with low renewal potential, including those with historically significant buildings and those with built area equal to or above the maximum index provided in the Plan;
- 1 (one) to 50 (fifty) for lots with medium renewal potential, with utilisation exceeding 50% of the construction potential indicated in the Plan;
- 51 (fifty-one) to 100 (one hundred) for lots with high renewal potential, with utilisation below 50% of the construction potential, reaching 100% renewal potential in the case of vacant lots.

Considering the three levels of renewal potential—high, medium, and low—the figure below illustrates the patterns according to the proposed categorization.

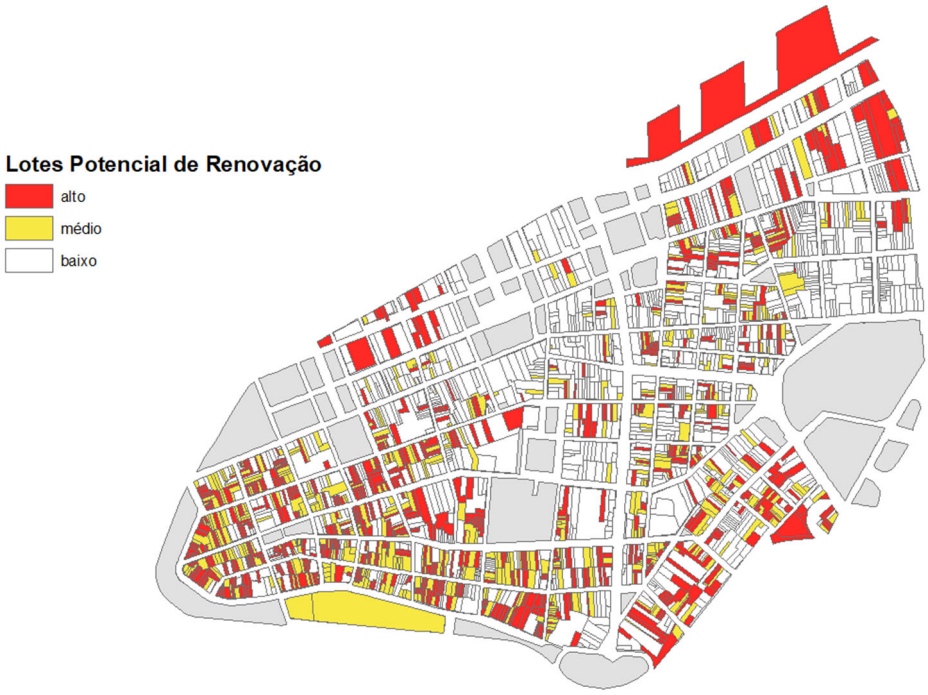

Figure 17: Lots classified according to renewal potential. PORTO ALEGRE, 2021.

A method for controlling volumetry: building envelope

Considering the tests conducted regarding parameters and metrics for land use and occupancy in the Historic Centre, it is proposed as a tool for volumetric control of buildings and the regulation of maximum volumetric limits by block. This solution mirrors the logic employed in other cities around the world, such as Barcelona, and the proposals presented in the Masterplan for the 4th District (UFRGS, 2016).

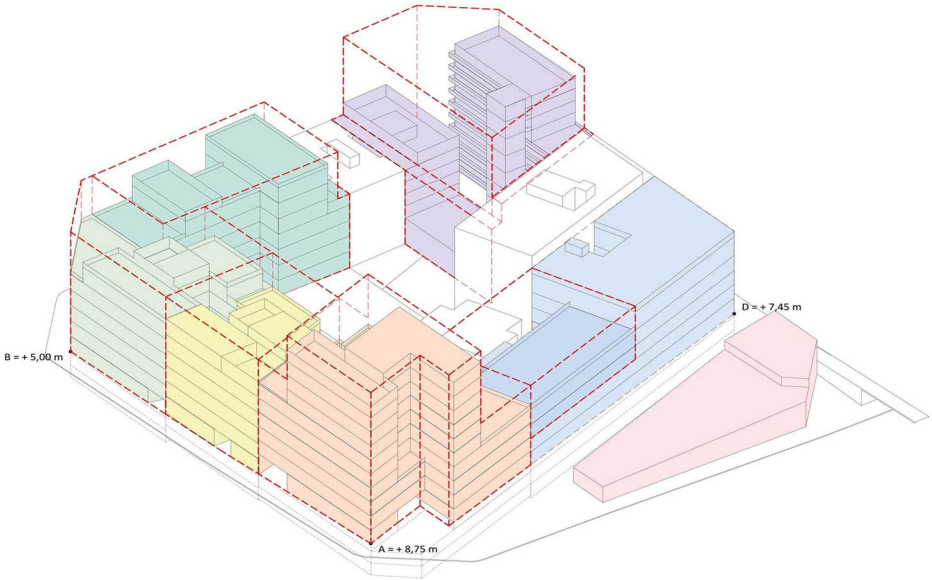

Figure 18: Study of maximum occupancy limits for a block in Barcelona. Source: Adapted from https://gde.barcelona/en/proyecto/zapp/.

According to the simulations conducted and presented in the previous sections, three criteria are established for the design of these maximum occupancy limits, especially in defining volumetric standards, to be detailed within the limits of the Adherence Perimeter of the Rehabilitation Program for the Historic Center of Porto Alegre:

TYPOLOGICAL DESCRIPTION: Evaluation of the typological morphological trends of consolidated blocks and axes, involving:

- Front setback defined, preferably by existing alignment or to be defined, considering specific urban or environmental situations;
- Exemption of lateral setbacks in defining the limits, ensuring the need for minimum clearances from adjacent properties, with a preference for continuity of the facade at the sidewalk level;
- Rear setback defined by compatibility with adjacent properties.

VIEWSHED:

- Respect for visual basins to be established in areas interfacing with elements of Historical Heritage and Lake Guaíba, and the city skyline;
- Differentiated volumetries at nodal points, landmarks, boundaries, and axes, in harmony with the consolidated surroundings;

HABITABILITY: Assessment of building performance according to standards of sunlight, illuminance, and ventilation.

BUILDING POTENTIAL: Assessment of building performance according to standards of sunlight exposure, illuminance, and ventilation.

RESULTS AND DISCUSSIONS

The overlay of the restrictions defined by the three parameters—height, visual landmarks, and habitability—resulted in the proposed building envelopes for the blocks within the study area. This is clearly illustrated in the 3D visualization, which demonstrates the relationship between the height of the buildings and the city's skyline, with the Gasômetro chimney serving as a key reference point, marking the lowest allowable elevation. The analysis highlights how the proposed design integrates with the existing urban landscape, preserving important visual corridors. Furthermore, the example of a proposed building, reviewed by the municipality's technical team, demonstrates how these guidelines can be applied in practice, ensuring that new developments respect the established parameters while enhancing urban cohesion.

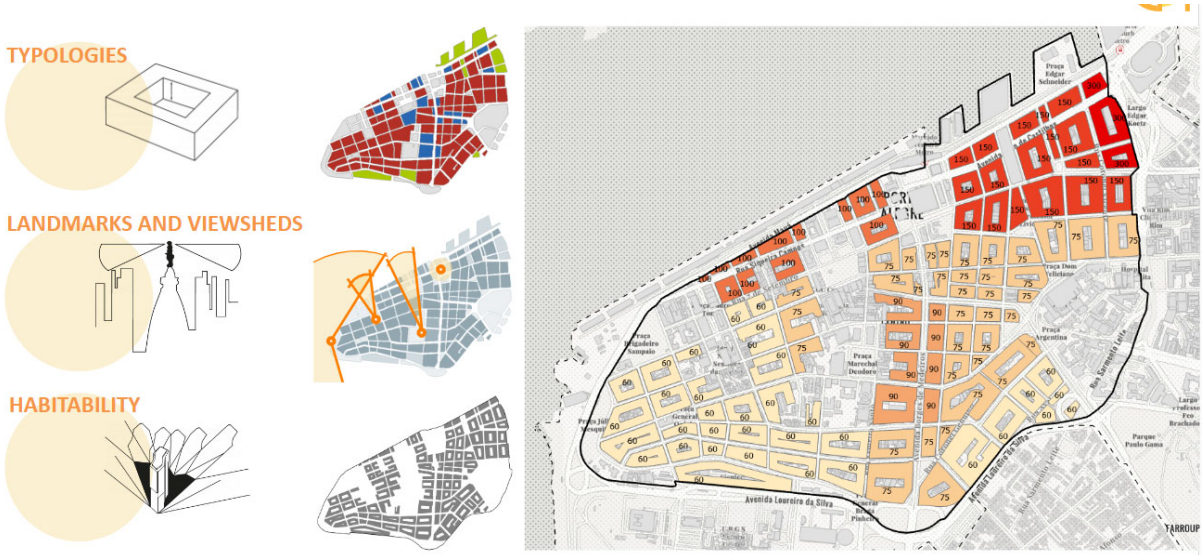

Figure 19: Overlay of the restrictions in Porto Alegre´s Historic Center. PORTO ALEGRE, 2021.



Figure 20:City Skyline. PORTO ALEGRE, 2021.



Figure 21:Final Proposal. PORTO ALEGRE, 2024.



Figure 22: Rua Siqueira Campos, 853 - OSPA Arquitetura e Urbanismo, 2024.



Figure 23: Porto Alegre Flood, 2024.

CONCLUSIONS

The extreme climate event in May 2024 in Porto Alegre marked an unprecedented moment in the city's history, highlighting the urgent need to revise urban and construction strategies with a focus on resilience. Analysis of the affected areas revealed the critical importance of avoiding residential uses on floors at risk of flooding as a preventive measure against material and human losses. Additionally, it was observed that building infrastructure must be redesigned to ensure that electrical and logical systems are not exposed to vulnerability. Another key aspect was the necessity to plan new facilities that can play a strategic role during emergencies, such as shelters and support centers. These directions clearly point towards the adaptation of building codes and urban planning regulations, emphasising the importance of incorporating resilience strategies in response to the challenges posed by climate change.

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Exploring periurban landscapes and river corridors: dynamics and planning in Zaragoza, Spain

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ABSTRACT

Traditional peri-urban areas in European cities have been the result of the interaction between human and natural forces. However, contemporary processes of growth in peri-urban areas are transforming the adjacent natural and agricultural landscapes into a complex mosaic, a palimpsest characterised by fragmentation, dispersion, vacancy and a variety of land uses. The emergence of what are commonly referred to as 'new peripheries' or 'peri-urban zones' has been greatly facilitated by the proliferation of infrastructure, particularly roads and railways. To maintain and improve environmental, visual and landscape quality, identity and open space management, a wide range of tools are used. The aim of this paper is the identification and evaluation of the strategies that have been implemented in recent decades in the city of Zaragoza (Spain) and its surroundings. The analysis focuses on 12 case studies located in the Ebro River corridor, 6 upstream and 6 downstream, in order to explore the conventional and emerging urban planning and landscape instruments. Despite their 'ordinary character', these peri-urban areas have a distinct identity with important eco-cultural values. An analysis of local plans and interventions in both areas reveals the sectoral impacts and inequalities in the conservation of this particular heritage.

Keywords: urban landscapes, planning tools, territorial governance, eco-cultural assets

INTRODUCTION

Traditional peri-urban areas in European cities have historically evolved as a result of the interaction between human and natural forces. However, contemporary processes of urban expansion are transforming adjacent natural and agricultural landscapes into a complex mosaic, a palimpsest characterized by fragmentation, dispersion, voids, and a variety of land uses.

This paper raises questions related to the governance of these territories, exploring both conventional urban planning — municipal General Plans — and other emerging strategies — sectoral plans, natural or cultural protection regulations, landscape studies, etc. — in order to evaluate the adequacy of current policies on peri-urban areas.

This study is part of the research project "Peri-Urban Strategic Areas in Transformation: Eco-cultural challenges in urban regeneration processes in Spanish Cities" (PER-START), which analyses twelve peri-urban areas in six Spanish cities. The analysis of the two areas in Zaragoza developed in the PER-START project, Huerta de Las Fuentes and Ranillas-Juslibol meander (frames c-d in Figure 2), is complemented here by the study of two new zones that allow this research to extend to the peri-urban landscape along the Ebro River corridor (frames a-b). The work has been carried out in six municipalities upstream (Alagón, Bárboles, La Joyosa, Pinseque, Sobradiel, and Torres de Berrellén) and another six downstream (Alfajarín, El Burgo de Ebro, La Puebla de Alfindén, Nuez de Ebro, Pastriz, and Villafranca de Ebro). These are areas that are undergoing profound transformations with some kind of degradation process.

The geographer José Sancho Martí defined this area at the end of the eighties as follows: "The peri-urban space of Zaragoza is located in the centre of the Ebro depression; at the confluence of a series of tributary rivers […] which through their action have decisively influenced the original site of the city, the geomorphological configuration of the territory, as well as its human use from an agricultural or industrial point of view, by having acted as true axes around which the different urban manifestations are most intensely felt."27 In recent decades, these axes have developed through new infrastructural and industrial components, often outpacing urban planning, which is especially weak and diverse on the periphery, as recognized by the General Plan itself: "the peri-urban space [of Zaragoza] is being overwhelmed by the irrational and continuous growth of the city and is suffering intensely from the progressive degradation of its natural and cultural values."[28]



Figure 1. Peri-urban landscapes in the Ebro River corridor. Photo credit: authors, 2023.

METHOD

[27] "El espacio periurbano zaragozano se localiza en el centro de la depresión del Ebro; en la confluencia de una serie de ríos tributarios […] que con su acción han influido decisivamente en el primitivo emplazamiento de la ciudad, en la configuración geomorfológica del territorio, así como en su utilización humana desde el punto de vista agrario, industrial u otros usos, por haber actuado como auténticos ejes en torno a los cuales se dejan sentir con más intensidad las diferentes manifestaciones urbanas." (Sancho Martí, 1989)

[28] "El espacio periurbano [zaragozano] está siendo arrollado por el crecimiento irracional y continuado de la ciudad y sufre intensamente la degradación progresiva de sus valores naturales y culturales." (Anejo 11 del PGOUZ, 1999)

The methodology used in this research involves identifying and consulting urban planning, environmental, and project-based instruments that have been implemented in the two delimited areas over the past fifty years (1970-2020). Once all this information has been gathered, and in view of the experienced evolution, the existing strategies for the peri-urban space of Zaragoza, particularly in the 12 case studies, are analysed, compared, and finally evaluated.

The open-source software QGIS Desktop 3.28.15 has been used to generate two maps that synthesize the impact of these initiatives at a territorial scale. Thanks to this tool and the work on the data sources indicated later, it is possible to quickly locate land classifications according to all current municipal General Plans (Figure 4) and the active cultural or natural protections in the area (Figure 5).

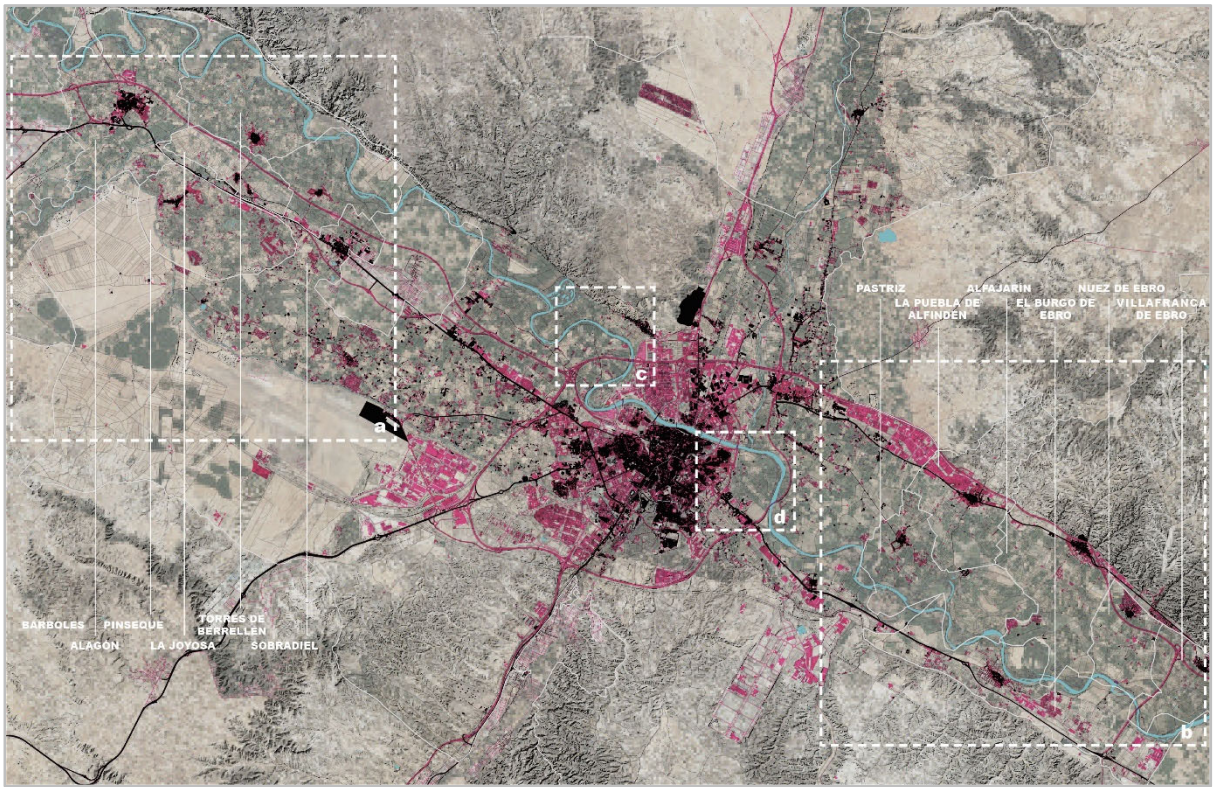

Figure 2. Urban explosion (pink) in both two areas, upstream and downstream (frames a-b). Frames c-d correspond to areas of 4x4 Km and indicate the case studies already analysed in the PER-START project. Photo credit: authors with QGIS Desktop 3.28.15 and PNOA ortophoto.

RESULTS AND DISCUSSIONS

Urban planning in the Ebro River corridor

The study area of this research encompasses 12 municipalities situated in the Ebro valley floor, whose General Plans, mostly adaptations of 'normas subsidiarias', have been drafted by different teams in each case, with the exception of 4 upstream municipalities, which were handled by the team led by Lorente.[29]

[29] PROINTEC group, PGOU Pinseque (2001). Architect J.A. Lorente Fernández, PGOU La Joyosa (2002). Architect J.A. Lorente Fernández and geographer Javier Albisu Iribe Sáez, PGOU Sobradiel (2004). Architect J.A. Lorente Fernández, geographer Javier Albisu Iribe Sáez and engineer Víctor Zorroaquino Lozano, PGOU Torres de Berrellén (2006). Architect Antonio Pla Ruestes, PGOU Utebo (2013). Architect J.A. Lorente Fernández, PGOU Bárboles (2015). Architects Daniel Olano Pérez and Alberto Mendo Martínez, PGOU Alagón (2018). Architects Eduardo Alonso Sola and Antonio Tirado Sebastián, PGOU Alfajarín (1990). MAR gruop, PGOU Pastriz (2002). Architect Antonio Fco. Núñez del Castillo and engineer Fausto Comenge Ornat, PGOU La Puebla de Alfindén (2005). Architect José Javier Ceña Lajusticia, PGOU

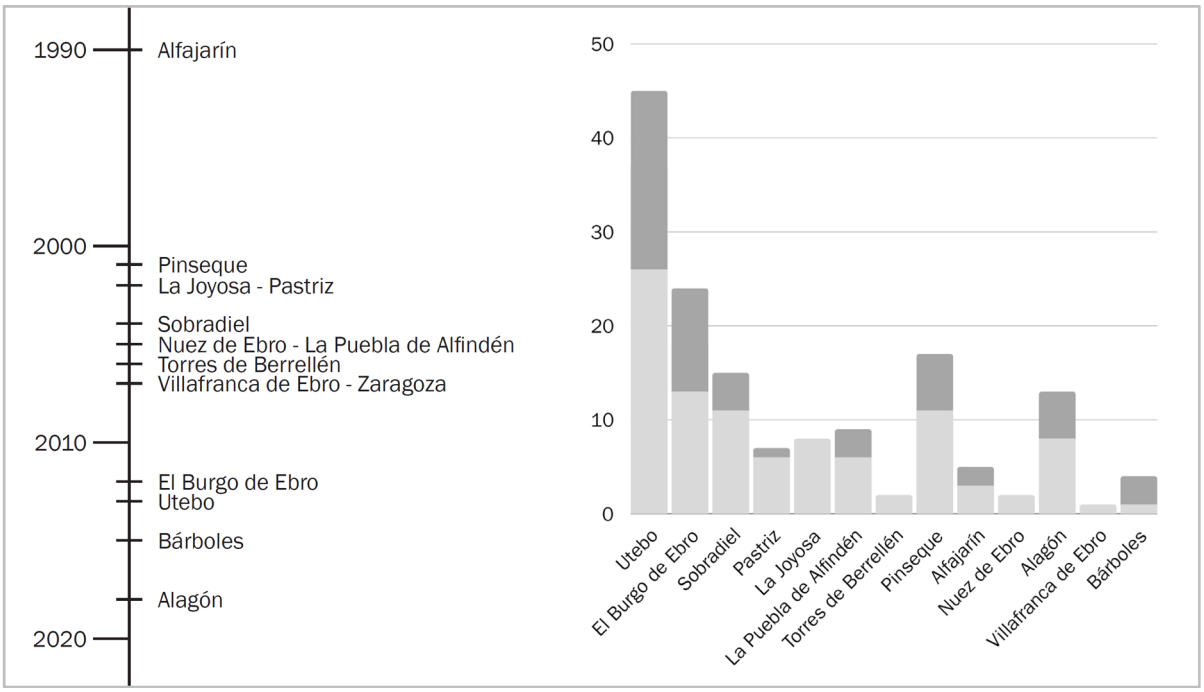

Figure 3. Left: chronology of the current General Plans in the study area. Right: record of their modifications (light gray) and developments (dark gray), ordered from the shortest to the longest distance from Zaragoza. Photo credit: authors with SIUA data. https://idearagon.aragon.es/SIUa/archivo/buscador

Two distinct groups of plans can be identified based on their general intentions. The municipalities with better accessibility from Zaragoza, and thus subjected to greater urban influence and pressure, predominantly aim for industrial development supported by the city's entry-exit infrastructure. They consider their rural origins or agricultural exploitation as part of the past. In this regard, Alagón currently plays a decisive role as the head of the Ribera Alta del Ebro region, and Figueruelas — bordering the study area to the west — acts as an attraction pole for the establishment of large industries. Downstream, La Puebla de Alfindén and Villafranca de Ebro advocate for the creation of a metropolitan area where proximity to Zaragoza becomes a real driver of economic and demographic growth.

On the other hand, the municipalities more independent from urban dynamics pay greater attention to the territorial context in which they are situated. This group includes Sobradiel, Torres de Berrellén, La Joyosa, and Bárboles, with plans drafted by the Lorente group, which show a certain willingness for coordination and continuity in preserving natural spaces along the banks of the Ebro and Jalón rivers. Among the downstream case studies, only Pastriz's plan emphasizes promoting high edaphological value irrigated cultivation and continuing to integrate with the environment through existing canals and paths.

Nuez de Ebro (2005). Architects Daniel Olano Pérez and Alberto Mendo Martínez, PGOU Villafranca de Ebro (2007). Architects Miguel Ángel Navarro Trallero and Mª de Loreto Navarro Monte, PGOU El Burgo de Ebro (2012).

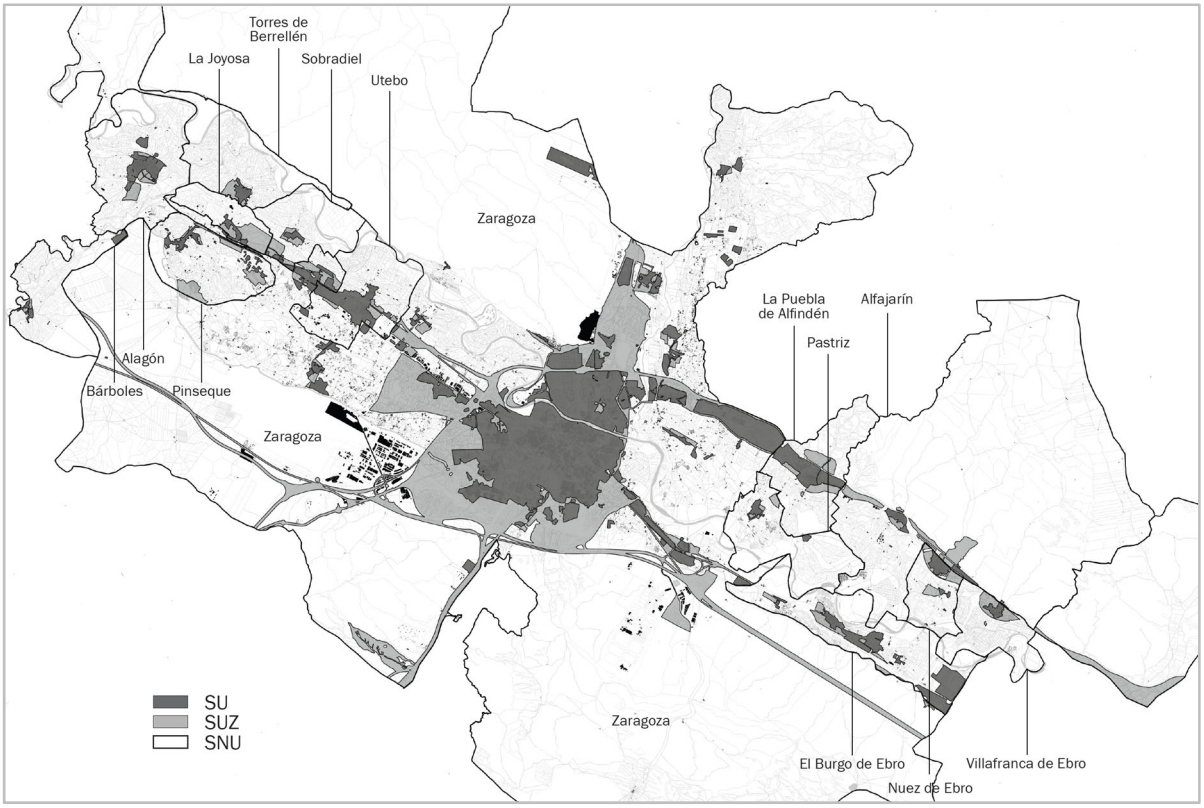

Figure 4. SU ('Suelo Urbano' or urban land, dark grey), SUZ ('Suelo Urbanizable' or developable land, light grey), and SNU ('Suelo No Urbanizable' or non-developlable land, white). Classification according to the General Planning in the study area. Photo credit: authors with QGIS Desktop 3.28.15 and ICEARAGON data.

Regarding the classification of land as non-developable, each General Plan applies its own criteria to define protections. Downstream, the continuous alignment of the Urdana canal sometimes serves as the natural boundary for non-developable land — such as in La Puebla de Alfindén before the 2015 modification, and Nuez de Ebro — while in other cases it is overlooked — such as in Alfajarín and Villafranca de Ebro — (Figure 4).

Lastly, there is an issue referenced by all the plans that affects the non-developable land on the periphery extensively: illegal subdivision of land, along with various types of constructions, irregular connections to public services, exposure to river flooding, and associated loss of crops. Regarding this conflict, each municipality adopts a different stance. Nuez de Ebro identifies and maps three major illegal subdivisions — "La Fuen", "Tozaletes", and "Contiendas" — and classifies them as SUNC (non-consolidated urban land), awaiting the subsequent drafting of a PERI (special interior reform plan) to provide them with urban services. Pastriz, on the other hand, maintains the classification of SNU (non-developable land) entirely and considers two scenarios: when illegal subdivision is included in SNU-E (non-developable land with special protection), it must follow the regulations of the natural resource management plan (PORN), and when included in SNU-G (non-developable land with generic protection), it can undertake actions to be classified as SUNC through modifications of the current General Plan and a specific PERI. Given the high number of illegal subdivisions, particularly in Pastriz, the plan includes an annex that meticulously maps and analyses all these allotments.

Other instruments in the Ebro River corridor

In addition to conventional General Planning instruments, there are several cultural and/or environmental strategies that apply to the study area and are considered in this communication.

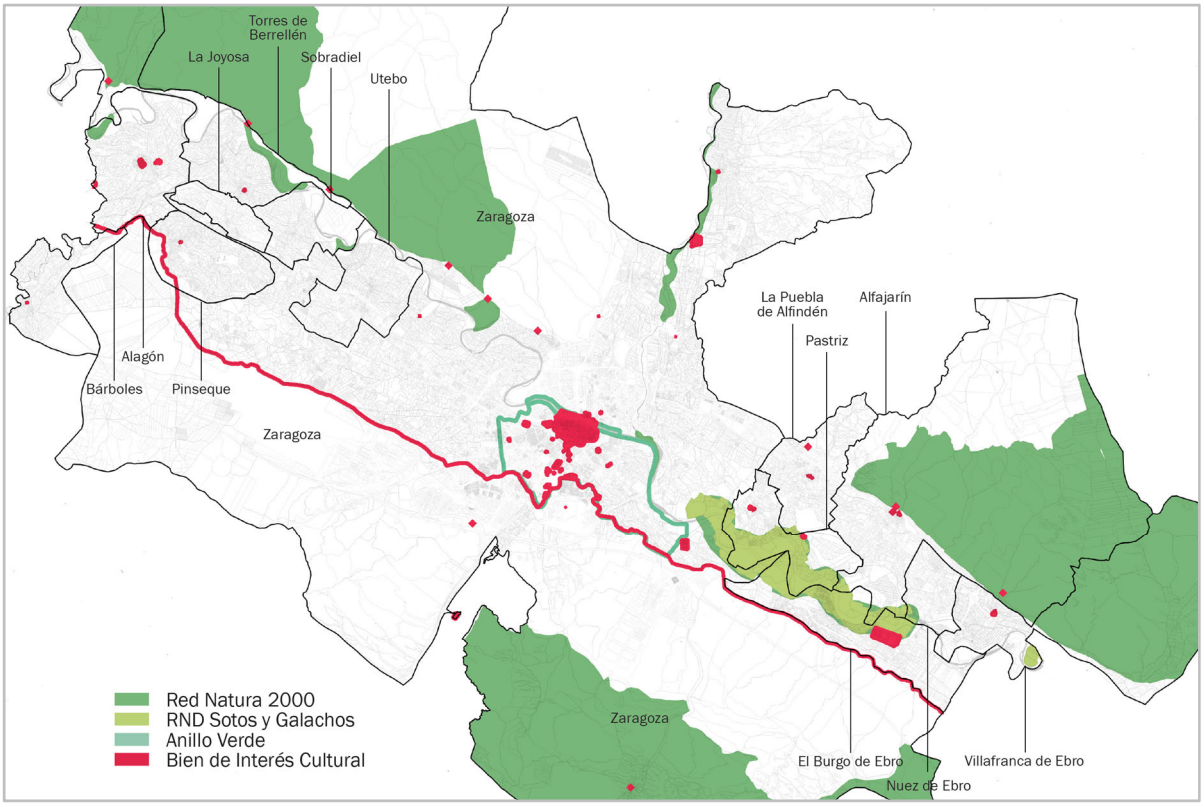

Figure 5. Figures of protection for cultural and natural heritage in the study area. Photo credit: authors with QGIS Desktop 3.28.15 and ICEARAGON data.

Firstly, as a link between the previous section and this one, the Catalogues collected from the General Plans assign different levels and conditions of protection, which are usually detailed in the corresponding 'normas urbanísticas'. Additionally, according to regional heritage legislation, 16 properties in the area are identified as assets of cultural interest (BIC). All BICs are included in the Catalogues, but not all catalogued buildings are BICs.[30]

Regarding natural heritage protection figures, it is notable the definition of the Reserva Natural Dirigida de los Sotos y Galachos del Ebro in 2011. This area, already recognized as a protected natural space in 1991, manages the river corridor environment: it carries out tasks for biodiversity conservation, cleaning, signage and trail mapping, and the promotion of interpretation centres, among other activities. It covers an area of 1,536 ha and is included in the European Natura 2000 network, where it overlaps with two Special Areas of Conservation (SAC) and one Special Protection Area for Birds (SPA). A plan for natural resource management (PORN, 2007) and a management and use plan (PRUG, 2022) have been approved for this space. Additionally, upstream, some isolated enclaves are included within the Natura 2000 network: Sites of Community Importance (SCI) near the

[30] Alagón: Iglesia de San Pedro Apóstol. Torres de Berrellén: Castillo de Pola. Utebo: Iglesia de Santa María. Sobradiel: Torre de Candespina. La Puebla de Alfindén: Castillo y Torre de la Iglesia de la Asunción. Alfajarín: Torre de Villafranca, Castillo de los Cornel, Iglesia de San Miguel Arcángel, la 'Torraza' y la 'Portaza'. Pastriz: casa-palacio del Barón Guía-Real, Iglesia de San Pedro y palacio, convento y caballerizas de La Alfranca. El Burgo de Ebro: yacimiento arqueológico 'La Cabañeta'. Villafranca de Ebro: Palacio del Marqués de Villafranca. Source: SIPCA.

Ebro, covering areas of Alagón, Torre de Berrellén, Sobradiel, and Utebo; and a large SPA in the Plana del Castellar of Torres de Berrellén.

Other environment-related and climate action instruments of European origin include the LIFE Programs.[31] For this research, two grant agreements signed in 2012 are of particular interest: Huertas LIFE Km0 and ZARAGOZA+ NATURAL. The first aims to "restore the environmental system of the peri-urban fertile soil of Zaragoza, traditionally used for cultivating fruits and vegetables and now in a state of regression"32, while the second wants to "protect, improve, enhance, understand, and publicize Zaragoza's Green Infrastructure, which includes the SCIs and SPAs, as well as the Green Belt and other areas of natural interest."33 In relation to the latter Program, the City Council had previously attempted to promote the Zaragoza Green Belt initiative, a continuous 30 km route for pedestrians and cyclists, which coincides within the study area with the GR 99 or Camino Natural de La Alfranca.

Finally, the elaboration of the Aragón Landscape Maps between 2015 and 2018 is noteworthy. These are public territorial information documents that "identify the landscapes of the different regions of Aragón, analyse their characteristics and the forces and pressures that transform them, identify their values and conservation status, and propose the landscape quality objectives that must be met."34 There is one Landscape Map for each Aragón region and, following the guidelines of the European Landscape Convention (ELC, 2000), it consists of 16 documents arranged in a logically studied sequence.[35]

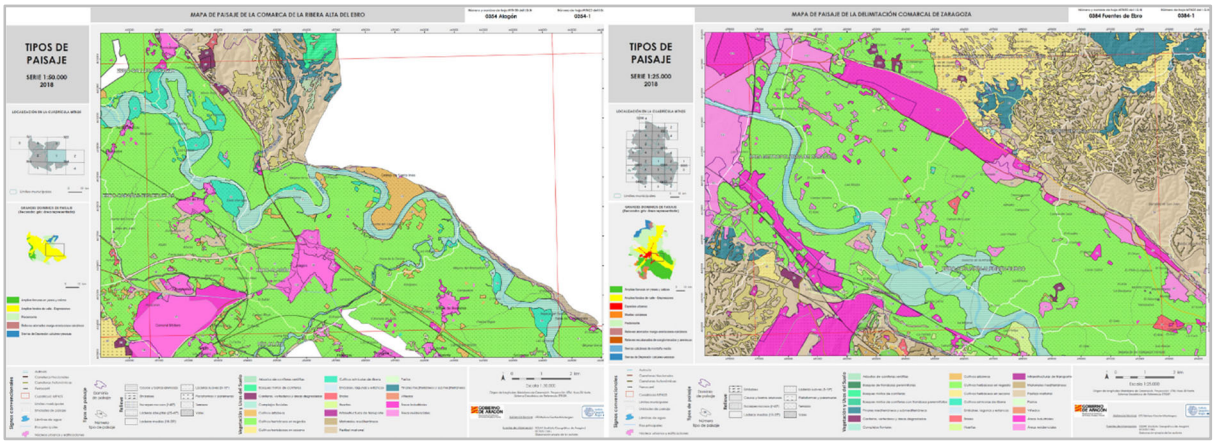

Figure 6. Documents of Landscape Types at 1:25000 scale for the Mapa de Paisaje Comarca de la Ribera Alta del Ebro (left) and Mapa de Paisaje Comarca de Zaragoza (right). Photo credit: Instituto Geográfico de Aragón and Departamento de Vertebración del Territorio, Movilidad y Vivienda, 2018.

[31] Zaragoza City Council and other local institutions have been beneficiary of the following projects: "Zaragoza: water saving city. Small steps, big solutions" between 1997 and 1998 (LIFE96 ENV/E/000509); "Zaragoza, development and demonstration of a pilot project for the development of strategies for multi-agent participation in the decision-making process" between 1998 and 2001 (LIFE98 ENV/E/000346); "Demonstration of water saving for watering uses through the experimentation of artificial intelligence integrated in traditional systems of water control" between 2003 and 2006 (LIFE03 ENV/E/000164); "Zaragoza saves paper ... and trees" between 1999 and 2002 (LIFE99 ENV/E/000371); "Environmental recovery of peri-urban areas through the intervention in the ecosystem and ecological farming. Huertas LIFE Km0" between 2013 and 2016 (LIFE12 ENV/ES/000919); "Creación, gestión y promoción de la Infraestructura Verde de Zaragoza" between 2013 and 2017 (LIFE12 ENV/ES/000567).

[32] https://www.zaragoza.es/ciudad/medioambiente/huertas/presentacion.htm

[33] https://www.zaragoza.es/ciudad/medioambiente/natural/presentacion.htm

[34] "Identifican los paisajes de las diferentes zonas del territorio aragonés, analizan sus características y las fuerzas y presiones que los transforman, identifican sus valores y estado de conservación, y proponen los objetivos de calidad paisajística que deben cumplir." (Gobierno de Aragón, 2015, 33).

[35] Landscape unities, landscape types, landscape shaping processes, negative impacts, unique elements, visibility, quality, fragility, suitability, social valuation, foresight, quality objectives, management proposals, routes of landscape interest, integration, and summary report.

Projects in the Ebro River corridor

Most projects on non-developable land consist of maintenance or improvement works along the riverbanks, rural roads, remnants of irrigation canals, old public washhouses and mills, or other municipal properties in a state of abandonment or ruin. These small-scale local works are mostly financed by the Diputación General de Aragón through the unified subsidy plan (PLUS) program, which has been operational since 2017. Most municipalities allocate these funds "to improve basic services such as street paving, water supply or sewerage, and also note an increase in requests for sports facilities and for building, rehabilitating, or equipping municipal housing to attract new residents."[36]

Notable cases include, for example, the project promoted by Zaragoza Ecuestre in 2006 to build an equestrian centre in the 'paraje Vicentón', belonging to La Puebla de Alfindén and very close to the Pastriz border. Due to objections from the latter, this project was abandoned and today it stands as a sort of 43,000 m² rubble dump in the irrigated area. Upstream, there is the project to develop a tree-lined pedestrian walkway on the left bank of the Almozara canal, which crosses the areas of La Joyosa and Sobradiel. However, this initiative also remained incomplete due to a lack of agreement between the involved municipalities and the absence of continuity in public offices.

More recently, disagreements between neighbours, property owners, environmental entities, political factions, and developers have made headlines regarding the implementation and regulation of renewable energy plants on the peri-urban 'huerta' (orchard). In particular, Movera faces strong pressure and a convergence of interests, with more than five ongoing projects for the installation of photovoltaic parks, some of which already have favourable urban compatibility certificates, environmental impact declarations, and administrative authorizations. These areas, close to the industrial development of Malpica and the A-2, have also been proposed in recent months for the establishment of large-scale regional projects, such as a new logistics hub (with large areas for companies like Inditex or Lapesa) or a future industrial complex named the Ebro valley agri-food logistics centre (CLAVE).

CONCLUSIONS

The following common features have been identified from the study and comparison of the General Planning of the analysed municipalities:

- Strong land demands in the municipalities most accessible from Zaragoza to accommodate new infrastructures and peri-urban uses, facilities or structures that are difficult to integrate into the urban fabric.

- Discontinuities in the classification, protection regime of non-developable land, and methods for regularizing illegal subdivision due to the lack of an integrated vision of the peri-urban area at a territorial scale.

- A passive protection regime, based on 'freezing' rural and riverside areas, lacking management plans, improvements, or enhancement efforts. Inaction in the face of abandonment and degradation of heritage and traditional agricultural activities. These plans

[36] "para mejorar servicios básicos como la pavimentación de calles, el abastecimiento o el alcantarillado y también destaca el aumento en las peticiones para instalaciones deportivas y para construir, rehabilitar o equipar viviendas municipales que sirvan para atraer nuevos pobladores." https://www.dpz.es/noticias/la-diputacion-de-zaragoza-aprueba-el-plan-unificado-de-subvenciones-2024-50-millones-de-euros-para-que-los-292-municipios-de-la-provincia-hagan-1-287-actuaciones-de-todo-tipo-1

usually contain much information about the local community's physical environment, but are rather descriptive, with less space devoted to efficient planning tools.

- Lack of coordination in the protections over special non-developable land (Table 1) and weak control over generic non-developable land. For example, El Burgo de Ebro rigorously defines protection guidelines for areas of cultural-archaeological interest — considering the number of sites included in the area —, livestock trails — including a study of the five main ones —, and infrastructure — many of which are recently constructed —. However, it neglects the presence of irrigation canals, or the zoning of spaces protected at the European level.

- Unequal references to other sectoral regulations such as natural resource management plans, sectoral guidelines on livestock activities and installations, or existing legislation on various elements that appear in the peri-urban landscape — power lines, roads, railways, industry, and extractive activities — especially regarding the definition of zones of impact and easement applicable to the area.

Table 1. Summary table of protections in Non-Developable Special Land as defined according to the General Planning in the study area. Credit: authors with SIUA data.

Municipality	Declared spaces	Ecological interest	Cultural-archaeological interest	Drylands	Irrigated land	Livestock trails	Rural roads	Irrigation canals	Public watercourses	Infrastructure
Alagón	X	X			X	X	X	X	X	X
Bárboles		X	X	X	X	X	X	X	X	X
La Joyosa					X	X	X	X		X
Pinseque				X	X	X	X	X		X
Sobradiel	X	X			X		X	X	X	X
Torres	X	X			X	X	X	X	X	X
Alfajarín										
El Burgo			X	X	X	X			X	X
La Puebla			X			X				X
Nuez									X	X
Pastriz	X	X					X	X		
Villafranca	X	X	X			X	X		X	X

The following conclusions can be drawn from the study and comparison of the strategies implemented in the analysed municipalities:

- Limited dissemination regarding the protection of buildings of interest and other elements in each municipal area. Without management aimed at activating peri-urban, natural, or cultural heritage, much of the local population is unaware of or does not recognize its value.

- The declaration of the Aragonese section of the Imperial Canal as a BIC is still pending resolution since the initiation of its file in the year 2000. Currently, a visit to the site shows deterioration in the crossings between its banks — Puente del Jubo in Pinseque, Puente del Camino in Alagón — and in the adjacent buildings — Almenara de Santa Emilia in Pinseque, or Almenara de San Martín in Grisén —.

- In retrospect, the efforts of HUERTAS LIFE to promote organic farming in Zaragoza's peri-urban 'huerta' have not been consolidated: the LIFE Km0 Market Garden Network only grouped 27 local farmers, and the municipal farm of Torre de Santa Engracia (Movera), conditioned as

Parcela Cero and as the Km0 Agricultural School, only hosted 21 students during the two training cycles held before being abandoned. On the other hand, this Program has left valuable publications such as “Diagnóstico de la Huerta de Zaragoza” (2014), “Planimetría de la Huerta de Zaragoza” (2014), and the book “Patrimonio Hidráulico en la Huerta de Zaragoza” (Rivas, 2017).

- ZARAGOZA+ NATURAL has been more fruitful, successfully promoting the drafting of several plans: management plan for the Barranco de Las Almunias, Zaragoza Natural action and tourism promotion plan, special plan for the protection of the Vedado de Peñaflor (2014), management plan for Monte de Torrero (2014), special plan for the Estepa (2016), and the Green Infrastructure Master Plan (2017).[37]

- The Green Belt has not been fully completed. It is still interrupted around the Delicias intermodal station, with an eastern closure too far from the city centre.



Figure 7. Almenara de Santiago Apóstol of the Imperial Canal as it passes through Pedrola in a state of deterioration. Photo credit: Miguel Ángel Laurenzana, 2022. Parcela Cero on the Movera-Pastriz road, abandoned after its initial boost by the Huertas LIFE Km0 in 2015. Photo credit: Cecilia Sanz, 2023.

The following conclusions can be drawn from the study and comparison of the projects supported in the analysed municipalities:

- The lack of agreement among the various stakeholders interested in peri-urban land often results in projects never being realized or remaining unfinished.

- Actions on non-developable land are limited to the improvement of urban services. Since these measures depend on various factors such as the sensitivity of the municipal team, their continuity over time, or the economic availability of the municipalities, projects aimed at peripheral areas, or the natural surroundings are rarely implemented.

[37] This Program also promoted ecological improvement actions on the banks of the Gállego River and signage operations through panels and brochures in the River Corridors of the Ebro, Gállego, and Huerva, and in the alluvial dolines of the municipality. Additionally, several documents were published regarding the groves and banks of the Ebro (2014): proposals for 21 itineraries, ecological valuation sheets, studies on the evolution of the river channel…



Figure 8. Balsa de la Marlofa (La Joyosa) undergoing conditioning works. Photo credit: Miguel Ángel Laurenzana, 2019. Abandoned structure for the equestrian project (La Puebla de Alfindén). Photo credit: Heraldo de Aragón, 2016.

Ultimately, the persistence of biodiversity loss and degradation processes is confirmed. It is evident that the proliferation and overlapping of regulations and instruments of all kinds do not guarantee adequate preservation, much less the revitalization of peri-urban landscapes. Although some strategies have worked well, particularly those aimed at the natural protection of exceptional sites with heritage value, the application of protection and revitalization instruments is insufficient, especially in ordinary landscapes, including peri-urban ones. In addition to the renewal of advanced intervention strategies and instruments, it is clear that reversing these processes requires greater awareness of the eco-cultural values of these peri-urban landscapes.

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Exploring the impact of urban form on social dynamics in Quintas within the Historic Center of Lima: a comparative study before and after COVID-19

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ABSTRACT

This study delves into the intricate relationship between urban form and social dynamics in quintas within the Historic Center of Lima, focusing on pre and post-COVID-19 periods. The goal is to comprehend how the layout of these historical neighborhoods influences daily interactions, providing insights for urban planners, architects, and community members seeking to enhance living spaces in this culturally significant area. Emphasizing the impact of the pandemic, the primary objective is to understand the connections between the urban form of quintas in the Historic Center of Lima and inhabitants' dynamics.

Objectives encompass researching space utilization patterns, assessing social interactions, and gauging resident satisfaction with design elements in this historic context. Using a multi-faceted approach, the study integrates direct observations, surveys, interviews, and a review of previous research. Observations capture daily activities and traffic flow within the quintas, both pre and post-COVID-19. Surveys and interviews gather subjective perspectives on how urban form impacts experiences and interactions, considering the evolving needs and behaviors of residents during the pandemic.

Preliminary findings reveal discernible patterns in space utilization, with specific aspects of urban form influencing social interactions within the quintas of the Historic Center of Lima. Residents express varying satisfaction levels with communal spaces and neighborhood layout, emphasizing the unique historical context and evolving dynamics post-COVID-19. This study aims to illuminate the complex interplay between urban form and social dynamics in quintas within the Historic Center of Lima, offering opportunities for informed urban planning improvements that respond to the changing needs and behaviors of residents after the pandemic.

The case study involves two quintas in Lima, representing distinct moments in the city's urban form creation. The research underscores the importance of adapting urban planning strategies to foster resilient and responsive communities that honor historical context while addressing contemporary challenges.

Keywords: quintas, social dynamics, neighborhoods, covid 19

INTRODUCTION

Urban form plays a pivotal role in shaping social dynamics within residential environments. This relationship becomes especially evident in compact, historically dense residential typologies, such as quintas, which are commonly found in the Historic Center of Lima. Quintas are characterized by their narrow pathways, shared courtyards, and the compact arrangement of housing units, resulting in spatial conditions that necessitate social interaction among residents. The COVID-19 pandemic, however, brought about significant disruptions to daily life, particularly in spaces where social proximity is unavoidable, raising questions about the adaptability of these urban forms in a post-pandemic world.

This research examines how the urban form of quintas has influenced social behavior, focusing on the comparative periods before and after the COVID-19 pandemic. Specifically, it seeks to answer the following research question: How has the urban form of quintas in Lima affected social interactions, community cohesion, and the use of shared spaces, particularly in response to the changes brought about by COVID-19?



Figure 1. Quinta in the historic center of Lima. El Comercio News.

The objectives of this study are threefold: (1) to analyze the morphology and physical characteristics of selected quintas in Lima's Historic Center, (2) to explore the social dynamics and interactions within these quintas, and (3) to compare how the urban form has influenced the use of communal and private spaces before and after the pandemic. By focusing on two case studies—Quinta Los Huérfanos and Quinta Baselli—this research will offer insights into how historical urban forms can adapt to modern challenges, particularly in terms of fostering social interactions while maintaining public health measures.

The findings of this study will provide valuable contributions to the fields of urban planning, architecture, and social theory, particularly concerning the resilience of historical residential forms in the face of unprecedented global challenges such as the COVID-19 pandemic.

Research problem and objectives

This research investigates how the urban form of quintas—defined by their dense spatial layout, narrow pathways, and limited public spaces—affects socio-spatial dynamics, particularly regarding social interaction, community cohesion, privacy, and access to shared spaces in these compact residential environments.

Main objectives:

- Analyze the morphology and physical characteristics of the selected quintas, considering changes before and after the COVID-19 pandemic.
- Explore the social dynamics and coexistence within these quintas, with a focus on how these dynamics have shifted due to the pandemic.
- Compare how urban form influences the use of common and private spaces, assessing differences in spatial usage before and after COVID-19.

Conceptual framework

To analyze the relationship between urban form and social dynamics in Lima's quintas, this research draws on key theoretical frameworks that examine the interplay between the built environment and human behavior. Two foundational theories guide this study: Amos Rapoport's theory of the built environment and social behavior, and Christian Norberg-Schulz's phenomenological approach to the sense of place. These frameworks provide a comprehensive understanding of how spatial arrangements influence social interactions and emotional connections to the environment.

Conceptual Framework

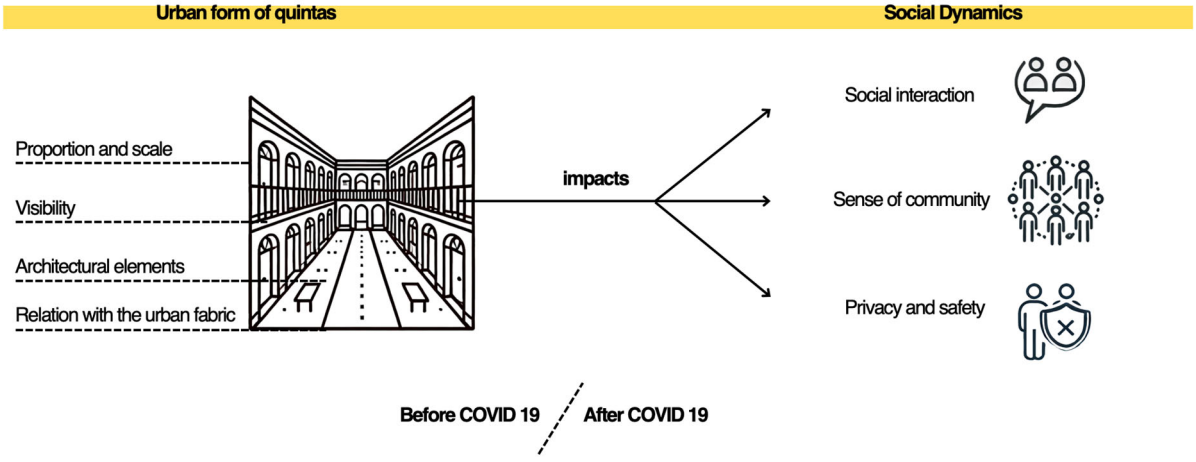

Figure 2. Conceptual framework as a conclusion from the literature review. *Own elaboration, 2024.*

Amos Rapoport – built environment and social behavior (1977)

Amos Rapoport's theory posits that the physical characteristics of a built environment, including its spatial organization, proportions, and the arrangement of public and private spaces, profoundly influence how people behave and interact within that space. Rapoport emphasizes the importance of spatial hierarchy, which refers to the gradation between public, semi-public, and private spaces. This hierarchy directly impacts the frequency and nature of social interactions within a given environment.

In the case of quintas, the dense spatial layout and narrow pathways create a setting where semi-public spaces, such as courtyards and corridors, serve as extensions of private spaces, leading to frequent interactions between neighbors. However, the **proportions and scale** of these spaces are critical. If communal spaces are too small or poorly designed, they can discourage social engagement, leading to a reduction in interaction and community cohesion. Conversely, appropriately scaled spaces can facilitate casual encounters and foster a sense of belonging among residents.

Additionally, visibility and access play a crucial role in shaping social dynamics. Communal spaces that are easily accessible and visible from private areas—such as corridors that face onto shared courtyards—encourage informal surveillance and interaction. In the context of this research, Rapoport's theory will help to assess how the spatial design of the quintas influences social behavior, particularly in light of the changes imposed by COVID-19. The pandemic has heightened awareness of personal space and health safety, making the role of spatial hierarchy even more critical in understanding post-COVID social dynamics.

Christian Norberg-Schulz – phenomenology and sense of place (1980)

Christian Norberg-Schulz's phenomenological approach to architecture focuses on the emotional and existential experience of space, particularly how the design of a space creates a sense of place. According to Norberg-Schulz, architecture does more than provide shelter; it shapes how individuals feel and interact within their environment. The built form can evoke feelings of belonging, safety, and connection, or, conversely, alienation and discomfort.

In the context of Lima's quintas, the concept of sense of place is particularly relevant. The communal spaces within quintas, such as shared courtyards and pathways, are not just functional areas but also social spaces that contribute to residents' emotional connection to their environment. Before the pandemic, these spaces fostered social cohesion by providing areas for informal gatherings and casual interactions. However, as the pandemic introduced new health risks, these same spaces may have become sources of anxiety and discomfort, altering the residents' emotional attachment to the place.

Norberg-Schulz also highlights the importance of architectural elements, such as proportions, visibility, and openness, in creating environments that support social interaction. In the case of Quinta Baselli, for example, the architectural layout may have continued to support social interactions even during the pandemic, as residents found ways to maintain a connection to the space despite health concerns. In contrast, in Quinta Los Huérfanos, the emotional detachment from the communal spaces may have contributed to social isolation during the pandemic. By applying Norberg-Schulz's theory, this research aims to explore how the emotional and cultural significance of space influences social behavior in the quintas, particularly in response to the disruptions caused by COVID-19.

Independent Variables (Architectural Features)	Description	Indicators
Proportions and Scale	Refers to the dimensions (height, width, and depth) of communal spaces like courtyards, pathways, and corridors, which can influence how residents perceive and use these spaces. Larger proportions may facilitate social gatherings, while confined spaces could restrict interaction.	Proportions of communal spaces like courtyards and pathways (height, width, depth) and their effect on social behavior.
Visibility and Sightlines	How well communal spaces are visible from windows, doors, or other vantage points. Greater visibility might promote a sense of safety or encourage social interaction, while limited visibility could lead to more privacy or social isolation.	Visibility from windows, doors, and pathways, and its impact on residents' sense of safety and connection.
Architectural Elements (Windows, Doors, Materials)	Focuses on the size, placement, and materials of key architectural components like doors and windows. These elements can affect residents' comfort, interaction, and security by shaping how they connect with their environment and with each other.	Placement and size of windows and doors, as well as how material choices affect comfort and interaction.
Dependent Variables (Social Dynamics)		**Indicators**
Social Interaction	Refers to the frequency and type of interactions among residents in communal spaces. This variable looks at how often residents engage in conversations or social activities and how these behaviors have changed before and after the pandemic.	Frequency and type of social interactions before and after COVID-19 through observations and interviews.
Sense of Community	Represents residents feelings of belonging and emotional connection to their neighbors and communal spaces. This variable examines how architectural features contribute to fostering or weakening the sense of community within a neighborhood.	Residents sense of belonging and community connection by examining how architectural features influenced emotional and social experiences.
Privacy and Safety	Refers to residents perceptions of their privacy and safety in communal and semi-private spaces. Architectural elements like windows, doors, and proportions can either support or hinder the feeling of security and personal space.	Residents perception of privacy and safety changed based on architectural features like visibility, space proportions, and materials.

Figure 3. Operationalization. Own elaboration, 2024.

METHOD

This chapter outlines the methodological framework employed to explore how the urban form of quintas in Lima's Historic Center influences social dynamics, focusing particularly on the shifts that occurred before and after the COVID-19 pandemic. The methodology integrates qualitative research methods, utilizing case studies to provide an in-depth understanding of both the spatial characteristics of quintas and their social outcomes. By employing observations, interviews, and architectural analysis, this study captures the complexities of communal living in two distinct historical quintas: Quinta Los Huérfanos and Quinta Baselli.



Figure 4. Quinta Baselli and Quinta Huerfanos, historic center of Lima. PROLIMA archive.

Research design

The research employs a qualitative case-study approach to allow for a detailed examination of the complex interactions between urban form and social behavior. This approach is particularly suitable for exploring the dynamics within small, contained environments such as quintas, where a range of social interactions and spatial variables coexist in a single physical setting.

The use of case studies allows for the examination of both social phenomena (e.g., interaction frequency, community cohesion, privacy) and architectural features (e.g., layout, proportions, visibility). This methodology provides an opportunity to study the quintas holistically, considering how

residents engage with their built environment both before and after the pandemic. By comparing the two case studies—Quinta Los Huérfanos and Quinta Baselli—the research identifies how urban form can produce varied social outcomes in similar architectural settings.

The qualitative nature of the study enables the collection of rich, descriptive data, which is essential for understanding the nuances of social interactions within these historical urban forms. This research design ensures that the complex relationship between architecture and social behavior is captured, providing insights that are both context-specific and potentially generalizable to other historical residential environments.

Data collection methods

The research relies on three primary methods of data collection: observations, semi-structured interviews, and architectural analysis. Each method plays a complementary role in building a comprehensive picture of how the quintas' physical form influences social dynamics.

Observations

Observational research was conducted to record the spatial use of communal areas such as courtyards, corridors, and entryways in both quintas. Observations were made before the pandemic (when possible, from resident accounts) and after, allowing for a comparative analysis of social behavior across these periods. The researcher observed both day-to-day interactions and special events in the quintas, noting changes in spatial use and resident behaviors.

Key aspects of observation included:

- Patterns of movement: How residents moved through and occupied communal spaces.
- Frequency of interaction: How often residents engaged in informal or formal gatherings.
- Modifications in use of space: Changes in how residents used courtyards or corridors before and after the pandemic, including avoidance or adaptation for social distancing.
- Space appropriation: How communal spaces were personalized or used by specific groups of residents, for example, in decorating or maintaining areas.

These observations were supplemented by photographic documentation and field notes, capturing the physical characteristics of the communal areas and how they were inhabited by residents.

Interviews

Semi-structured interviews were conducted with a diverse group of residents from both quintas. The semi-structured format allowed for flexibility, enabling the researcher to explore key themes while adapting the conversation based on residents' personal experiences. The interviews provided qualitative insights into how residents perceived the built environment, particularly how they navigated communal spaces and how their social interactions were affected by the pandemic.

The interview guide was structured around the following key topics:

- Perceptions of community and interaction: How often residents interacted with neighbors and the nature of these interactions.
- Use of communal spaces: How residents utilized courtyards, pathways, and other shared areas.
- Impact of COVID-19: How the pandemic altered their use of communal spaces and affected their sense of privacy and safety.
- Architectural influence on behavior: How elements such as the layout, lighting, and visibility of communal areas affected their social behavior and feelings of community.

Interview data were transcribed and coded using thematic analysis to identify common patterns and unique perspectives. By coding for key themes such as community cohesion, privacy, and social isolation, the study was able to draw connections between architectural features and social outcomes.

Architectural Analysis

The architectural analysis focused on the physical layout and design features of each quinta, including the spatial distribution of units, the size and accessibility of communal spaces, and specific architectural elements such as windows, doors, and pathways. This analysis was essential for understanding how the built environment facilitated or hindered social interactions.

Measurements were taken of key spaces to determine the proportions of communal areas relative to the number of residents, as well as the visibility between private and public spaces. The analysis also assessed the condition of materials, including whether the communal areas were well-maintained or deteriorating. This helped to identify whether the physical state of the space influenced residents' willingness to use it.

The analysis drew on the theoretical frameworks of Amos Rapoport and Christian Norberg-Schulz, which were used to interpret how specific spatial features influenced residents' sense of place and social behavior. By examining how residents interacted with these spaces, the study linked the architectural elements of the quintas to broader social outcomes.

Selection of Case Studies

The decision to focus on Quinta Los Huérfanos and Quinta Baselli was made based on their contrasting social outcomes despite their similar architectural characteristics. Both quintas are located within the same historical district and exhibit similar layouts, yet the social behavior within them diverged significantly in response to the pandemic.

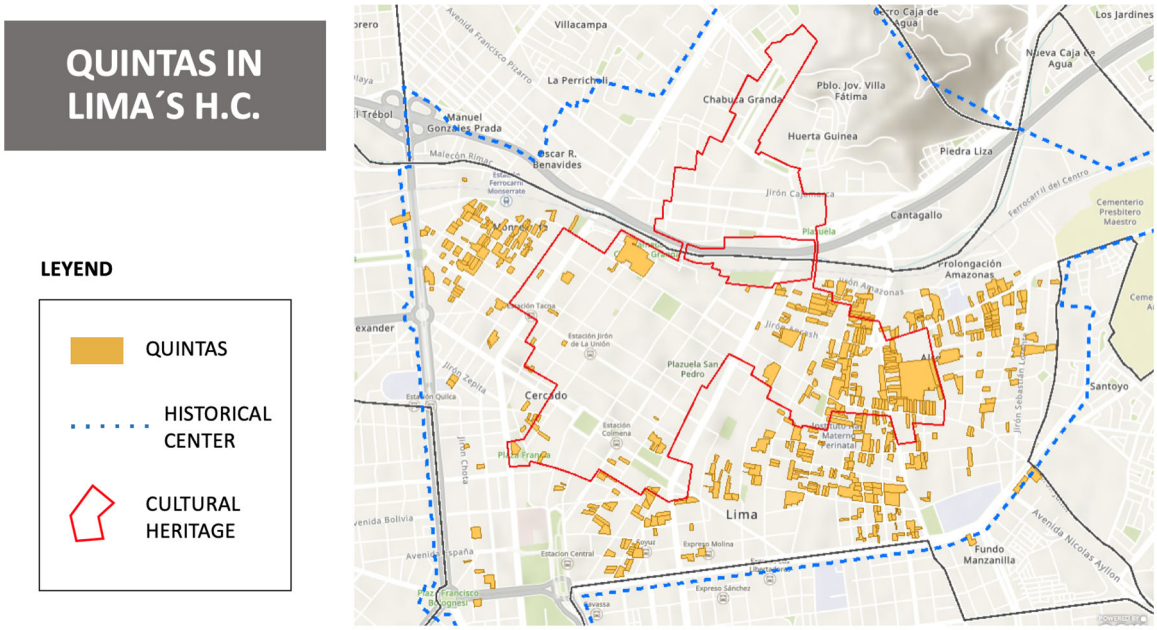

Figure 5. Quintas in Lima historic Center. PROLIMA archive.

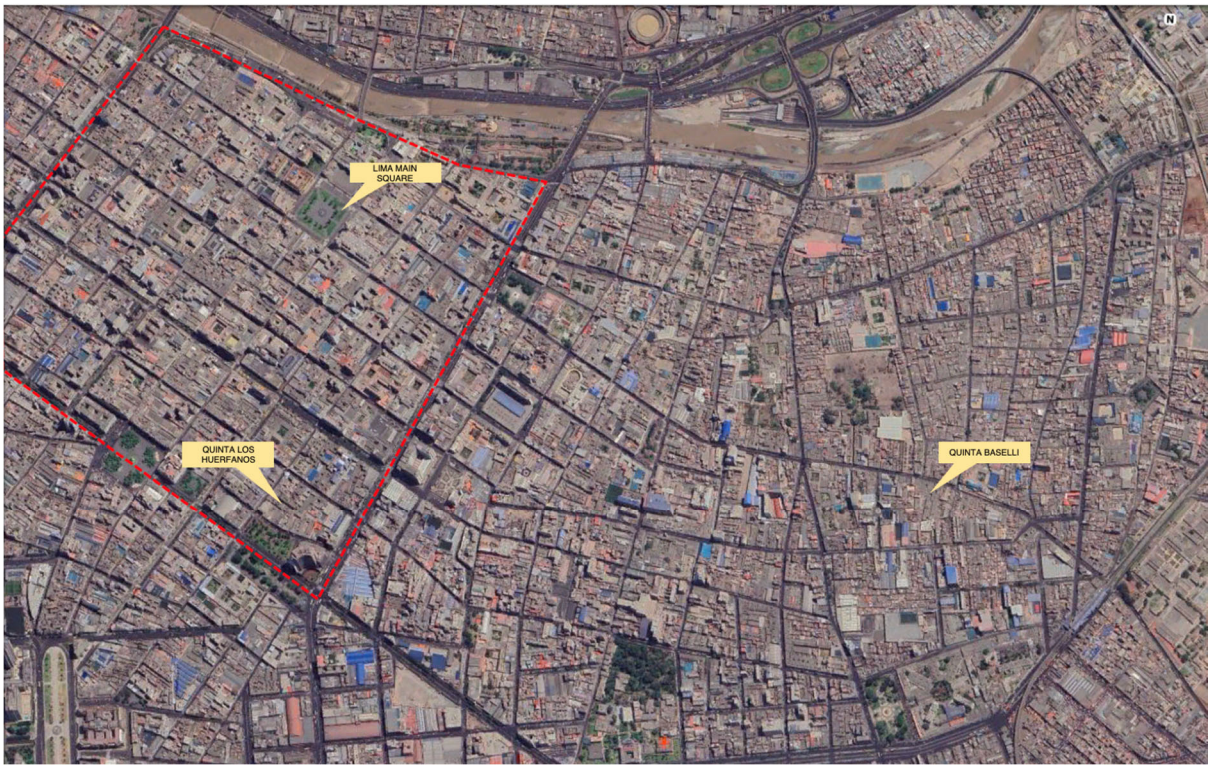

Figure 6. Location of Quintas in Lima historic Center. Own elaboration.

Quinta Los Huérfanos was selected because it exemplified a decline in social cohesion after the pandemic, with residents becoming more isolated due to health concerns and changes in spatial use. Quinta Baselli, on the other hand, was chosen because it exhibited resilience and adaptability, with residents continuing to engage in social interactions and even organizing collective efforts to improve the communal spaces during the pandemic.

These contrasting outcomes made the quintas ideal for a comparative analysis, allowing the research to explore how similar urban forms can produce different social dynamics depending on how they are inhabited and adapted by their residents.



Figure 7. Quinta Los Huerfanos,, 2024. Personal Archive.



Figure 8. Quinta Baselli, 2021. PROLIMA Archive.

Data analysis

The data from the observations, interviews, and architectural analysis were analyzed using a combination of thematic analysis and comparative case-study analysis.

- Thematic analysis: This method was used to identify and categorize key themes that emerged from the interviews and observations, such as privacy concerns, social distancing practices, use of communal spaces, and community initiatives. The themes were coded and grouped to allow for comparisons between the two quintas.

- Comparative case-study analysis: This approach enabled the research to systematically compare the findings from each quinta, drawing attention to the ways in which urban form and resident behaviors influenced social outcomes. By comparing the pre- and post-COVID-19 periods, the analysis was able to highlight how changes in spatial use and interaction patterns differed between the two quintas.

Findings and discussions

This section explores how the **independent variables**—the architectural features of quintas, such as **proportions and scale**, **visibility**, and **architectural elements**—affect the **dependent variables**—the social dynamics of **social interaction**, **sense of community**, and **privacy and safety**. These relationships are analyzed through observations and interviews conducted in **Quinta Los Huérfanos** and **Quinta Baselli**. Each architectural feature influences specific social outcomes, as detailed below.

Independent variables (architectural features)

Proportions and Scale

Proportions and scale refer to the dimensions (height, width, and depth) of communal spaces such as courtyards and pathways. These proportions influence how residents perceive and use these spaces, with larger areas often facilitating social gatherings and smaller areas potentially restricting interaction.

In Quinta Los Huérfanos, the communal courtyard is relatively small and confined. Before the pandemic, this space was sufficient for informal gatherings, but after the outbreak of COVID-19, residents found it too cramped to maintain social distancing, which led to a significant reduction in its use.

One resident noted: *"The courtyard is just too small now. We don't feel comfortable meeting there because we can't keep a safe distance."* (Interview 2, Quinta Los Huérfanos)

In contrast, Quinta Baselli has a larger communal courtyard, which allowed for continued, though limited, social interaction during the pandemic. The increased size of the space enabled residents to maintain distance while still using the area for small gatherings.

A resident from Quinta Baselli explained: *"We've been able to use the courtyard safely because there's enough space to spread out."* (Interview 7, Quinta Baselli)

The findings highlight that larger proportions in communal spaces provide flexibility for social interaction, even during periods of restricted mobility, while smaller, confined spaces can limit such interactions, particularly during a public health crisis.

Visibility and sightlines

The visibility of communal spaces from individual units, such as through windows and doors, plays a significant role in shaping social interactions and perceptions of safety. Higher visibility allows residents to engage in passive surveillance, enhancing their sense of security while promoting informal interactions.

In Quinta Los Huérfanos, visibility between the private and communal spaces is limited. Residents often keep their windows and doors closed for privacy, which reduces the opportunities for casual exchanges and informal social monitoring. This limited visibility has further contributed to the reduction in social interaction post-pandemic.

One resident remarked: *"We don't see much of what's happening in the courtyard anymore because most people keep their windows shut."* (Interview 4, Quinta Los Huérfanos)

On the other hand, Quinta Baselli benefits from higher visibility, with windows and doors that face the courtyard, allowing residents to keep an eye on communal activities and engage in informal conversations without having to leave their homes. This layout facilitated continued interaction during the pandemic, even when physical gatherings were restricted.

A resident explained: *"We can see each other through our windows, so even when we can't meet in person, we still greet each other and keep in touch."* (Interview 9, Quinta Baselli)

The findings indicate that high visibility promotes both a sense of safety and informal social interactions, while limited visibility can contribute to social isolation and a reduction in community cohesion.

Architectural elements (windows, doors, materials)

The placement, size, and materials of windows, doors, and other architectural elements influence residents' ability to interact with their environment and each other. These elements can either facilitate or hinder social engagement, depending on how they are designed.

In Quinta Los Huérfanos, the architectural elements were designed to prioritize privacy, but this has also reduced the opportunities for spontaneous interaction. Residents reported that while the closed-off design provided a sense of security, it also made them feel more isolated during the pandemic, as they could no longer engage in the informal exchanges they were used to.

One resident stated: *"Our windows and doors are great for privacy, but now we feel more disconnected because we don't talk as much as we used to."* (Interview 5, Quinta Los Huérfanos)

In Quinta Baselli, the architectural elements strike a better balance between privacy and interaction. The placement of doors and windows allows for casual communication between neighbors, even when residents are inside their homes. This layout helped maintain a sense of community during the pandemic, as residents could engage in informal conversations without the need for face-to-face meetings.

A resident shared: *"The windows and doors are well-placed, so we can still chat with our neighbors, even from a distance."* (Interview 10, Quinta Baselli)

The findings suggest that architectural elements that prioritize privacy can inadvertently reduce social engagement, while elements that allow for informal interaction help to maintain community connections.

Dependent variables (social dynamics)

Social interaction

Social interaction refers to the frequency and type of interactions that occur among residents in communal spaces. The architectural features of the quintas play a crucial role in either facilitating or hindering these interactions.

In Quinta Los Huérfanos, the confined proportions of the communal spaces and limited visibility from individual units led to a significant reduction in social interaction, especially after the outbreak of COVID-19. Residents reported feeling uncomfortable gathering in the courtyard due to its small size and lack of sufficient spatial separation.

A resident noted: *"We don't interact as much anymore because the courtyard is too small for us to gather safely."* (Interview 3, Quinta Los Huérfanos)

In contrast, Quinta Baselli experienced a more moderate decline in social interaction. The larger courtyard, combined with the high visibility of communal spaces from individual units, allowed residents to continue engaging in informal exchanges, even during periods of social distancing.

A resident explained: *"We still greet each other from our windows and doors, so we haven't lost that sense of connection."* (Interview 9, Quinta Baselli)

These findings illustrate that larger, well-designed communal spaces with good visibility are better able to support social interaction, even during periods of restricted mobility.

Sense of community

The sense of community reflects residents' feelings of belonging and emotional connection to their neighbors and communal spaces. Architectural features that encourage interaction and visibility can help strengthen this sense of community, while features that prioritize privacy may weaken it.

In Quinta Los Huérfanos, the sense of community was significantly weakened during the pandemic. The reduced use of communal spaces and the closed-off design of windows and doors contributed to residents feeling more isolated from their neighbors.

A resident shared: *"We used to feel like a close-knit community, but now, with the pandemic, everyone is more withdrawn."* (Interview 4, Quinta Los Huérfanos)

In Quinta Baselli, the sense of community remained strong despite the challenges posed by the pandemic. The architectural features that allowed for informal interaction, combined with the residents' continued use of the courtyard, helped maintain a sense of connection and belonging.

One resident remarked: *"Even though things have changed, we still feel like a community because we can interact with each other in small ways."* (Interview 10, Quinta Baselli)

The findings indicate that architectural features that promote interaction help to foster a strong sense of community, while features that prioritize privacy may hinder the development of these connections.

Privacy and safety

Privacy and safety refer to residents' perceptions of their privacy and physical safety in communal and semi-private spaces. Architectural elements such as windows, doors, and proportions can either support or hinder these feelings.

In Quinta Los Huérfanos, the confined communal spaces and limited visibility reduced residents' sense of safety. The lack of spatial separation made it difficult for residents to feel secure in communal areas, leading to a decline in their use.

One resident expressed: *"I don't feel safe using the courtyard anymore because it's too small and there's no privacy."* (Interview 5, Quinta Los Huérfanos)

In Quinta Baselli, the larger courtyard and higher visibility contributed to residents feeling safer in communal spaces. The ability to monitor activities from their windows and doors provided a sense of security, which encouraged continued use of these areas.

A resident explained: *"The fact that we can see what's happening in the courtyard makes us feel safe, even when we're not outside."* (Interview 9, Quinta Baselli)

These findings highlight that architectural features that support visibility and spatial separation can enhance residents' perceptions of safety, while features that limit visibility may reduce these feelings.

Comparative overview of findings

In this comparative overview, we examine the different outcomes of the architectural features (independent variables) and social dynamics (dependent variables) in Quinta Los Huérfanos and Quinta Baselli. Both quintas share certain architectural characteristics—such as communal courtyards and narrow pathways—but the way these features influenced social interactions, sense of community, and perceptions of privacy and safety differed significantly between the two.

Proportions and scale

- Quinta Los Huérfanos: The proportions of the communal courtyard were too confined to support socially distanced gatherings after the pandemic. Before COVID-19, the space had functioned well for social interactions, but the pandemic highlighted the limitations of smaller, more enclosed communal spaces. This resulted in a drastic reduction in social interactions, as residents felt uncomfortable using a space where they couldn't maintain physical distance.

  Key Impact: Smaller spaces became restrictive, causing a reduction in social interaction and contributing to a weakened sense of community.

- Quinta Baselli: The larger courtyard in Quinta Baselli allowed residents to continue using the space, even with social distancing measures in place. The flexibility provided by the larger dimensions supported informal gatherings in a safe manner, helping to preserve social interaction and the sense of community.

  Key Impact: Larger, more flexible spaces enabled ongoing interaction, maintaining community ties even in difficult circumstances.

Quinta	Proportions and Scale	Impact on Social Dynamics
Quinta Los Huérfanos	Small, confined courtyard	Reduction in social interaction, weakened sense of community due to spatial restrictions.
Quinta Baselli	Larger, more flexible courtyard	Maintained social interactions and sense of community by allowing socially distanced gatherings.

Table 1. Comparison in proportions and scale of the case studies. Own elaboration.

Visibility and sightlines

- Quinta Los Huérfanos: Visibility between units and the communal courtyard was limited, as residents tended to keep their windows and doors closed for privacy. This reduced the opportunities for informal surveillance, which in turn diminished both social interaction and residents' feelings of safety. The lack of visual connection between private and communal spaces contributed to feelings of isolation.

  Key Impact: Limited visibility reduced both social interaction and residents' sense of security, weakening the overall sense of community.

- Quinta Baselli: The design of Quinta Baselli encouraged higher visibility, with windows and doors facing directly onto the courtyard. Residents frequently opened their windows and doors to observe activities in the communal space, engaging in informal monitoring and interaction. This allowed for a continuous sense of social connection, even when physical gatherings were restricted.

  Key Impact: High visibility enabled informal interactions and increased feelings of safety, supporting ongoing social cohesion and community ties.

Quinta	Visibility and Sightlines	Impact on Social Dynamics
Quinta Los Huérfanos	Limited visibility between units and courtyard	Reduced interaction and sense of security, contributing to social isolation.
Quinta Baselli	High visibility between units and courtyard	Informal interactions and sense of safety maintained through visual connections between units.

Table 2. Comparison in visibility and sightlines of the case studies. Own elaboration.

Architectural elements (windows, doors, materials)

- Quinta Los Huérfanos: The placement of windows and doors prioritized privacy, but this came at the cost of reduced social engagement. The materials and layout offered security but limited opportunities for spontaneous interaction between residents. During the pandemic, these architectural features amplified feelings of isolation, as there were fewer opportunities for informal exchanges.

  Key Impact: Architectural elements favored privacy over interaction, reducing social cohesion and contributing to isolation.

- Quinta Baselli: In Quinta Baselli, the placement of windows and doors allowed for easier communication between residents. The materials provided a balance between privacy and openness, enabling spontaneous interactions and maintaining a sense of community. Even during the pandemic, residents were able to interact from a distance by using windows and doors as points of contact.

Key Impact: Architectural elements facilitated informal interactions, contributing to a sustained sense of community despite the limitations imposed by the pandemic.

Quinta	Architectural Elements (Windows, Doors, Materials)	Impact on Social Dynamics
Quinta Los Huérfanos	Closed-off design for privacy	Reduced opportunities for interaction, contributing to social isolation and weakened community ties.
Quinta Baselli	Open design facilitating informal interactions	Encouraged spontaneous exchanges, maintaining social cohesion and a sense of community.

Table 3. Comparison in architectural elements of the case studies. Own elaboration.

Dependent variables: social dynamics

Social interaction

- Quinta Los Huérfanos: Social interaction declined significantly due to the confined proportions of the courtyard, limited visibility, and architectural elements that prioritized privacy. The pandemic exacerbated these limitations, making it difficult for residents to engage in even casual exchanges.

  Key Impact: Social interaction became infrequent, weakening the overall sense of community.

- Quinta Baselli: Social interaction was maintained through the use of larger communal spaces and higher visibility between units. The architectural features allowed for continued interaction, even during times when physical gatherings were limited.

  Key Impact: Social interaction remained relatively stable, helping to sustain a strong sense of community.

Sense of community

- Quinta Los Huérfanos: The sense of community weakened over time as residents became more isolated due to the limitations of the architectural features. Reduced interaction and a lack of visual connection between units contributed to feelings of disconnection.

  Key Impact: A weakened sense of community as social isolation increased.

- Quinta Baselli: Despite the challenges posed by the pandemic, the sense of community in Quinta Baselli remained strong. The layout and use of communal spaces, combined with the architectural elements that encouraged interaction, helped maintain residents' feelings of belonging.

  Key Impact: A strong sense of community persisted, supported by design features that facilitated ongoing interaction.

Privacy and safety

- Quinta Los Huérfanos: Residents in Quinta Los Huérfanos felt less secure in communal areas due to the confined proportions and limited visibility. The lack of spatial separation and opportunities for informal monitoring led to a decrease in both privacy and safety.

Key Impact: Reduced feelings of safety in communal spaces, contributing to further isolation.

- Quinta Baselli: In Quinta Baselli, residents reported feeling safer due to the higher visibility and the ability to monitor communal spaces from their windows and doors. This sense of security helped maintain the use of communal areas and contributed to a continued sense of community.

  Key Impact: Stronger perceptions of safety supported by the layout, visibility, and continued use of communal spaces.

Quinta	Social Interaction	Sense of Community	Privacy and Safety
Quinta Los Huérfanos	Declined significantly due to space constraints and limited visibility.	Weakened as social interaction decreased and isolation increased.	Residents felt less safe due to confined spaces and poor visibility.
Quinta Baselli	Maintained through larger communal spaces and informal interactions.	Strong sense of community despite challenges posed by the pandemic.	Residents felt safer due to higher visibility and informal monitoring.

Table 3. Comparison in architectural elements of the case studies. Own elaboration.

Key insights from the comparative overview

The comparative analysis between Quinta Los Huérfanos and Quinta Baselli reveals that while both quintas share similar architectural elements, the outcomes in terms of social dynamics vary greatly due to differences in proportions, visibility, and design priorities. The primary insights include:

1. Proportions and Scale Matter: Larger, flexible communal spaces enable residents to maintain social interactions even during times of restricted mobility, whereas smaller spaces limit interaction and weaken community ties.

2. Visibility Enhances Safety and Interaction: High visibility between units and communal areas promotes informal interactions and a sense of security, whereas limited visibility contributes to isolation and reduced social engagement.

3. Architectural Elements Influence Community Dynamics: Features such as windows and doors that balance privacy with openness support spontaneous interactions and help maintain a sense of community, while features that prioritize privacy at the expense of interaction may lead to isolation.

4. Resident Adaptability Plays a Crucial Role: In both quintas, residents' ability to adapt their use of space, particularly during the pandemic, significantly influenced social outcomes. Architectural features provided the framework, but it was the residents' responses that ultimately determined the strength of social cohesion.

CONCLUSIONS

The analysis of Quinta Los Huérfanos and Quinta Baselli provides a comprehensive understanding of how architectural features influence social dynamics within residential environments, particularly in the context of a global pandemic. While both quintas share common architectural characteristics, such as communal courtyards and narrow pathways, the outcomes in terms of social interaction, sense of community, and perceptions of safety varied significantly. This variation is largely attributable to differences in the proportions and scale of spaces, visibility and sightlines, and the design of architectural elements like windows and doors.

The conclusions drawn from this comparative study are as follows:

Proportions and scale are critical for social interaction

The proportions and scale of communal spaces, such as courtyards and pathways, play a critical role in facilitating or limiting social interaction. In Quinta Los Huérfanos, the confined communal spaces became barriers to interaction during the pandemic, leading to a reduction in the use of these areas. The inability to maintain physical distance in such confined spaces made residents feel uncomfortable and less likely to gather, weakening the overall sense of community.

In contrast, the larger proportions of Quinta Baselli's communal spaces provided residents with the flexibility to continue interacting safely, even under social distancing measures. The ability to spread out within the courtyard allowed for informal gatherings, helping to sustain social interactions and maintain community cohesion.

Conclusion: Larger communal spaces support flexible social interactions, even during periods of restricted mobility, while smaller, confined spaces become restrictive, reducing interaction and weakening the community.

Visibility and sightlines enhance safety and foster interaction

The visibility between private units and communal spaces emerged as a key factor in determining both social interaction and perceptions of safety. In Quinta Los Huérfanos, the lack of visibility from private spaces to communal areas contributed to feelings of isolation and reduced social engagement. Residents were less likely to monitor or casually interact with their neighbors due to the limited sightlines between units and communal spaces.

By contrast, in Quinta Baselli, the higher visibility provided by well-placed windows and doors allowed residents to engage in passive surveillance and informal social interactions. Residents could monitor activities in the courtyard and greet their neighbors from their windows, maintaining a sense of connection even when physical gatherings were not possible. This visual connection also contributed to an increased sense of safety, as residents could observe their surroundings.

Conclusion: High visibility between private units and communal spaces fosters informal interactions and enhances perceptions of safety, while limited visibility can lead to social isolation and reduced feelings of security.

Architectural elements shape privacy and social engagement

The design of architectural elements such as windows, doors, and materials significantly influences residents' ability to balance privacy and social interaction. In Quinta Los Huérfanos, the placement of windows and doors prioritized privacy, but this came at the expense of spontaneous interaction. The

closed-off design elements led to a reduction in casual exchanges, particularly during the pandemic, as residents sought to protect their privacy and security.

In Quinta Baselli, the architectural elements provided a balance between privacy and openness, allowing for informal communication between neighbors. Windows and doors facing communal areas facilitated spontaneous interactions, helping to sustain social engagement and maintain the sense of community. The ability to balance privacy with interaction proved crucial in maintaining social ties during periods of restricted mobility.

Conclusion: Architectural elements that balance privacy with openness promote spontaneous social interactions and help maintain community cohesion, while designs that prioritize privacy can limit social engagement and lead to isolation.

Resident adaptability is key to sustaining social dynamics

While architectural features set the framework for social interactions, the adaptability of residents in using these spaces plays an equally important role in shaping social dynamics. In Quinta Baselli, residents were able to adapt their use of communal spaces and windows to maintain interactions even during the pandemic. This adaptability helped preserve the sense of community and ensured that social ties remained strong.

In Quinta Los Huérfanos, the architectural limitations of the communal spaces, combined with the lack of adaptability, contributed to a more pronounced decline in social interactions. Residents felt constrained by the small communal areas and reduced visibility, leading to feelings of isolation and a weakening sense of community.

Conclusion: Resident adaptability in using communal spaces is crucial in sustaining social dynamics, particularly in challenging circumstances like a pandemic. Architectural features can facilitate interaction, but how residents respond to these features ultimately determines the strength of social cohesion.

Architectural design should prioritize flexibility and connection

The findings from this study have significant implications for the design of residential environments, particularly in historical settings like Lima's quintas. While preserving the architectural integrity of these environments is important, it is equally essential to prioritize features that allow for flexibility in how communal spaces are used and facilitate connection between residents.

- Communal spaces should be designed with flexibility in mind, allowing residents to use them for a variety of activities, including social gatherings and safe distancing.
- Visibility should be integrated into the design to enable residents to monitor communal spaces and engage in informal interactions, enhancing both security and community ties.
- Architectural elements such as windows and doors should be placed to balance privacy and openness, ensuring that residents feel both secure and connected.

Conclusion: Future urban and architectural designs should prioritize flexible, adaptable spaces and architectural elements that facilitate social interaction, enabling residents to maintain social ties even in challenging circumstances.

Final thoughts

The comparative analysis of Quinta Los Huérfanos and Quinta Baselli demonstrates that architectural design plays a pivotal role in shaping the social dynamics of residential communities. However, the findings also highlight that architecture alone is not enough to sustain social cohesion—residents' adaptability and engagement with their environment are equally important. Design flexibility, visibility, and balanced architectural elements are essential in fostering strong, resilient communities, particularly in historical urban settings where communal living spaces play a central role in daily life.

As cities continue to evolve and adapt to new challenges, particularly in the wake of global health crises, the lessons learned from these quintas can inform the future of urban design. The balance between privacy, openness, and flexibility will be crucial in designing spaces that not only preserve social dynamics but also enhance them in times of uncertainty.

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Exploring the integration of urban morphology as a methodological framework in urban planning

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ABSTRACT

This study investigates the integration of morphological analysis methods into the urban planning process as a design control tool, specifically within the Turkish context. It underscores the critical relationship between urban morphology and planning, emphasizing its role in zoning plan formulation. The research aims to elucidate the significance of urban morphology studies in planning, outline the integration process of these methods into zoning plans, and demonstrate the contributions of a proposed morphological analysis approach. A five-step morphological analysis method, incorporating the Spacematrix quantitative approach, was applied to an urban settlement in Turkey to map urban density and identify regions. The study confirms the method's effectiveness in identifying character regions and their relationships, establishing its value in regional zoning plans. The proposed method provides planners with a systematic tool for analysing urban structure, aiding in informed planning decisions and controlling fragmentary urban interventions. This research enhances the understanding of urban morphology within urban planning, offering a practical tool for regional planning in Turkey.

Keywords: Historic-geographical Approach, Zoning Plans, Morphological Regions, Urban Development

INTRODUCTION

The development and improvement of all individuals in society (their health, skills and tendencies, life expectancy, productivity, morality, and family life) became one of the fundamental aims of states with the establishment of nation-states in the 20th century. While the state guarantees the peace and security of individuals, it expects them to comply with a prescribed set of rules (Scott, 2008). These rules apply to individuals, society, and the environments in which society exists. Therefore, rules also play a role in the planning and design of the environments we live in. Alongside technological and industrial advancements, cities began to be planned and designed systematically and hierarchically. Over time, different planning approaches have been adopted during various periods. Sometimes these approaches reflect the ideological manifestations of absolute state control, and sometimes they stem from efforts to adapt to the changing and evolving world, leading to various transformations in space (Scott, 2008).

The emergence of planning as a discipline dates back to the 1950s. Early planning approaches were based on improving living conditions, particularly in industrialized cities. To overcome these problems, construction activities were carried out in cities within the framework of comprehensive plans and programs through infrastructure and redevelopment efforts. With the planning approaches that emerged in later periods, a regulatory system was established to ensure the balanced use of the natural and human resources cities possess.

Planning involves making multi-faceted decisions within a system of mutual relationships to achieve a set goal and to develop objectives. Based on these decisions, the "formation of urban space is directed through long-term and multi-dimensional actions within a comprehensive planning approach" (Suher, 1996; 65).

The fundamental approach in comprehensive planning is to organize the city into a coherent and understandable spatial structure at a large scale. Ensuring order across the entirety of the city is crucial for preventing health problems and improving living standards. Plans encompassing the whole city shape the environment in which individuals live, within the framework of building regulations. In turn, individuals produce on the building scale according to the rules set forth by these plans, and this reciprocal relationship establishes the dynamic of the place from the smallest scale to the city as a whole. The way this dynamic functions also affects the form and structure of the city. In this process, the integrity of the individual, space, and urban system must be ensured, and a healthy operational mechanism must be established. The changes and transformations the city has undergone throughout its historical process are also significant within this system. Therefore, planning processes that consider all local dynamics should be defined.

However, in today's urban development, large-scale transformations that resemble each other are occurring in planned cities. Plans that fail to anticipate these changes cannot prevent the erasure of historical or existing traces in the urban fabric and the creation of new urban patterns disconnected from the past. Change and transformation occur based on legal and administrative tools in regulations, and the legislation that defines minimum design and planning standards. While these regulations and legislation guide the shaping of space and the planning process, they have limitations in maintaining local character. Consequently, effective control tools and approaches are needed within the current planning system to guide the shaping of urban space.

In this context, studies of urban morphology are important. Kropf (2011) emphasizes the guiding role of urban morphology in the planning process, particularly in relation to urban design, conservation, and planning practices. His research demonstrates how urban morphology tools can provide a foundation for understanding, organizing, transforming, and managing the structure and complexity of the built environment. Similarly, Moudon (1997) notes that studies of urban form and morphology can be integrated into every type of construction process (transformation, new area development) in cities, and they offer a guiding scope for city planning, architecture, and real estate fields. From the 2000s onwards, many theorists have advocated for the guidance of morphological approaches in the development of large metropolises and modern urban fabrics, in addition to traditional and historical environments (Barrett, 1996; Scheer and Petkov, 1998; Moudon and Hess, 2000; Stanilov and Scheer, 2004; Waldheim, 2006; Tatom, 2006; Whitehand, 2007).

Even though the term "urban morphology" is not explicitly defined in planning and design studies, urban morphology methods are applied in a significant portion of these works. Furthermore, the use of urban morphology methods across various fields such as historical environment conservation, urban character, environmental performance, movement analyses, planning control tools, and urban design highlights their importance. These wide-ranging studies provide informative and guiding insights for the disciplines of urban design, city planning, and architecture.

It is essential to understand and define the morphological change and transformation in cities' developmental processes. These studies allow for a clear inquiry into the past and future, enabling a better understanding of the layering in urban structures, urban fabric patterns, and the dynamics that shape them throughout history. Urban morphology should not be viewed merely as a physical historical record of the city. In this process, while conducting the spatial reading of the city, traces of social life are also documented, and significant data related to the social structure is obtained. This is because urban planning is a discipline that encompasses physical, economic, and social dimensions. In the context of the relationship between planning and morphology, several studies have focused on these dimensions.

A good example of the social dimension of urban planning is the urban character study conducted by Hansen and Thompson in 2009 in Brighton & Hove. This comprehensive study examined the fabric characteristics of different neighborhoods in Brighton & Hove, aiming to contribute to future planning policies and thus support decision-making processes in planning (Brighton & Hove City Council, 2009). The study included land use and zoning analyses regarding the perceptions of residents, identifying how/when/how often/for what purposes the urban fabric was used by different groups. This research is significant in revealing the relationship between social structure and urban fabric.

Another crucial area in the urban planning process is the studies carried out using the space syntax method developed by Bill Hillier, which discuss the relationship between urban mobility and urban morphology. These studies, fundamentally based on questioning the physical structure of urban space without ignoring the presence of social structure, originated from the search for solutions to the failure of social housing projects and the lack of a sense of community in the social housing developments in the United Kingdom during the 1960s and 70s. Space syntax is used as a mathematical spatial analysis technique to address this issue. This method was developed to understand the structure of urban fabric and its effects on human movement, based on people's spatial experiences. Using space syntax, planning and design efforts are guided by conducting studies at various and large scales, from building components to regional levels, while considering not only the physical space but also the social and economic structure.

Studies in urban morphology that guide comprehensive planning efforts have become widespread, especially since the 2000s. One example is the "Plan Local d'Urbanisme (PLU)" plan for the city of Rennes in the Brittany region of France. In the PLU, urban fabric analyses were used as a planning tool for implementation (Kropf, 2009). Through morphological analyses, the city was divided into different regions, with distinct fabric typologies defined. The characteristics of these defined fabrics (roads, parcels, buildings) were identified. These character definitions were later used as a guide in the regulations for similar areas.

A similar approach was adopted in the preparation of the 'Stratford-on-Avon Design Guide' in the UK. The study included an analysis of urban character, where morphological components such as street fabric, parcel structure, and building-parcel relationships were examined and connected to the urban planning terminology to create a guide (Kropf, 2009). The guide is a comprehensive study that includes morphological characteristics of various areas in the city, from building level to fabric level. These studies, in which morphological data were effectively integrated into urban development and spatial production processes, highlight the significance of morphological analyses. However, in Turkey, such approaches that guide urban development have yet to be effectively incorporated into the planning process.

In Turkey, which is undergoing a rapid urbanization process, state policies, incentives, and the free market system over the past 20 years have led to the reproduction of urban space (Şengül, 2009). In this reproduction process, especially in city centers, original urban fabrics are being demolished and rebuilt according to new construction regulations and systems. These areas are often large functional spaces left idle and residential areas that have developed without planning within the city. On the outskirts of cities, residential areas are generally being planned for middle- and upper-income groups. Urban space is being produced not for all citizens but rather by specific individuals or groups (Balamir, 1975). In other words, newly developing and transforming urban areas are being formed while ignoring the existing morphological character. In this case, planning and urban design interventions that could be made effective through planning tools (laws, regulations, plans, guides, etc.) often fall short. Additionally, in Turkey, no morphological analysis method has been defined within the urban planning process. In this context, it is both important and necessary to define morphological analysis methods that are compatible with the country's planning system and tools and that can be used in planning practice.

The implementation tools (laws and regulations) developed in parallel with planning periods influence the formation of urban form and urban fabric. When examining Turkey's urbanization experience, it can be said that, at times, laws have been very strict and restrictive, or they have consisted of a series of regulations aimed at legalizing spontaneously developed urban fabrics. Moreover, urban fabrics are shaped at the block and parcel level through parcellation plans prepared by surveyors lacking the basic morphological knowledge required by urban planning. As a result, over time, cities have developed spatial patterns that remain unchanged, following uniform plans. To prevent this uniformity, a process that considers local data and dynamics must be defined. In this process, it is essential to define the spatial structure of cities in light of morphological data. This can only be achieved through a clear understanding of the city's morphological structure, and there is a need to define analysis methods that can guide planning efforts accordingly.

Historically, Turkish planning efforts, initiated during the Tanzimat period in the 19th century, have been conducted under various laws and regulations. The legal framework of the modern Turkish urban planning system, based on early construction regulations, was established in the 1930s as part of the Republic's comprehensive modernization program. Initially, legal regulations were developed at the street and building scales, later expanding to encompass the urban scale, providing legal support for urban planning. In 1930, the Municipality Construction and Roads Law was enacted, requiring all municipalities to prepare maps and plans in accordance with the development policies set by law (Ersoy, 2017). After World War II, rapid urbanization necessitated a new and comprehensive development law, leading to the enactment of Law No. 6785 in 1957. This new legislation introduced

the concepts of "Master Development Plans" and "Development Planning" (Keleş, 1972; Tekeli, 2013). The master plans aimed to control the macro structure of cities, while regulations defined the basic standards for small-scale implementation plans controlling the formation of individual parcels.

In urban planning practice, local character, social structure, economic and environmental factors are critical elements influencing the morphological structure of cities. Understanding and defining the morphological transformations and changes in the development processes of cities is crucial for future planning decisions. To prevent the uniformity in cities, processes that take local data and dynamics into consideration should be defined. In this process, it is essential to define the spatial structure of cities through morphological data. This can be achieved through a proper reading of the city's morphological structure and by defining analytical approaches and methods that can guide planning decisions.

The purpose of this study is to discuss how morphological analysis methods can be integrated into Turkey's urban planning process and practice as a control tool. In this context, the relationship between urban morphology and planning is examined, emphasizing the significance of urban morphology methods in the preparation of zoning plans. Accordingly, the study proposes a morphological analysis method and outlines its steps. In line with these objectives, the following questions are addressed:

- What is the role and importance of urban morphology studies in the urban planning process?
- How can urban morphology methods be integrated into the zoning plan preparation process?
- What contributions will the proposed morphological analysis approach make to the planning process?

A MORPHOLOGICAL APPROACH INTEGRATED INTO THE URBAN PLANNING PROCESS

The aim of the study is to explore how morphological analysis methods can be incorporated into the urban planning process and practice as a regulatory tool, and to define a morphology-based analysis method that can guide zoning plans. The tracking of changes in the city's morphological structure has allowed for the identification of local dynamics and the examination of the current state of residential fabrics and their transformations over time. In this way, the layered structure of the city’s morphological development across different periods has been systematically analyzed, and its relationship with the urban planning process has been questioned. Five interrelated steps have been defined for the analysis method.

A morphology-based analysis method consisting of five steps has been developed for incorporating urban morphology data into the planning process in Turkey. In defining this method, a Historical-Geographical approach was followed, and Spacemate (Urban Density Analysis) was used as a numerical method. The steps of the method defined in the study are:

Field Study (Collection of Data Related to the City/Area)

Publications related to the city's history, such as research reports and written documents about the study area, historical maps, and city plans of various scales, are important references for a morphological analysis. These documents were gathered from the municipal archives of the city of

Görele, which is the study area. Additionally, scientific publications related to the city were reviewed by conducting research in national and university libraries. Past and present photographs, as well as local publications concerning the area, were also examined.

Planning process-related data:

Spatial plans and reports, aerial photographs, and current maps necessary for evaluating the morphological changes and transformations of the city were obtained from various individuals and institutions, including the Municipality, General Directorate of Mapping, İller Bankası, and engineers and planners.

Field study:

A thorough analysis of the study area is important for evaluating the city's current land use, identifying its growth trends, center analysis, and understanding the city's natural structure and thresholds. The current state was analyzed through observations and interviews with individuals and experts (architects, planners, surveyors, etc.). In-situ observations were conducted on the natural and built environment of the city, and photographs were taken. In addition, information was gathered from third parties/experts who have witnessed the city's morphological development and have either directly or indirectly influenced its changes, but whose contributions are not documented in many written sources. Interviews provide insight into the urban formations and multilayered structure of the city across different periods. During the interviews, aerial photographs and old images were examined, and the locations of demolished buildings (such as public, commercial, and monumental structures) were identified. Furthermore, oral information about the city's socioeconomic structure, major urban planning activities (such as road construction and sewer infrastructure), and public investments was collected and analyzed in relation to the spatial context.

Evaluation and Analysis of Data, Identification of Regions

Morphological development of the city from its first settlement period to the present:

Spatial data, such as maps, aerial photographs, and plans from different historical periods, along with cadastral records, population records, tax registers, reports, writings on the city's history, research, travelogues, and records on buildings (such as schools, pharmacies, post offices, etc.) as well as information gathered from interviews, were analyzed. Maps of the city from different periods were created.

Natural and artificial environmental features influencing the city's morphological structure: Natural environment analyses, such as topography (slope and elevation) and aspect analyses, along with land use, solid-void (buildings and parcels), transportation, building heights, and FAR (Floor Area Ratio) and GSI (Ground Space Index) analyses, were conducted. Each analysis was converted into spatial data, and the effects of both natural and built environmental features on the city's morphological structure were examined.

Identification of Character Regions

The identification of character regions was based on the morphological region definitions of M.R.G. Conzen and J. Whitehand. According to Conzen, urban development should be perceived as a process, and in order to accurately analyze the changes within this process, the smallest units that constitute the city (buildings, parcels, streets, etc.) must also be included in the analyses. One of the key actions in defining a city's physical development is to divide it into morphological regions. A morphological region can be defined as an area that is distinct from its surroundings and possesses internal cohesion

(Whitehand, 2001; Conzen, 2009). Morphological regions refers to the process of identifying and mapping morphological regions. The fundamental elements of such zoning are the historical and geographical structure of the settlement. The textures within the settlement represent the urban fabric formed during various periods. Through regions, the textures created during different periods are defined. In order to understand the textures in an urban area, various urban fabric components, the regulations that guide the formation of these fabrics, spatial formations, and their relationships with one another should be evaluated (Whitehand, 2009).
Based on these definitions, natural and built environment analyses played a decisive role in identifying the regions within the study area. The natural structure analyses were overlaid to create a synthesis of natural data, identifying regions that are homogeneous in terms of their natural features. When defining the boundaries of these regions, parcel boundaries, zoning plan limits, and roads were used as references. Similarly, analyses of the built environment were overlaid, and in the structural synthesis map that was produced, different regions with distinct urban characters were identified.

Selection of Fabric Samples from Identified Regions

Housing fabric samples to be evaluated using the Spacemate (urban density analysis) method have been selected from each of the regions. There are several considerations that should be considered when selecting fabric samples. The first consideration is the scale at which the selected fabric will be analysed. For instance, information at the level of an individual building is collected at the parcel scale, but this may not be sufficient or appropriate for analysing the entire city. Therefore, determining at what stage and at which scale the obtained data will be analysed is crucial for the application of the Spacemate (urban density analysis) method (Berghauser Pont and Haupt, 2009). In selecting the fabrics to be analyzed, this consideration has been taken into account, and certain criteria have been observed:

In defining the boundaries of the sample housing fabrics, the cadastral status (parcel boundaries) has been taken into account. The building conditions on the parcels have been considered, and parcels without any structures have been excluded from the fabric (Figure 1).



Figure 1 . Sampling Urban Fabrics, photo credit: Beyza Karadeniz, 2020.

Care has been taken to ensure that the selected sample housing fabrics are areas with identical structures. To identify identical regions, all structural analyses (land use, FAR, GSI, number of floors, and parcel size) have been overlapped in a GIS (Geographic Information Systems) environment to create a single spatial map. Codes have been defined for the colors on the map. Areas composed of identical colors represent a homogeneous fabric, while areas where color identities could not be matched represent a more heterogeneous fabric with similar color distributions. With all these considerations and assumptions, the boundaries of the sample housing fabrics have been defined (Figure 1).

Analysis of Fabric Samples Using Spacemate (Urban Density Analysis)

Housing fabrics selected from each region have been analysed using Spacemate, allowing for the identification of fabric typologies and density characteristics. Queries have also been conducted using Spacemate in the context of the proposed building forms in the zoning plans for the examined housing fabrics (Figure 2). This approach enabled a comparison between the existing structure of the housing fabrics and the fabric that would result from the plan. The transformation of housing fabrics throughout the historical process has been analysed at the block scale using Spacemate, in relation to the level of morphological layering. The adequacy of the road network, parking, and lighting levels has been examined by comparing the existing fabric, the fabric to be formed by the plan, and the alternatives developed according to the Spacemate analysis method.

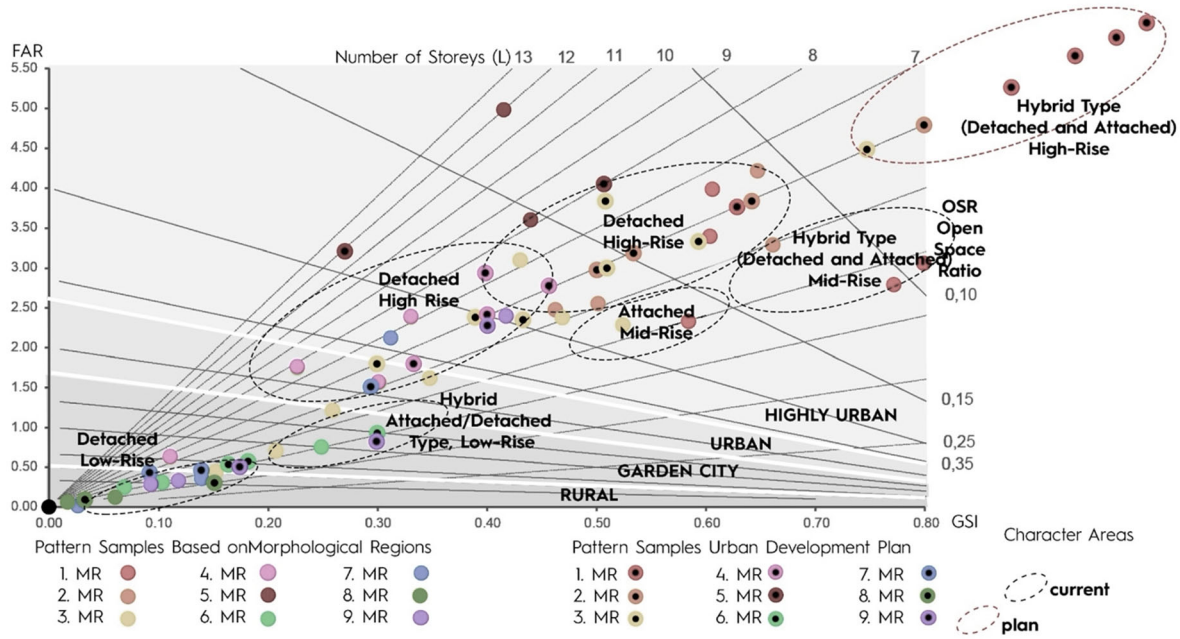

Figure 2 . Analysis of Fabric Samples, photo credit: Beyza Karadeniz, 2020.

Housing fabrics selected from each region were analysed separately, and subsequently, all fabrics within the character regions were collectively evaluated to conduct the Spacemate analysis for that specific region. There is a relationship among the four fundamental variables of Spacemate analysis: FAR (floor area ratio), GSI (ground space index), OSR (open space index), and L (building height). Specifically, the OSR (open space index) is inversely proportional to the values of GSI, FAR, and L. In contrast, there is a direct proportionality between the FAR value and the values of L and GSI. However, two fabrics with the same FAR value may have different L (number of stories) and GSI values. Similarly,

two fabrics with the same OSR (open space index) value may have different FAR, GSI, and L values. Therefore, the morphological characteristics of the fabrics should be interpreted by considering the relationships among these variables.

RESULTS AND DISCUSSIONS

The method has been tested in a specific urban settlement. As a result, the application of the defined analysis method has enabled the identification of the regions of the city, the distribution of urban density within these regions, and the relationships between them. Thus, it has been demonstrated that the method can serve as a tool to guide planners in the process of creating urban plans. This tool is also effective in controlling fragmented interventions within urban fabrics. In summary, the defined method is suitable for integration into the planning process. This allows for the establishment of a systematic process aimed at analysing the morphological structure of the city, providing significant clues and references to guide anticipated planning decisions.

The significance of defining regions in this study lies in their ability to guide plans regarding relationships and transitions between these regions. Developing building forms and associated density decisions that are appropriate to the natural and physical structures of character regions is important for both urban quality and aesthetics, as well as for feasibility and economic viability. This step of morphological zoning is also crucial as a foundation for density zoning studies used in the preparation of master plans.

The analysis and definition of regions are followed by the selection and analysis of the urban fabrics to be examined. The method of color coding defined in this study has been used to analyze the residential fabrics within the identified regions. This approach addresses the fact that not all residential fabrics in the city are planned and distinct, and it aims to clarify the boundary definition, which is the most decisive factor in residential fabric analysis. This technique can be used/recommended/developed as a boundary determination tool for analyzing modern residential fabrics.

For the analysis of residential fabrics, the Urban Density Analysis (Spacemate) developed by Pont and Haupt in 2009 has been used. The reason for utilizing this method in this thesis study is that it presents a morphological approach that addresses current changes in urban planning and design practices and aims to provide a tool based on the relationship between physical density and urban form. In this context, various residential fabrics identified in the study area have been examined (Figure 3).

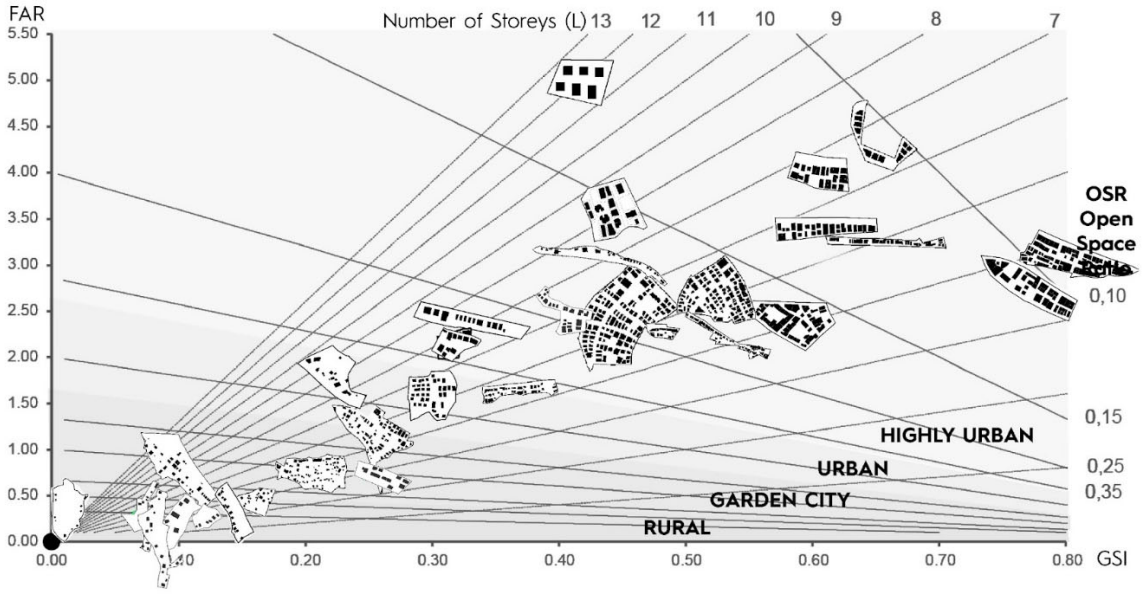

Figure 3 .Placement of Sample Urban Fabrics on Spacemate, photo credit: Beyza Karadeniz, 2020.

This morphological atlas, which can be referred to as Figure 3, serves as a foundation for planners when making development decisions regarding the related fabrics and the vacant areas within their respective regions. While the Spacemate method provides a basis for analyzing the fabrics, it is crucial that these fabrics are not limited to purely mathematical values without on-site examinations. As mentioned in the findings section, it is essential to analyze the formal characteristics (such as building-parcel relationships, slope, etc.) in relation to the urban context.

CONCLUSIONS

Morphological studies in Turkey began later than in Europe, initially focusing on historical and conservation areas. However, a systematic process for these studies has yet to be clearly defined. Urban morphology extends beyond special areas, examining the components of urban space, their configurations, and the transformations cities undergo over time, making it a unique research field that guides urban planning and design.

The role of urban morphology in Turkey's urban planning process is still not well-defined. Various experts conduct urban fabric analyses and density zoning using different techniques, but these approaches lack sufficient discussion across schools of thought. Symposiums organized by the Turkish Urban Morphology Network, starting in 2015, have been significant for addressing the relationship between urban morphology and planning. Recent publications on analytical techniques in urban planning have also contributed valuable insights into a process-oriented approach.

Recent housing developments have often been created independently of local character, leading to the loss of many unique urban fabrics under market pressures. This situation arises from a master plan approach that neglects the structural components and sensitivities of urban areas, leading to a top-down determination of urban fabric without strategic elements. Additionally, many changes and revisions to implementation plans occur independently of the decisions made in the master plans.

Urban planning encompasses studies on how cities should be shaped and structured. Urban morphology guides this process with various approaches and analytical methods aimed at

understanding urban form. Urban morphology studies rely on a process-oriented approach, necessitating intensive and systematic work and archiving. Continuous updating and recording of new information are vital. The relationship between urban planning and urban morphology cannot be separated; however, the connection is often fragmented. Studies aim to establish this relationship, allowing planners to visualize and discuss the third dimension of space through professional terminology rather than intuition. Recent regulations in Turkey seek to address this disconnect. For instance, the Spatial Planning Regulation states that proposed plans will be evaluated regarding urban fabric and liveability aspects. Additionally, it is specified that existing building density and fabric analysis must be conducted in the preparation of implementation plans. However, uncertainties about how these analyses should be conducted persist.

The morphological analysis approach defined in the thesis can serve as an effective tool for systematically analyzing existing urban fabrics and density relationships. Moreover, the character regions approach proposed in this study can act as a supportive framework and boundary-setting tool for urban areas under market pressures in the planning process. This approach may facilitate feedback between planners and relevant institutions, helping prevent erroneous density decisions in plans. Despite the emergence of various housing types and building technologies in recent decades, a design control approach responding adequately to these typologies has not been developed.

Urban morphology studies should evaluate fabrics created in different periods alongside contemporary planning experiences. Thus, the systematic analysis approach defined in the thesis can be integrated into the planning process. A key challenge in these studies is the unique complex structure of the process, comprising different historical periods, each with distinct social and economic reasons behind its physical changes. The analysis phase and methods must be detailed in a morphological context, ensuring each analysis is interpreted toward the specified objectives. The analytical approach developed in the study can identify issues in existing urban fabrics and inspire new building regulations, serving as a descriptive document for cities undergoing transformation and providing data for comparative studies in similar urban contexts.

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Exploring the nonlinear relationships between virtual and physical space features and urban vitality: A case study of Hengfu historic and cultural area in Shanghai

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ABSTRACT

The relationships between built environment and urban street vitality have been widely studied. The role of virtual spaces like social media in promoting urban street vitality has also gained attention in recent years. However, most existing urban street vitality research fail to reveal the relationships between virtual space features and urban street vitality. Moreover, the complex relationships between physical and virtual space features, as well as their threshold effects, are rarely explored. In response, this study uses multi-source urban data and XGBoost model to explore the nonlinear relationships between physical and virtual space features and urban street vitality. Since social media plays an important role in the renewal of historic areas, this study takes a typical Shanghai historic and cultural area as an example. Based on the '5D' built environment theory and a literature review, the study selects physical and virtual space features as independent variables and street vitality as dependent variable. Based on the quantitative calculation results of these variables, an XGBoost machine learning model of this series of variables and urban street vitality is constructed. Specifically, physical space features play a significant role in enhancing street vitality, with subway station accessibility demonstrating a particularly strong effect. Furthermore, the nonlinear impacts of both physical and virtual space features on vitality are prominent. Notably, negative threshold effects on street vitality are observed when the proportions of road, building density, and virtual popularity exceed certain critical thresholds. The study also highlights the interaction effects among key features. This research not only advances the understanding of urban street vitality and addresses theoretical gaps in built environment studies, but it also offers a theoretical framework for targeted urban regeneration and the revitalization of historic and cultural area

Keywords: Historic and cultural area; urban street vitality; nonlinear relationships; physical and virtual space features

INTRODUCTION

Research Background

It is widely recognized in the field of urban design that the vitality of urban streets is an important indicator for assessing the attractiveness and spatial quality of urban neighbourhoods (Jacobs, 1961).

As both physical and social spaces for human activities, the built environment of urban streets is closely related to vitality (Yue *et al.*, 2021). Many urban design theories have been proposed to promote the vitality of urban street. Extensive research has been conducted into the mechanisms by which relevant physical environment variables (e.g., building density, building type, etc.) affect the vitality of urban streets (Ye, Li and Liu, 2018). It is noteworthy that the nonlinear effects of physical environment variables have been shown to be prevalent in these relationships, yet they have not received much attention until recent years (Han et al., 2024).

With the development of information and communication technologies, the number of users posting content on social media platforms, such as Twitter and Facebook, continues to increase. The creation of social media has triggered new behavioural patterns (e.g., ‘check-in activities’) that geographically correlate digital virtual spaces with physical urban spaces. These behavioural patterns demonstrate the impact that virtual spaces can have on urban spaces by altering people's daily lives, such as increasing street life to promote street vitality (Jacobs, 1961).

Literature Review

In order to create attractive cities, many studies have been conducted on how the built environment stimulates street vitality. It was first suggested that the physical spatial features of the built environment, such as functional mix, neighbourhood scale, and density of street intersections, are the key factors influencing street vitality (Jacobs, 1961). With the generation of urban multi-source data and the development of quantitative urban morphology, scholars have made finer and more precise quantitative calculations of built environment features, further confirming the relationship between urban morphological elements and street vitality, such as greening rate (Lopes and Camanho, 2013), street interface continuity, underlying interface transparency (Zeng, Zhang and Yuan, 2019) and traffic accessibility (Zhang *et al.*, 2021) are elements that are strongly related to street vitality. However, traditional research methods using linear regression models can no longer meet the need to reveal the complex relationships between street vitality and built environment variables. With the development of emerging algorithms such as machine learning, a number of studies have emerged in recent years using machine learning models to explore the nonlinear relationship between street vitality and built environment (Li *et al.*, 2022; Han *et al.*, 2024; Doan *et al.*, 2025). However, there are still few studies exploring the nonlinear relationship between the built environment and urban vitality in historic districts, and there is a lack of studies revealing the relationship between virtual space activities and urban street vitality.

With the rise of social media, people can post on social media platforms with geolocation information. These location-based social media platforms are creating a new kind of space (Ash, 2009; Ash, Kitchin and Leszczynski, 2018), which can be defined as a virtual space (Kellerman, 2014). Users express their attitudes towards locations through a series of activities (e.g., liking, commenting, sharing) within the virtual space (Lloyd and Cheshire, 2017), which we call virtual activities. Based on social media recommendation algorithms, the more frequently a post receives virtual activities such as likes and shares, the more likely it is to be pushed to more interested users. Different sizes of exposure enable virtual locations to also produce location locational features similar to those in physical space. At the same time, by changing people's daily life and consumption behaviour (Bissell, 2020), a close relationship between virtual and physical spaces is created (Leszczynski, 2020). Taking the example of the popularity of ‘clocking activities’ in China, people are interested in attractive posts and are

motivated to visit these places on-site (Cao, 2024), thus contributing to the vibrancy of a particular place. However, current research in the field of urban design related to social media focuses more on the new urban intentions it generates (Huang et al., 2021), and there is a lack of research on the relationship between virtual spaces and the vitality of urban streets.

Research gaps and the significance of the study

Overall, current research has discussed a wide range of built environment elements that have an impact on urban street vitality and explored the nonlinear relationship between the two. However, few research results have revealed the relationship and threshold effects of virtual space activities and urban street vitality, as well as the lack of interactive effects between virtual and physical space features in influencing urban street vitality. Therefore, the study aims to explore the nonlinear relationships between virtual and physical space features and urban street vitality. The results of the study can provide a reference for the creation of vibrant street spaces in urban design, and provide a theoretical framework for the vitality revitalization of historic and cultural areas.

The first part of this paper describes the background of the study. The second part describes the research framework and experimental methods. The third part takes Hengfu historic and cultural area in Shanghai as an example for the statistical analysis. The fourth part summarizes the innovation and value and presents the limitations of this study.

METHOD

Research Framework

Figure 1 illustrates the research framework of this study. Based on the ‘5D’ built environment theory and a literature review, the study selects physical and virtual space features as independent variables and street vitality as dependent variable. Taking Hengfu historic and cultural area in Shanghai as an example, this study combines urban multi-source data such as LBS, POIs, Xiaohongshu, Meituan and other spatial analysis software such as ArcGIS Pro to calculate each variable in detail. Lastly, a XGBoost machine learning model was built using python programming language, and SHAP values were used to explain the nonlinear and interaction effects of these features, thus providing insight into the relationship between physical and virtual space features and urban street vitality.

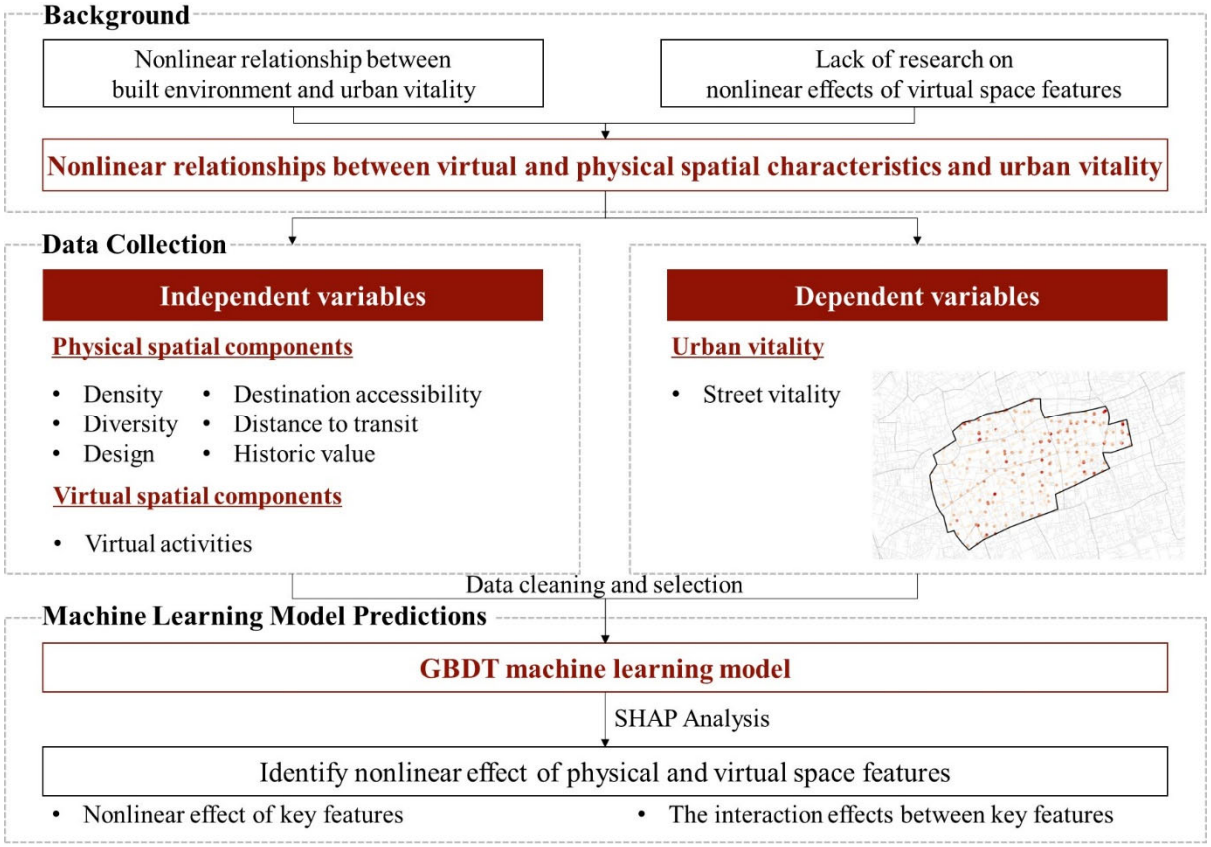

Figure 1. Research framework

Study area

The Hengshan Road-Fuxing Road Historic and Cultural Area, or Hengfu historic and cultural area for short, is one of the first 12 historic and cultural areas in Shanghai to be publicly announced by the Shanghai Municipal Bureau of Planning and Natural Resources. It is also the largest historic and cultural area in the central city of Shanghai, with the largest number of outstanding historic buildings and the most complete historic landscape pattern. In particular, Hengfu historic and cultural area is a high-density built-up area, with complete data of the built environment and a higher density of social media data. Consequently, 1515 street segments in this area were selected as the data set, and the detailed information of the selected area is shown in Figure 2.



Figure 2. The study area

Data and variables

Table 1 presents the independent variables used in the study. The independent variables were classified into two categories: physical space variables and virtual space variables. In the physical space variable, the "5D" dimension (Ewing and Cervero, 2010), which describes the characteristics of the built environment, is employed to construct a system of indicators for the physical space characteristics in terms of density, diversity, design, accessibility to destinations, and distance to transportation facilities. Furthermore, given the pivotal role played by historic value in the resilience of historic and cultural areas, the independent variable of historic building density was incorporated into the study to delineate the historic environment (Zhang and Han, 2022). In calculating the physical space variables, two calculation ranges are used, a 55-meter street buffer (Guo, Chen and Yang, 2021) and a 500-meter street buffer, which represents the walking distance from the street (Zhang *et al.*, 2019). In the virtual space variables, the behaviours of individuals within virtual space (e.g., virtual visits, virtual ratings, etc.) are employed to characterize the virtual space.

Table 2 presents the dependent variable used in the study. The study used street activity intensity as a proxy for urban street vitality. Temporal and spatial records of mobile users' activities were obtained from location-based service (LBS) data (Zeng *et al.*, 2018), that is, anonymized user geolocation data provided by Amap. LBS data for one week (24 hours per day for 7 days) within the first month of 2020 was selected and the average daily activity intensity data for the seven days of the week was used as the total street activity intensity.

Table 1. Independent variables

Major	Dimension	Variable	Description	Data source
Physical space	Density	Building density	Proportion of base area of buildings within 500m buffer of the street to the area of the zone (%)	OSM
		Floor area ratio	Average land-use intensity of adjacent blocks	
		Road density	Length of streets per square meter within 500m buffer of the street	
		Intersection density	Number of junctions per square meter within 500m buffer of the street	
	Diversity	Function diversity	The entropy of the POIs within 55m of the street using the method of Shannon's Diversity Index	Amap
		Function density	Number of POIs per meter within 55m buffer of the street	
	Design	Vegetation	The average value of the tree proportions in all the street view images on the street	Baidu map
		Sky	The average value of the sky proportions in all the street view images on the street	
		Building	The average value of the building proportions in all the street view images on the street	
		Sidewalk	The average value of the sidewalk proportions in all the street view images on the street	
		Road	The average value of the road proportions in all the street view images on the street	
		Furniture	Number of street furniture per 100 meters	
	Destination accessibility	Walking accessibility	Walking accessibility using the betweenness in sDNA when the radius is 800m	OSM

		Vehicle accessibility	Walking accessibility using the betweenness in sDNA when the radius is 9500m	
	Distance to transit	Distance to bus stop	The Euclidean distances from the midpoint of each street to the nearest bus station	Amap
		Distance to subway station	The Euclidean distances from the midpoint of each street to the nearest subway station	
		Bus stop (counts)	Number of bus stations within 500m buffer of the street	
	Historic value	Historic building density	Number of historic buildings per meter within 500m buffer of the street	
Virtual space	Virtual activities	Virtual visiting activities	Number of virtual visits (likes, comments, favorites, shares) to premises addresses within 55m buffer of the street	Xiaohongshu
		Virtual popularity	Ratio of the number of times a premises address in the street 55m buffer has been virtually visited to the number of times the address has been mentioned	
		Virtual score	Average rating of addresses of locations within the 55m buffer zone of the street	Meituan

Table 2. Dependent variable

Major	Variable	Description	Data source
Urban vitality	Street vitality	Average of daily summaries of the density of people active during the week within 55m of the centre line of the street to either side	Amap

Upon completing the data collection process, ArcGIS Pro 3.0 was employed to calculate the variables. Subsequently, a preliminary correlation analysis was conducted (Figure 3). The results of the correlation analysis indicate that the analysis revealed a strong positive correlation between the Density dimension and the Design dimension within the physical space features. Conversely, the virtual space features demonstrate a relatively weak positive correlation with the majority of the physical space features. Finally, in response to the multicollinearity between indicators, the vegetation and building variables have been excluded from the analysis, as they exhibited VIF values exceeding 7 and a correlation coefficient exceeding 0.6 with either variable.

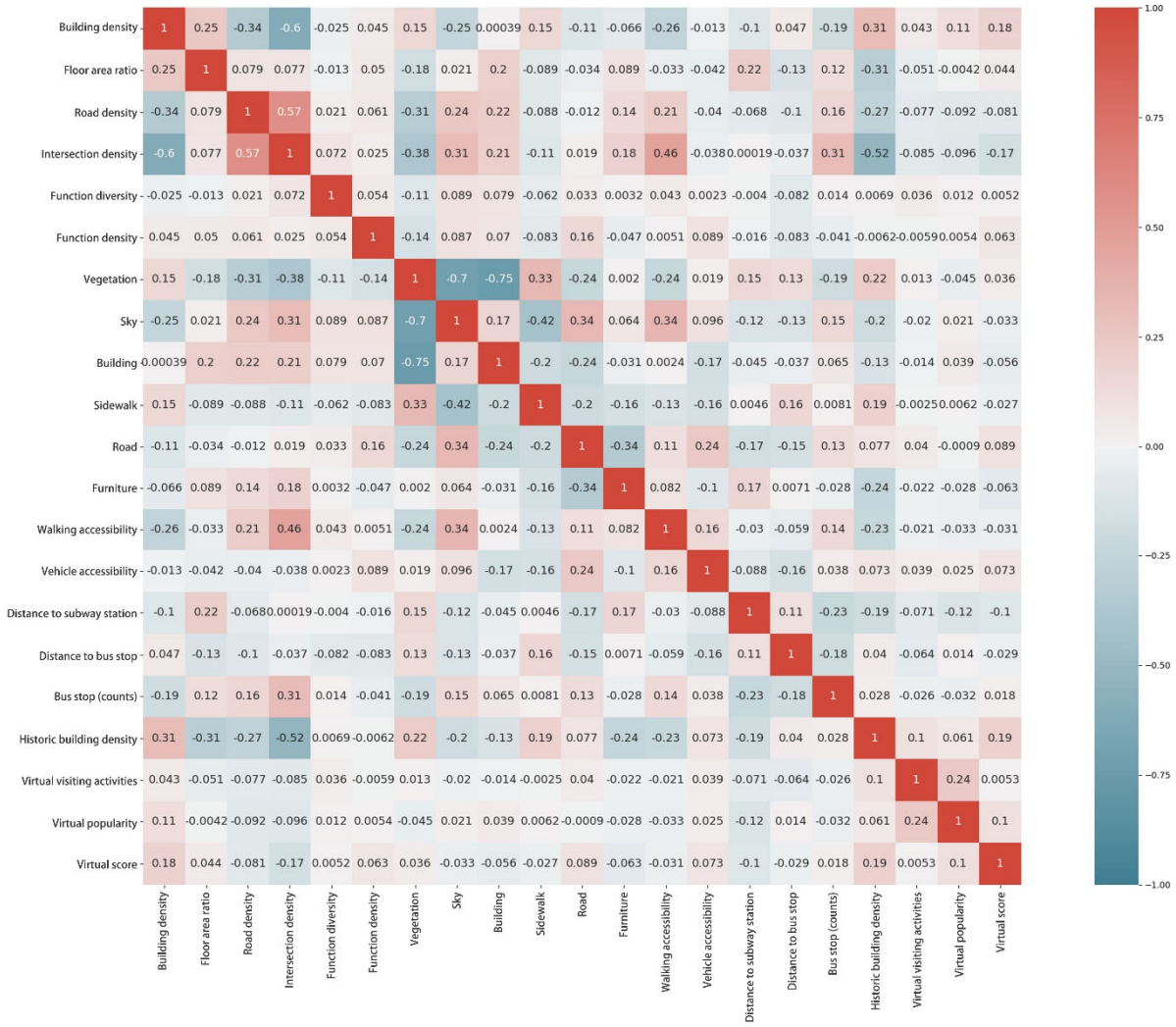

Figure 3. Correlation matrix

Modelling approach

The study applied Ensemble learning to construct a street vitality prediction model that is based on both physical and virtual space features. The study employed Random Forest, GBDT, and XGBoost models for regression modelling and evaluation and compared the performance of each model based on accuracy evaluation metrics such as MAE (Mean Absolute Error), RMSE (Root Mean Square Error), and R^2 (coefficient of determination). After a comprehensive comparison of the performance metrics of each model, XGBoost shows better performance in all metrics. In comparison to traditional linear regression models, XGBoost, a gradient boosting-based decision tree algorithm, is capable of achieving efficient model training and prediction by optimizing the objective function and introducing parallel computing (Chen and Guestrin, 2016).

Table 3. Performance comparison of the three machine learning models

Performance	Random Forest	Gradient Boosting	XGBoost
MAE	149.994	154.501	144.118
MSE	47839.322	53664.945	45815.322
RMSE	218.722	231.657	214.045

R^2	0.364	0.286	0.391

The study employed the xgboost package (Python 3.9.13) to estimate the XGBoost model. For XGBoost model, key parameters such as n_estimators, learning rate, and maximum depth are of significant importance in determining the model's overall performance. The learning rate controls the step size of each round of boosting, with lower values resulting in slower learning but improving generalization and preventing overfitting. The max_depth largely determines the complexity of the model, and higher values may result in better performance, but carry the risk of overfitting. The results of the testing phase demonstrated that the combination of n_estimators = 500, learning_rate = 0.05, subsample = 1, colsample_bytree = 1, and min_child_weight = 1 yielded the highest R-squared value of 0.403 for XGBoost, indicative of enhanced model performance.

RESULTS AND DISCUSSIONS

To examine the local effects of independent variables and their interaction effects in conjunction with other variables, the SHAP package (Python 3.9.13) was utilized to interpret the XGBoost model. SHAP, which is based on game theory, can be used to enhance machine learning explanations (Lundberg and Lee, no date). The SHAP approach offers a comprehensive analysis of global, local and interaction effects that cannot be effectively captured by partial dependency graphs and cumulative local effects methods. In previous studies of urban planning, SHAP and XGBoost were employed to elucidate that the built environment and road vehicle factors exhibit positive nonlinear relationships with urban vitality (Doan *et al.*, 2025).

Relative importance of variables

The relative importance of each feature is calculated and ranked based on the mean absolute SHAP values. The relative importance of variables implies their ability to make a successful prediction. The features are visualized collectively, with a dot on the right representing a street sample, where a redder colour means a larger feature value.

Physical space variables contribute more to the successful prediction. Among the physical space features, the Distance to transit dimension has the highest relative importance of 24.92%, followed by the Design, Density dimension. Specifically, the Distance to subway station variable, Percentage of sidewalks in the street, and Vehicular accessibility are more important than other features. Street segments closer to subway stations, a higher percentage of sidewalks, and a higher level of vehicle accessibility have higher street vitality. This indicates that accessibility plays a more critical role in promoting street vitality than other urban form characteristics. In addition, streets with high density of historic buildings in historic and cultural districts usually have lower vitality, which may indicate that most of the historic buildings have not fully utilized their historic value and their attractiveness needs to be improved.

Among the virtual space features, virtual popularity has the highest importance, and most of its high value points correspond to negative SHAP values, i.e., higher virtual popularity corresponds to lower street vitality in historic and cultural areas. The possible reason for this is that stores at lower street vitality in historic and cultural districts are more inclined to advertise on virtual platforms such as social media and attract crowds of people to hit them, but the number of people hitting them is still a small percentage of the total number of people in the total amount of vitality. It suggests that the popularity of a location in virtual space has some degree of influence on street vitality in reality.

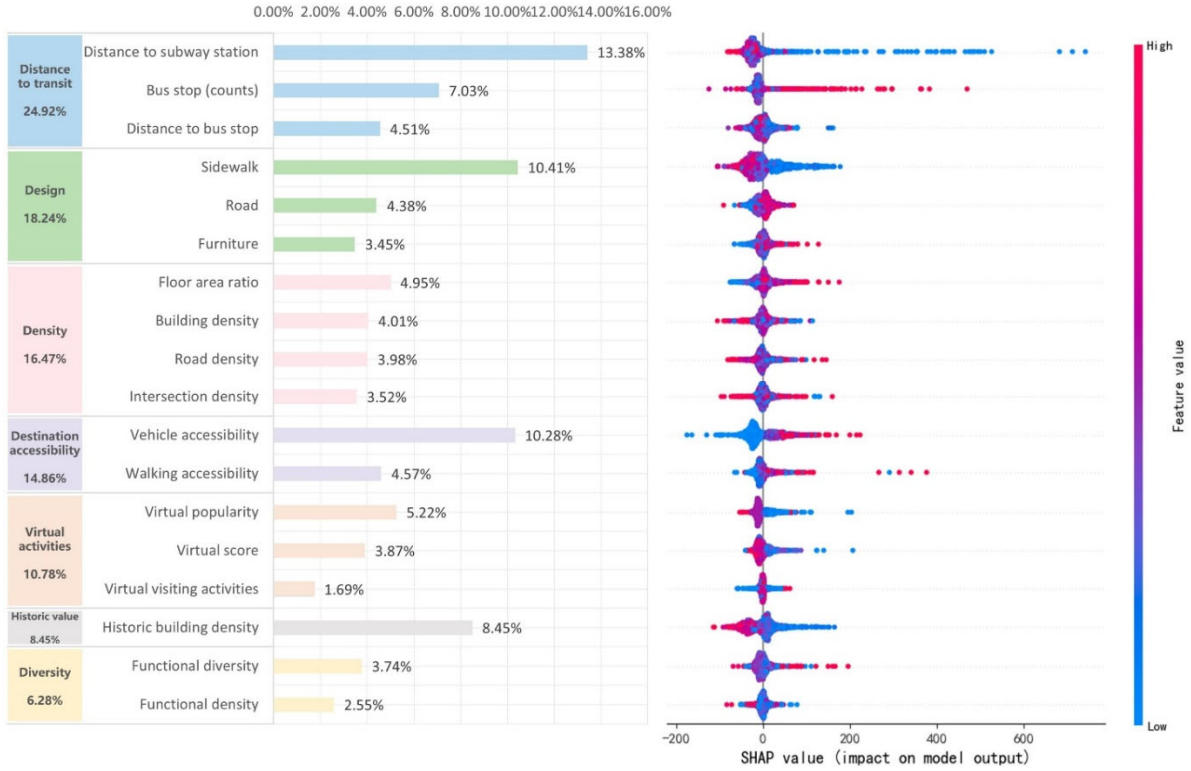

Figure 4. *The relative importance of variables*

Nonlinear effect of key features

The SHAP dependence plots of key features (relative importance greater than 3%) are shown in Figure 5 to show the nonlinear relationships and threshold effects of physical and virtual space features with urban street vitality(Friedman, 2001). Sample point-fit curves (Locally Weighted Scatterplot Smoothing, LOWESS) were generated to the plots to better identify trends of the local effect. A steeper slope of the curve indicates a higher marginal benefit and a rising curve indicates that the independent variable is positively correlated with street vitality and vice versa. It can be found that the relationships between the key features of this study and the vitality of the city streets all show a complex nonlinear relationship.

Physical space major

When there are more than 10 bus stops within the 500m buffer zone of a street, street vitality increases sharply with the number of stops; when the distance from the nearest subway station is less than 200m, vitality decreases sharply, and when it is greater than 200m, the change tends to be stabilized; and when the distance from the nearest bus station ranges between 100-200m, the increase in distance has a negative effect on vitality. Compared to similar studies examining industrial cities, the thresholds for distance from public transportation stops in this study are relatively smaller, consistent with the high-density characteristics of historic urban areas.

In the design dimension, the proportion of sidewalks tends to decrease in the range of 0.01-0.12, while driveways and street furniture show an overall increasing trend, but have a negative impact on vitality when the proportion of driveways exceeds 0.32.

Regarding density dimension, increases in floor area ratio within the range of 0-2.5 and improvements in road network density can enhance street activity intensity. However, excessively high building density may lead to overcrowding and compression of public space, potentially reducing street activity. Additionally, further increases in intersection density beyond a certain threshold do not significantly affect street vitality.

In the accessibility dimension, the local effects of both pedestrian and vehicular accessibility are generally on the rise, indicating that not only residents traveling on foot, but also a larger number of tourists traveling by car, are active within the historic and cultural areas.

In terms of historic value, the threshold effect of density of historic buildings shows an overall decreasing trend, indicating that most of the historic buildings still have not fully utilized their historic value and their attractiveness needs to be improved. In terms of diversity, when functional facilities are richer and more diverse, they will have a positive impact on street vitality, which is consistent with common sense.

Virtual space major

The threshold effect of virtual popularity decreases at the beginning and then increases slightly, although the overall trend is decreasing, which may be due to the fact that the people who carry out visiting activities in the virtual space come from all over the country, and only some of them have a high likelihood of being able to reach the real location, so as the heat of the virtual visit increases while the number of the people who actually visit the physical location does not have a large change, popularity is negatively correlated with street vitality. The threshold effect of virtual score likewise shows an overall decreasing trend.

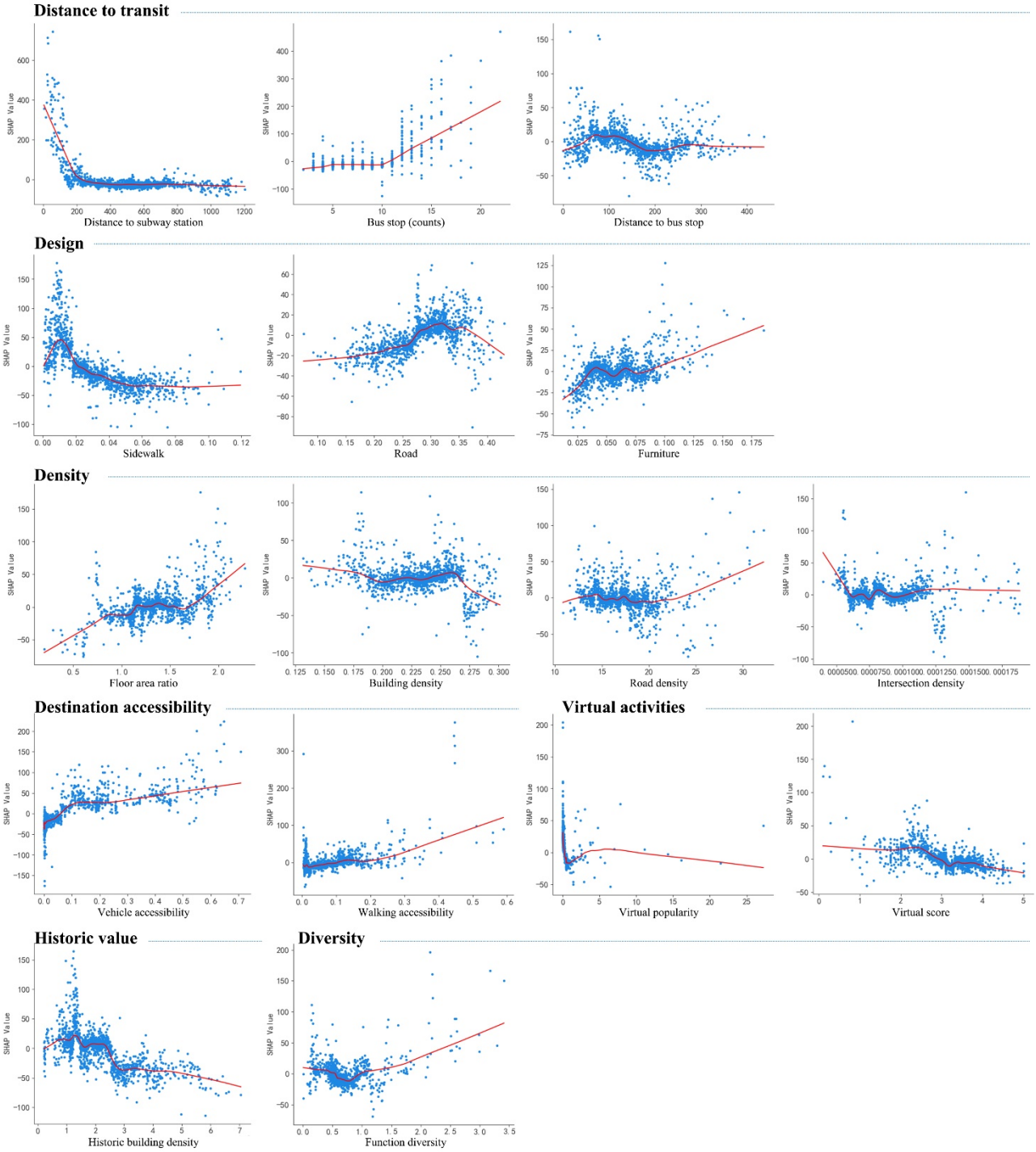

Figure 5. *Nonlinear effect of key features*

The interaction effects between key features

Figure 6 illustrates how the effect of one feature on street vitality depends on another through a SHAP dependency plot. Each point in the plot represents a sample, the X-axis represents an independent variable, the colour bar indicates the size of the other independent variable with which it has the

strongest interaction, and the Y-axis represents the SHAP value. It can be found that there are two interaction effects between the key features - synergistic interaction and inverse interaction.

There is a negative synergistic interaction between the number of bus stops and subway station accessibility, leading to a detrimental effect on street vitality when both are at low or high levels. It indicates that too many public transits may cause wastage of space and hinder the generation of street vitality instead, so the number and density of both bus stops and subway stations should be kept within appropriate limits.

There is an interaction effect between virtual activities and design, as well as the distance to transit. Virtual popularity and sidewalk presence have opposite effects on street vitality. The two interact positively only when the sidewalk percentage is below 0.02 and virtual popularity is high. When the sidewalk percentage exceeds 0.02, virtual popularity at a low level does not strongly impact street vitality negatively. Additionally, an increase in the number of bus stops negatively affects vitality when the virtual score is below 3; the interaction effect is not significant when the score is higher. A similar inverse interaction exists between historic building density and floor area ratio. At low levels of historic building density, higher floor area ratios are linked to lower vitality, as overly dense urban spaces create negative spatial perceptions that harm street vitality.

Vehicle accessibility and sidewalk have opposite effects on street vitality. The greater the proportion of sidewalk, the greater the negative effect on vitality when vehicle accessibility is below 0.1, and vice versa. This may be due to the fact that as the city expanded, the number of lanes on major roads in the historic urban area no longer meets the demands of today's vibrancy growth.

Both pedestrian accessibility and intersection density show a negative synergistic interaction. That is, low levels of both characteristics exacerbate the weakening of street vitality and conversely strengthen it. However, when pedestrian accessibility is below 0.2, increasing intersection density has no effect on street vitality, suggesting that urban design with small neighbourhoods and a dense road network is less helpful in enhancing street vitality when the area is not sufficiently walkable.

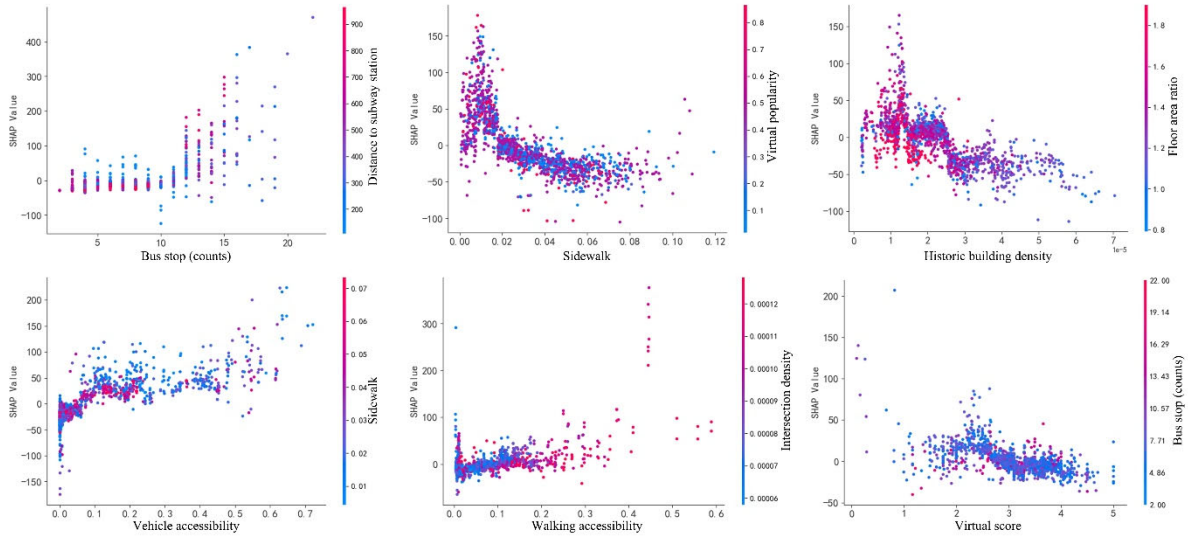

Figure 6. *The interaction effects between key features*

CONCLUSIONS

Overall, based on multi-source urban data and machine learning algorithms, this study establishes a XGBoost model for 21 physical and virtual space independent variables and the dependent variable of urban street vitality. Using the Shanghai Hengfu historic and cultural area as a case study, the study explores the nonlinear relationship between these independent variables and street vitality and examines their interaction effects using SHAP.

However, this study has certain limitations. Firstly, urban vitality is a complex concept that may not be fully expressed in terms of social activity intensity, and a wider variety of data can be added to jointly describe urban vitality in future research. Secondly, the optimal walking distance for calculating urban form features may vary across cities and regions, while the model performed well in this study, the applicability of 55m and 500m in Shanghai's historic and cultural area can be further verified in future studies. Finally, this study was limited to extracting location information from social media text, and future research could explore extracting more information from images for more in-depth studies.

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Form, design and urban codes. A study on Rimini (Italy)

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ABSTRACT

As stated by Ben-Joseph (2019), designers, planners and those who wish to work on the built environment cannot easily escape the obligation to create and maintain places where rules do not oust physical qualities. This thinking underlies the concept of quality of place and at the same time the flexible performance of urban rules in a formal action perspective. In this sense, codes could be used in a generative way, to specify generic urban elements and relationships, such as the type of building, the way buildings relate to the hierarchies of pathways, and so on, in order to create a number of variations around the formal theme. The research here presented analyses the historical centre of Rimini (north-east coast of Italy) with the objective of triggering urban regeneration mechanisms, arguing that it is possible to deepen the concepts of street and block as composite units for an inter-scalar vision of the urban environment in order to generate new rules based on form. The research methodology reflects the principles of the Italian school of urban morphology with particular reference to the urban studies by Saverio Muratori and Gianfranco Caniggia in a transitional perspective. What needs to be questioned is the ability of codes to mediate between individual interests and common goals (Marshall, 2011), fostering the connection between urban form and design devices. The essential aspect of codes as generic specifications naturally tends to promote a combination of flexibility and continuity over time, as well as consistency across scales and between multiple actors. Above all, codes can contribute to the creation of an overlapping and interconnected urban vision associated with traditional, route-based urban fabrics where the designs of buildings, streets and blocks are intertwined with each other.

Keywords: transitional morphologies, urban design, urban codes, historical centre, Italy

INTRODUCTION

The quality of space

The approach here presented is founded on the concept of quality of places while promoting the flexible application of urban rules within a formal action framework. In this context, codes can be utilized in a generative way to define general urban elements and relationships—such as building types and how they interact with the network of streets—leading to various formal design outcomes. In a generative code, while the specific elements and relationships are controlled, the final form emerges organically from the development process. An emergent structure possesses qualities that are not explicitly predefined in the rules governing its creation, such as guidelines for construction, layout, or aggregation (Marshall, 2011). The term *emergent urban structure* refers to a settlement

pattern that forms naturally, without strict planning or predetermined design. These patterns arise from individual decisions, user adaptations, and spontaneous interactions, producing a seemingly organized configuration that evolves over time. Historic centres exemplify emergent structures, having taken shape over centuries as streets, buildings, and public spaces gradually adapted to human needs and social dynamics. Key scholars such as Christopher Alexander (1977; 2008) and Michael Mehaffy (2008; 2020) have explored these concepts. Their theories, along with research by Michael Batty (2005; 2018) on generative algorithms and urban science, and Bill Hillier's (1996) work on spatial interaction networks, advocate for the use of generative codes over traditional master plans. The framework thus offer a new perspective on city-making (Plater-Zyberk, 2008). Theories on urban permanence and variation, as studied by Muratori (1959) and Caniggia (& Maffei, 1979), also suggest that urban form can be a key generator of codes and vice versa. In addition, these methods highlight how the arrangement of elements at one scale influences the integration of components at larger scales, creating a cohesive urban vision. For instance, the combination of buildings and public spaces forms specific types of streets, while the interplay of walls, doors, and windows shapes a building façade. In traditional urban layouts, where streets serve as the primary matrix of settlements, there is a clear interconnection between buildings, streets, and public spaces (Marshall, 2011). Urban elements are composed of smaller sub-elements, which contribute to a larger whole (Alexander, 1977). In fact, Alexander critiqued the overly simplistic hierarchical design of urban environments, which lacks the richness of complex overlapping elements. Planners often struggle to conceptualize and implement such complexity on the ground (Alexander, 1966).

Based on these theories, the Rimini case study was conducted with the goal of initiating urban regeneration within the historical urban fabric. This process began with a formal analysis and concluded with the creation of new design guidelines. The study is structured into three key sections. The first, Reading the form of Rimini, analyses the urban form of Rimini's historic centre, identifying the major elements shaping the area. It categorizes urban structures into morphological clusters, which are parts of the urban fabric with shared characteristics in terms of building types or patterns of aggregation. In the second part, each cluster is used to explore potential meta-design interventions, referred to as "devices", drawing on the concepts of "dispositive" and "device" from Foucault, Deleuze, and Agamben. Finally, in the third part, a synoptic matrix is produced that offers an early vision of an urban code, providing direction for the future development of the historic centre, which, in Italy, often serves a symbolic role regardless of its actual value.

Reading the form of Rimini

To thoroughly describe the composition of Rimini's urban fabric, it is crucial to use the right tools and methods to grasp the complexity of the urban landscape. Recognizing that the visible appearance of the urban environment results from various processes—each with its own logic and origins—that intersect and overlap over time, leaving traces, defines the urban territory as a palimpsest, continuously reshaped (Corboz, 1983). These processes together create an urban landscape where transformations are difficult to reverse, and the sum of these transformations represents the territorial fixed capital, which both enables and restricts regeneration efforts. In working with established urban fabrics, it is necessary to clearly identify certain key elements that make up the structure of a historic centre. First, the structural elements, which are components of the urban environment that have remained almost unchanged over time and form the identity of the historic

centre. These elements include the street layout—an overlay of Roman, medieval, and later systems—and the natural hydrography, such as Rimini's Marecchia canal. Second, the settlement systems, which are clusters of urban buildings that are interdependent on these structural elements but follow internal rules (such as old Roman insulae now forming closed blocks, open blocks, or linear and terraced developments). These settlement systems contain some homogeneous morphologies, or clusters defined by specific building densities, layouts, and prevalent types. Homogeneous morphologies group together similar architectural typologies and building arrangements, such as closed blocks or linear fabric. The coexistence of these elements and the layering of urban transformations form the city's inherited identity. Describing the city's form is not the end of urban analysis; rather, it opens up various design possibilities rooted in understanding the complexities of these formal layers (Albrecht & Galli, 2021). This kind of analysis helps to establish a taxonomy of the built environment by recognizing different patterns of aggregation based on typological units (Caniggia & Maffei, 2017). In Rimini's historic centre, five distinct homogeneous morphologies have been identified, each contributing to the city's urban identity. These include a compact fabric of layered blocks, a fabric with special buildings, fringe fabric with uneven elevations, buildings aligned along streets, and urban areas containing structures that are out of place in relation to the traditional urban fabric. Together, these morphologies paint a diverse and complex picture of Rimini's historic core (Fig. 1).

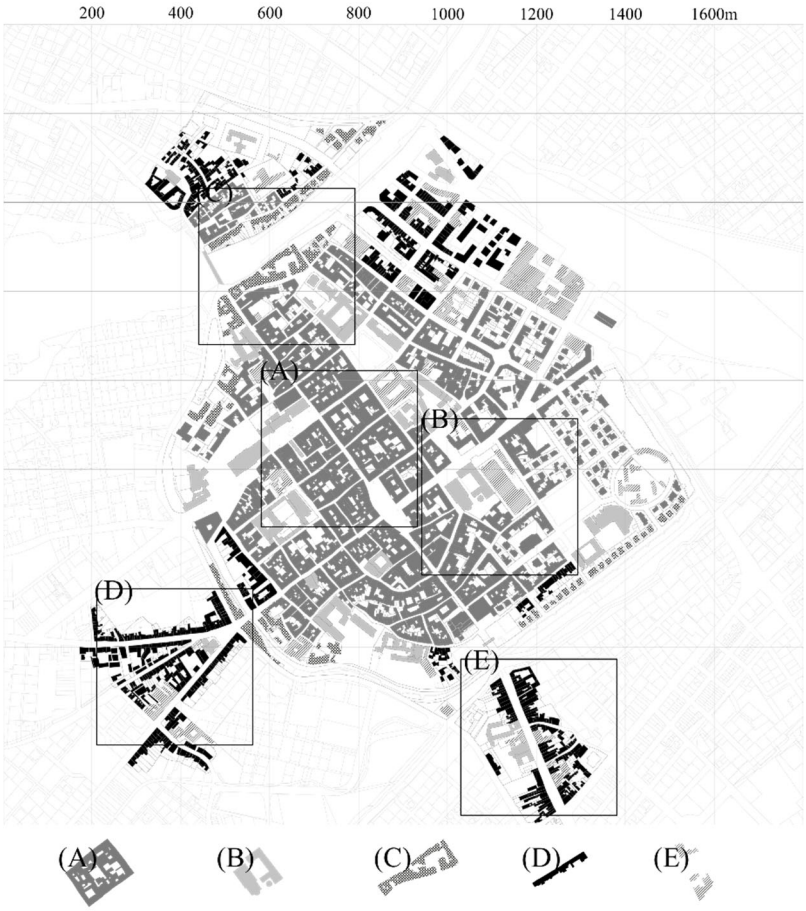


Figure 1. Morphological clusters in the historical centre of Rimini. Author, 2023.

The clusters were classified based on the typologies and forms defined by Caniggia and Maffei (2017) for basic buildings. To understand these clusters better, each has been examined through a sample

of its urban fabric. A morphological analysis and a meta-design (or device) were conducted on each sample. These devices not only propose preliminary urban configurations aligned with the area's identity, but also generalize these findings across similar urban fabrics. The study of clusters involved analysing the formal transition of the urban samples, identifying recurring patterns and variations over time. The accompanying table (Fig. 2) illustrates how the evolution of each sample reveals its unique characteristics, enabling comparisons. For example, sample A, representing the compact block fabric, shows that the block structure is sometimes disrupted by a porous quality. Sample B, containing special buildings, highlights how the continuity of the blocks has been compromised over time. In the fringe fabric (sample C), there is a reconfiguration of the cluster, revealing aspects of fragmentation and disintegration. Sample D, composed of buildings aligned along streets, reveals a clear relationship between urbanization, street layout, and building façades. Lastly, in sample E, which contains buildings out of scale with the surrounding structures, although urbanization phases are visible, the disruptions caused by these typologies are less obvious. Despite their differences, these extraneous buildings often align with the overall urban fabric's aggregation principles but still stand out due to their distinct architectural and typological features.

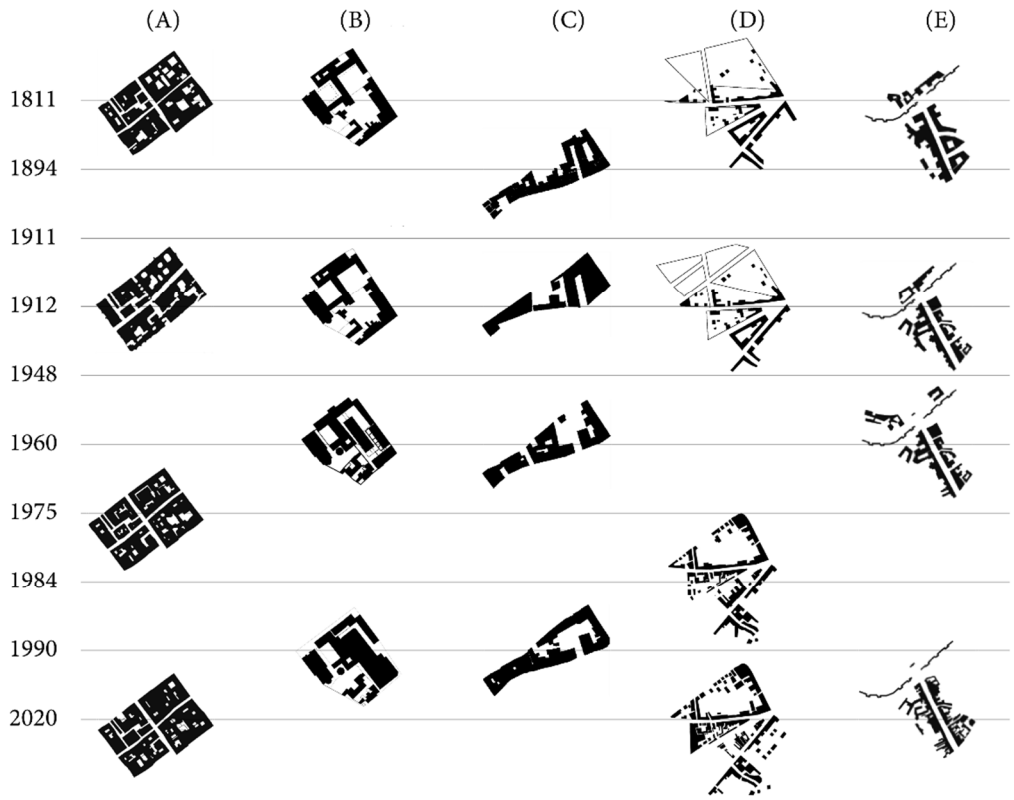
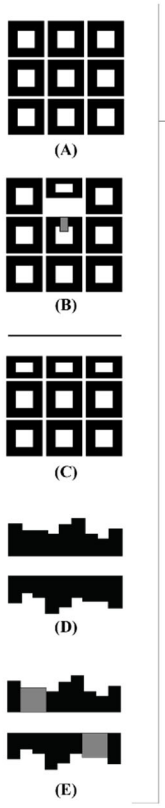


Figure 2. Formal urban transition of the study samples of the five morphological clusters in Rimini. Author, 2023.

Samples laboratory

The analysis of morphological transitions alone, as seen with sample E, doesn't capture all characteristics of historic urban fabrics. To address this, each sample was assessed using a typological abacus to better outline qualities within the urban fabric across multiple scales. A summary table (Fig.

3) was created for an integrated view of all clusters. In the first three columns, this table captures the main characteristics and relationships of the forms analysed, while the final two columns present areas for action and suggested strategies to foster urban regeneration based on the data. The table is organized hierarchically, descending from settlement patterns to architectural components. For each scale, intrinsic and extrinsic characteristics and relationships are outlined. Qualitative aspects point to areas for potential intervention, such as courtyards or roof elements, while quantitative goals aim to guide regeneration of the consolidated urban fabric, preserving identity while addressing multiple scales.



Field of observation	*Characteristics of elements*	*Intrinsic and extrinsic relationships*	*Qualitative specifications (interventions)*	***Quantitative specifications (objectives)***
Settlement (Rimini)	Mixed urban areas with a mixture of typologies	Position and relationship with the natural and anthropic territory	Urban landscape	**Urban regeneration of compact fabrics while preserving local identity**
Urban fabric (cluster)	Compact fabric with blocks (A) Fabric with the presence of special buildings (B) Margin fabric (C) Townhouse Fabric (D) Fabric with presence of extraneous buildings (E)	Porosity (A) Influence of the poles (B) Discontinuity and fragmentation (C) Continuity with the eaves line (D) Extraneous typologies and blind fronts (E)	Internal courtyards, facades and roofs (A) Exceptionality in the urban fabric (B) Private and collective space (C) Relationship with the road (D)	**Increase in building capacity in terms of surfaces and volumes** **Greater use of collective spaces**
Streets and collective space	Driveways (A, C, D, E) Pedestrian routes (A, B) Public squares (A) Cycle routes (E) Parking (A, B) Courts (A, B, C)	Ratio between squares and driveways (A, B, C) Ratio between the different degrees of transit (D, E) Ratio between inside/outside of thr block(A, B, C)	Path hierarchy distribution (A, B, C, D, E)	**Accesses** **Openings** **Facades and height of buildings**
Building typologies	Courtyard buildings (A,B,C,D) Special buildings (A, B) Ordinary building (A, B, C, D, E) Buildings arranged in line (D, E)	Position of lots in relation to the road hierarchy (A, B, C, D, E) Setbacks (B) Property boundaries (A, B, C, D, E)	Maintaining Architectural Principles (B) Maintenance of morphotypological and identity characters (A, B, C, D)	**Surface reports** **Dimensions of the building** **Height of buildings** **Distances**
Building Components	Roof typology (B, D, E) Elevations and facades (A, C, D, E) Structural components Porches, balconies, overhangs (C, D, E)	Relationship between openings (doors and windows) (A, C, D, E) Eaves lines (D) Railings (D)	Materials (A, B, C, D, E) Ornaments and decorations (A, B, E) Green roof (A, E) Superelevations (D, E)	**Dimensions of surface and volume additions** **Roof slopes** **Maximum overhangs and overhangs**

Figure 3. Qualities and Quantities summarised after the analysis of the sample in Rimini. Author, 2023.

This analysis enabled design experimentation on each sample through the use of a "device." In the compact fabric with blocks (Sample A), the focus was on small-scale, temporary urban acupuncture interventions to retain local identity. For Sample B (urban fabric with special buildings), the approach involved reshaping the fabric through competitions and design that enhance monument-centered areas. The marginal fabric (Sample C) allowed for the use of "parasitic" architecture and residual spaces. Sample D, the fabric with buildings in line, was tested with a dynamic growth device, where a building can be extended upward in line with its tallest neighbours. For Sample E, featuring buildings incongruous with their surroundings, strategies involving air rights were explored. Below is a detailed overview of the approach on Samples C and D.

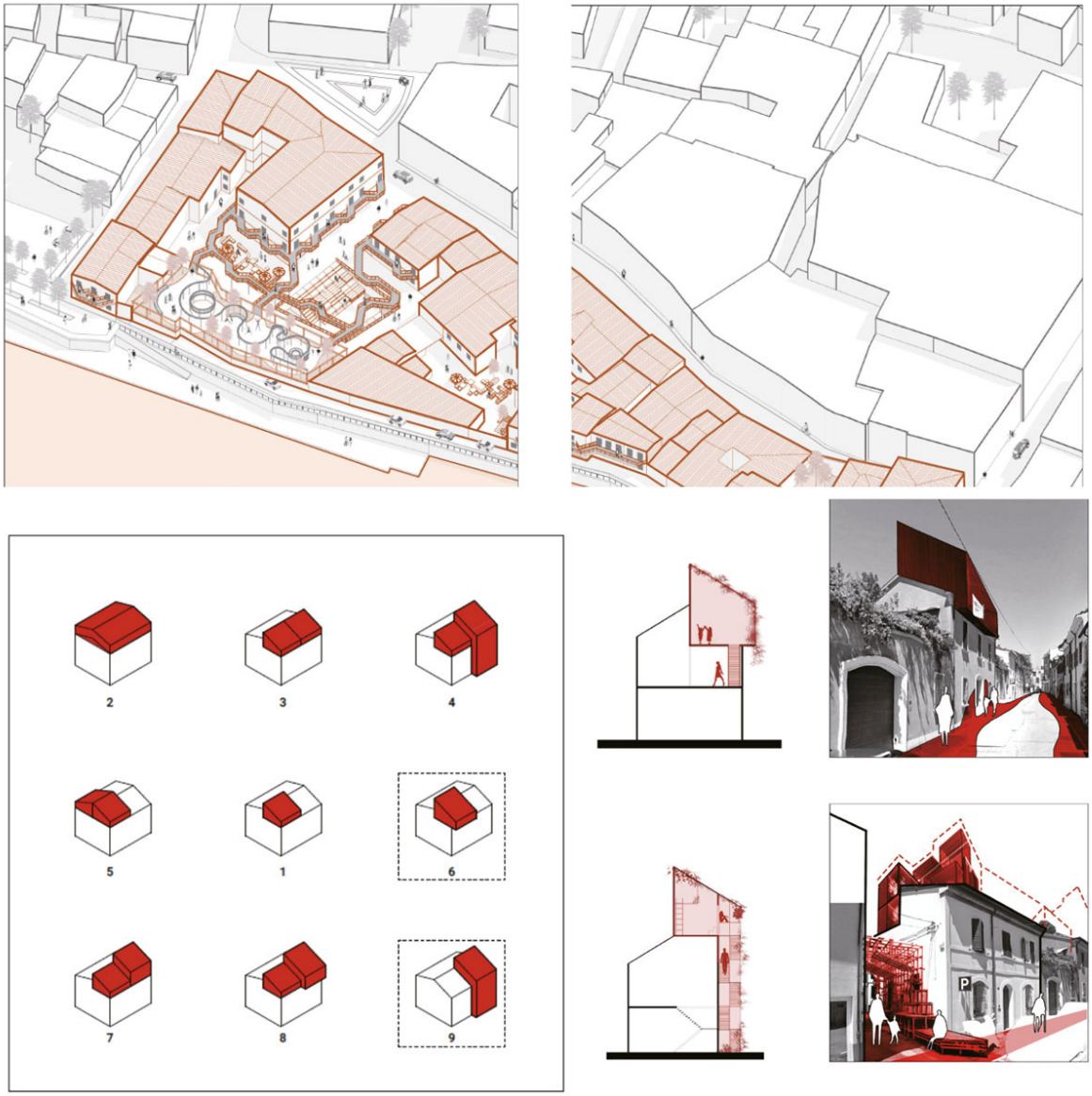


Figure 4. Devices visualisation on sample C and D in Rimini. Author, 2023.

(C) Within mixed urban fabrics that combine various building types, the marginal fabric can be identified by semi-open blocks with internal courtyards, used both collectively and individually by lot owners. These areas are predominantly occupied by ordinary buildings, with heights consistently ranging from one to five stories, featuring structural components like arcades, overhangs, and balconies arranged in a regular manner. There is a strong connection to the natural and infrastructural surroundings, contributing to the characteristic discontinuity and fragmentation typical of marginal areas. Given these characteristics, intervening in the mix of private and collective spaces becomes a valuable asset in these fabrics. Experimenting with the addition of architectural intrusions and interferences in underused spaces within marginal fabrics can increase building capacity both in terms of surface area and volume. In this way, the margin becomes a design category, not only to fill social or formal gaps but to generate new relationships that, to some extent, mend urban fragmentation (Fig. 4).

(D) The fabric with buildings arranged in a line is identifiable by the dissolution of the closed block and the strong connection each lot has with the street. Here, the courtyard becomes the rear and assumes the layout of divided lots, sometimes in an irregular manner. Under these formal conditions, the features that gain the most value are the façades and the continuity of the eaves line along the street, which acts as an attractor and hierarchically dictates the alignment of the lots. The morphological analysis of these fabrics shows a growth trend aimed at increasing height in terms of volume and/or surface area for each unit. This growth is derived from observing eave lines and building layouts, along with the need to maintain a connection to the street—key identity features of this fabric. Therefore, dynamic growth could include solutions for volume additions, either fully or partially based on the lot area, relative to adjacent units. Codifying this strategy from a transformational perspective allows the prediction and control of urban fabric growth (even simultaneously), preserving Rimini's architectural identity and solutions. Thus, this device takes on a meta project role where the growth of each individual building unit is related to adjacent units over time (Fig. 4).

Decoding Rimini

The synthesis of Rimini's urban fabric analysis shows that every urban regeneration proposal is rooted in a morphological approach. This involves analysing fabric structures, aggregations, and typological cells, which form the foundation for any prescriptive or regulatory framework. The devices, in turn, serve as experimental models, suggesting design actions that support regeneration objectives. These insights pave the way for creating a synoptic matrix that connects formal analysis to actionable devices, providing a foundation for drafting an urban code. The table in Fig. 5 outlines the five morphological clusters, including the intervention zone requirements (IF), possible actions within urban fabrics based on device testing (ALLOWED), the entities responsible for regeneration (PROMOTERS), benefits for stakeholders (ADVANTAGES), and limits or operational measures in each cluster (LIMITS/QUANTITIES). While the table encapsulates findings across all samples, two examples (C, D) are elaborated below.

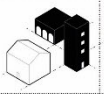
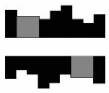
URBAN FABRIC (cluster)	IF (morphological characters)	IS ALLOWED (operations permitted)	PROMOTERS	ADVANTAGES	DEVICE	LIMITS QUANTITIES
	There are conditions of compact building fabric with closed blocks and stratifications	Rethinking the urban space to make the fabric more porous through: • temporary interventions on the system of voids (courtyards and courtyards); • interventions on the internal facades; • interventions on roofs and flat roofs.	Private owners	• Remediation • Incentives on environmental taxes • Increase of surfaces	Urban Acupuncture 	• Occupation of private land by the public on private concession • Surface increase in accordance with the building typology.
	Types of special buildings that have polar characteristics with respect to the surrounding urban fabric	• Remodel the urban fabric while maintaining the layout of the special building; • Recognize the morphogenetic archetypes of the tissues affected by polarity; • Parametrically modulate the interventions between the identified morphogenetic archetypes.	Public administration	Increase in surfaces and volumes as a percentage of the urban fabric under analysis.	Morphological replasmation of tissues 	• Occupation of private land by the public on private concession • Surface increase in accordance with the building typology.
	Margin tissue conditions are present with proximity to topographical and/or anthropic borders	Recover cubage through: • the increase in surfaces and volumes served by walkways or paths; • the temporary occupation of private open spaces (courts and courtyards if any) by the public administration to create public spaces or gardens.	Private owners Investors Public administration	Increase of surfaces and volumes	Parasite architecture 	• Occupation of private land by the public under concession • The overhangs must respect a maximum overhang comparable to the addition of balconies on the street facade • The "parasitic architectures" must occupy no more than 20% of the façade on which they are built.
	There are compact urban fabrics with typologies arranged in line (row houses)	• Increase the building capacity of surfaces and volumes by addition while preserving the characteristics of the original typology • The elevation of buildings is enabled through a dynamic index which is governed by the height of the tallest adjacent building	Private owners Investors	• For urban quality, the preservation of local identity • For investors, increase in area/ volume	Dynamic growth 	Height raising with dynamic index: • h h near +1 • traditional standard maximum height • 5 floors Adding volume to the facade: • Maximum projection: 1 m • Coverage of the existing facade: max 20%. • No addition of ground floor towards the public road. Roof: • Compensation gauge (partial or total • Residential destination • Addition of dormer window • Partial removal max 20%
	There are compact urban fabrics that have extraneous typologies (out of scale and that have blind facades)	Increase the cubic capacity by adding volumes and surfaces through the transfer of air rights.	Private owners Investors	Increase of surfaces and volumes	Air Rights 	• Occupy all or part of the outline of the lowest lot with structures that are catalysts of good urban qualities. • adding maximum volume between buildings (private spaces); • added as a percentage of the maximum volume (private spaces); • addition of volume to connect two buildings (collective spaces); • addition of the maximum volume for more than one building (collective spaces).

Figure 5. Synoptic Matrix. Author, 2023.

(C) In the presence of marginal fabric conditions close to topographic or man-made edges, it is permissible to recover volume through: increasing surface areas and volumes accessible by walkways or paths; and the temporary occupation of private open spaces (courtyards or patios, where present) by the public administration to create public spaces or gardens. The promoters are private owners or investors, with participation from the public administration. The benefits include increased surface areas and volumes through the use of parasitic architecture devices. The limitations of these interventions concern the public's occupation of private land under concession; overhangs must respect a maximum protrusion comparable to balcony additions on street-facing façades; and parasitic structures must occupy no more than 20% of the façade they are built on.

(D) In compact urban fabrics with building types arranged in a row (terraced), it is permitted to increase building capacity in terms of surface area and volume through additive processes while preserving the characteristics of the original typology. Elevation of buildings is allowed through a dynamic index regulated by the height of the tallest adjacent building. The promoters are private owners and/or investors, with benefits including concessions for increasing volume and surface area and preserving local identity. The device for these morphologies is dynamic growth, with building elevation based on a dynamic index (h = height of adjacent building +1), up to the traditional standard height of five stories. Façade volume addition is allowed with a maximum overhang of one meter, and coverage of the existing façade must not exceed 20%. Additions are not permitted on the ground floor. Roof operations are allowed through partial or total compensatory silhouettes, with the usage remaining residential.

This framework, applied to all generalized areas based on morphological-typological patterns, establishes relationships between spaces, entities, and intervention guidelines for Rimini's historic centre. Flexibility in interventions is maintained by allowing variations within these established systems. Typological-morphological analysis enables the identification of components and configurations, defining potential adjustments within Rimini's historic centre's established structure.

A historic centre urban model

Future research directions may also be mentioned. The selection of analysis samples began with identifying Rimini's urban forms, chosen for their intrinsic potential to support new dynamics. Reflecting on the analysis, two main perspectives emerge: morphological analysis and devices. First, Rimini's historic centre was found to be predominantly compact, with much of it organized in closed blocks. However, this does not suggest a uniform interpretation; rather, the historic centre consists of distinct spatial configurations and morpho-typological subcategories. Each cluster represents a unique expression of compact fabric, with at least three of the five samples (A, B, C) presenting unique block aggregations that transcend mere block categorization. This indicates that urban fabric analysis involves both general classifications (such as compact urban fabric) and local variations (deformations or replacements), each contributing uniquely to the relationships between urban entities at different scales.

Secondly, categorizing urban fabrics into clusters facilitated the development of devices with varied impacts on urban design. These devices can be classified according to their transformative influence, stemming from the identity recognition of specific locales. For example, the convergence of cardus and decumanus—the city's traditional main streets—marks a prime location for significant power and representational structures, where deeply ingrained morpho-typological and architectural traits define the central core of the historic area. This differentiation suggests two regeneration tempos: a slower, more concentrated rhythm within the historic core and a swifter, more dynamic one for outer areas.

This methodology offers promising generalizability. The matrix produced for Rimini—summarizing morphological transitions, formal criteria, dimensional standards, and transformation devices derived from local morphology—could be adapted to other historic contexts. The primary advantage is that each recommendation is tailored to the site, enhancing and preserving local identity. Broadly speaking, this approach suits any established urban fabric, relying on an existing built environment with a coherent visual identity to inform form-based analysis. Thus, this methodology could guide transformations of both prominent city areas, like historic cores, and more ordinary or peripheral zones, acknowledging their distinct urban roles.

Future research should focus on interdisciplinary integration, bridging urban design with public law and parametric design (Oxman, 2017). Public law could inform regulatory frameworks that support dynamic, morphology-based urban codes, while parametric design could provide digital tools to model the multiple morphological outcomes under dynamic growth regulations. Additionally, tools like Space Syntax (Hillier, 1996) could complement this work by addressing spatial issues central to land-use strategy, such as promoting economic growth, revitalizing core areas, enhancing social sustainability, and improving cycling and pedestrian access. With its data-driven approach to accessibility and walkability, Space Syntax could test and validate strategic urban interventions.

While urban codes encompass more than physical form, also addressing land use and planning, they can foster diversity by balancing aesthetic goals and mediating individual and collective interests. Urban codes, far from merely preserving the status quo, offer alternatives to conventional planning perspectives, incorporating input from planners and other stakeholders. In conclusion, this generative approach to the urban environment can shape a proactive, dynamic urban form that evolves alongside the community's needs.

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Grande ABC regional masterplan: rediscussing intermunicipal urban morphology through natural aspects

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ABSTRACT

Urban form studies start from delimitations based on political limits that range from macro to microscale, revealing configurations of the formation and development of the cities. However, in the context of metropolitanization of cities, local configurations are dependent on regional configurations. In Brazil, there is a provision in law for joint governance: Intermunicipal Consortia. It is an instrument for shared management of conurbated municipalities within metropolitan regions. To analyze the possibility of applying intermunicipal governance through this instrument, it is necessary to consider the federalism of the Brazilian State, which establishes the powers of each entity in the country. Consortia are provided in Brazilian law Federal Constitution of 1988 and gained more objective contours with the Law of Consortia (Law Nº. 11.107/2005) and the Statute of the Metropolis (Law Nº. 13.089/2015). Within the Brazilian experiences of intermunicipal associations, the one that stands out most is the Consórcio Intermunicipal Grande ABC. This Consortium developed, in partnership with the Federal University of ABC (UFABC), in 2016, a Regional Masterplan with perspectives for the joint development of the seven cities that make up the sub-region called “Grande ABC”, a sub-region part of the Region Metropolitan of São Paulo. This Regional Masterplan was pioneer at the national level and is relevant for covering the economic, urban and environmental aspects with a multidimensional perspective. From the spatialization of plans and data through georeferenced bases processed in GIS (global information system) software, it is possible to verify that the influence of urban planning goes beyond municipal logic, enabling a morphological analysis based not only on its political-administrative limit. Thus, natural and urban aspects become the real delimiters of regional morphology. Finally, we conclude that there are possibilities for advances in local and regional development when territories are understood jointly, even if considering local municipal characteristics.

Keywords: intermunicipal consortia, regional masterplan, urban morphology, local development, environmental aspects

INTRODUCTION

Studies in the field of urban morphology initially require a necessary definition of its scope. The analysis seeks to encompass streets, blocks, and urban infrastructure that make up a municipal-scale analysis, as well as to investigate and understand the relationship of this scale with the local level: buildings, their patterns, and their relationships with the city and where they are situated. Borges

(2020) points out that, although the etymology of the term naming this disciplinary field dates back to the late 18th century, it is evident that urban form has been more widely studied and disseminated in the last three decades. The author also notes that there are few studies that use São Paulo as an object of analysis, with an emphasis on urban morphology.

In this context of constructing the scope of the disciplinary field, the contribution of articles and papers presented at academic events such as the International Seminar on Urban Form (ISUF) is of great value. In a paper presented at ISUF, Moudon (1997) establishes the basic principles that urban morphology analysis encompasses, among them being the recognition of scales of analysis. The author identifies four scalar levels: buildings, streets, cities, and regions. In the context of São Paulo, these scales are important for the scope of this article because, in addition to the micro-scale represented by its buildings and neighborhoods, its processes of conurbation make the city of São Paulo one of the largest metropolises in the world. Neighboring it are 38 municipalities, constituting what is called the Metropolitan Region of São Paulo (RMSP). Within the limits of the RMSP, this article focuses on the group of municipalities known as "Grande ABC," composed of a cluster of seven municipalities that share a common genesis and have become so conurbated due to accelerated development that it is difficult to interpret the boundaries of this group. Despite this recognition of Grande ABC as a grouped entity, considering the Brazilian administrative structure, these municipalities do not constitute a region per se if the concept of region is understood through the criteria for establishing metropolitan regions.

The creation of metropolitan regions is governed by the Metropolis Statute (Law No. 13,089/2015); however, the formulation criteria remain ambiguous. As Barreto (2012) points out, the first nine RMs created in the 1970s had populations exceeding two million inhabitants and were centered around a state capital, a criterion that ceased to exist after the promulgation of the Federal Constitution (CF) of 1988. With the CF, municipalities gained greater management power, and state governments were given the responsibility of creating new RMs, leading to a weakening of the criteria for their establishment. Bringing this discussion to the context of Grande ABC, considering its population and the integration between municipalities, it is understood that it would be possible to delineate it as an RM, with Santo André and São Bernardo do Campo as its centers. However, because they are within the influence of São Paulo, the ABC was incorporated into the RMSP, which, due to its magnitude and extensive size, is divided into five sub-regions, one of which is Grande ABC (RMSP's southeastern sub-region). This division of sub-regions is understandable if the concept of a region is understood through the concepts of "geographic region," "natural region," and "homogeneous region," as discussed by Cunha (2000) to explain that a regional cluster can be constituted for various justifiable reasons. It should be noted that the definition of the scope and coverage of a region resides in a more complex realm than mere administrative delineation.

In Brazil, the responsibility for managing and liaising at the regional planning scale lies with state governments. They have autonomy in the management and allocation of resources for regions, following the compositions provided for in Brazilian law, such as metropolitan regions (RMs), urban agglomerations (AUs), and integrated development regions (Rides). Thus, applying the principle defined by Moudon (ibid.), it is understood that the constitution and characterization of regions are objects of study for urban morphology, although it is possible to visualize an impasse between the formal administrative characterization of regions in Brazil and the intense conurbation shared by municipalities within the metropolis, which more closely resemble the concepts of a geographic region

and a homogeneous region. Therefore, it is possible, morphologically, to extract elements and clues that justify the transformations that have occurred in municipalities over the past century. With a particular focus on Grande ABC, the joint development of its cities finds answers and justifications in its formation processes, which corroborates the principle defended by Moudon that urban morphology can only be understood historically, given that urban organisms are in constant mutation. Recognizing the similarities between the municipalities and understanding that their challenges and problems are shared, the city halls of the seven cities undertook the founding of an associative body for the formulation and implementation of policies, actions, and programs aimed at integrated development. This is the Intermunicipal Consortium of Grande ABC, founded and managed in a democratic and equitable manner, aiming at joint action to achieve the established goals. Throughout its operation, notable examples of actions that have brought about territorial transformations in fields such as health, education, and public management, among others, have been recorded.

As mentioned, the Consortium has a constitutionally democratic and equitable management system, so its leadership is exercised through a rotating system among the current mayors of the municipalities. Although only one of the seven mayors serves as president, the other six comprise the executive board, collectively discussing the actions to be allocated to the territories. Due to its participatory association origins, the Consortium has historically also given voice to social participation, culminating in the drafting of multi-year plans with the assistance of civil society through participation in public hearings, generating important documents of guidelines and perspectives for action. In 2016, the Consortium drafted and launched, in partnership with the Federal University of ABC (UFABC), the ABC Regional Master Plan (PDR). This is a document with specialized readings of the territory, identifying the region's characteristics and deficiencies for the formulation of new projects and policies for its development. This initiative was pioneering at the national level, with no other similar experiences for local comparison, and therefore allows for analysis in the urban field from various perspectives, including that of urban morphology.

To facilitate the discussion of the regional planning scale from the perspective of urban form, this article initially presents a brief review of the existing literature, seeking to delineate the concept of urban morphology, its theoretical scope, and scales of coverage to meet the objectives of the work. Based on the theoretical framework, the characterization of the municipalities of Grande ABC is structured, focusing on the role of the Intermunicipal Consortium as a development driver, also considering the Brazilian legislation that underpins public policies applied at the regional level. From this, through the acquisition of cartographies and data developed by the Regional Master Plan produced by the Consortium, it is intended to analyze its territory in light of the theoretical framework, based on the reading provided by the cartographies, considering the concept of homogeneous regions[38] and their governance. The objective is to understand how the urban form, in the study region of ABC Paulista, is delineated and discussed based on homogeneous, physical, and natural aspects. It is expected to confirm that local and regional urban morphology within the boundaries of Grande ABC are congruent with each other, confirming the hypothesis that neighboring municipalities are not

[38] According to Nóbrega (2015), a homogeneous region consists of a grouping based on similar characteristics, making the components of the homogeneous region distinguishable from other entities outside the region that do not follow the same organizational logic. In the case of cities, morphological elements are the most commonly used for identifying homogeneous characteristics.

merely grouped by the chance of geographic proximity but share common formative traces that justify their current configurations, and therefore, their association.

THEORETICAL FRAMEWORK

The applicability of the term morphology to the urban domain has been shaped over decades through the work of various authors, such as Muratori (1959), Conzen (2004), and Moudon (1997). As a general idea, the use of the terms urban morphology or urban form has become standard to designate the object of this field of knowledge, which focuses on the study of cities, their street layouts and subdivisions, their buildings, and open spaces. Thus, it is possible to simultaneously encompass, through a morphological analysis, the micro-scale—represented by buildings and their typological patterns—and the macro-scale, represented by the city as a whole, its subdivisions and occupancy, as well as the inclusion of these elements within the natural landscape that contains them (Costa and Gimmler Netto, 2015). In this way, urban form describes not only what cities are but also their identities. When investigating the historical processes of foundation and development of municipalities, it is possible to see the decisive role of utilizing physical and natural aspects as boundaries for administrative and political delimitations. In this context, one can observe the importance of the morphological aspect in the field of history and urban morphology for the shaping of a city. But what about metropolises and metropolitan regions? How are they formed? In this scenario of conurbation between municipalities in the metropolis, do urban forms still distinguish themselves and persist despite the mutation of cities? To seek clues to these questions, it is important to analyze Brazilian regionalism and the historical foundation of municipalities.

Focusing on the regionalist context, regarding the Brazilian administrative structure, it is evident that the primary form of articulation of a regional territory is the metropolitan regions. These are municipal associations formed by neighboring cities that are generally conurbated, starting from core municipalities. The first metropolitan regions (RMs) in Brazil were established in 1973, and the concept quickly spread and intensified, as there were initially only nine, and currently, there are 84[39] (Blanco Junior, 2021). Researchers such as Klink (2013) criticize the organizational structure and management model of these arrangements, classifying them as “ungovernable.” Although they are officially recognized by the Brazilian state and have regulations for their establishment and maintenance, the RMs still require better delineation of their planning and operational possibilities, so that the objectives of joint development and regional integration can be achieved by all participating entities. Furthermore, Klink (ibid.) points out that other forms of metropolitan association could achieve better results in intermunicipal management. An example is the Consórcio Intermunicipal Grande ABC. This Consortium, established in 1990, aims to formulate, implement, and promote plans, projects, and actions in various fields such as economy, environmental management, economic development, mobility, among others, enabling the development of a group of seven neighboring municipalities located within the São Paulo Metropolitan Region (RMSP), collectively known as “Grande ABC” or “ABC Paulista” (Consórcio Intermunicipal Grande ABC, 2024a).

The seven constituent municipalities of ABC Paulista are Santo André, São Bernardo do Campo, São Caetano do Sul, Diadema, Mauá, Ribeirão Pires, and Rio Grande da Serra. Together, they form the

[39] Currently, Brazil has 76 metropolitan regions, five urban agglomerations, and three integrated development regions, totaling 84 regional planning units institutionalized based on Brazilian law (Blanco Junior, ibid.).

southeastern region of the RMSP, concentrating over 10% of the population residing in this RM. United, the seven cities total nearly three million inhabitants and a Gross Domestic Product (GDP) that would be the fifth largest in Brazil if they were a single city (Consórcio Intermunicipal Grande ABC, 2024b). Seeking justifications that explain the joint interpretation of these municipalities, the main hypothesis lies in the formation processes of each city. Originally, the town of Santo André da Borda do Campo was founded in 1553, located near the top of the Serra do Mar. This town was later incorporated into the town of São Paulo de Piratininga and ceased to exist. Three centuries later, with the establishment of the São Paulo Railway, the intense flow of people and goods gave rise to a series of settlements near the railway stops, leading to the re-emergence of Santo André near the end of the 19th century (Prefeitura de Santo André, 2024). After changes in the municipality's name, the two largest municipalities in the region, Santo André and São Bernardo do Campo, consolidated between the 19th and 20th centuries, giving rise to the other five municipalities through a series of political emancipations and territorial divisions. In 1964, the city of Rio Grande da Serra was founded after its emancipation from Ribeirão Pires, being the most recent of the seven municipalities. With the intense industrial activity installed in the region, processes of accelerated development began, making ABC the largest industrial hub in Latin America (Yamauchi and Tourinho, 2021).

This common initial root for all the municipalities of ABC dates back to the period of the “boom” of Brazilian urbanization during the 20th century, which Milton Santos (1996) describes as a “generalized” urbanization, with Brazil later entering a stage of macro-urbanization and metropolization. Despite this, the author points out that, during this period, the process of generating new cities was greater than the process of urbanization itself. It is also worth noting that, from the 1940s onwards, the country experienced a significant increase in industrial activity, which Santos (ibid.) understands as a complex social process, as, besides the actual creation of industries, a national market was also being formed, consumption was expanding, and the country was integrating. All this greatly expanded urbanization, increasing the urban population throughout Brazil. Grande ABC became a major industrial hub, especially as it received a large part of the automotive industry that began to settle in the country. Although the automotive industries were mainly established along the Anchieta Highway in the municipality of São Bernardo do Campo, they contributed to the overall development of the region by occupying the other municipalities with industry workers, as well as the development of other industrial, commercial, and service activities that followed the booming industrial activity of that period. It was possible to find traces of the intrinsic subsistence relationship between the municipalities of ABC.

The scenario of economic instability experienced in the post-military dictatorship period in Brazil culminated in significant impacts on the territory. The shifts in economic policy, combined with currency changes, exchange rate fluctuations, uncontrolled inflation, and the fiscal war between municipalities paved the way for a process of industrial deconcentration, with Grande ABC being greatly affected. Many industries left the region and moved to other localities where there was a greater availability of tax incentives (Santos and Silveira, 2003). Thus, there was a gradual decline in the industrial sector's participation in the region's economy and a significant increase in the services sector's participation. Parallel to this movement, the Consórcio Intermunicipal Grande ABC was being created in the 1990s. Initially conceived as a committee for discussing pollution control policies and promoting the protection of the Billings Reservoir, the association soon took the form of a multisectoral consortium, encompassing, among its various fronts, the challenge of the region’s

economic and productive restructuring. Here, there is a progressive vision of the role of urbanism and associative governance as a driver of development, recognizing that the entities are interdependent and that actions in one territory have almost simultaneous consequences in another.

According to Moudon (ibid.), the historical genesis of an urban fabric is a fundamental element for understanding its urban morphology. Given this, it is consistent to read the different territories of ABC as an integrated association, considering that their joint action was desired even before the formation of the consortium entity for their management (Klink, 2009). Considering the entire territory, we have a rich variety of situations and thematic elements that constitute it. Among the natural elements, we can mention the environmental protection areas bordering the Serra do Mar, the presence of the Billings Reservoir, and the large ecological parks on its shores. Among the infrastructural elements, there is the railway connecting the municipalities to the city of São Paulo, in addition to the major highways such as Anchieta and Imigrantes, which provide access to the São Paulo coast (Consórcio Intermunicipal Grande ABC, 2024b). Between the natural elements and the constructed infrastructures, the presence of induced urbanity is observed in all seven municipalities in the region, with commercial, leisure, service, residential activities, and all other aspects necessary for the primary condition of a city being evident, even though economic disparities are present when comparing the municipalities. Fix and Pereira (2013) assert that there is a contemporary consensus that the municipal scale is not the most appropriate for most public policies, recognizing that urban problems do not occur and are not resolved solely within the municipalities themselves. This argument supports the logic of interdependence among the cities that make up ABC Paulista, regarding environmental preservation and the need for joint action to achieve the objectives of the associated action among them.

METHOD

The methodological procedures adopted are based on the consolidation of the concepts of urban morphology and region. The foundation of the scope of urban form is established through a brief review of the existing literature, identifying authors who have contributed to the delineation of the objectives and actions of this field of knowledge. Parallel to the conceptualization of morphology, an effort was made to identify, distinguish, and understand different notions of what constitutes a region. In this topic, concepts applied in the field of geography were used, seeking a multiscalar approach to regionalism present in Brazil and identifying the concept most appropriate to the hypotheses that justify the association of the Grande ABC municipalities in the form of a consortium.

Based on the consolidation of the state of the art on urban morphology and regionalism, the Regional Master Plan of Grande ABC (PDR) was examined, seeking data and cartographies that would allow for a spatial analysis of plans applied to the territory. Through these cartographies, the aim was to verify the application of instruments in an integrated manner, beyond the political-administrative boundaries of the municipalities. Furthermore, these cartographies sought to position the main physical delimiters and natural aspects of this region, understanding them as structuring elements of the regional urban form. With these surveys, the intention was to cross-reference the consulted literature with the cartographic practice produced by the Consortium to discuss the hypotheses outlined as the basis of this article.

RESULTS AND DISCUSSIONS

As mentioned, the Grande ABC is part of the São Paulo Metropolitan Region, forming the southeastern sub-region of the RMSP. As shown in figure 1, the grouping proposed for these sub-regions follows an administrative and geographical logic, although in the case of Grande ABC, this logic also aligns with the historical processes of technical-political genesis of the municipalities that comprise it.

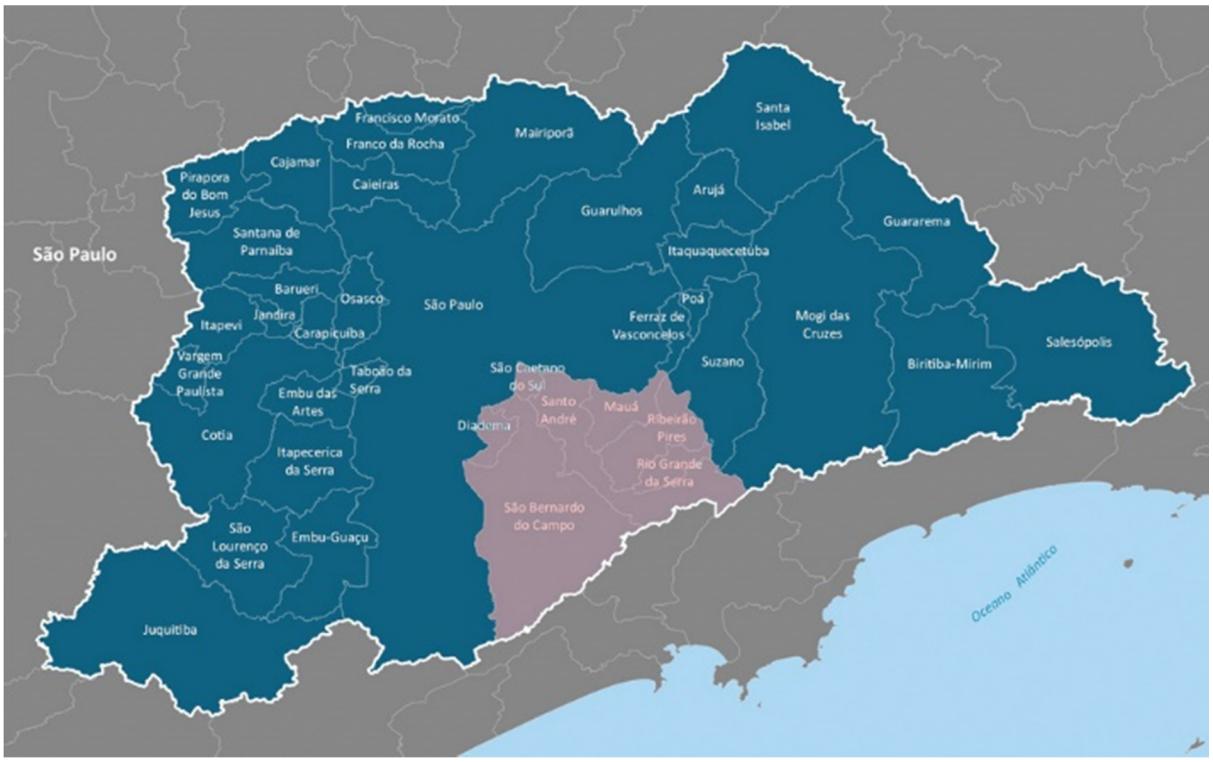

Figure 1. Map of the Metropolitan Region of São Paulo with emphasis on the southeastern sub-region (Grande ABC). Source: modified by the authors based on FNEM, 2018.

The map shows the privileged location of the region, situated between the city of São Paulo and the Serra do Mar, forming an important route linking the major metropolis to the sea. This location was chosen for the establishment of the Village of Santo André da Borda do Campo in the 16th century precisely because of its strategic position, which allowed for the protection of the territory by the natural barrier imposed by the Serra do Mar (Prefeitura de Santo André, ibid.). Three centuries later, when the municipality was reestablished, its geographical position again played a decisive role, as it was chosen as the route for the São Paulo Railway due to its position on the axis formed by the municipalities of Jundiaí and São Paulo, leading towards the Baixada Santista. This path established a faster route between São Paulo and the Port of Santos, facilitating the flow of coffee production destined for export (Mazzoco and Santos, 2005).

Through these historical factors, it is evident that, beyond the use of natural aspects as a foundation for economic development, the entire region was shaped according to the homogeneous characteristics of the morphology of its municipalities. The seven municipalities, formed from the division and emancipation of a single initial entity, have distinct political-administrative boundaries. In urban areas, the boundaries are based on avenues and other transportation infrastructure, while in undeveloped green areas, there is not always an easily identifiable pattern explaining the boundary lines. As illustrated by figure 2, which shows the Billings Reservoir basin in the target region, the political-administrative boundaries do not align with the natural green and blue web of the region,

such as the Alto Tietê watershed, remnants of the Atlantic Forest reserve, Billings Reservoir, and water source protection areas, in addition to ecological parks and proximity to other natural assets such as the Guarapiranga Reservoir and the Serra do Mar (Plano de ação de enfrentamento às mudanças climáticas do Grande ABC, 2017).

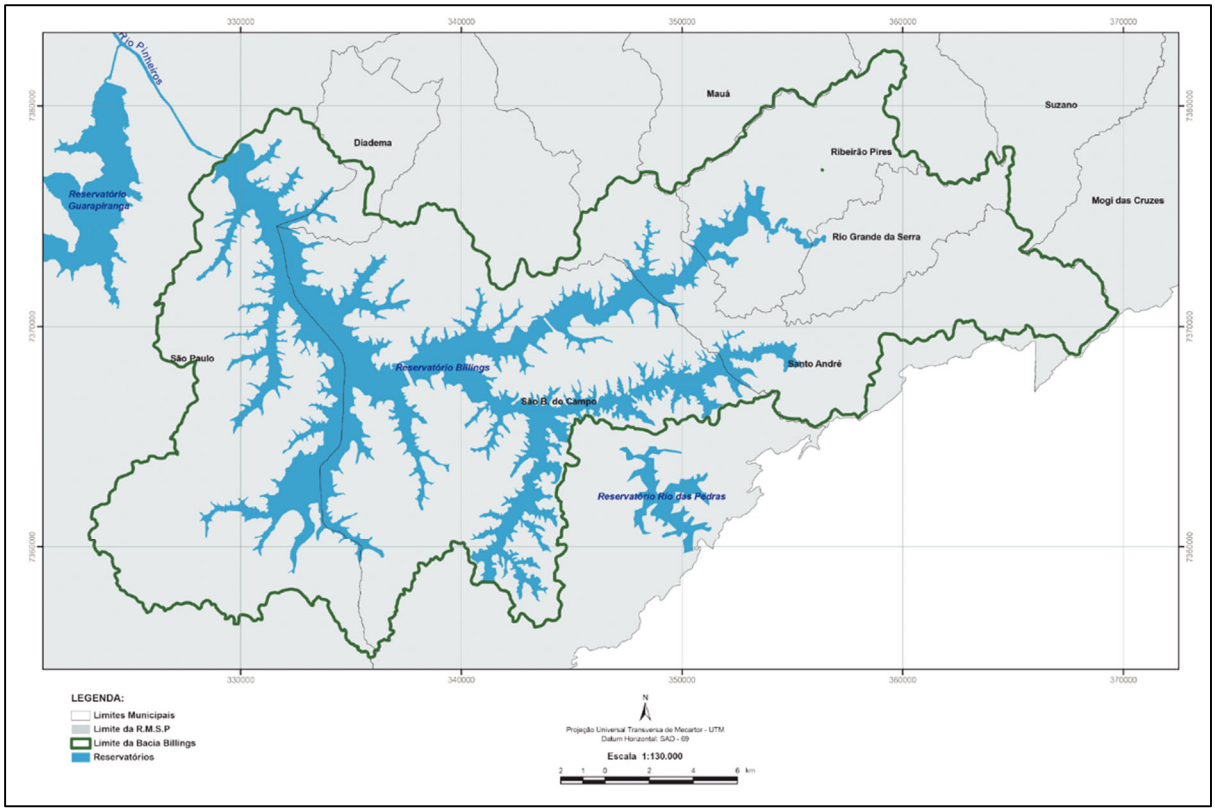

Figure 2. Map of the Billings Basin within the Grande ABC. Source: Plano de ação de enfrentamento às mudanças climáticas do Grande ABC, ibid..

This morphological pattern, based on the understanding of natural aspects, is the subject of study in the Regional Master Plan produced by the Grande ABC Intermunicipal Consortium (Plano Diretor Regional do ABC, 2016). Of the three initial guidelines in the document, two align with environmental factors as key premises for development: the formation of a compact city-region and sustainability with environmental justice (Plano Diretor Regional do ABC, ibid.). Initially focusing on the concept of a city-region, Magalhães (2008) defines it as "the urban form of the metropolization process." The metropolization process in the region is evident through the expansion of the urban area, with visible conurbation among the municipalities, not only within the ABC region but also with other municipalities in the Metropolitan Region of São Paulo (RMSP), as shown in figure 3. The figure highlights that, in addition to the ABC municipalities, several other RMSP municipalities, such as Guarulhos, Osasco, and Itaquaquecetuba, merge with the city of São Paulo at various borders. This conurbation phenomenon allows the Grande ABC cities to be assimilated as a single entity in the form of a region.



Figure 3. Urban areas of the municipalities merge in such a way that it becomes difficult to identify their administrative boundaries. Source: created by the authors based on Google Earth, 2024.

Regarding the second PDR guideline on environmental justice, its motivation is understood, given that approximately 41% of the region is covered by forests and other vegetation, thus requiring specific preservation plans (Russo, 2010). As mentioned, crossing the political-administrative boundaries of the cities toward the natural axes of the region (Billings Reservoir, ecological parks, and the top of the Serra do Mar), it is evident that these boundaries do not necessarily delimit the municipalities administratively. However, in the PDR, they are understood as major foundations for sustainable development plans for the region. As shown in figure 4, which illustrates the actions proposed by the PDR to integrate infrastructure programs throughout the region, it is clear that environmental preservation and containment of urban expansion into protected areas are integral parts of the intended urban form for the cities within the context of integrated development.

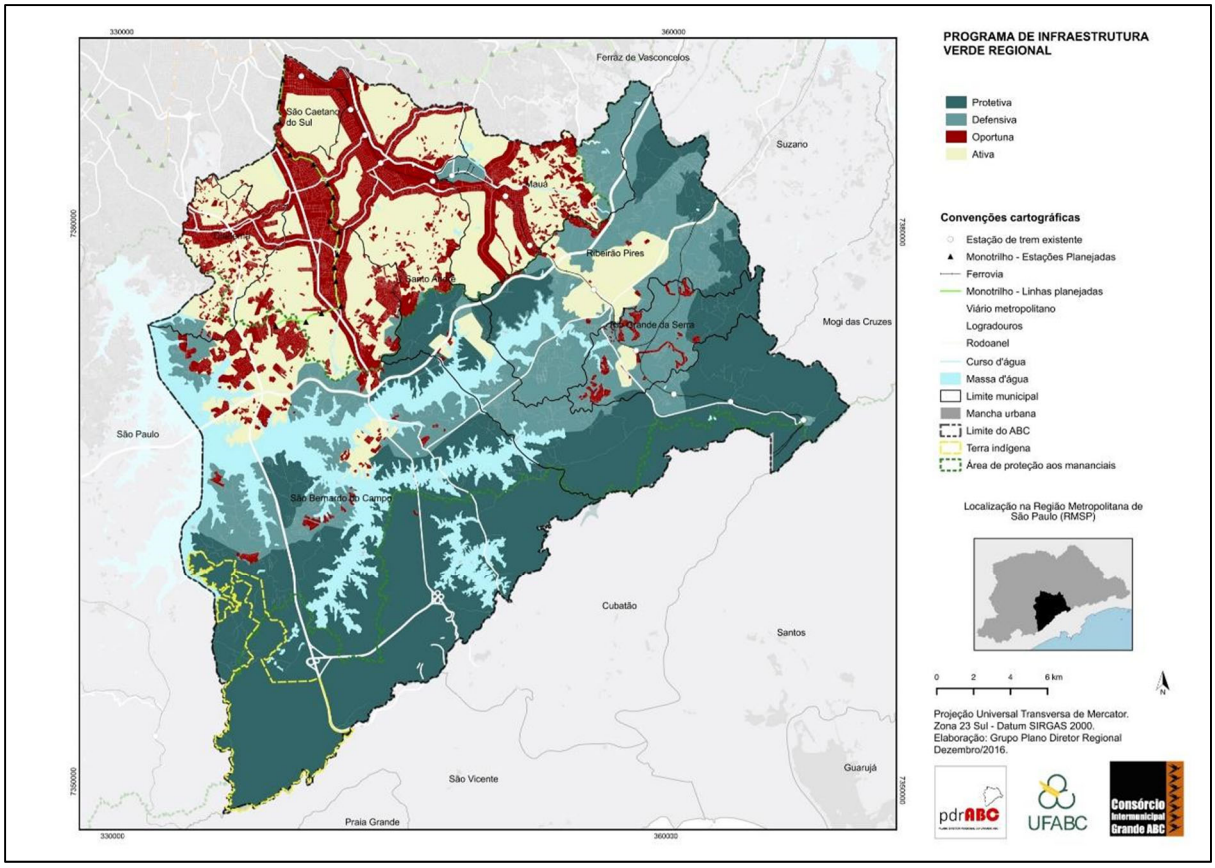

Figure 4. Map of the implementation of green infrastructure programs proposed by the PDR. Source: Plano Diretor Regional do ABC, ibid..

As also evident in figure 4, the PDR offers a comprehensive view of the territory regarding green infrastructure strategies, even in fully urbanized areas. Figure 5 shows that the regional urban area is concentrated in the northern sector of the ABC, with the municipalities of Diadema and São Caetano do Sul fully encompassed within the urbanized area, and the municipalities of Mauá, Santo André, and São Bernardo do Campo being densely populated. It is possible to observe intense conurbation up to the edge of the Billings Reservoir to the south, which, despite being an environmental protection area, has occupations along its margins, revealing another significant challenge faced by regional urban planning regarding conflicts between urbanization and preservation (Alvim, Rubio, and Marques, 2023). Figure 5 also reveals the PDR's understanding of the need for regional integration, even though major transportation axes may conflict with the layout of green infrastructure such as the reservoir and natural green reserves in ecological parks and water source areas. As a guideline, the PDR adopted a maximum distance of 2 km between the urban area and a transportation axis, equivalent to a walking distance of less than 30 minutes, recognizing the importance of mobility access and its structuring role in the territory, as it allows for the dispersion of social infrastructure across the territory and also enables balanced development among locations. The PDR also acknowledges that a grid transportation system better aligns with the regional characteristics, as it facilitates integration and movement between the region's municipalities, not just outward from the region, as predominantly established in the study area with a radial system primarily planned for the transportation of goods. Although the structural proposals outlined by the PDR align with contemporary urban planning best practices by promoting mass public transportation as a structuring element for cities, less than 10 years after its launch, a review of this proposal is already necessary, considering that the planned monorail, which is included in the map below, was canceled by the state government, highlighting once again the political challenges faced by regional planning as an obstacle.

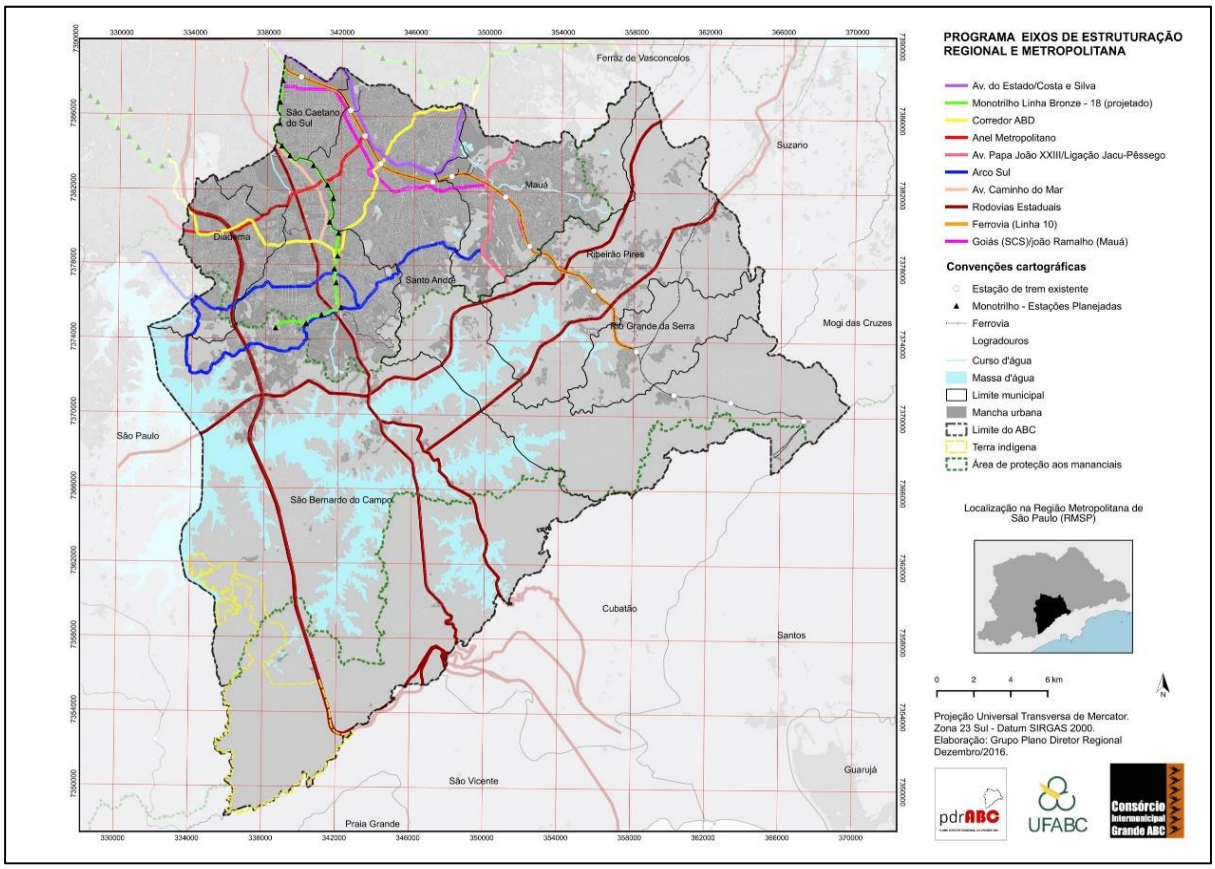

Figure 5. Map of regional and metropolitan structuring axes in the Grande ABC region. Source: Plano Diretor Regional do ABC, ibid..

The central areas of the municipalities of Santo André, São Bernardo do Campo, São Caetano do Sul, Diadema, and Mauá are primarily encompassed within the macrozone of urbanization consolidation, as shown in figure 6. These areas are fully urbanized but still have potential for improving housing density and increasing the supply of social interest housing, aiming to bring economically vulnerable populations closer to areas with higher concentrations of employment and income. Practically delimiting the areas of urbanization consolidation, the metropolitan structuring macrozone is arranged around major transportation axes, representing an attempt to develop the areas through denser occupation near mobility infrastructure, generating concurrent social and economic development. As these axes connect the region to its different sectors, they pass through sections with physical natural elements such as vegetation areas and reservoirs. As seen in figure 6, the reservoir practically divides the region in two, clearly showing that the plans for the area above the reservoir are primarily focused on structuring, while the primary objective for the area below is environmental preservation. Although this approach may seem obvious, considering that urban concentration is closer to São Paulo while environmental concentration is closer to the Serra do Mar, the practical application of this guideline in the territory is of great importance to contain the expansion and density in precarious areas, which pose joint social and environmental risks. In the region, precarious occupations can be observed in areas represented on the map by the macrozone of vulnerability reduction and environmental recovery, constituting an impasse that highlights the urgent need to design interventions that minimize environmental damage while respecting the population's right to housing (Alvim, Rubio, and Marques, ibid.).

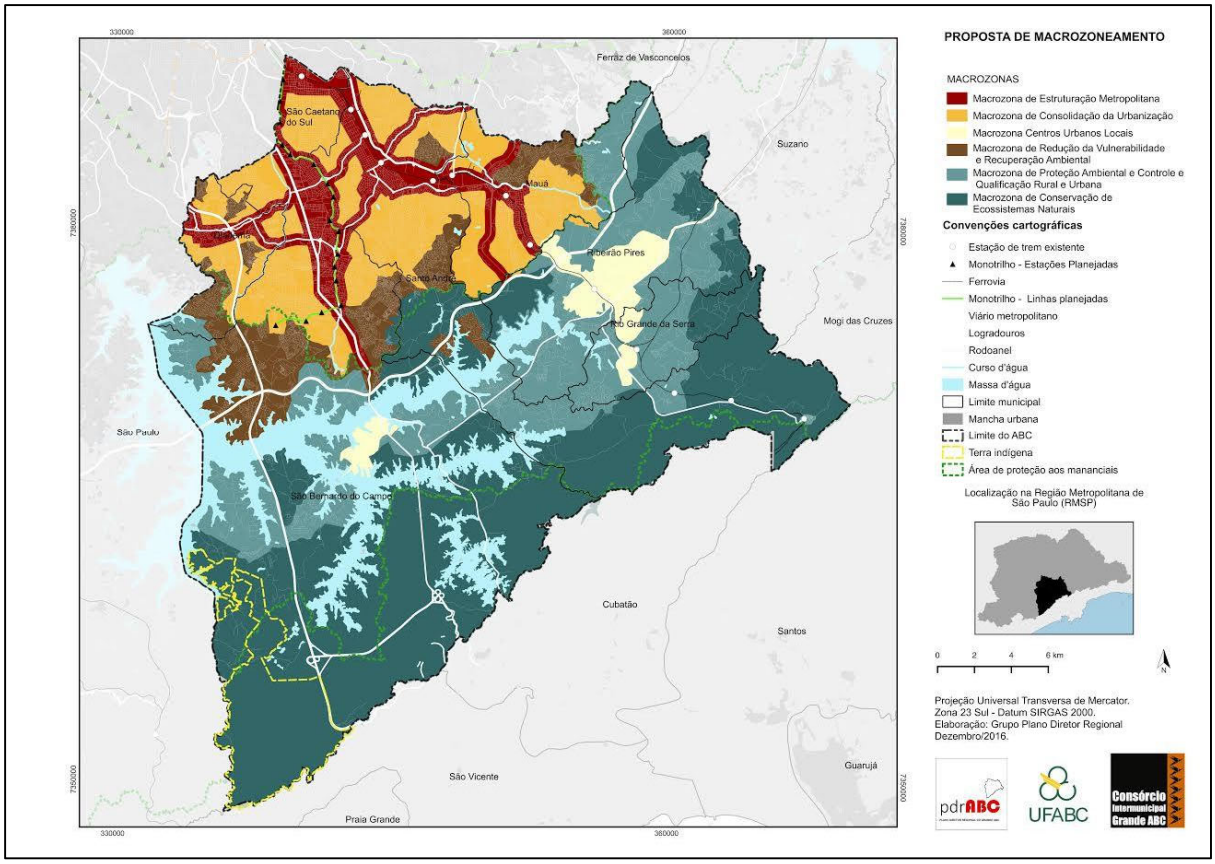

Figure 6. Macronozoning proposed by the PDR. Source: Plano Diretor Regional do ABC, ibid..

CONCLUSIONS

The intersection of the theoretical literature in the field of urban morphology with the ABC Regional Master Plan facilitated the reflection on the role of urban form as a theoretical field in the practical application of its precepts in the regional territory. In the study area, there is a clear common genesis of the municipalities, and therefore their current forms reflect homogeneous characteristics that justify their reading as a grouped entity, even though the levels of development and urbanization vary among municipalities. Although they are municipalities with their own administrative structures, as neighboring and conurbated entities, there are interdependencies among them that become evident when studying the individual characteristics of each one. Additionally, there is an understanding of the associative contribution as a means of obtaining resources from higher planning bodies and an understanding of the interdependent relationships between each municipality regarding management, resource use, environmental preservation, and the implementation of plans in the territories.

Overall, the understanding of the grouped entity as a region in the homogeneous sense of the word corresponds to the urban planning proposed by the PDR. However, being an urban policy, it encounters resistance in its formulation and even greater obstacles in its effective implementation in the territory. As mentioned, even though it has been less than 10 years since its promulgation, parts of the PDR study can already be considered obsolete, especially in the field of mobility, where projects have been revised, discontinued, and even extinguished, making way for other plans that do not necessarily follow the same design logic. The obstacles in the process create opportunities for future studies, seeking project practices that are adaptable to political instability and the passage of time in

the metropolis, considering short, medium, and long-term scenarios that may affect implementation conditions, in addition to the search for interventions that can be implemented in full or in parts without compromising the proposed objective.

It is also concluded that the apprehension of regions through the morphological pattern of local scales enables the understanding of territories, allowing the understanding of current processes based on historical formation processes. Although development is necessary and desired, there is a global movement to adapt cities to climate change and perspectives on the necessary transformations of cities to achieve a sustainable future. In this context, urban morphology as a field of knowledge enables the identification of territorial characteristics, making urban projects more effective when aligned with sustainable practices suitable to local realities.

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History and urban morphology of a garden neighbourhood on the outskirts of São Paulo: Sete Praias

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ABSTRACT

The text addresses the issue of historical and morphological inventory of neighbourhoods in São Paulo city, since the municipality is made up of a diverse set of urban fragments that reflect the specificities of different times of foundation of its subdivisions and territorial diversity identified in its vast territory. The problem identified is that São Paulo historiography still presents significant gaps that must be filled by studies to complement its historical collection. Therefore, the objective is to contribute to partially filling this gap by presenting the history of Sete Praias neighbourhood, located on Billings Reservoir banks, in the south zone of São Paulo. The choice is because it is a garden neighbourhood according to the classification of the Municipal Planning Department, which carried out research between 1984 and 1985 and grouped 31 subdivisions into 22 sets of garden neighbourhoods in the city. The research methodology is historiographical, and the results of the investigation demonstrate the urgency of discussing the diversity of forms of occupation of the city's watershed area, which is recognized as a peripheral region marked by its contrasts between social and economic vulnerabilities and cultural and environmental strength. The morphological and environmental qualities of Sete Praias neighbourhood date back to its origins in the mid-20th century and have been preserved for more than a century, constituting an important setting for the tradition of garden neighbourhoods.

Keywords: urban morphology, garden neighbourhood, São Paulo historiography

INTRODUCTION

Between 1984 and 1985, a team of professionals from the Municipal Planning Department of the City of São Paulo conducted a comprehensive study called “Registration of Significant Wooded Areas in the Municipality of São Paulo – 1984-85” with the aim of surveying, mapping and identifying significant tree groups and specimens in the municipality. Given the impressive results achieved, years later the Environmental Department of the State of São Paulo edited and published this work in the book “Significant Vegetation in the Municipality of São Paulo” in 1988, as an incentive to protect the environment and to encourage the proposal of legislation related to the permanent preservation of plant species.

The groups and tree specimens were registered in files grouped into the following categories: reserves and protected areas; state and municipal parks; squares and public spaces; areas of public and/or institutional use; cemeteries; clubs and private recreation areas; schools; garden neighbourhoods; tree-lined neighbourhoods; tree-lined streets; residential gardens; industries; groupings of tree-lined spaces; unoccupied plots in urbanized areas; remaining farms in urbanized areas; areas predominantly occupied by farms and ranches; reforested areas; secondary forests; large secondary forests and isolated specimens.

The publication divided the identified neighbourhoods into two distinct categories: Garden Neighbourhoods and Tree-lined Neighbourhoods. What differentiates the two categories are the formal configurations of the streets, blocks, lots and buildings, since tree-lined neighbourhoods can be made up of horizontal or vertical housing, that is, neighbourhoods with multi-story buildings; the lots can be smaller and the buildings can occupy a large part of the lot area; the residences do not necessarily have trees, and sometimes, they do not even have green areas in their open spaces.

Garden neighbourhoods, as defined by SEMPLA[40], were identified as such because they represent a "set characteristic of a certain era, its way of life or its aspirations for a new style of living" (SEMPLA, 1988, p. 285). The period mentioned refers to the early 20th century, when neighbourhoods intended for the coffee aristocracy turned to hygiene concerns and the first Brazilian garden neighbourhood was built, Jardim América, a project designed by Barry Parker in 1915. The proposal was carried out by Companhia City[41], a company with French and English capital, which imported the subdivision model inspired by the precepts of Ebenezer Howard (Garden Cities of Tomorrow, 1902).

Thus, garden neighbourhoods present a particular configuration that characterizes a predetermined landscape intention, both from the perspective of the whole, composed of the streets and blocks, and from the point of view of the minimum land unit:

> The lots, not always regular between the curvilinear streets of these neighbourhoods, are, as a rule, sufficient to accommodate a house isolated from its limits. This form of occupation, in addition to the usual backyard, implies appreciable setbacks that allow or require gardening. Plants of all types and sizes blend in with the abundant trees of the public road and with the occasional planted square, through low walls and railings, required from the beginning, or high walls, more recent and the result of other care. Although not exclusive in the country and despite so many changes, these gardens have been preserved in such a way that they constitute decisive and characteristic elements of the São Paulo landscape. And they make up, together with many others, more cramped, but more suggestive of certain sectoral landscape preferences, a complex, difficult to evaluate, but extremely rich, sample of home gardening in the last decades in the City of São Paulo (SEMPLA, 1988: 286).

In the category of garden neighbourhoods, the study had identified 31 subdivisions grouped into 22 sets, namely: Horto Florestal, Vila Marieta, Vila Albertina, Tremembé, Alto da Lapa, Alto de Pinheiros, Jardim das Bandeiras, Sumaré, Pacaembu, Jardim São Bento, Morumbi, Jardim América, Jardim Europa, Jardim Paulistano, Vila Nova Conceição, Jardim Novo Mundo, Alto da Boa Vista, Jardim Santo Amaro, Jardim Petrópolis, Jardim Cordeiro, Jardim dos Estados, Brooklin Paulista, Vila Lusitania,

[40] Municipal Planning Secretariat of São Paulo
[41] City of São Paulo Improvements and Freehold Land Co Ltd

Granja Julieta, Chácara Pouso Alegre, Jardim Hípico, Chácara Flora, Vila Nova Caledônia, Interlagos, Sete Praias and the portion close to the University City (Figure 1).

Among these neighbourhoods, some have already been the subject of research and publications, such as: Lapa (Santos, 1969), Jardim América (Bacelli, 1969; Wolff, 1985), Jardim Europa (Reale, 1982), and Higienópolis (Homem, 1980; Macedo, 2012). Other garden neighbourhoods in São Paulo, however, have not yet been covered by historical research, or have been partially investigated under specific aspects, as is the case of Interlagos, analysed in the master's dissertations of Galhardo (2010) and Martins (2012) and in scientific articles (Oliveira et al., 2021); Higienópolis with the doctoral theses of Silvio Soares Macedo (1988) and Denise Antonucci (2005); Chácara Flora (Oliveira and Pronin, 2020).

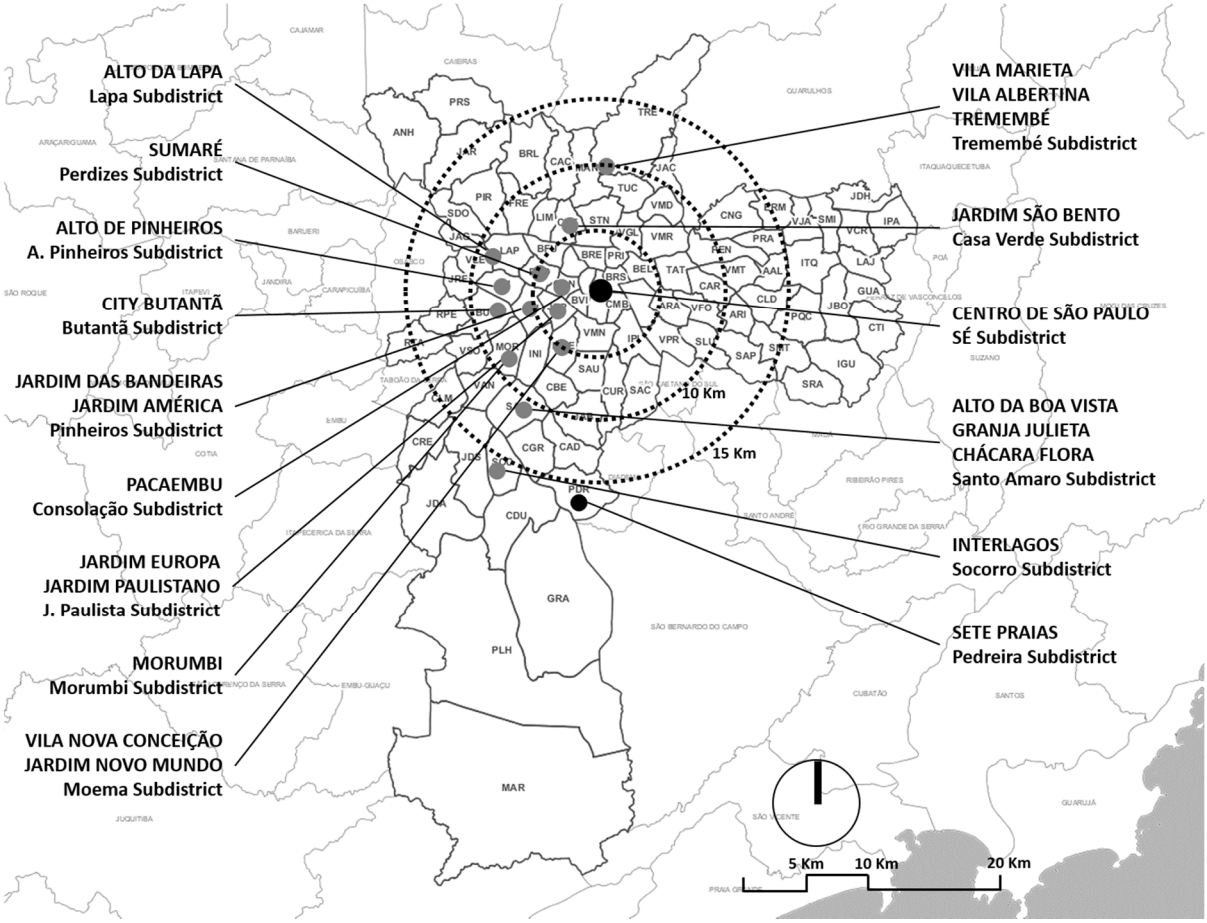

Figure 1. Location map of the 22 sets of garden neighbourhoods identified by SEMPLA in 1988 - Municipality of São Paulo, source: prepared by the authors based on Geosampa, 2024.

Given the scenario presented, the objective is to help fill a gap in the historiography of São Paulo's garden neighbourhoods. Thus, among the 22 garden neighbourhoods classified by SEMPLA, Sete Praias was selected as the object of study. This is the garden neighbourhood located to the south, on the banks of the Billings Reservoir, in the Pedreira district, belonging to the Cidade Ademar Subprefecture (Figure 2). Among the garden neighbourhoods, only two of them are in a water source protection area: Interlagos, located on the east bank of the Guarapiranga Reservoir, and Sete-Praias, which is located on a peninsula in the eastern portion of the Billings Reservoir.

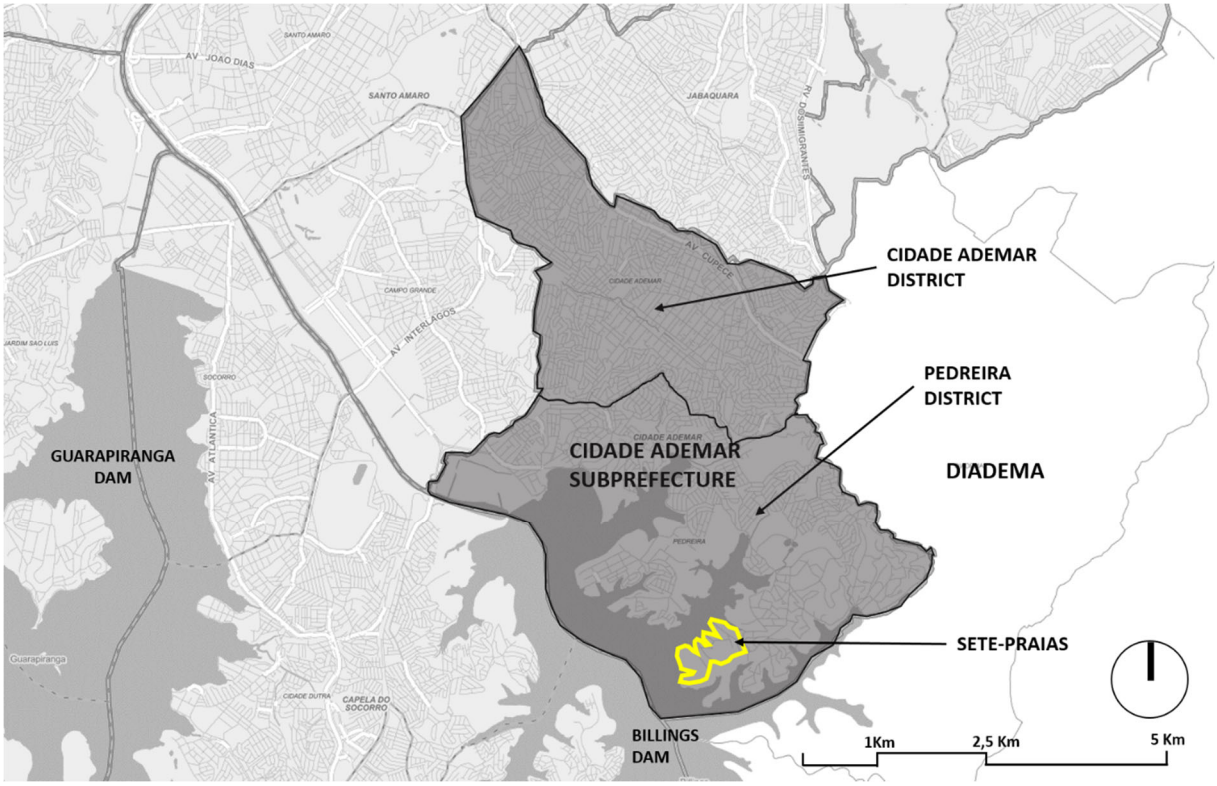

Figure 2. Location map of the Sete-Praias neighbourhood, in the Pedreira district, Cidade Ademar Subprefecture, source: prepared by the authors based on Geosampa, 2024.

Interlagos was a project conceived by the British engineer Louis Romero Sanson, a partner in the company S/A Auto-Estradas, who invited the French architect Alfred Agache (1875-1959) to develop the urban design of a garden neighbourhood. The first conversations between Louis Romero and Agache began in 1928 and 1929, when the Interlagos region still belonged to the former municipality of Santo Amaro, which would be annexed to the municipality of São Paulo in 1935.

However, the implementation of the Interlagos residential subdivision only began in 1937 due to the delay in acquiring the chosen land, at the time called Haras Palmeiras and belonging to Colonel Juliano Martins de Almeida, a businessman and breeder of competition horses (Oliveira et al., 2021).

Unlike Interlagos, the Sete-Praias subdivision was not originally conceived as a garden neighbourhood, nor was it designed by a renowned urban planner of the time. Since it is located on the banks of the Billings Reservoir, it is important to draw a parallel between the history of the subdivision's implementation in relation to the creation of water reservoirs and the forms of occupation of the spring areas in the southern zone of the city of São Paulo.

METHOD

The research methodology is historiographical and uses two approaches that are similar to the English school of urban morphology: the reconstruction of the historical context of the period in which the urban fragment was formed and the analysis of the urban form, considering issues related to its implementation on urban land based on the layout of roads and blocks, the division of lots and the occupation of buildings within the lots.

RESULTS AND DISCUSSIONS

The Sete Praias subdivision is located between the Guacuri and Grota Funda streams, 3 kilometers in a straight line from the Pedreira Pumping Plant, located on the Jurubatuba River, an arm of the Pinheiros River. The "Approximate Map of the Former Municipality of Santo Amaro", dated 1938, indicates that the land belonged to Theodoro Putz and the area was called "Paraiso da Represa" (Figure 3).



Figure 3. Map of the former municipality of Santo Amaro, in 1935. On the left, location of the land of the current Sete Praias condominium, called at the time "Paraiso da Represa", property of Mr. Theodoro Putz, source: prepared by the authors based on Museu Paulista, 1938.

The Austrian industrialist, naturalized Brazilian, Theodoro Putz joined forces with the engineer Alfredo Luthold in a commercial partnership called Theodoro Putz & Cia and in 1913 they set up the first rubber factory in the state of São Paulo (Correio Paulistano, 1913: 10).

The partnership was dissolved a few years later, in 1917, when Theodoro Putz left the company, which remained in the same line of business under the name Fábrica Nacional de Artefatos de Borracha, remaining under the management of Alfredo Luthold (O Combate, 1917).

In 1932, Theodoro Putz was the Austrian Consul in São Paulo and was the CEO of the company Sociedade Industrial de Borracha Elastic S.A., headquartered at Rua Abílio Soares, in the 1940s (Diário Oficial: 1947). Theodoro Putz died at the age of 75 on October 20, 1966.

No information was found about when and why the Sete Praias lands were sold by the Putz family, but on October 14, 1982, the subdivision of the region was regularized at the request of Abílio Ashcar (1909-2000), together with other partners and owners of the area.

Abílio Ashcar was Brazilian and became an important industrialist and businessman, president of the Association of Watch Manufacturers of the State of São Paulo. The industrialist was elected Secretary Director of the company Relógios Brasil S.A. in 1962, leaving his previous position as Superintendent Director. He died on November 8, 2000, at the age of 91.

Long before Abílio Ashcar requested the regularization of the subdivision, the region was already a prestigious location, visited and frequented by politicians and businessmen since the mid-20th

century. There was a restaurant there called “Sete Praias”, which hosted dignitaries for lunches. On May 9, 1940, the then mayor of the city of São Paulo, engineer Francisco Prestes Maia (1896-1965), who had been appointed by federal interventor Adhemar de Barros in 1938, was honoured for the 2nd anniversary of his administration at a luncheon offered by the directors and assistants of the City Hall Departments. The guests left the central area in a convoy of cars to the event venue and after lunch they took a tour of the Santo Amaro region:

> After lunch, the Mayor of the capital, accompanied by his friends and admirers, made a long visit to several picturesque spots in the surrounding area, Interlagos, the Autodromo, the Health Center and Villa de Santo Amaro (Mourão, 1940: 1).

In addition to local politicians, the restaurant and the region were also visited by politicians from other states. On June 22, 1940, Antônio Novaes Filho, governor of Recife, came to São Paulo and took a tour to see the city's urban developments. On that occasion, the then Mayor Prestes Maia hosted a lunch at the Sete Praias restaurant.

> His Excellency was present at this warm meal, accompanied by his wife and his secretary, Dr Francisco Oiticica. Also present at the lunch were Dr Sebastião Medeiros, Secretary of the Government; Tito Franco da Rocha, official in the Mayor's office; Constantino Pereira Rodrigues Junior, technical assistant to His Excellency; Francisco Pati, director of the Department of Culture; and His Excellency. After lunch, which took place in a pleasant and cordial atmosphere, the guests headed to the dam, which they toured by boat, kindly accompanied by Dr. João Baptista Monteiro Filho, from the superintendence of Light and Power Co. They also visited Interlagos, Santo Amaro and Congonhas Airport (Mendes, 1940: 3).

On June 21, 1947, another lunch was held for the then governor Adhemar de Barros:

> A banquet will be held today at 1:00 p.m. at the restaurant in Sete Praias, Eldorado, in honour of Mr. Adhemar de Barros and state authorities, including Mr. Teixeira Pinto, mayor of Santo Amaro, and Mrs. Tereza Delta, mayor of S. Bernardo. The banquet will be offered by residents and friends of Eldorado, as a sign of recognition for the promise of public improvements for that place, by the competent authorities (Monteiro, 1947: 4).

After its closure, the restaurant and other buildings were abandoned and became a safety problem for the neighbourhood.

In the 1950s, the Eldorado and Sete Praias neighbourhoods were praised as a very pleasant region in the south of São Paulo, despite the difficult access to the area and the lack of urban infrastructure:

> There are no public places or locations accessible to the residents of São Paulo or tourists, whether domestic or foreign, except for the places where the Anchieta and Anhanguera highways pass, so that they can spend a few days and, especially, the weekends. And so, the pleasant, picturesque locations near the capital of São Paulo, such as Represa Nova, the “Sete Praias” and Eldorado, true attractions for those who live in this capital and those who visit us, are no longer visited, solely due to the lack of electricity and roads. For this reason, their residents and visitors, most of whom are car owners through us, are asking Light and the competent departments of the Santo Amaro Subprefecture and the Department of Transportation, respectively, to install lights and pave or asphalt the existing road. This one, a little over twelve kilometers, starts in the Jabaquara neighborhood. The light that

> reached Chácara dos Fernandes, about eight kilometers from Eldorado, could reach the place with a few more kilometers after passing through the town of Diadema, which, in turn, can be supplied with light from the Nova dam, by the Guacuri quarry. All the towns mentioned, with thousands of residents and visitors, would undoubtedly benefit greatly from the extension of the light and from the paving of the horrible existing road, where cars wear out and people get bored, not to mention those who intend to drive the future foreign tourists who should flock to the upcoming celebrations of the fourth centenary of São Paulo (Netto, 1953: 1).

The 1958 aerial photo shows that the land already had defined streets and there were few buildings built on the site (Figure 4).

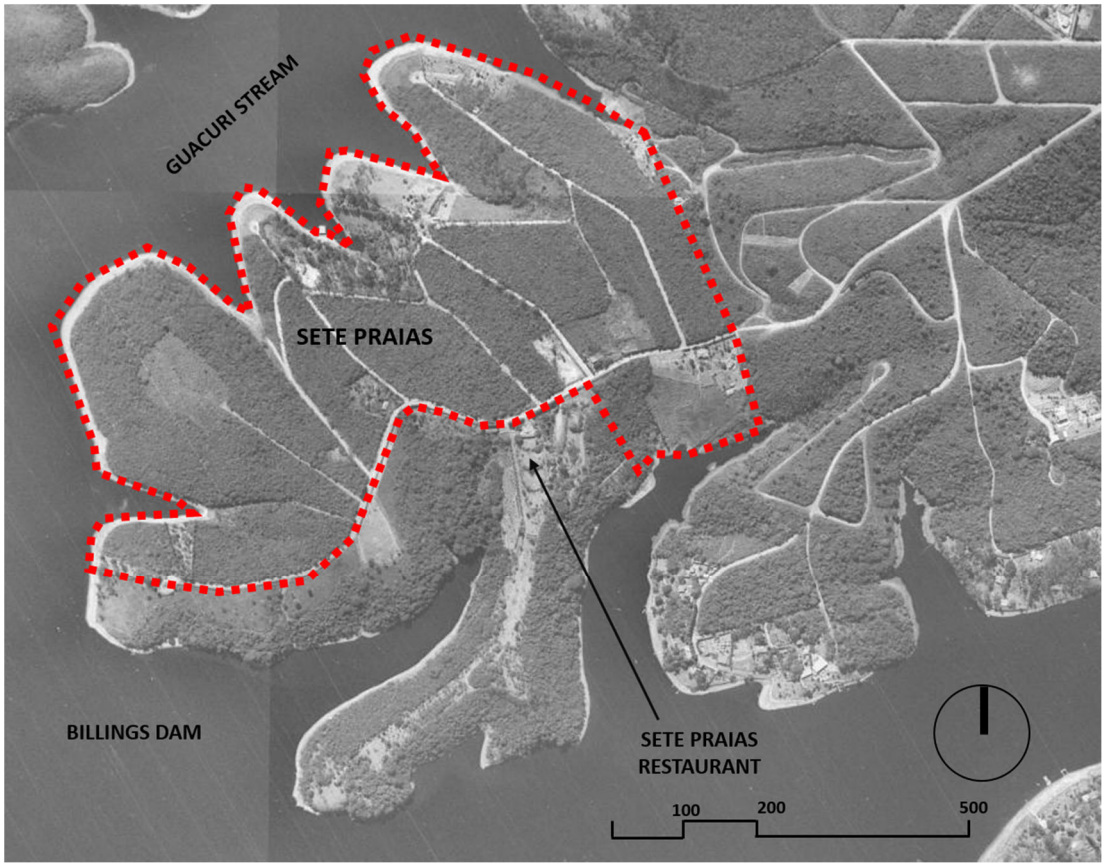

Figure 4. 1958 aerial photo of the Sete Praias Condominium, showing the streets already in place and few buildings, source: prepared by the authors from Geoportal, 2024.

The formation of the Billings Reservoir and the process of occupation of its banks

The Billings Reservoir, created by damming several rivers, is linked to the history of São Paulo, since, before the flooding, the Estrada do Mar (Sea Road) used by D. Pedro I on his trips back and forth from the coast to São Paulo passed through its lands.

It consists of two lakes connected by the Summit Control, known as the Schimit Canal. At the top of the Serra do Mar, near São Paulo, there are two reservoirs: the first, the Rio das Pedras, with a surface area of 7.6 square kilometers and 727 meters above sea level, and the second, the Rio Grande, with a total volume of approximately 1.2 trillion liters of water (Castilho, 1997). Its surroundings were initially

occupied without major harm to the native fauna and flora, with developments such as Praia Vermelha, in Eldorado, and Sete Praias (Neto, 1981). The construction of the Billings Dam was approved by Decree No. 16,844 of March 27, 1925, signed by President Arthur da Silva Bernardes (1875-1955). The decree responded to a request from the concessionaire The São Paulo Tramway, Light & Power Company Limited to use some tributaries of the Tietê River as hydraulic power to generate low-cost electricity, taking advantage of the height difference of the Serra do Mar, approximately 700 meters. The legislation allowed the expropriation of land and improvements made by the former owners to create the reservoir. Thus, initially the waters of the dam were used primarily for the generation of electricity from the operation of the Henry Borden plant (Sobral, 1996).

The dam was named Billings in 1949, in honour of the American engineer Asa White Kenney Billings, born in 1876, who arrived in Rio de Janeiro in 1922 with the task of being an inspector of the electrical system of Light Company. He graduated in electrical engineering from Harvard University and had already worked on the construction of hydroelectric plants in Cuba, Mexico and Spain. In 1924, the Pombos Generating Plant in Rio de Janeiro was completed under his supervision and, in 1925, he began the project in Serra do Mar that would become one of the largest in the world at the time, with the source of its driving force being the dam then called Rio Grande (Castilho, 1997; Mc Dowall, 2008).

To increase the hydroelectric potential of the dam, the Light Company carried out an ingenious operation in the 1940s, when it reversed the direction of the waters of the Pinheiros River, which stopped flowing towards the Tietê River and started flowing towards the dam. In this process, in addition to the water, the reservoir began to receive pollutants and sewage, which was not a problem for the operation of the plant, since the quality of the water was not relevant to the operation of the turbines.

From 1958 onwards, the Billings dam became a water supply source and began to provide drinking water for the growing population of the ABC region of São Paulo[42]. However, due to the compromised quality of its waters, which became polluted by the backflow of sewage discharged into the Tietê and Pinheiros rivers, its reservoir had to be separated by a dam that allowed only an unpolluted arm to be used for water supply.

Back in the 1950s, the Represa Nova region was considered a pleasant, picturesque place, relatively close to the capital of São Paulo, especially the Eldorado neighbourhood and the Sete Praias subdivision. However, the area had problems such as a lack of electricity and good roads, which discouraged tourism and visitors (Netto, 1953).

From the 1970s onwards, the southern region of the city of São Paulo was one of the regions most affected by illegal subdivisions and invasions due to peripheral urban expansion. Urban planner Regina Monteiro states that the problems began at this time, with the zoning law implemented by the Integrated Development Master Plan/PDDI-Law No. 7.688/71, which divided the city into 19 different zones and the water source areas were classified as Z-14 and Z-15. Both zones allowed predominantly residential use with low population density and the lots had to have areas greater than 2,000 and 5,000 square meters respectively. Since the minimum lots were very generous and with a restricted occupation area, between 12 and 26% of the lot area, this ended up encouraging subdivisions and division of land into smaller fractions, of 125 or 250 square meters. The developers based their

[42] Municipalities: Santo André, São Bernardo, São Caetano, Diadema, Mauá, Rio Grande da Serra e Ribeirão Pires.

decisions on Federal Law No. 6,766 of 1979, which dealt with the Subdivision of Urban Land, and which ended up allowing changes in the dimensions of lots in other types of areas of the municipality (Moreira, 1998). Thus, the smaller lots were marketed as irregular, but with the hope that in the future they could be regularized by Law No. 6,766 (1979).

It was also in the 1970s that the first state laws emerged: Law No. 898, of December 18, 1975, which regulated the use of land for the protection of water sources, courses and reservoirs and other water resources of interest to the Greater São Paulo Metropolitan Region; and Law No. 1,172, of November 17, 1976, which delimited the areas that should be protected.

However, the legislation was unable to slow down or interrupt the occupation process that was already underway in the region, since despite its distance from the city center and the lack of infrastructure, the region ended up becoming attractive, especially for migrants who came to São Paulo in search of employment. Among the neighbourhoods that initially faced the problem of illegal subdivisions in watershed areas were: Sete Praias, Praia Azul, Jardim Recreio, Vista Alegre and Rubilene (Moreira, 1998).

It was only in October 1992, that three years after the enactment of the State Constitution on October 5, 1989, that the Billings Reservoir stopped receiving the pumping of polluted water from the Tietê and Pinheiros rivers, as stated in the law:

> Article 46 - Within three years, counting from the promulgation of this Constitution, the State and Municipal Public Authorities are obliged to take effective measures to prevent the pumping of sewage, waste and other polluting substances into the Billings dam (Constituição Estadual, 1989).

Furthermore, with the installation of industries in the greater ABC region and the lack of sanitation in the region, several environmental disasters occurred, causing illnesses and infant deaths, in addition to the death of fish caused by the dumping of toxic substances into the water (Castilho, 1997).

Even in the face of so many serious and adverse events, it was only 20 years after the enactment of the first state laws that a review of the guidelines and standards for the protection and recovery of the hydrographic basins of the sources of regional interest in the State of São Paulo was carried out, which led to the approval of Law 9.866, of November 28, 1997. The Law defined the Water Source Protection and Recovery Area (APRM) as one or more hydrographic sub-basins of the sources of regional interest for public supply and determined that each APRM would indicate its areas of intervention and respective specific environmental and urban guidelines and standards based on the creation of individual state laws. Currently, 5 APRMs have their own regulations in the State of São Paulo: Guarapiranga, Billings, Alto Juquery, Alto Tietê Cabeceiras and Alto Cotia.

APRM Billings was created and defined by Law 13,579 of July 13, 2009, that is, 74 years after the damming of the region's waters, ratifying the situation of pollution of its waters and the intense irregular occupation of its banks.

According to Law 13,579 (2009), the Sete Praias condominium is classified as a Low-Density Occupation Sub-Area – SOB – which belongs to the Environmental Compartment of Central Body I,

which suggests that the minimum lot size be 500 square meters; utilization coefficient 0.5; Permeability Rate 40% and Vegetated Area Index 20% (Figure 5).

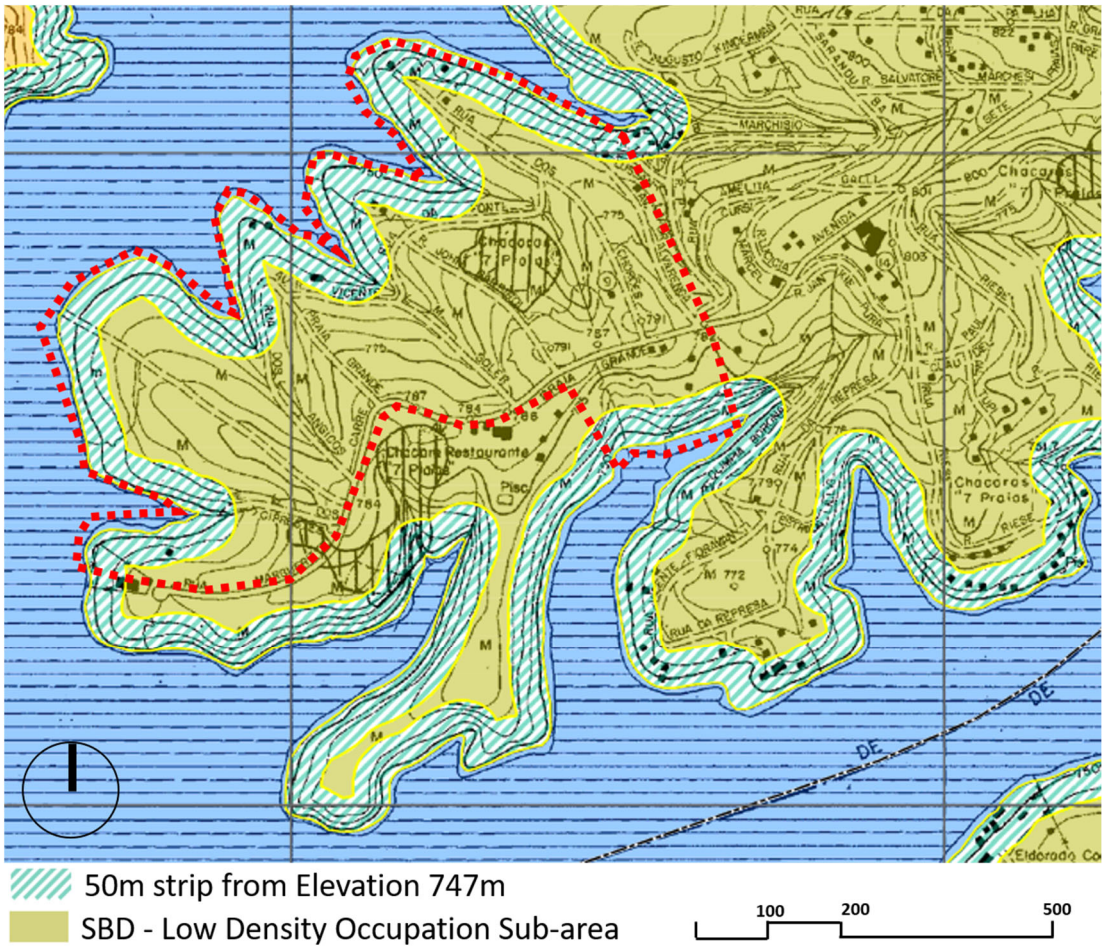

Figure 5. Map of the Sete Praias Condominium area, indicating the classification of the region as a Low-Density Occupation Sub-Area, according to Law 13,579 of 2009, source: prepared by the authors from Geoportal, 2024.

According to the classification of Law No. 16,402, the Zoning Law of the Municipality of São Paulo, the Sete Praias condominium is an Exclusively Environmental Residential Zone – ZERA, which indicates the following occupation parameters: Minimum lot of 500 square meters; maximum utilization coefficient of 1; Permeability rate of 30% and Vegetated Area of 18%.

The same law provides that in the zones included in the protection and recovery area of the water sources, the pertinent state legislation applies, when more restrictive, according to § 2 of article 5 (Law No. 16,402). This reservation is relevant, since the parameters of the Water Sources Law are more restrictive than the Zoning Law of the municipality, becoming an important instrument for regulating and monitoring the ongoing process of occupation of the region's lands.

Study of the Urban Form of the Sete Praias condominium

The Sete Praias Condominium area is contained in the Ribeirão Guacuri micro-basin, which is part of the Billings Hydrographic Basin. The condominium has four streams that flow into the Billings Reservoir. The highest point of the land is located to the southeast of the area, at an elevation of 790

meters, from where it drops 45 meters to an elevation of 745 meters towards the banks of the Billings Reservoir (Figure 6).

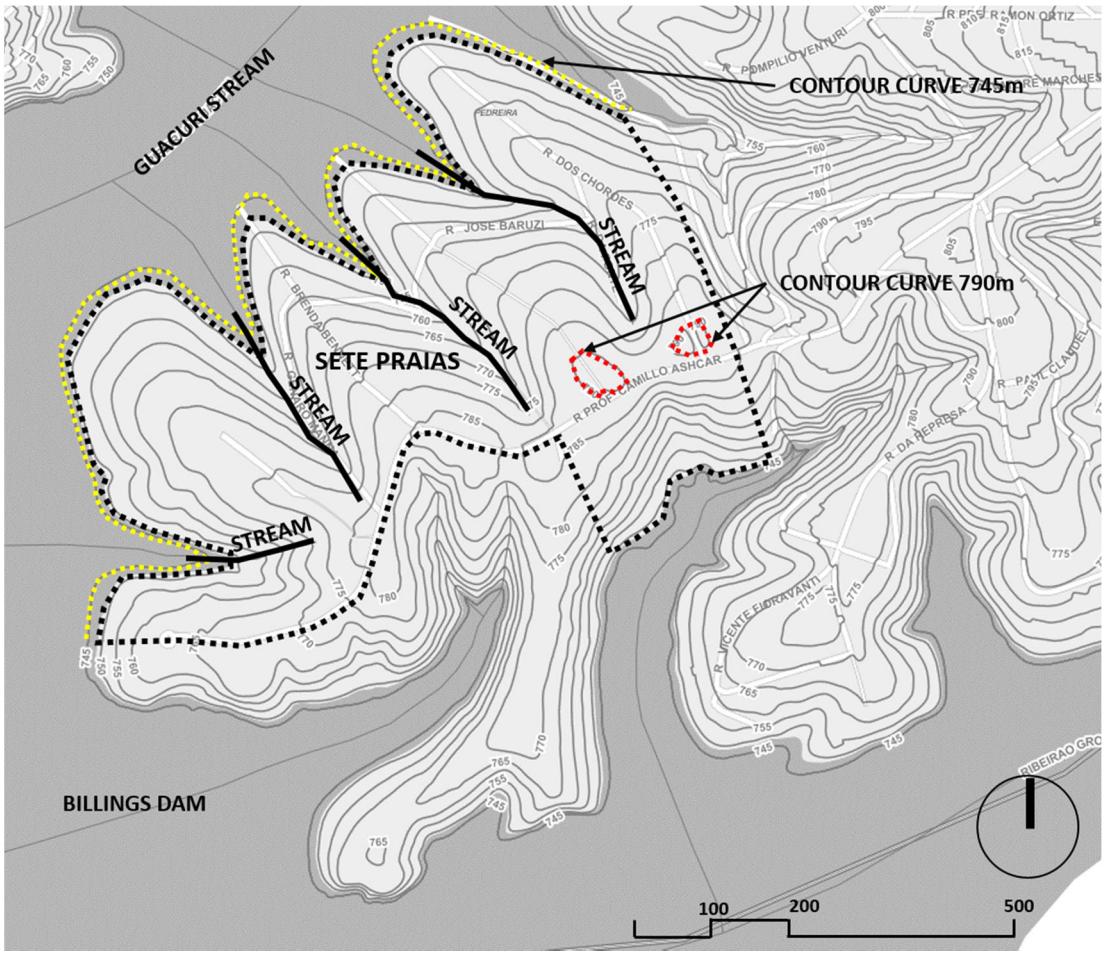

Figure 6. Map of the Sete Praias Condominium, with streets, hydrography and contour lines every 5 meters, source: prepared by the authors from Geoportal, 2024.

The organic design of the road system follows the slope of the terrain, with a main road, Professor Camilo Ashcar Street, which follows the ridge in an east-west direction, from where the other roads start and descend towards the lowest level on the edge of the dam. Most of the streets do not have sidewalks for pedestrians, nor are they paved (Figures 7 and 8).



Figure 7. Rua dos Chorões, with curves that follow the slope of the place, source: Rafael Schimidt, 2024.

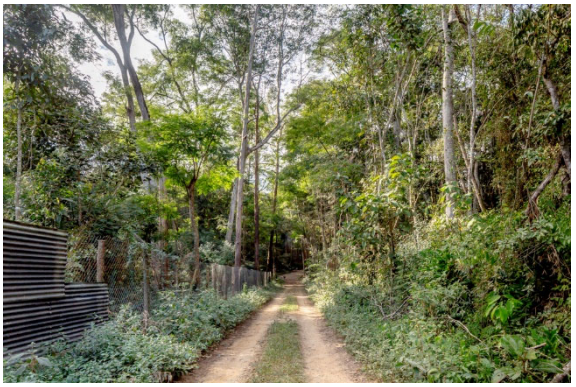

Figure 8. Vicente Soler Street, without sidewalks for pedestrians, source: Rafael Schimidt, 2024.

Currently, the area comprising the Sete Praias Condominium is 486,000 square meters. Based on the survey carried out on the Digital Map of the City of São Paulo (Geosampa, 2024), it was found that the condominium has 99 lots distributed across 9 blocks and 8 streets: Professor Camilo Aschar Street, Vila dos Ciprestes Street, Vicente Martin Soler Street, Brenda Bennett Street (formerly Praia Grande Street), Genaro Manna Street (formerly Angicos Street), John Barbirolli Street, José Baruzi Street (formerly Fonte Street) and Chorões Street. The changes to the names of public thoroughfares in Sete Praias occurred as of Decree No. 38,705, of November 25, 1999, during the administration of Mayor Celso Pitta (São Paulo, Municipality, 1999). The largest lot is 118,956 square meters and the smallest lots are approximately 1,900 square meters.

The condominium has three portions of open green areas shared by residents: at the end of Rua dos Chorões; on Rua José Baruzi and at the intersection of Rua Vicente Martin Soler and Rua José Baruzi (Figure 9).

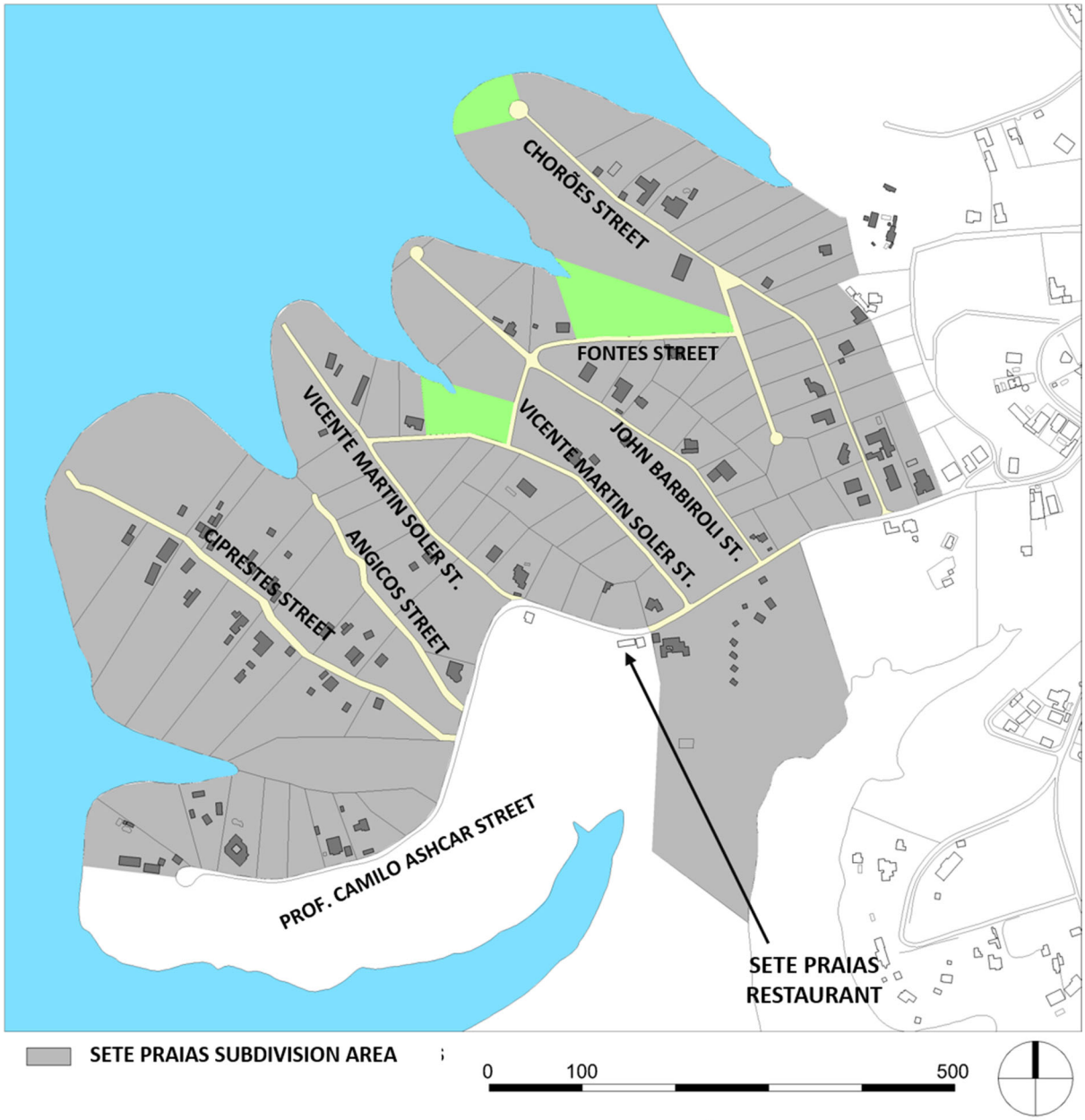

Figure 9. Map of the Sete Praias condominium, indicating the streets, lots, buildings up to 2010 and the three public green areas, source: prepared by the authors based on Geosampa, 2024.

The 2020 orthophoto shows the predominance of green areas still very present in the region, but deforestation has already been observed, creating a clearing on Rua dos Ciprestes, in the western portion of the subdivision (Figure 10).

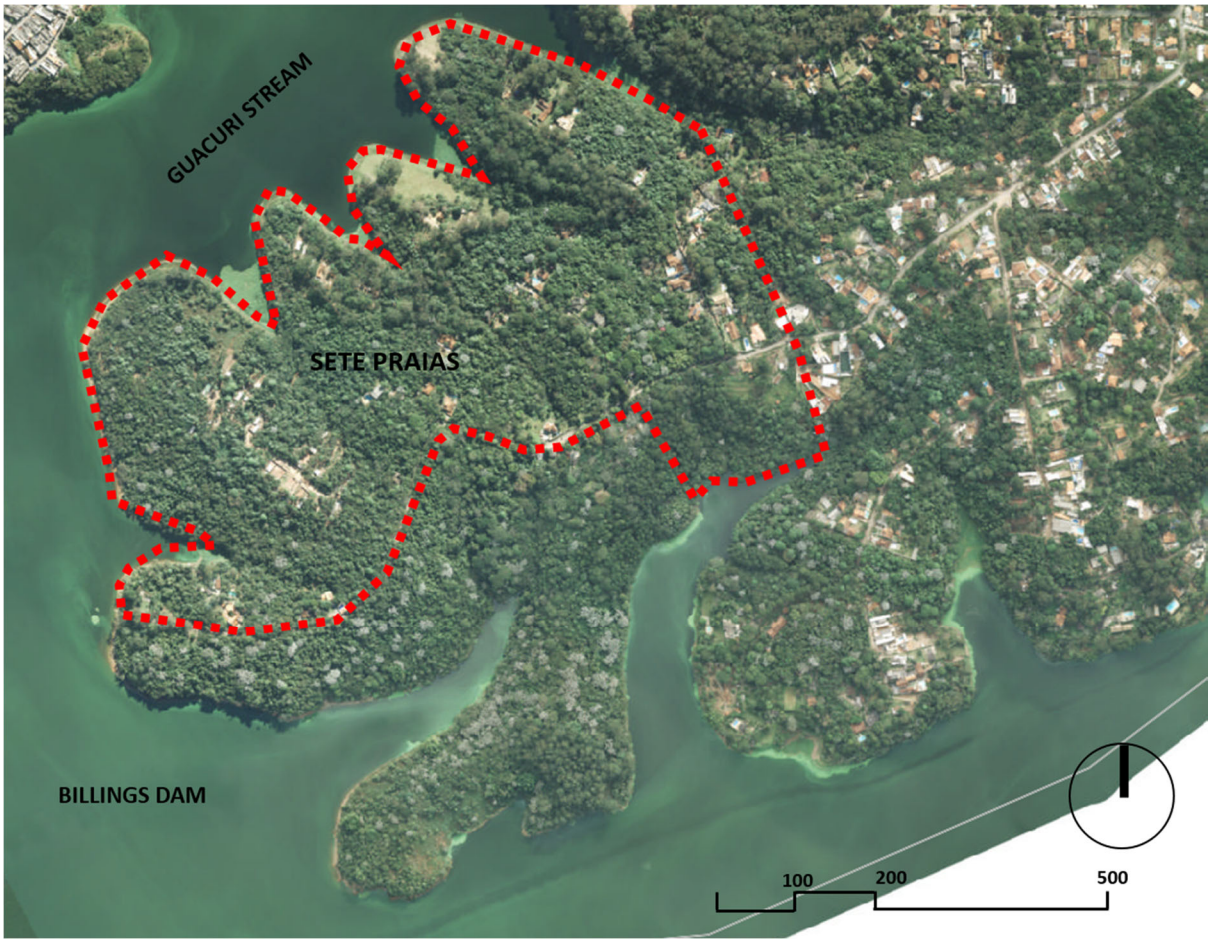

Figure 10. 2020 orthophoto of the Sete Praias condominium, where the predominance of green areas can be seen, source: prepared by the authors based on Geosampa, 2024.

CONCLUSIONS

The Sete Praias condominium, despite having the qualities and morphological characteristics that led to its identification and classification as a garden neighbourhood, according to the survey carried out by SEMPLA in 1988 (Environmental Secretariat, 1988), is a subdivision that achieved this classification, unlike other neighbourhoods in the southern part of the city that were designed based on the principles of garden neighbourhoods, such as: Chácara Flora (1915), Interlagos (1935) and Granja-Julieta (1956).

Initially, the area around the Billings Reservoir attracted the attention of entrepreneurs interested in subdividing the region because it was a pleasant and picturesque place, but in the 1950s it still had problems with infrastructure, water supply, road circulation and a lack of public transportation. When the 1971 Zoning Law was implemented, it imposed specific rules for land use and occupation in the areas surrounding the water sources. The standard followed the principles already adopted in the Sete Praias subdivision, considered a good occupation model.

Therefore, while the Sete Praias subdivision can be considered a good solution for occupying areas close to watercourses, on the other hand, due to the size of the lots and the resulting standard of construction, it may represent an elitization of the areas close to water bodies. This is not a reflection

that applies only to the Sete Praias subdivision, since in São Paulo, garden neighbourhoods are mostly intended for the high-income population, due to the high value of urban land.

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Interaction and adaptation: A morphological research on the regional water system of the Pearl River Delta

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ABSTRACT

In delta regions characterized by complex water environments, the relationship between humans and water is one of the decisive factors in the formation, growth, and transformation of human settlements. In the current context of global climate change and increasing water-related risks, an in-depth study of the water systems in estuarine delta human settlements is of particular importance and practical significance. This paper focuses on the human settlements in the Pearl River Delta Water System (PRDWS) as the research object. It adopts a dual-scale morphological analysis framework, examining both the geographical scale and the settlement cluster scale, to explore the various patterns of human-water relationships in this region. This paper arrives at three main conclusions: 1) The dynamic interplay between natural hydrological elements and human productive and living activities is the core process determining the development of the Pearl River Delta (PRD). 2) The human settlements within PRDWS exhibit highly diverse and complex characteristics, encompassing a consistent range of natural substrate types and built-up area development types. 3) Based on the natural substrate and built-up area development types, PRD can be classified into four categories: weakly urbanized areas with plateau-hilly terrain and limited water resources, marginally urbanized areas in the lower reaches of various rivers with delta water networks, core urbanized areas with composite delta water networks, and areas of intense change in the coastal zones of estuarine alluvial plains. This study plays a crucial role in uncovering the interactive and symbiotic processes between natural hydrological elements and human productive and living activities. It deepens our understanding of the complexity and diversity of both natural and cultural characteristics in PRD. Furthermore, it is significant in exploring contemporary directions for the adaptive and ecological construction of water cities in PRD.

Keywords: Regional Water System, the Pearl River Delta, Morphological Mapping, cross-scale, complexity

INTRODUCTION

Natural hydrological conditions have consistently been a primary consideration influencing human settlement patterns throughout history. While river systems have provided essential conditions for human habitation, production, and livelihood, the expansion and development of settlements have also faced threats from various hydrological features such as rivers, lakes, and coastal areas. To establish safe and stable living spaces, humans across different periods have engaged with natural

hydrological processes through corresponding artificial management methods. These efforts have led to the comprehensive utilization of water resources, ultimately forming regional water systems that support the development of human settlements in the area.

The Pearl River Delta (PRD) is one of the world's most dynamic and densely populated regions, as well as one of China's areas with the most rapid economic development and highest degree of urbanization. The region boasts a well-developed water system with abundant water resources. However, its subtropical monsoon climate, characterized by high temperatures and heavy rainfall, coupled with coastal influences, makes the area frequently susceptible to water-related disasters such as floods and storm surges. Global climate change has exacerbated these challenges, with rising sea levels and more frequent extreme weather events intensifying the destructive impact of coastal phenomena such as typhoons, rainstorms, and floods. Consequently, the issue of sustainable human-water relationships in PRD has garnered increasing attention.

The dynamic equilibrium between water systems and human-built environments has consistently been a core issue in the development of PRD. Based on long-standing experiences of coexistence, symbiosis, and co-governance with water, PRD has nurtured a rich and diverse human settlement landscape system dominated by water systems, which serves as a significant carrier of the region's geographical characteristics. This landscape system achieves a dynamic balance of human-water coexistence over extended periods and across multiple scales, maintaining sustainable development of human-land relationships by providing adaptive ecosystem services. Analyzing the adaptive and interactive characteristics of PRDWS helps deepen the understanding of the diversity and complexity of the region's human settlements. Furthermore, it has positive implications for exploring ecologically resilient design methods for urban and rural human-water cohabitation spaces in PRD.

METHOD: DUAL-SCALE MORPHOLOGICAL ANALYSIS FRAMEWORK AND PROCESS OF PRDWS INTRODUCTION

PRDWS represents a complex landscape of human-water cohabitation, characterized by diversity, dynamism, and adaptability typical of complex systems. Traditional research approaches often focus on single-scale or single-case, lacking systematic integration of multiple scales. There is a need to construct a cross-scale systematic research paradigm that enables cognitive analysis through comprehensive patterns of spatial and temporal associations among numerous factors.

This study focuses on PRDWS and its human settlements, employing morphological analysis theory as its core. It constructs a morphological research framework by selecting geographical and settlement cluster landscape scales. The research process first establishes a continuous scale division framework, then integrates five steps: theme identification, sample determination, information reduction, hierarchical decomposition, and pattern extraction. This approach interprets spatial types and characteristics at different scales. Finally, based on the morphological analysis results at various scales, it integrates continuous scale spatial slices from macro to micro levels, from systemic commonalities to individual characteristics, to construct a morphological atlas of PRDWS.

Conducting morphological analysis simultaneously across multiple scales helps uncover the complex system's scale-nested behaviors and dynamic process characteristics of PRDWS. This approach emphasizes the landscape as a materialized spatial regional entity, highlighting the ongoing interactive changes and adaptive relationships with the water system. Through comprehensive allocation and

utilization of resources, it ultimately achieves a dynamic equilibrium state of human-water symbiosis within a certain range of natural climate variations.

Dual-scale morphological analysis framework

The formation of deltas is a result of combined natural and human actions. In the process of delta formation, sedimentation, river channel changes, and coastline development are considered the main natural driving forces (Lange, 2019). The primary human driving forces include the construction of levees, land reclamation, aquaculture, fish pond construction, major road development, and settlement expansion (Xiong, 2020). The interaction between natural and human forces shapes three types of human settlement environment processes in deltas: geological evolution, landscape formation, and settlement development.

Geological evolution is the earliest occurring process and forms the foundation for all natural ecological processes in the delta. Accompanying the geological evolution process is the formation of large-scale geomorphology and human settlement landscapes, which includes two sub-processes: the formation of mountain and water landscapes, and the formation of settlement cluster landscapes. The settlement development process is the primary human activity process, encompassing three sub-processes: settlement formation and development, housing agglomeration and place-making, and the formation of activity and communication spaces.

Different scale hierarchies correspond to distinct scale domains, and spaces within the same scale domain exhibit certain similar characteristics. By extracting the characteristic scales within a scale domain, one can most effectively demonstrate the spatial pattern features at that scale (Wu, 2014). In this study, the discussion of PRDWS and its human settlement processes corresponds to two levels of spatial morphological organization: the geographic pattern and the settlement cluster landscape pattern.

The geographic pattern scale reveals the morphological characteristics of the natural substrate layer and the interactive relationship between the natural substrate and human productive and living activities over a large area. The settlement cluster scale displays the specific morphological structure and characteristics of human activities.

According to scale domain theory, by mapping the generation of morphological processes and the display of morphological characteristics at different scales onto actual spaces, specific morphological quantification operation scales can be determined. Specifically, these are: 200km-400km for the geographic pattern scale, and 40km-60km for the settlement cluster scale.

Multiple map selection experiments were conducted to determine the characteristic scales. During the experimental process, it was necessary to avoid both the mixture of elements in the selected area due to overly large scales and the loss of typical characteristics of the scale domain due to overly small scales. Finally, specific parameters for characteristic scales at each level were determined, each scale level was coded, and the main research content and corresponding morphological analysis elements were identified (Table 1).

Table 1. The two study scales and the content of each scale.

Study Scale	Code	Study Field	Content	Mapping Elements

Geographic pattern scale	G	400km×400km	Geographical pattern of mountains, waters, and cities in PRD from a physical geography perspective	Distribution patterns and combinatorial characteristics of mountains, waters (rivers and sea), cities, and fields in PRD
Settlement cluster scale	La	50km×50km	Different urban-water landscape pattern types in PRD from an urbanization perspective	Morphological structure and main features of the urban-water Landscape Pattern

Dual-scale morphological analysis process

Further analysis of the cross-scale morphological analysis process for PRDWS can be divided into five steps: theme determination, sample determination, information reduction, hierarchical decomposition, and pattern extraction.

Study subject

Due to the inconsistency of spatial structures and primary characteristic elements across different scale levels, it is first necessary to determine the main research themes and content for each scale according to the research objectives. Based on this content, the morphological analysis elements should be further specified (Table 2).

Table 2. Data source of two study scales.

Study Scale	Sample Range	Data Sources
G (400km×400km)	9 cities in PRD administratively: Guangzhou, Foshanm Zhaoqing, Shenzhen, Dongguan, Huizhou, Zhuhai, Zhongshan, Jiangmen	Google satellite maps, vector data from and geospatial data platforms, historical maps, and literature materials
La (50km×50km)	Zoning with different geographical characters based on the pattern relationships between natural landscapes and built-up Areas	Google satellite maps, historical maps, and literature materials

Study sample and data

The determination of research precision at each scale is related to grain and extent. Grain refers to the characteristic length, area, or volume of the smallest discernible unit. Extent refers to the spatial spread or continuity of the object of study (Wu & Li, 2006). Based on these two fundamental concepts, three types of scale transformations emerge: extent scaling, grain scaling, and simultaneous extent and grain scaling (Wu, 2014).

Extent scaling involves expanding the extent range while maintaining a constant grain, which means changing the size of the selection frame. Grain scaling refers to maintaining a constant selection frame size while adjusting the grain size, resulting in images of the same area with different levels of clarity. Simultaneous extent and grain scaling involves changing both the size of the extent and the grain, producing images with different levels of clarity and varying study areas.

In this study, as the scale progresses from large to small, a scaling method that reduces both extent and grain is adopted. The two scales are uniformly represented on a 20cm × 20cm canvas at 300 dpi. The actual lengths represented by the smallest grain at each scale are 169.35m, 21.17m respectively. At this point, the transformation from natural inherent scales to research scales is essentially complete.

Information reduction

Upon completion of data collection, it is necessary to screen, reduce, and extract the required information for each scale of research. This process primarily involves the following three steps:

(1) Overlay multi-source data for samples at each scale, performing preliminary screening and correction through data matching to obtain an accurate understanding of the sample area;

(2) Identify important spatial elements that need to be retained in the study, in conjunction with the research objectives and content for each scale;

(3) Extract structural characteristics of similar elements, reduce irrelevant information in spatial elements, and transform complex multi-source data into symbolized spatial drawing information to create morphological tracing maps with geographic coordinates.

Layering Analysis

The tracing maps reflect the complexity of PRDWS landscape. Through a layered analysis method, it is possible to further understand the interactive relationships between different morphological elements. In 1996, Dutch scholars De Hoog, Sijmons, and Verschuuren proposed a layered model for complex spatial systems (Van & Klaasen, 2011), focusing on the driving forces and processes of spatial development. Based on the dynamic characteristics (rate of change) of spatial elements, they established a three-layer model consisting of 'substrate layer - network layer - occupation layer'.

Dutch Delta Urbanism further developed this layered model, proposing that all urbanized deltas globally can be abstracted as complex systems dynamically composed of three subsystems: substrate, networks, and occupation (Meyer & Nijhuis, 2013). The substrate layer, located at the bottom of the layered model, includes natural elements such as water and soil. It has the lowest dynamicity, typically requiring several centuries to produce substantial changes. The network layer, positioned in the middle of the layered model, primarily consists of basic production and living infrastructure elements. It creates conditions for human settlement, economic activities, and mobility. Infrastructure projects often require substantial costs and complex technologies; therefore, their rate of change is slower compared to cities but faster than the natural systems in the substrate layer. The occupation layer, situated at the top of the layered model, encompasses urban forms and human activities. This layer typically experiences very rapid changes, with substantial expansion or transformation occurring within relatively short periods.

This study draws upon the research methods of Delta Urbanism, interpreting the current state of PRDWS as comprising three layers: a natural substrate layer characterized by geographical environment, an agricultural network layer influenced by agricultural landscape, and a settlement occupation layer (SOL) primarily characterized by built-up areas. The rate of change in morphological elements gradually increases from the natural substrate layer to the settlement occupation layer, while the stability of spatial structures progressively decreases.

Mode refining

The deconstruction and analysis of complex landscapes can distill the spatial characteristics of each subsystem and the spatial relationships between subsystems, summarizing spatial structures and determinant spatial elements. In this process, the spatial composition logic of the samples gradually emerges. By extracting this spatial composition logic, we can obtain the typical spatial characteristics of the samples. Subsequently, through multi-sample comparison, we can determine typical spatial prototypes and draw abstract spatial pattern maps.

In the following sections, this study will conduct cross-scale analysis experiments on the macro-morphology of PRDWS and the meso-morphology of the Northwest River complex delta, based on the dual-scale morphological research framework.

GEOGRAPHIC PATTERN: MORPHOLOGICAL ANALYSIS OF PRDWS (400KM × 400KM)

Mapping of PRDWS at the Geographic Pattern Scale

In urban planning-related fields, PRD typically refers to the south-central part of Guangdong Province, the flourishing region of Cantonese culture, encompassing nine cities: Guangzhou, Foshan, Zhaoqing, Shenzhen, Dongguan, Huizhou, Zhuhai, Zhongshan, and Jiangmen. A 400km × 400km sampling frame is used to capture the complete area of the nine PRD cities. Satellite imagery data (2020) for the sampling area is obtained through Google Earth and placed within a 20cm × 20cm, 300dpi data frame, establishing a minimum grain size of approximately 169.35m (Figure 2). At this scale, spatial elements and their characteristics corresponding to the extent and resolution precision are identified, and a tracing map is drawn (Figure 1).

Through the deconstruction and analysis of PRD at the geographic scale (400km×400km), the following characteristics can be observed in its layered structure and inter-layer relationships:

The natural substrate layer presents four mountain-water geographical patterns: The outermost circle is characterized by towering hills with rivers winding around them; the second circle consists of plain terraces with unobstructed rivers; the third circle features compound plains with networked rivers; and the fourth circle displays a mix of plains and terraces with a denser river network.

The agricultural network layer exhibits a structure that varies from the mountains to the coastline, in accordance with the changing geographical patterns. Mountain agriculture is distributed on the flat lands and terraces between mountains. Agriculture and aquaculture typical of hot and humid plains are concentrated on the delta plains of the lower reaches of various rivers. The compound deltas in the lower reaches of rivers are convergence areas for dike-pond agriculture, while the coastal sandy fields are characterized by strip-like agriculture.

The settlement occupation layer exhibits a concentrated form in the central areas and a scattered distribution in the periphery. Over 90% of the built-up areas are concentrated in the PRD plain, while the sparse, scattered built-up areas in the surrounding mountainous regions align with the river courses.

The natural substrate layer has the longest formation history and the highest degree of stability. The formation and differentiation of both the agricultural network layer and the settlement occupation layer occur on the foundation of this established natural geographical pattern. Comparatively, the former one is more dependent on the natural substrate layer. However, with the progression of urbanization, the settlement occupation layer has shown a significant increase in differentiation.

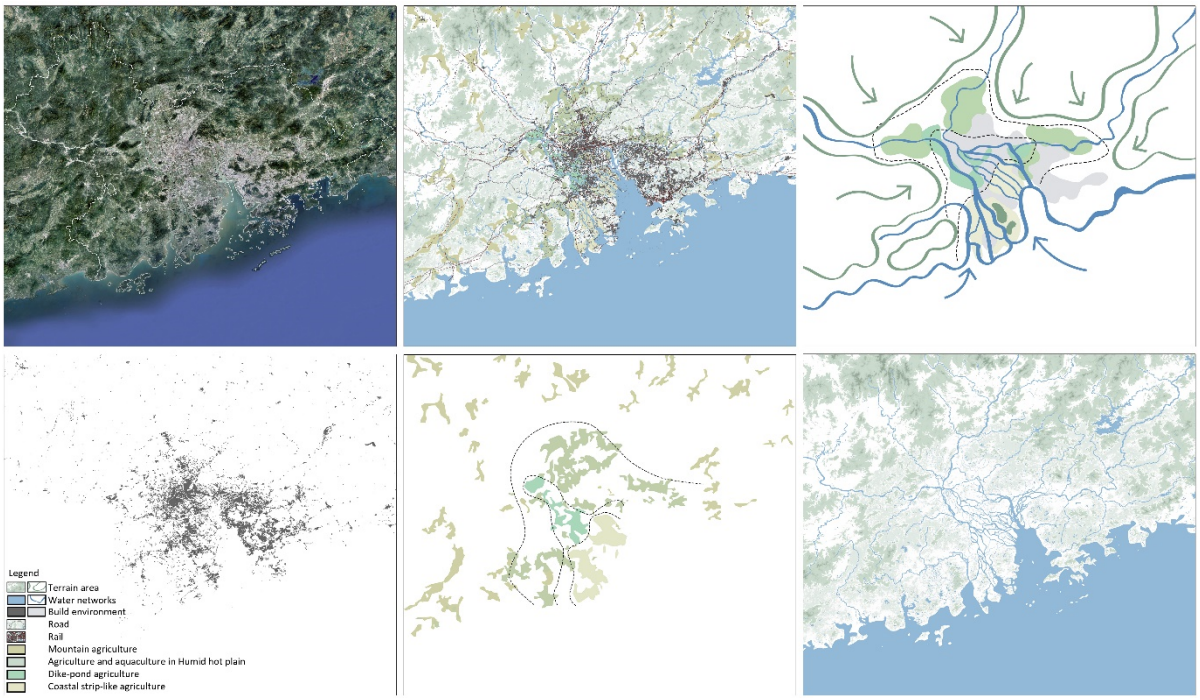

Figure 1. Mapping at the geographical pattern scale. image credit: drawing by author.

Morphological analysis of PRDWS at the Geographic Pattern Scale

At the geographic pattern scale, PRD presents four distinct geographical patterns characterized by mountains, water, cities, and fields, as well as varying degrees and characteristics of urbanization. These can be specifically categorized into:

(1) Zone One: Plateau and hilly areas with sparse water networks - weakly urbanized regions;

(2) Zone Two: River network areas in the lower reaches of various rivers' deltas - peripherally urbanized regions;

(3) Zone Three: Compound delta river network areas - core urbanized regions;

(4) Zone Four: Coastal zones of alluvial plains at river mouths - regions undergoing intense changes.

Zone One encompasses the peripheral plateau and hilly areas, characterized as a weakly urbanized region. Being the highest terrain segment in PRD, its geographical pattern is relatively the most stable. The mountain-water geographical configuration in this zone was largely established in prehistoric times. Early migrants to PRD predominantly settled in this area. However, due to topographical constraints, settlements in this segment are scattered across the flat lands between mountains and on plateaus. Consequently, the urbanization density is extremely low, and the degree of urbanization is the weakest in this zone.

Zone Two comprises the lower delta regions of various rivers with enclosed fields, representing the urban expansion periphery. The mountain-water configuration in this zone was also formed in prehistoric times. This segment has relatively higher terrain, and its water network system is not complex. Settlements are predominantly distributed near streams, with some urbanized areas along the rivers. This zone serves as the peripheral radiation area for the urbanization of PRD's core region.

In the process of rapid urbanization, this area has gradually received industrial relocation and influence from the Guangzhou-Foshan urban core. Consequently, the built landscape exhibits a highly mixed and fragmented pattern of industrial, agricultural, and residential functions.

Zone Three is the compound delta area with enclosed fields, representing the core region of PRD's urban agglomeration. The compound deltas in the lower reaches of various rivers were formed from the early historical period to the Tang and Song dynasties. This area has relatively flat terrain, consisting of plains formed by river sedimentation. It was primarily developed through the joint efforts of Han migrants who moved south from the Song dynasty onwards and local indigenous inhabitants who were gradually sinicized through economic and cultural exchanges. This zone has been the core area of PRD since ancient times.

During the Ming and Qing dynasties, this segment began to form a contiguous characteristic Lingnan watertown landscape, with mulberry dike-fish pond systems as the primary mode of production. In modern times, leveraging the central positions of Guangzhou and Foshan, the urban areas in this region have rapidly expanded and become highly developed.

Zone Four is the sandy field area of the estuary's alluvial plain in PRD, representing the region experiencing the most dramatic urban changes. The formation of the alluvial plain in this area results from the combined actions of rivers, sea, and islands. Part of the river sediment impacts small islands in the sea, forming accumulations around them; another part collides with seawater, causing gradual sedimentation near the coastline. Thus, the alluvial plain is formed by the joint effects of sediment accumulation around islands and seaward deposition.

On the alluvial plain in this segment, the water network system is complex, forming watertown settlements in sandy field areas characterized by strip-shaped landscapes, primarily dominated by rice cultivation, with dike-pond agriculture as a secondary feature. As the degree of development and utilization intensifies, human intervention in the landscape spatial evolution of the Pearl River estuary has gradually strengthened.

The transformation trend of the PRD's estuarine coastal zone is predominantly seaward extension, mainly due to coastal engineering construction, tidal flat reclamation, sea enclosure for land creation, and artificial aquaculture. Artificial land creation stands as the primary driving factor in this process.

LANDSCAPE PATTERN: MORPHOLOGICAL ANALYSIS OF PRDWS (50KM × 50KM)

Mapping of PRDWS at the Settlement Cluster Scale

Based on the geographic pattern scale, we conducted an investigation into the geographical patterns of mountains, water, cities, and fields in PRD. This led to the identification of four major types of geographical segments. Representative samples were then selected for experimental graphic analysis at the settlement cluster scale, coded as La1, La2, La3, and La4 (Figure 2).

Satellite imagery data (2020) for each sampling area was obtained through Google Earth. The data was placed within a 20cm×20cm, 300dpi data frame, establishing a minimum granularity of approximately 21.17m. Based on this scale and research precision, we drew tracing maps and identified different landscape pattern characteristics of mountains, water, cities, and fields, as well as the morphological types of settlement clusters in PRD.

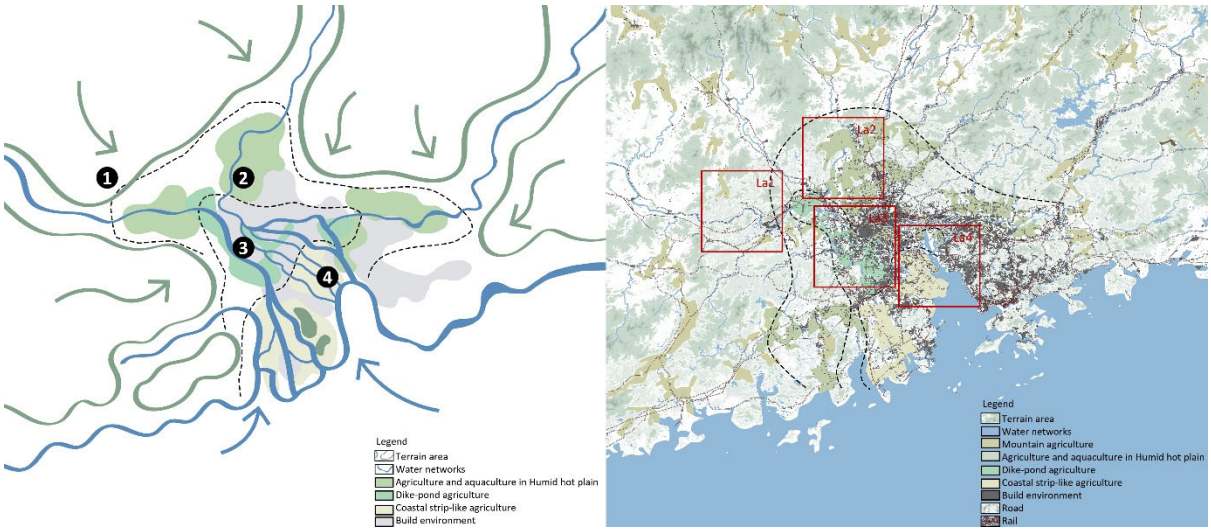

Figure 2. Four zones in PRD at the geographical pattern scale. photo credit: drawing by author.

Through the deconstruction and analysis of four selected blocks at the settlement cluster scale, the following characteristics of their layered structures and inter-layer relationships can be observed:

Within the natural substrate layer, the morphology of the water system emerges as the primary spatial determinant. Specifically, the natural water systems in La1 and La2 are relatively simple, dominated by the main streams of large rivers. La3 is more complex, characterized primarily by a dense network of water bodies. La4 presents the highest complexity, featuring two water morphologies - seawater and rivers - which form a relatively intricate topographical and geomorphological relationship on land.

In the agricultural network layer, La1 is predominantly mountainous, characterized by mountain agricultural landscapes. Plains of considerable scale form at river bends, giving rise to agricultural facilities such as ponds. Additionally, transportation and trade along the main river streams have become auxiliary industries in this region.

La2 exhibits larger plains on both sides of the main stream, forming large-scale enclosed field and pond agriculture. Due to the influence of urbanization, fragmented small-scale industrial facilities exist interspersed with agricultural areas.

La3 features a dense and complex water network, presenting a highly diverse agricultural field-pond landscape system. Near the confluence of the West and North Rivers, water is abundant, and the terrain is relatively high, resulting in lower flood pressure and stronger human control over water. This facilitates the formation of a more complete embankment system. Between the downstream West and North Rivers, influenced by topography and river dynamics, several tributaries interconnect. Numerous artificial canals have been excavated along these tributaries, dividing the relatively flat downstream area of the West-North River compound delta. Here, human control over water is relatively strong, and for production convenience, artificial fish ponds of appropriate scale and homogeneous form have been constructed.

La4 is influenced by both seawater and river water systems. Under the natural action of tides and artificial land reclamation, agricultural water conservancy facilities have emerged through human modification. These are primarily sandy fields, gradually transitioning into residential areas suitable for human production and living.

In the settlement occupation layer, there are significant differences in the density of settlement clusters, with La1 < La2 < La4 < La3. Regarding the distribution and spatial pattern of settlement clusters: for La1, settlements are distributed in a punctuated manner along rivers between mountainous areas. In the larger plains on the concave bank of the West River, large settlements have formed and developed into regional central cities. For La2, settlements are primarily distributed along the eastern bank of the North River. The settlements form a network-like distribution, jointly constituting a human habitation network with the intersecting fields and ponds. For La3, this area has the highest settlement density, with settlements connecting to form contiguous patches. For La4, the settlements exhibit significant variations, corresponding to changes in the geographical pattern.

Morphological analysis of PRDWS at the Settlement Cluster Scale

At the settlement cluster scale, the four selected sample areas exhibit distinct spatial structures. Moreover, the dynamic interplay between natural hydrological elements and anthropogenic production and living activities demonstrates varied characteristics across these regions (Figure 3).

La1 exhibits a landscape pattern characterized by mountainous terrain and hills, dominated by main streams, with artificially built areas scattered in mountains and concentrated in river valleys. This region is significantly influenced by natural topography and hydrological conditions. The difficulty in artificially modifying the mountainous and hilly terrain has resulted in a predominance of small-scale, dispersed agricultural settlements in the mountain areas, with limited settlement sizes. The spatial pattern primarily reflects human activities adapting to the natural environment.

However, in the larger plain areas along the West River, concentrated settlement activities have been facilitated through the construction of embankments and artificial land reclamation. These areas have gradually developed into the central city of Zhaoqing, which serves as the regional hub.

La2 presents a landscape pattern characterized by low-lying terrain, encircled by water networks, with settlements uniformly dispersed and interwoven. This region is located in the North River basin, with the eastern bank generally low-lying, forming a basic pattern of plains embraced by water networks. Within the enclosed area, relatively low-lying riverside plains have formed. To minimize potential losses from flood disasters, settlements are arranged in extremely small-scale, dispersed clusters, creating a sesame seed-like pattern of settlement groups.

This area is adjacent to core cities such as Guangzhou and Foshan, situated on the periphery of the PRD’s central urban agglomeration. Due to the outward diffusion of industrial activities from the core area, this region has been influenced to some extent, manifesting urban phenomena such as industrial parks. However, due to the lack of a comprehensive, large-scale regional planning approach, urbanized areas have developed in a fragmented manner, without exhibiting obvious systematic structural characteristics.

La3 exhibits a landscape pattern characterized by concentrated plains, interwoven rivers and canals, and diversified settlements connecting to form continuous areas. This pattern is distributed in the downstream confluence of the West and North Rivers (between the West and North Rivers). The region is situated at the hydrological hub of PRD, with Guangzhou and Foshan as its core cities.

In its early development stage, this area's elements of mountains, water, cities, and fields constituted an excellent feng shui pattern. Moreover, benefiting from both river ports and sea bays, convenient

transportation facilitated prosperous trade, thus exerting significant economic, political, and cultural influence.

In subsequent urban development, the region has implemented a spatial development strategy of 'advancing east, connecting west, expanding south, and optimizing north.' The continuous improvement of infrastructure networks has further expanded the urban framework. Consequently, in the flat hinterland, the urban built-up area has progressively integrated surrounding agricultural settlements, independent towns, and other scattered land uses into a cohesive whole, expanding outward from the core.

La4 presents a landscape pattern characterized by coastal sandy fields, river-sea interface, and settlements transitioning gradually from land to sea. This region is situated at the estuary of the Pearl River, with its coastline directly exposed to sea waves. The area is significantly impacted by typhoons and floods, thus in the early stages of development, urban built-up areas tended to be distributed in a punctuated manner closer to inland areas, under the shelter of hills and mountains.

Moreover, due to geological processes, the mixing and deposition of river and sea sediments at the estuary have resulted in shallow seabeds, making it difficult to form deep-water harbors similar to those near Hong Kong.

The punctuated urban built-up areas have developed along transportation routes or main streams, embedded among farmlands, water systems, and hilly green spaces, forming a spatial pattern of multiple elements collaged together.

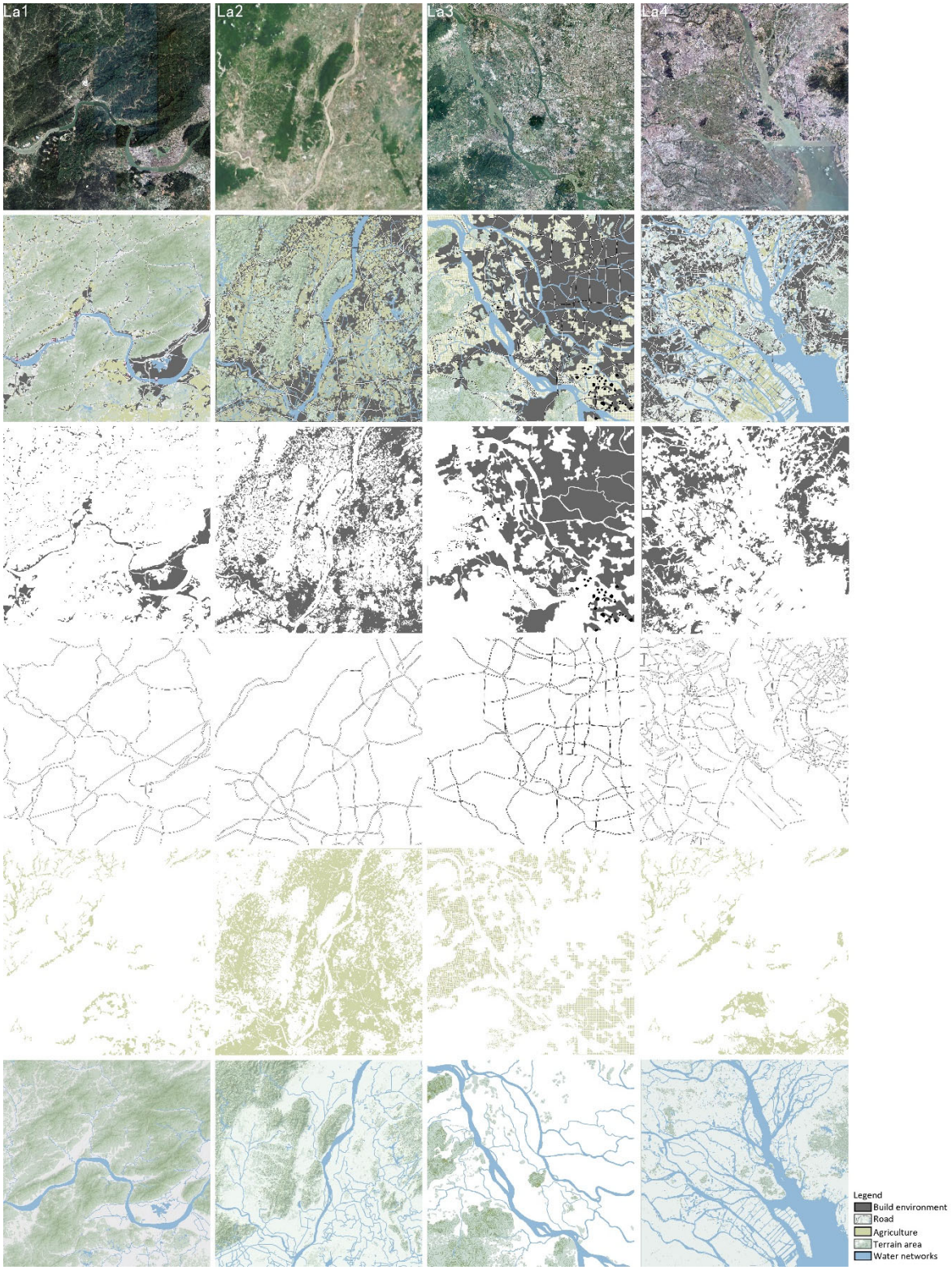

Figure 3. Mapping at the settlement cluster scale. image credit: drawing by author.

CONCLUSIONS

In estuarine delta regions where complex water environments play a dominant role, the relationship between humans and water is one of the decisive factors determining the formation, growth, and change of human settlements. Since the beginning of the 21st century, coastal and delta regions have

faced numerous problems, such as imbalances in erosion and sedimentation caused by tidal surges. In the current context of global climate change and increasing water-related risks, in-depth research on human-water relationships in estuarine delta regions is of particular importance and practical significance.

PRD has a typical regional water system. Influenced by the unique interaction between runoff and tides in this region, different characteristics of human-water relationships have developed through the symbiosis between residents and the aforementioned environment. This study draws on the theory and methods of delta urbanism to conduct a dual-scale graphic analysis experiment from macro and meso perspectives (focusing on the West-North River compound delta area), yielding three main conclusions:

(1) The dynamic interplay between natural hydrological elements and anthropogenic production and living activities is the core process determining the development of PRD.

(2) PRDWS exhibits highly diverse and complex characteristics. At the geographic pattern scale, PRD can be divided into four types of water system areas: peripheral plateau and hilly areas, downstream delta enclosed field areas of various rivers, compound delta enclosed field areas, and alluvial plain sandy field areas. These areas respectively demonstrate four states: weak urbanization, urbanization margins, urbanization core, and dramatic changes.

(3) There exists a long-term dynamic balance between PRDWS and the urbanization process. At the settlement cluster scale, the differences of the four zones can be analyzed. The natural water system is initially the core dominant factor in urban and rural landscapes. Simultaneously, the rapid construction and evolution of infrastructure and industries drive the expansion of core built-up areas towards the periphery, forming new spatial patterns.

Acknowledgements

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Land Readjustment and Control of Urban Expansion in Medellín's Green Belt

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ABSTRACT

The extensive expansion of major Latin American cities represents a growing threat to the preservation of green spaces crucial for ecological balance and human well-being. Faced with the challenges of the environmental crisis and climate change, the relationship between urban expansion and environmental preservation needs to be addressed by urban planning instruments at different scales. The city of Medellín stands out in facing the challenge of containing its urban expansion while fostering sustainable development in the area of its Green Belt, dealing with complex relationships between access to housing and infrastructure, environmental preservation, and socioeconomic development. This article aims to present and discuss an innovative approach to dealing with urban expansion in Medellín's Green Belt, Colombia. The importance of the Partial Plan instrument through Land Readjustment as a fundamental strategy is highlighted. This instrument aims not only to contain the expansion but also to promote an equitable redistribution of land ownership, encouraging collaborative decisions among different actors. The proposed methodology is based on the analysis of the implementation of Partial Plans that use land readjustment as a means to reorganize the land ownership structure in the Green Belt. Practical cases such as the Pajarito Partial Plan will be analyzed, assessing the impacts of applying this strategy on urban dynamics, considering the active participation of the community and local authorities. The results include a more controlled urban expansion, with preserved green areas and a more equitable redistribution of ownership. The discussion addresses the challenges faced, the successes achieved, and the lessons learned, highlighting how the application of this instrument can contribute to a sustainable balance between urbanization and environmental preservation. Thus, the article aims to contribute to discussions of urban form and sustainable development, offering support for similar urban contexts.

Keywords: Expansion: Global South, Megamorphologies, Morphometrics, Tent Cities

INTRODUCTION

In a world with high urbanization rates, where the majority of the population lives in cities, urban challenges are intertwined with multiple contemporary crises, encompassing social, economic, and

environmental dimensions. In the context of Latin America, the intense and dispersed urbanization process, which accelerated throughout the 20th century, has led to high levels of urbanization and social inequality. Currently, about 80% of the Latin American population resides in urban areas, reflecting a scenario of profound transformations and challenges for sustainable development (Leite et al., 2020). The extensive expansion of large Latin American cities into green areas and environmental preservation zones poses a growing threat to the conservation of green spaces, which are crucial for ecological balance and human well-being. These areas provide vital ecosystem services such as climate regulation, water and food production, and air purification, among others.

Urban sprawl in Latin America has often been characterized by unplanned growth, frequently occurring outside the formal planning frameworks of cities. In large metropolitan areas like São Paulo and Mexico City, urban expansion and the reduction of green areas have increased surface runoff, subsequently raising the risk of flooding during the rainy season (de Lima et al., 2023). This phenomenon has led to irregular land occupation, lack of basic infrastructure, and inadequate public services, while also contributing to environmental degradation. In the face of the environmental crisis and climate change, the need to address the relationship between urban expansion and environmental preservation through urban planning tools at various scales has become increasingly evident (Marques, 2024).

In the Latin American context, the city of Medellín stands out for addressing the challenge of containing urban sprawl while promoting sustainable development in its Green Belt area, albeit in a limited way, as it navigates complex relationships between access to housing and infrastructure, environmental preservation, and socioeconomic development.

This article explores the case of Medellín, Colombia, as a reference case in the development and implementation of integrated urban expansion control tools. Medellín, once known for its high levels of violence and inequality, underwent an urban transformation process that included innovative planning and territorial management measures (Leite et al., 2020). The article is structured into four parts, beginning with the theoretical framework, followed by the Colombian context, the Green Belt, and the case study of the Pajarito Partial Plan.

Theoretical Framework

In the context of this article, Land Readjustment is highlighted as an important tool for urban reorganisation, especially in areas with precarious urbanisation. This instrument allows for the equitable redistribution of land with the aim of restructuring urban spaces and promoting the development of infrastructure. Within discussions on urban form, Manuel de Solà-Morales (1997) emphasises that urban form is directly linked to the organisation of public space and is essential for creating more inclusive and functional cities. The author advocates interventions that integrate fragmented areas, improving connectivity and social cohesion - a concept in line with Land Readjustment, which seeks to regularise spatial morphologies and promote a more cohesive and connected development.

On the other hand, Carlos Dias Coelho (2013) complements this analysis by addressing the relationship between urban form and the historical processes of land appropriation. According to him, urban morphology is the result of specific social and economic processes, and instruments such as Land

Readjustment need to respect these dynamics to avoid perpetuating inequalities. In the case of Medellín, the use of this tool cannot just be technical, but must take into account local characteristics and needs, promoting social and spatial integration.

For Solá-Morales (1997), urban form is directly linked to the structure and organisation of public space, which is essential for creating more inclusive and functional cities. The author emphasises the importance of intervening in the territory in order to integrate fragmented urban areas, which is in line with the logic of Land Readjustment, in which the redistribution of plots seeks to regularise spatial morphologies and improve urban connectivity. Solà-Morales' (1997) concept of urban acupuncture also reinforces the idea of targeted interventions that can catalyse the regeneration of entire areas, a principle that can be applied to land readjustment projects.

Coelho (2013) complements this analysis by focusing on the relationship between urban form and the historical processes of land appropriation and subdivision. According to him, urban morphology, especially in informal areas, is the result of multiple processes of adaptation and transformation that respond to specific social and economic logics. From this perspective, and reflecting especially on the Medellin context, Land Readjustment is not just a technical matter of land redistribution, but also a process of social negotiation that must take into account pre-existing dynamics and local needs, while respecting the social and spatial structure of the areas involved.

In this sense, the articulation between Land Readjustment and urban form involves not only the physical reorganisation of the territory, but also the incorporation of cultural and social elements that shape the space. This instrument must take into account the preservation of local identity and the strengthening of connections between public and private areas, promoting greater social and spatial cohesion. In this context, discussions about urban form linked to this instrument contribute to a critical vision of urban transformation, in which Land Readjustment, linked to other urban instruments, can be a tool for inclusion and requalification of cities.

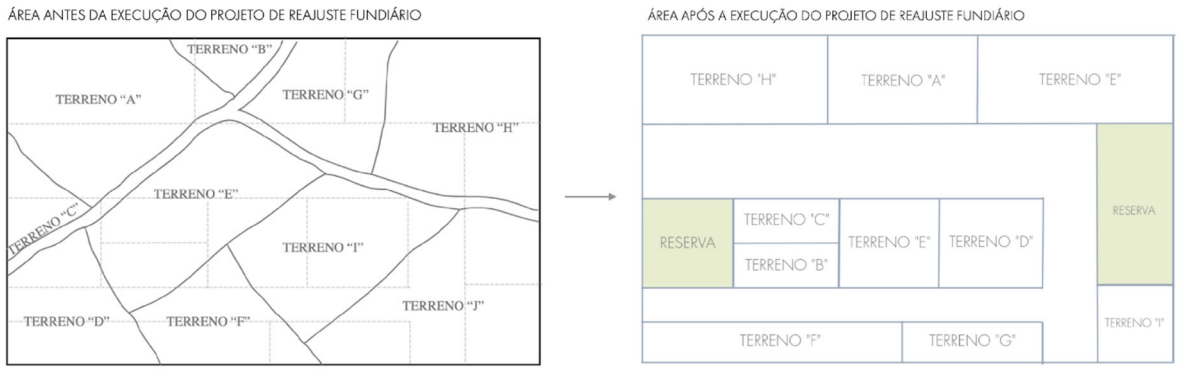

Figure 1 - Land Readjustment Concept. Source Pereira (2024)

Patterns of disordered and sprawling development generally characterise urban form and expansion in the peripheries of large Latin American cities. These trends are driven by a combination of factors, including inadequate land-use regulations, pressure for affordable housing, and the expansion of urban areas without proportional investment in infrastructure. The result is a fragmented urban fabric

with low population densities and insufficient infrastructure, which can exacerbate socioeconomic inequalities and environmental degradation.

In response to these challenges, there has been a growing emphasis on the need for more integrated and sustainable approaches to urban development in Latin America. This shift has been driven by concepts such as the compact city, urban regeneration, and the right to the city, which highlight the importance of densifying urban areas, revitalising existing neighbourhoods, and ensuring equitable access to urban resources and opportunities (Lefebvre, 1996).

The city of Medellín, Colombia, offers an example of how these approaches can be put into practice through the implementation of the Green Belt strategy, which aims not only to protect environmentally sensitive green areas on the city's periphery but also to serve as a platform for the development of public spaces and social housing, thereby integrating peripheral populations into the rest of the city. The Green Belt strategy departs from the traditional “plot-by-plot” urbanism, which tends to further fragment the urban fabric and exacerbate issues of mobility, infrastructure, and social exclusion.

Its implementation was facilitated by the use of innovative urban planning tools, such as Partial Plans and Land Readjustment. These instruments allowed the city to reorganise land ownership structures, promote collaborative decision-making among various stakeholders, and ensure the equitable distribution of the benefits and burdens of urban development.

The case of Pajarito demonstrates an effort to improve the quality of urbanisation in expansion areas while establishing respect for nature.

The Colombian Context

The current cycle of urban projects in Colombia began with the approval of Law 9 of 1989, known as the Urban Reform. In 1991, a new federal constitution was enacted, and later, in 1997, Law 388, the Urban Development Law, was promulgated. This law aimed to update Law 9, aligning it with the changes introduced by the 1991 Constitution. This process took place in a context of market liberalisation policies, where territorial planning decisions were decentralised to the municipal level. According to Bocanegra (2014), this resulted in two scales of power and influence: the National scale, responsible for regulating and managing certain resource sources, and the Municipal scale, in charge of planning, financing, and control.

Within this framework, one of the main urban planning instruments at the municipal level is the Land-Use Plan (POT), which defines the specific areas of the territory requiring urban interventions, projects, and specialised instruments. The POT also spatially distributes the municipality’s economic activities and determines major infrastructure projects to achieve its objectives (Ferro, 2010, p. 23).

The POT also designates Strategic Intervention Areas (AIE), which are programs and projects derived from the policies and strategies of the municipal POT. These actions must be approved and ensure a structural impact on the quality of life and spatial organisation of the city.

The execution of AIEs takes place through urban macro-projects, which are a set of technically defined and evaluated actions. These projects aim to carry out large-scale urban operations that impact the city's structure and guide its growth. Macro-projects must provide coordinated solutions to problems,

involve interested public and private entities, establish mechanisms for capturing land value appreciation, and ensure a fair distribution of costs and benefits among stakeholders.

Within this framework of transformations applied to the legal urban planning system, the role of the Partial Plan (PP) stands out. This tool, primarily technical but imbued with significant political and social implications, emerges as a paradigm in Colombia's new urban planning system. The Partial Plan is the instrument that develops and complements the POT's provisions in specific urban areas. It is mandatory for the development and transformation of expansion areas and urban renewal projects, linking land planning and management.

POTs establish guidelines and parameters for Partial Plans, determining the scale, complexity, and conditions for the projects. Each Partial Plan addresses specific urban programs and projects. There is no fixed definition of their magnitude, nor are they limited to small areas. The focus is on criteria, not specific areas. The key criteria refer to urban development and planning guidelines, which enable the creation of various Partial Plans aimed at implementing and financing the directives outlined in the POT, ensuring an equitable distribution of costs and benefits.

Law 388 of 1997 also mandates that PPs be developed through Urban Action Units (UAU). It is through this instrument that the rational use of land is achieved. The law defines UAUs as sectors of intervention within a Partial Plan. This scale of urban planning is precisely where Colombia's urban projects fit. Each UAU focuses on a set of plots, blocks, or groups of blocks, accounting for the need for public works and establishing rights and obligations for property owners (Montandon, 2009).

The Medellín Green Belt: Urban Expansion Control and Integrated Urban Revitalization

In the Colombian context and in line with the metropolitan planning established by the Metropolitan Area of Valle de Aburrá (AMVA), the city of Medellín has included the Jardín Circunvalar de Medellín in its strategic planning. The goal is to contain the urban sprawl towards green areas while also ensuring the urban redevelopment of already occupied areas from an integrated perspective. This approach not only addresses the urban design of these areas but also considers social, environmental, and economic dimensions.

The Jardín Circunvalar de Medellín, also known as Medellín's Green Belt, is a strategic urban project aimed at controlling the city's expansion and promoting environmental conservation while integrating marginalized communities into the broader urban fabric. This ambitious initiative aims to balance urban growth with ecological preservation and social inclusion by creating a green buffer zone around the city's perimeter. It not only curbs unplanned urban sprawl but also enhances the quality of life for the local population through integrated urban revitalization efforts.

Medellín's Green Belt project was conceived as a response to decades of disordered urban expansion, particularly in the city's peripheral and hillside areas. These zones, characterised by informal settlements and environmental degradation, were in dire need of infrastructure, public services, and environmental protection. The Jardín Circunvalar project aims to address these challenges by creating a continuous green corridor that serves both as a natural barrier to urban sprawl and a space for recreation, community engagement, and environmental education.

The project has two main objectives: controlling urban expansion and improving the quality of life in the city's peripheral areas. To achieve this, the Green Belt incorporates a range of interventions, including reforestation, the construction of parks and green spaces, and the development of social housing and public infrastructure. These efforts aim to integrate the peripheral communities into the city's urban dynamics while preserving the natural landscape.

Key elements of the Jardín Circunvalar include:

- Urban Expansion Control: The Green Belt acts as a physical and regulatory boundary, limiting further expansion into ecologically sensitive areas and protecting Medellín's surrounding hillsides from deforestation and environmental degradation. By creating a natural buffer zone, the project helps contain the city's growth within its existing urban footprint, preventing unplanned settlements in vulnerable areas.

- Environmental Conservation: The reforestation of degraded areas and the protection of existing natural spaces are central to the project. The Green Belt promotes the restoration of ecosystems, improving biodiversity and reducing the city's environmental footprint. It also contributes to climate regulation by preserving green spaces that help mitigate the urban heat island effect.

- Social Inclusion and Urban Revitalization: One of the project's core components is the integration of marginalised communities living in informal settlements. Through the construction of new infrastructure, public services, and social housing, the Green Belt project aims to provide these communities with better living conditions and greater access to the city's economic and social opportunities. The creation of parks, public spaces, and cultural facilities fosters social cohesion and encourages the active participation of residents in the development of their neighbourhoods.

- Public Spaces and Ecotourism: The project has also introduced a network of public spaces that offer recreational opportunities and promote ecotourism. Trails, parks, and viewing points are integrated into the Green Belt, providing residents and visitors alike with access to natural areas and creating new opportunities for economic development through tourism.

The Jardín Circunvalar of Medellín is an example of how urban planning can address both environmental and social challenges in a holistic manner. By integrating urban expansion control with community-driven revitalisation, the project not only curbs sprawl and protects natural spaces but also empowers local populations, fostering a more inclusive and sustainable city.

To achieve this, a series of urban instruments are coordinated, with the main one being the Territorial Ordering Plan (POT) of Medellín (2014-2027), which was updated in 2014. This plan establishes three Strategic Intervention Areas (AIE): AIE Centro River, AIE Edge, and AIE Transversals, as indicated in Figure 2. The Jardín Circunvalar de Medellín includes the AIE Edge, which is divided into five macro-projects: (1) Northwest Urban-Rural Edge (BUR), (2) Southwest BUR, (3) San Antonio BUR, (4)

Northeast BUR, and (5) South BUR, as well as part of the AIE Transversals, divided into two macro-projects: (1) La Iguana and (2) Santa Elena.



Figure 2 - Medellín's strategic intervention areas and macro-projects. Available at: https://www.medellin.gov.co/irj/portal/medellin?NavigationTarget=navurl://1835433ab6162f1d159791ea638561aa. Accessed on 15 September 2023.

Within the framework of the Jardin Circunvalar de Medellín, the macro-project areas were divided into 14 Master Plans and, on this more detailed scale, specific objectives and strategies were established for each sector. This article will discuss the case of Pajarito (12) (Figure 3).

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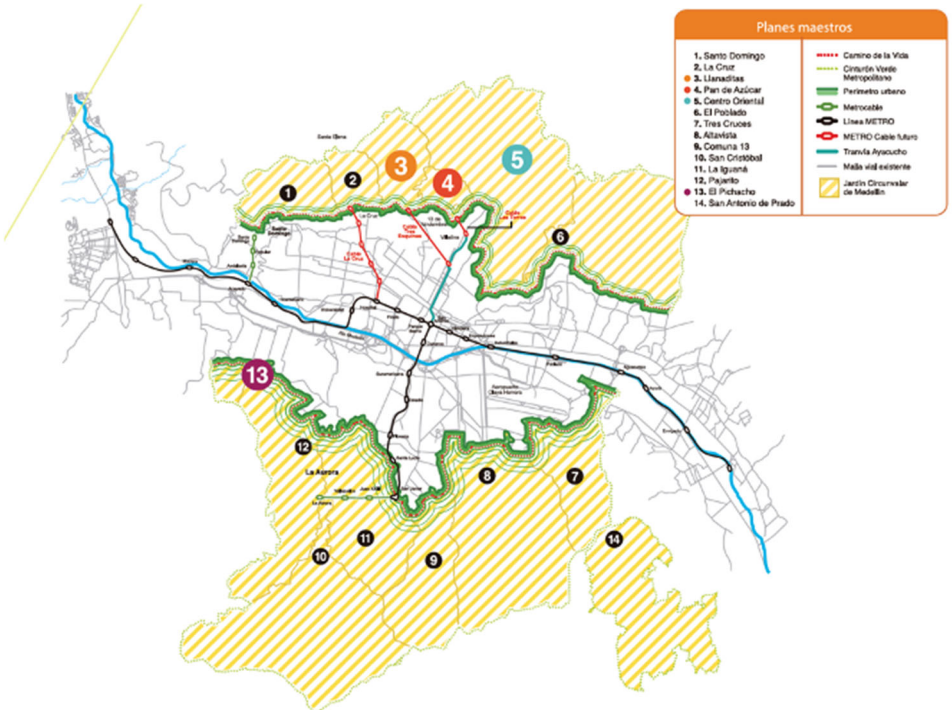

Figure 3 - Masterplan of the Medellín Circumpolar Garden. Source: Alcaldía de Medellín and EDU (2015)

The Jardín Circunvalar de Medellín has adopted a systemic intervention strategy in the territory, involving local communities through pedagogical models of consultation, dialogue, design, implementation, evaluation, and feedback. To achieve this, three strategic lines have been fundamental: (1) sustainability and environmental recovery, (2) comprehensive improvement of the habitat for life, equity, and social cohesion, and (3) pedagogical urbanism. Controlling urban expansion and enhancing environmental character and historical heritage are developed through ecological restoration, the establishment of public facilities, community gardens, recreational areas, and ecotourism; these uses are linked with activities that generate employment and income. Additionally, actions aimed at risk management are proposed, ensuring dignified and sustainable housing while improving local urban mobility and its connections with the Medellín Valley through sustainable public transportation.

These actions are coordinated to generate territorial transformation based on five attributes: (1) integral sustainability of the territory, (2) inclusive and structuring public space, (3) control of urban expansion with a holistic view of development, (4) quality connections within the territory, and (5) dignified, safe, sustainable, and affordable housing.

The Master Plans highlighted in Figure 3 provide the overall framework and strategic guidelines mentioned above, which must be followed by the Partial Plans. The Partial Plans, in turn, apply and detail these guidelines in the local context, ensuring that interventions are suitable for the specific characteristics of each area of the city. One way to develop a Partial Plan (PP) is through Land Readjustment. Although not every PP is derived from land readjustment, every land readjustment occurs within a PP. Land Readjustment is an instrument incorporated into the Colombian urban legal framework under Law 9 of 1989 and later regulated by Law 388 of 1997.

Land Readjustment is a method of urban development executed collaboratively, where property owners and tenants contribute to financing and executing the project, equitably sharing the costs and benefits of urban development. This practice is authorised by specific legislation, and its execution is managed by a multidisciplinary technical agency known as the implementation agency, which is responsible for the transformation process of the various land units within the project's boundaries (SOUZA, OCHI & HOSONO, 2018, p. 29).

Articles 45, 46, and 47 of Law 388 of 1997 define the bureaucratic process for carrying out a Land Readjustment project in Colombia. The project always occurs within an Urban Action Unit and must be approved based on the Partial Plan. Once presented, it must be approved by a minimum number of landowners representing at least 51% of the project's surface area. The project must include rules for valuing the lands and properties contributed to the project area and must consider the current urban regulations for the area. Restitutions will be made from the resulting land lots unless it is not possible, in which case an economic compensation will be provided. It is important to mention that there is also a regulation stipulating that 20% to 25% of privately owned lands in a Partial Plan are mandatorily allocated for Social Housing projects.

Pajarito

The Pajarito Partial Plan is the largest area designated for urban expansion as outlined in the Territorial Ordering Plan of 1999 and was later revised in 2012, accounting for nearly half of the areas allocated

for expansion in the same plan. Three main guidelines guided the project: the first proposed the creation of an urban edge, the second aimed to create social housing in a region lacking adequate housing, and the third focused on its environmental appeal, surrounded by rivers and mountains.

Determined by the Territorial Ordering Plan, it was established that the entire area would consist solely of a Partial Plan, which caused significant controversy since the area spans 230 hectares, whereas partial plans typically range between 10 and 20 hectares in size. Formulated between 2001 and 2002, this was the first Partial Plan with these characteristics approved in Colombia. The plan envisioned the construction of 1,258,684 m² for housing and 67,641 m² for complementary uses, divided into central zones for service provision and commerce. However, a large portion of the area is deemed unsuitable for construction due to environmental restrictions, resulting in a significant expanse dedicated to green spaces, linear parks, and river protection, totalling nearly 329,000 m² (Bocanegra 2010).

These characteristics make this urban edge a permeable territory that ensures the continuity of environmental systems and an abundance of open green areas, while also emphasising two essential urban conditions: low occupancy with buildings and housing complexes with heights ranging from four to eight stories, which is crucial for social housing. Additionally, the rugged topography facilitates access at intermediate building levels (Bocanegra 2010, p. 153).

The Pajarito Partial Plan, located in the expansion zone of Medellín, encompasses the incorporation of 38 plots of land from 36 owners. Of the total area, 43% will remain unoccupied due to environmental or geological conditions, while only 28% of the land is suitable for construction. Thus, only 63 hectares (27.3%) of the original 230 hectares are left for residential use and other new functions, after a final assessment of the other pre-designated areas. The project was conceived to provide high-density social housing in buildings of eight stories, containing between 100 and 238 housing units. The costs of urban infrastructure and services totalled $45 million. The municipality acquired 80% of the land through voluntary sales at prices that did not include expectations of future land value, and guaranteed the construction of infrastructure to ensure that the developments or sales of real estate products remained below the thresholds established by the Partial Plan. It is important to note that the constructed housing units are subsidised (Rojas Eberhard and Rave 2013).

The application of the ‘Land Readjustment’ tool in areas of urban expansion, especially in regions of social vulnerability, presents some differences from the use of this instrument in already consolidated areas. In these consolidated areas, each owner assigns part of their land, which is transferred to a trust. A complete redesign of the layout of the plots in the area is then carried out. In the case of Pajarito, the city council had to acquire some land, although the logic of development through urban action units was maintained.

This type of intervention in areas of expansion, especially in socially vulnerable areas, requires stronger government involvement, both in negotiation and in financing. It also involves greater sensitivity to social issues, since it is necessary to ensure that the original residents benefit and are not excluded from the urban transformation process. The ‘Land Readjustment’ tool, in this case, adapts to the need to reconcile urban development, land redistribution and social inclusion, while respecting the local reality and the demands of the residents. In the case of Pajarito, the instrument was also used as an important tool for relocating families living in risk areas.

Table 1 illustrates how the articulation between urban planning instruments is reflected in the urban form. To discuss the case of Pajarito, certain categories and elements of urban form established by Scheer (2016) were used. With regard to land and plots, it is important to note that this area specifically presents some challenges in terms of scale; the Partial Plan covers an area of 230 hectares, which is between 10 and 20 times larger than the partial plans established in the more central areas of Medellin. In addition, the area faced several environmental restrictions, such as complex and steep topography, as well as the presence of natural springs. As a result, 43% of the area could not be developed due to environmental or geological restrictions, and only 28% of the land is suitable for construction.

With regard to paths, there is a low road density resulting from environmental restrictions, combined with wide streets and irregular routes shaped by the natural morphology of the site. The limitation of roads hinders connectivity and impacts mobility within the area. This highlights the strong influence of geographical features on urban planning in the area, which has resulted in roads adapting to the irregular nature of the terrain.

The area has many open spaces and green areas, although there are relatively few trees. The built environment consists mainly of tall buildings, all with a uniform typology of eight storeys. The infrastructure is characterised by wide streets, which creates a more isolated environment dependent on the use of cars for transport, making it difficult to create a denser, more integrated urban fabric.

Table 1 - Analysis of key elements of urban form in the case of Pajarito. The categories are based on the elements of urban form established by Scheer (2016)

Built form	
Objects Paving, lawn, cultivated vegetation, signs, canopies, fountains, art, signals, and poles, planters, curbs.	**1. Many open areas/green spaces, but few trees**
Buildings Occupied buildings, topologically whole. Accessory buildings, sheds, kiosks, garage.	• **High rise buildings - 8 floors** • **The buildings have a homogeneous typology**
Infrastructure Large scale, occupied: bridges, stadium, canal, clock tower, city gate, city wall, triumphal arch, monuments.	• **Wide streets - isolated car-dependent area**
Boundary Matrix	
Plots Bounded, parcel or lot, signifying control	• **Challenges of scale (230 ha area)** • **Topographical and environmental challenges** • **Many open/green areas**

	The partial plan has an area of 230 hectares (between 10 and 20 x larger than usual partial plans)
Paths Continuous, the bounded space of the right of way of the street, rail, canal.	• **Low road density due to environmental restrictions** • **Wide streets** • **Irregular path due to morphology**
Land	
Land Watershed, natural vegetation, slope and aspect, river, harbours, topography.	• **Complex/rugged topography** • **Slopes** • **Springs** **43% will not be occupied due to environmental or geological restrictions, and only 28% of the land is suitable for buildings.**

Concluding remarks

In the context of debates on urban form, the discussion in this article has shown that the combination of different urban planning instruments, from strategic planning to partial plans and Land Readjustment, makes it possible to achieve a more organised urban form, overcoming the traditional "plot by plot" development approach. In the case of Medellín, this articulation aims for a more cohesive urbanisation, which despite its limitations, has allowed the reorganisation of a large area like Pajarito, respecting environmental and geological restrictions, which translates into more sustainable and controlled urban planning, guaranteeing development in a way that mitigates negative impacts.

As well as promoting a more organised urban form, this integration brings social and environmental benefits that are worth mentioning. In Pajarito, 43% of the area has been preserved due to environmental and geological restrictions, while only 28% of the land is earmarked for construction. This reflects a commitment to preserving the environment and promoting high-density social housing, especially benefiting resettled families who previously lived in risk areas. This approach balances the need to urbanise with the preservation of natural resources, promoting more inclusive urban development.

However, there are contradictions between the strategy and the executed plan. While the strategic planning defines the Green Belt as an area to contain urban sprawl, it also establishes new areas for urban growth, which raises questions. Is it possible to reorganise built spaces more efficiently? Is the verticalisation proposal really in line with the idea of a ‘compact’ and ‘polycentric’ city, as envisaged in the strategic plan? Such doubts raise discussions about the sustainability of this urban development model, especially considering the social and environmental impact of planning decisions.

Partial plans in central areas differ significantly from those applied in expansion areas such as Pajarito, where the scale of the project and environmental factors introduce various complexities. The need to integrate a series of urban planning tools in a large area, subject to environmental restrictions, demands specific solutions that are not always necessary in more centralised and consolidated areas. Despite the challenges, this integration of instruments seeks to avoid fragmented development and

promote more planned urbanisation, which represents an advance on traditional urban expansion practices.

The analysis of Medellín's Green Belt, based on Land Readjustment, reflects the attempt to reorganise fragmented urban areas with a view to social inclusion and environmental preservation. However, looking at it from the theoretical perspective of Manuel de Solà-Morales, who emphasises the importance of the relationship between urban form and public space, one can question the extent to which these interventions actually promote sustainable urban cohesion. Solà-Morales argues that connectivity and the integration of fragmented areas should be priorities, and the Pajarito Partial Plan, although it has preserved 43 per cent of the area for green spaces, still presents a dispersed urban form with low connectivity, especially due to topography and environmental restrictions. The use of uniform typologies of high-density buildings can also be criticised in the light of Solà-Morales' idea of the importance of interventions that respect the specific characteristics of each territory.

Furthermore, Carlos Dias Coelho emphasises that specific historical and social processes shape urban morphology, and that interventions such as Land Readjustment must take these dynamics into account to avoid reproducing inequalities. In the case of Pajarito, although the project seeks to integrate the vulnerable population and offer social housing, the centralisation of decision-making power in the hands of the municipality and the lack of typological diversity may raise questions about the initiative's real inclusive impact. In addition, the verticalisation proposed may be at odds with the notion of a compact, polycentric city, exacerbating socio-spatial segregation by creating isolated areas with little integrated urban infrastructure, which goes against the guidelines of a more balanced and sustainable urban development advocated by these theorists.

In the case of the Pajarito Partial Plan, the theoretical discussions reveal both the advances and the practical limitations of the application of Land Readjustment. Although the preservation of 43 per cent of the area for green spaces represents a commitment to sustainability, low connectivity and the use of uniform, high-density typologies can limit the inclusive impact of the intervention. By adopting a verticalisation solution, there is a risk of creating isolated areas, which could exacerbate socio-spatial segregation, contrary to Solà-Morales' recommendations on the importance of interventions that respect the specific context of each territory. Furthermore, Carlos Dias Coelho's criticism of the lack of typological diversity and the centralisation of decisions can be applied to Pajarito, where verticalisation does not necessarily promote the desired cohesion, raising questions about the long-term effectiveness of this approach.

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Lost waterways of Country: A morphological approach to interpreting maps of hidden streams beneath Australian cities

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ABSTRACT

The planning for colonial settlement in the 'new world' often originated with maps that accurately charted the topographical landscape features that were 'as found' by the colonial surveyors, upon which the first outlines of the proposed town plan of blocks and plots was drawn. While the intent of the maps was the blueprint for a future built manifestation, in the context of Australia the settlement drawings represent a contemporaneous record of the landscape that had been under the custodial care of the first nations peoples for millennia. These maps record the landscape features of immense cultural significance that were to be irrevocably disturbed, altered, or destroyed. The paper proposes to develop recent published research by the authors with the aim of this paper to develop a broad comparative study through the archival research and analysis of Geelong, Brisbane, and Sydney. The findings suggest a widespread phenomenon whereby the earliest colonial settlement surveys and maps can be understood as a representation of an end of a sequence of continual human habitation, rather than the conventional reading of the start of a morphological sequence. We conclude that colonial surveys maps are a valuable source for evidencing the form and location of important sites of lost cultural landscapes, in particular the lost waterways of Country, submerged beneath the modern city, that may be re-interpreted through design reparation for new urban design approaches, with implications for meaningful reconciliation of cultural heritage and identity.

Keywords: Urban morphology, Country, Lost waterways, Australian cities

INTRODUCTION

The notion of "Country" is fundamental to Australian Aboriginal understanding of spiritual, cultural, and social ties to the environment. Unlike the Western understanding of a geographic area, Country embodies the deep interconnected relationship between land, water and sky (Neale, 2020; Government Architect NSW, 2023). We begin by acknowledging the traditional owners of Country that are the subject areas of this paper, namely the Wadawurrung people of the Geelong, the Turrbal and Jagera people of Brisbane, and the Gadigal people of Sydney.

Generally speaking, every part of Country in Aboriginal Australia contains a set of travel paths crisscrossing the landscape, in which sacred places occur that were created by the ancestors. (Page and Memmott, 2021, 34)

Country is infinite where time and place are continuous, part of a seamless flow of life with no concept of a beginning or ending and is also known as the Dreaming. The Creator ancestors shaped Country (also referred to as Creation Stories). Songlines, connected to the Dreaming link sites of knowledge and are embodied in the features of the land (Neale, 2020). Every aspect of Country is interconnected and symbiotic, removing one element is detrimental to the whole system.

The terrestrial waterways of Country are dominated by existing large river systems such as the Murray Darling that drain vast continental basins, despite having been altered or manipulated. However, it is at the locations of city and towns, established over the last two centuries, where often the smaller streams, creeks and gullies have disappeared from view, confined into subterranean engineered drainage systems. Once an important fresh water source, these waterways have systematically been submerged and covered and are now lost as a tangible feature of the natural landscape.

Identifying significant landscape features that have been erased by colonial settlement and development can aid reconciliation by acknowledging and evidencing their histories towards restoring connections to important features of ancestral lands. This paper aims to identify former surface waterways as an example of lost landscape characteristics using archival maps, that provide evidence of pre-settlement natural environments.

The French theorist Michel de Certeau critically examines maps, arguing they are not mere objective representations of space. Instead, they are crafted by those in power to project political ideology and control over the inhabitants of a given area. Maps influence future outcomes and wield power through what they omit or deliberately exclude, distorting reality and reinforcing control (de Certeau, 1984). Maps also generate radical changes to existing conditions by their projective and future oriented imaginary. Mapping and territorial surveys are particularly spatial representations that both represented topographical conditions and produced a way of knowing, a system of knowledge that substituted and replaced other ways of knowing. Colonial land surveying was a means of claiming ownership. Mapping or planning envisioned a future imposed on the present land, reshaping its physical and socio-cultural characteristics. These maps gave speculative ideas a sense of reality, anticipating and facilitating future changes and transformations.

Various interpretations of a single document can often conflict, shaped by different historical perspectives as well as author positions. Survey maps, as tools of power, guided the development of cities by imposing colonial visions on the landscape. Indigenous communities navigated these imposed boundaries with strategic flexibility, described by de Certeau (1984) as a ‘turn’ of events. The lines of settlement—grids, fences, roads, and boundaries—ultimately became instruments of dispossession (Sanders et al. 2021).

The authors build on recent published research (Sanders et al. 2021, 2024) that establishes an alternative reading of the earliest colonial topographical features surveys and settlement maps, that they evidence the end of a sequence of continual human habitation, rather than the conventional reading of the start of a morphological sequence. The paper thereby proposes a ‘reverse gaze’ on colonial history, a look back in time, rather than a projective ‘forward’ looking gaze. This series of investigations have pursued this lens and frame of analysis towards developing a reparative approach to history, a historiography of revision and repair; and a reparative approach to urban design. This

paper aims to add to the ongoing discussion about urban landscapes and the importance of understanding the past as a complex and contested heritage.

Urban morphology, as a field of study, documents the physical structure and form of cities from their founding to their subsequent changes and developments. This method provides a solid foundation for compiling evidence of environmental changes using archival maps, photographs, and documents. Such data can prompt new questions that challenge the conventional Western historical narrative, which often overlooks negative and destructive human and environmental strategies integral to colonial settlement processes.

METHOD

Urban morphology, as a field of study, documents the physical structure and form of cities from their founding to their subsequent changes and developments. This method provides a solid foundation for compiling evidence of environmental changes using archival maps, photographs, and documents. Such data can prompt new questions that challenge the conventional Western historical narrative, which often overlooks negative and destructive human and environmental strategies integral to colonial settlement processes.

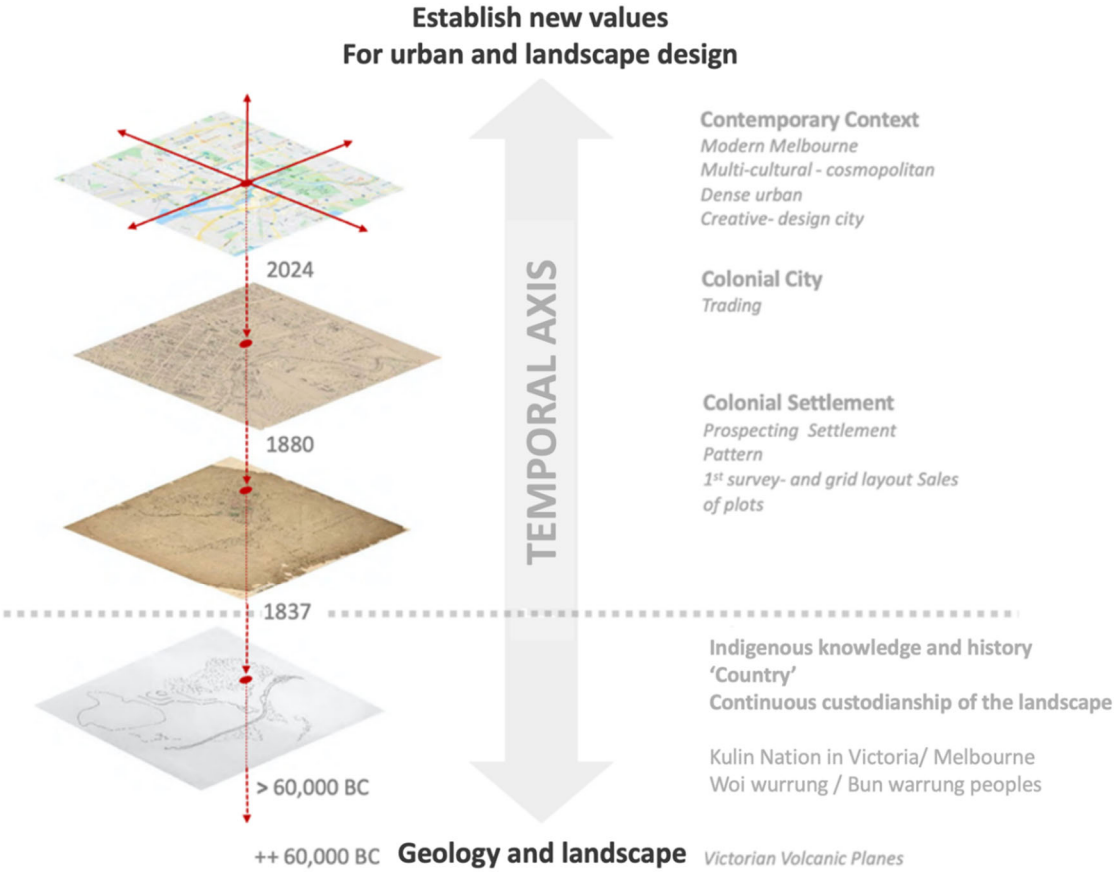

Figure 1. Temporal Axis from geological foundations of site to contemporary design values: Example of Melbourne, Australia. Source Authors.

The conceptual framework (Figure 1) establishes a temporal axis including the geological foundations that underpin the physical landscape through the various and multiple evolving morphological events to the present urban condition. The embodied connection of Country stretches across all these

temporal phases but remains unrepresented through such mapping. We suggest that the interpretation of the inherent dichotomies of pre and post-colonial dimensions of this temporal axis can establish new values for urban and landscape design.

According to Memmott et al. (2022) architects, urban designers, and landscape architects in Australia and other First Nations regions, are increasingly seeking specialised consultancy to integrate Indigenous cultural history and landscapes into their projects. This trend is driven by political movements emphasising Reconciliation Action Plans, decolonisation, Indigenous sovereignty, and intercultural ethics. However, these projects are concentrated in state capitals, where colonial forces were most destructive to Indigenous societies, resulting in fragmented and lost cultural knowledge.

In recognising that the historical geography of cities has been shaped by settler-colonial influences, Coyne et al. (2020) suggest that by examining urban infrastructures such as drainage, hydro-imperial knowledge must yield to culturally inclusive urban water designs.

Indeed, the restoration of rivers to former ecological and natural conditions, and the field of Water Sensitive Urban Design (WSUD) are becoming prevalent in the consideration of urban environments.

In this paper, we focus on a common phenomenon across three selected Australian cities of Geelong, Brisbane, and Sydney in which streams, creeks, or gullies that were important sources of water sustaining pre-colonial environments, have been confined within sub-terranean drains systems as urban development proceeded. To give substance the potential for design reparation, we feature a speculative student design project in Sydney, that provides clues to how lost landscape feature of Country can be re-imagined.

WESTERN GULLY: GEELONG, VICTORIA

The traditional name for Geelong is Djilang understood to mean ‘a tongue of land’. For the Wadawurrung people of the Kulin Nation the area of ‘coastal cliffs, wetlands, grassy and volcanic plains, and people were all formed by Bundjil and the Ancestor spirits who continue to live in the land, water and sky’ (Wadawurrung Traditional Owners Aboriginal Corporation, 2004). Bundjil, a Wedge Tailed Eagle, is the name of the great ancestral creator spirit.

Geology and topography

The physical aspects of Wadawurrung Country sits on the geological foundations of Pleistocene volcanics and Pliocene sediments known as Moorabool Viaduct Sands (MVS). Volcanic flows cross the central and southern parts of the reserve, creating an east-west ridge with views of Corio Bay to the north and the Barwon River to the south. The MVS forms soft sandstone cliffs along Corio Bay's southern and western shores, with a terrace sloping southward towards Geelong’s main ridge. The Barwon River, marking the southern boundary of the reserve, provided early settlers with fresh water but remained physically separate from Corio Bay. McKillop Street runs along the ridge, dividing the reserve into two halves. The southern half was drained by natural gullies formed through MVS erosion, as there were no tributaries or creeks (Brownhill, 1990; Marshall, 2020).

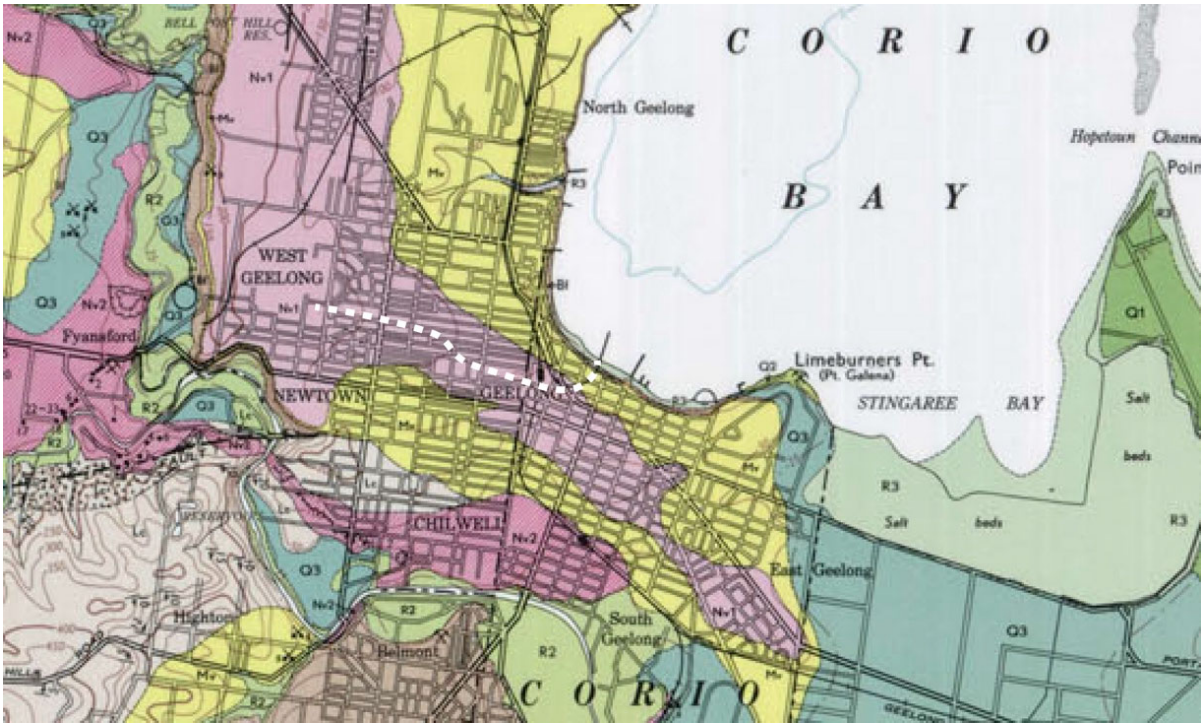

Figure 2. Geological Survey of Victoria, 1963. Geelong. 1 mile to 1 inch, geological map. Department of Mines, Victoria. . The course of The Western Gully is shown with a white dotted line. Accessed online August 19th at http://earthresources.efirst.com.au/product.asp?pID=370&cID=33.

The lateral ridgeline of Newer volcanics prevented the Barwon River from reaching Corio Bay, leading to several gullies that naturally drained the bayside districts mainly through the MVS. Among these, the Western Gully was particularly notable for its extended reach. Early maps trace the gully's path eastward to Corio Bay (Marshall, 2020). The Western Gully posed an obstruction to landward movement, and uncontrolled stormwater flow posed significant challenges for colonial settler mobility and travellers, especially on dark and stormy nights (Keavy, 1968).

Settlement maps and engineered drawings of waterway confinement

The Western Gully was first charted in its natural course on early settlement plans for Geelong. In Hoddle's map of 1850, it is shown flowing through a demarcated reserve of 59 acres for 'Ornamental Grounds Gardens', before discharging into Corio Bay through a smaller reserve allotment (see Figure 3). A reading of this alignment is that Hoddle anticipated the future preservation of the unhindered water course flowing through a landscaped reserve.



Figure 3. Hoddle, R. 1838, Plan of the Town of Geelong. Source: State Library of Victoria Maps Collection, M 821.411 A 1838.

However, in 1849 a first alternation occurred when a dam was built within the gully to manage water flow and prevent flooding, making it passable to the new colony. The dam, partly natural and partly artificial, served as a traffic route to and from La Trobe Terrace. It also aimed to provide water for horses and bullock teams, but the steep embankments and poor lighting made the location hazardous, leading to several drownings. By 1886, the dam contained little water but a large amount of mud due to seasonal fluctuations and drainage issues. As colonial Geelong developed, the business and traffic flow were significantly hindered by the gullies and elevated embankments, necessitating construction work. The most significant challenges and expenses were encountered during the filling of the Western Gully and the extension of the street to the bay front. In 1871, a determined effort led to a more level and cohesive streetscape, with soil from Victoria Terrace playing a crucial role (Brownhill, 1955; Rowe, 2021).

Figure 4. Johnstone Park Stormwater Sewer. 1912. Source: REF A33, Geelong Heritage Centre Collection, Public Records Office Victoria (PROV).

In 1912, a stormwater culvert was constructed between Johnstone Park and Corio Bay, incorporating a drain under Cunningham Street. During the 1930s depression, public funds were directed to civil engineering work to provide employment, leading to the construction of a brick-lined stormwater barrel drain along the Old Western Gully route.

The final major phase of confining the Western Gully occurred in 1964 with the construction of a light industrial zone between La Trobe Terrace and Pakington Street. The council executed eight schemes, with the most substantial involving Gordon Avenue above the old gully and its drain. Through various phases of construction, the Western Gully was permanently eliminated within a stormwater management system of brick culverts and underground sewers. These works aimed to improve sanitation and prevent flooding (Brownhill, 1955; Seaton, 1978; Rowe, 2021).

Creative reparation

In establishing new values for design reparation through urban and landscape design in Geelong, there are a few examples of interpretation and critical work related to paintings as historical documents, which provide crucial details and data for physical reparative measures. Creative strategies and performative events in Geelong offer glimpses of lost Country. One such event is Mountain to Mouth, conceptualized as a way to walk together in the footsteps of Aboriginal ancestors. The annual series of curated walks activated a way of remembering lost views in a changing environment (City of Greater Geelong, 2020). Johnstone Park has also been recognized as a site of cultural significance, highlighted by commemorative events like the NAIDOC (National Aboriginal and Islanders Day Observance Committee) Week trail and Reconciliation Day (Tournier et al. 2013).

In this context, ideas and recommendations to revive memories of lost waterways, such as the Western Gully in Geelong, can also be considered. There is potential for symbolic restorative urban landscape projects. By opening the buried culvert and re-landscaping Johnstone Park, remodelling the Geelong Waterfront, and revealing the exit of the culvert into Corio Bay, the presence of the Western Gully Creek could be revitalized (Sanders et al, 2024).

WHEAT CREEK: BRISBANE, QUEENSLAND.

The traditional name of Brisbane is Meanjin meaning the place of the blue water lilies (https://www.turrbal.com.au/our-story). The river "known as Maiwar, has been a meeting place, a highway and a source of food" (Murray, 2023) for the Turrbal and Jagera people, the original Aboriginal inhabitants of the area.

Geology and topography

The city area mainly consists of undulating to low hilly lands, generally below 80 meters in elevation, but rising to around 120 meters, with a few isolated higher hills like Mount Gravatt, which reaches 255 meters. This unit also includes very low-level plateaus, such as the Sunnybank area, which are small remnants of an ancient surface that sloped gently toward the coast. The low hilly areas typically have gentle to moderate slopes, while the middle to upper slopes of higher ridges, particularly in the western suburbs and on isolated prominent hills, are moderately to steeply sloped. This unit features a variety of rock types, including carbonaceous shales and lithic sandstones of the Tingalpa Formation, primarily exposed east of the city centre between Aspley and upper Tingalpa, extending to the coast in the Wynnum-Manly area. Additionally, a narrow, north-south band of rhyolitic tuff (ignimbrite) is found east of the city (Beckmann et al. 1987).

Figure 5. City of Brisbane Geological Map Sheet 3 [Extract]. The course of Wheat Creek is shown with a dark dotted line. Source:Geological Survey of Queensland Publication Number 323, 1965, Drawn by J.A.Wright, Department of Mines, Brisbane.

Settlement maps and engineered drawings of waterway confinement

When the Moreton Bay Penal Settlement moved to Brisbane from Redcliffe in 1824, it was established along the ridgeline beside the Brisbane River, chosen for its access to creeks, lagoons, and swamps (Brisbane City Council, 2008). Even during the period when the convict settlement was being dis-established, preparations for 'free-settlement' (albeit British colonial settlers) were already well underway. Starting in 1839, three surveyors had been sent to Moreton Bay to conduct trigonometrical surveys to determine topography as well as to report on the condition of soils, water and timber supply, with a view to recommending sites for towns, villages and other purposes (Johnson, 1988) (See Figure 5). As the settlement expanded, waterways cutting through what would become the Central Business District (CBD) were diverted and incorporated into new streets, named Creek, Tank, and Water Streets (Brisbane City Council, 2008).



Figure 6. Ham, T. & Co. 1863. Ham's Map of the City of Brisbane, Queensland, 1863. [Cartographical material]. 'Ham's map of the city of Brisbane, Queensland, compiled from official and private sources and lithographed by T. Ham & Co. Published by J. W. Buxton, Queen Street, Brisbane. Scale 4 chains to 1 inch.' Copied and digitised from an original map held by the John Oxley Library. Item is held by John Oxley Library, State Library of Queensland. Accessed online on September 8th 2024 at https://www.data.qld.gov.au/dataset/digitised-maps/resource/22bd64b9-1c7b-4a30-9dff-cc86227632a8/view/ec89b884-c017-464e-bef3-812c9eacdcdb.

Urban Morphologist Arnis Siksna identified that the settlement pattern of Brisbane was based on 200x90m 'medium rectangular blocks' with a street spacing mesh of 221x111m; internally divided with 20 equal back-to-back lots (Siksna, 1997, p.30). In Figure 5 the creek is existent but altered. Ham's 1863 Map of Brisbane (Figure 6) positioned reserves to accommodate the course of the main creek and the Roma Street Reservoir was constructed to manage the supply of water. Nonetheless, Ham's 1863 map (Figure 6) also shows the creek drawn as it meanders across the subdivision of blocks. It intersected and co-existed with the subdivisions, but this was a tenuous arrangement, as the construction of buildings between Queen and Adelaide Street would necessitate realignment of the creek.

Before 1866, Brisbane lacked a dependable and secure water supply. During the convict period, an earthen dam was constructed over Wheat Creek, in the area now occupied by Roma and Little Roma

Streets. Water was transported through a pipeline made up of connected hollow hardwood logs, which was powered by a convict-operated treadmill (Brisbane City Council, 2022).

In both Geelong and Brisbane, a dam was constructed across the stream to harness the supply of water, revealing this practice as integral to colonial strategies that altered the land and landscape. In the making of Geelong and Brisbane, open space was initially provided to accommodate the natural waterway, perhaps anticipating its future retention.

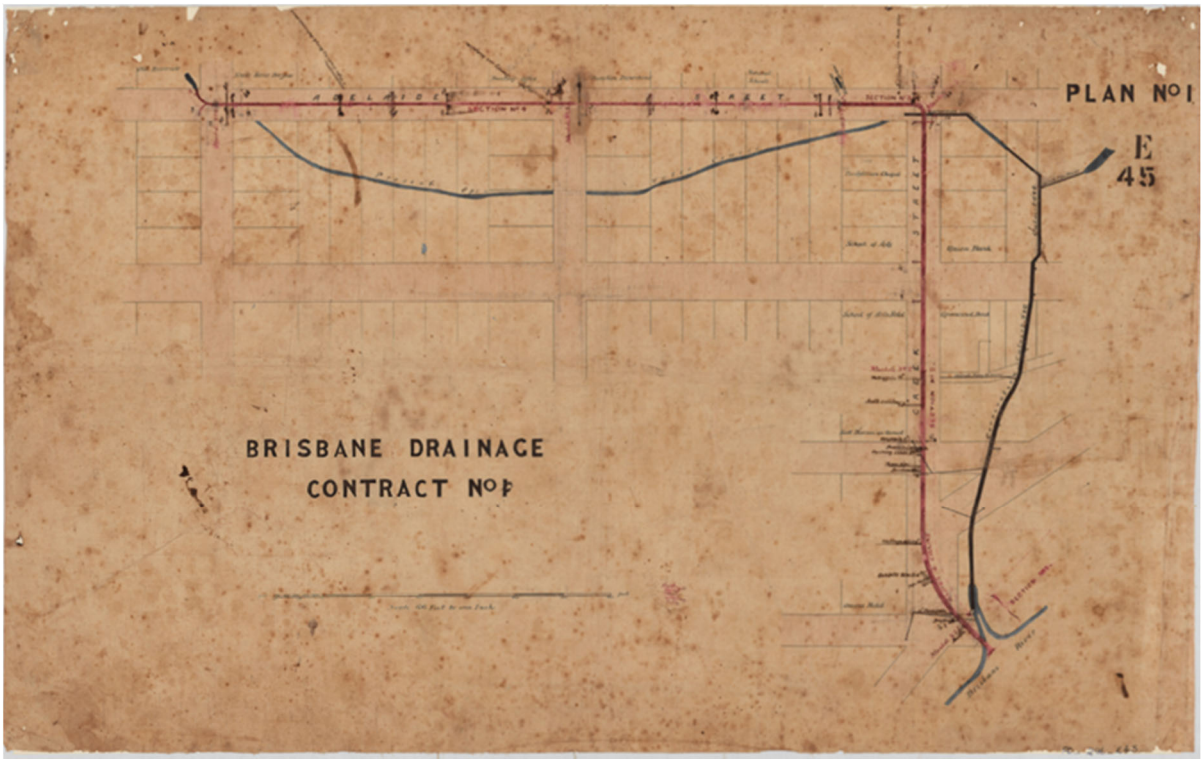

Figure 7. Brisbane Drainage Contract No 1. Source: Queensland State Archives, Item ID ITM3484685. Wheat Creek is redirected into a drain below Adelaide Street and Creek Street before discharging into the Brisbane River.

Brisbane's unpaved streets often became muddy in heavy rain. In 1860, the Municipal Council, incorporated a year earlier, built its first stormwater drain in Albert Street. However, inadequate stormwater drainage led to severe flooding in 1863. To address this, the Council constructed the Wheat Culvert at Adelaide and Albert Streets in 1863. Despite these efforts, most inner city drains were privately built to suit individual properties, and the Council's comprehensive drainage plans were delayed due to a lack of funds (Brisbane City Council, 2008).

In February 1875, a series of violent storms and floods brought the drainage issue to a crisis. Queen Street, the main shopping area, flooded three times, damaging basements and stock. Water from the swamp in Tank Street, which had become a cesspool, worsened the situation. Following pressure from building owners and Council representatives, the colonial government passed the Brisbane Drainage Act on 13 July 1875. William David Nisbet, the new Engineer of Harbours and Rivers, presented a drainage plan for Brisbane, proposing ten underground stormwater drains to manage natural water flows and discharge stormwater into the Brisbane River. The Brick Contract No. 1 Drain was completed in March 1877, serving as the main outfall for Brisbane's CBD. It collected flow from the 1863 Wheat

Creek Culvert, the "Corporation Culvert," and Robert Armour's private drain, running under Adelaide Street to Creek Street and then to the Brisbane River (Brisbane City Council, 2008).

Creative reparation

There are very few existing traces of the existing subterranean Wheat Creek apart from the physical stormwater drainage street grates. At a small park named Eagle Place, there is a plaque adjacent to an old fig tree that commemorates the water course from which Creek Street also takes its name. A fragment of the Wheat Creek culvert that was constructed in 1861 as part of the original drainage system was removed to make way for a bus tunnel and has been carefully reconstructed as a heritage display piece in the new underground King George Square Bus Station.

The opportunity for creative reparation of the lost creek has unfortunately been overlooked. For example, an obvious opportunity was for one of the numerous artworks commissioned for the public spaces at the new Brisbane Court precinct, situated on the former reservoir site, to have reflected the lost waterway. Nevertheless, some works do acknowledge Aboriginal history, particularly Fiona Foley's *Witnessing to Silence* (2005) in which the names of 94 massacre sites sandblasted into tiles are scattered around the area of the work (Cosic, 2005).

TANK STREAM: SYDNEY, NEW SOUTH WALES.

The original Aboriginal inhabitants of the City of Sydney local area are the Gadigal people of the Eora Nation, Eora meaning 'from this place' (City of Sydney 2017). The Boora Birra is one of the sacred Dreamings that details the creation of Sydney Harbour (NSW Government, 2024).

Geology and topography

Tank Stream was a source of water for the Gadigal people (Hinkson, 2001). Evidence that the stream was a location of importance was confirmed by archaeologist who discovered that the stream had been a burial site. Excavations in the late 1990s also uncovered 54 small stone artifacts, primarily waste material from tool-making, indicating that Aboriginal people once crafted stone tools near the stream (Irish and Goward 2024).



Figure 8. Sydney Geological Map. The course of Tank Stream is shown with a dark dotted line. Source: Commonwealth of Australia (Geoscience Australia) 2021, Sydney Geological Map - Australian Government Geoscience Australia Portal. Accessed online August 19th at https://portal.ga.gov.au/restore/3967feb2-d4e0-45f6-b994-c9601aea9663

The source of the stream was from swampy ground that was fed by water seeping from the underlying sandstone (Hinkson, 2001). The stream dropped about 30 metres through a series of waterfalls to Bridge Street, where it met the harbour. Draining about 82 hectares, it was supplemented by springs in what are now King and Spring Streets (Sydney Water 2010).

Settlement maps and engineered drawings of waterway confinement

Soon after the Sydney Cove settlement was established, the Tank Stream became polluted by waste and construction runoff. The stream's water supply was inconsistent, with nearby springs and wells quickly depleted during droughts. By 1796, a reservoir was built near the stream's mouth for water collection, reinforcing the same strategies of infrastructure that effected the most radical transformation of land and Country. The underlying sandstone was excavated to create three storage tanks, each tank held 20,000 litres of freshwater (Muecke, 2016), hence the stream derived its name. However, upstream contamination soon led to waste accumulation in the tanks (Casey and Lowe, 2016).

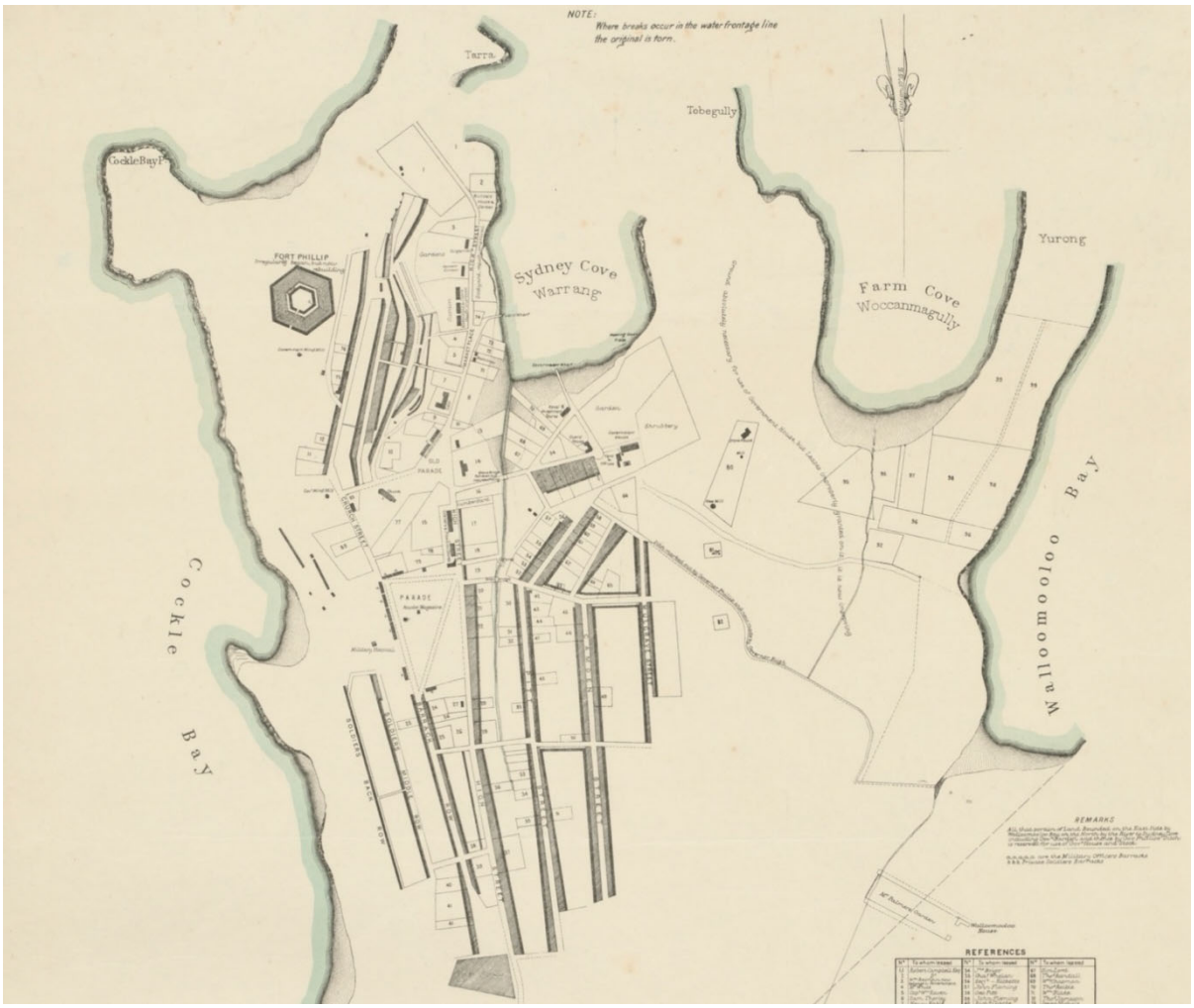

Figure 9. Meehan, J., and Bligh, W., 1754-1817. (1807). Plan of the town of Sydney in New South Wales [cartographic material] / by Jas. Meehan, assistant surveyor of Lands by order of His Excellency Governor Bligh, 31st October 1807. The Tank Stream flows through allotments between Pitt Street and High Street before discharging into Sydney Cove. Source: https://nla.gov.au/nla.obj-229911438.

Throughout the 19th century, efforts to regulate and improve the Tank Stream's condition failed. Prohibited activities near the stream included slaughterhouses, tanneries, and washing clothes (See Figure 9). By 1826, the stream was no longer used for drinking water, with the colony's administrative settlers relying on wells and rainwater instead. In 1833, the Tank Stream's condition and management were revisited, particularly regarding sewage disposal and silt accumulation in the harbour. By October 1856, the Tank Stream was enclosed, with significant drainage work completed by September 1857. Despite these efforts, problems persisted, especially after heavy rains (Casey and Lowe, 2016).

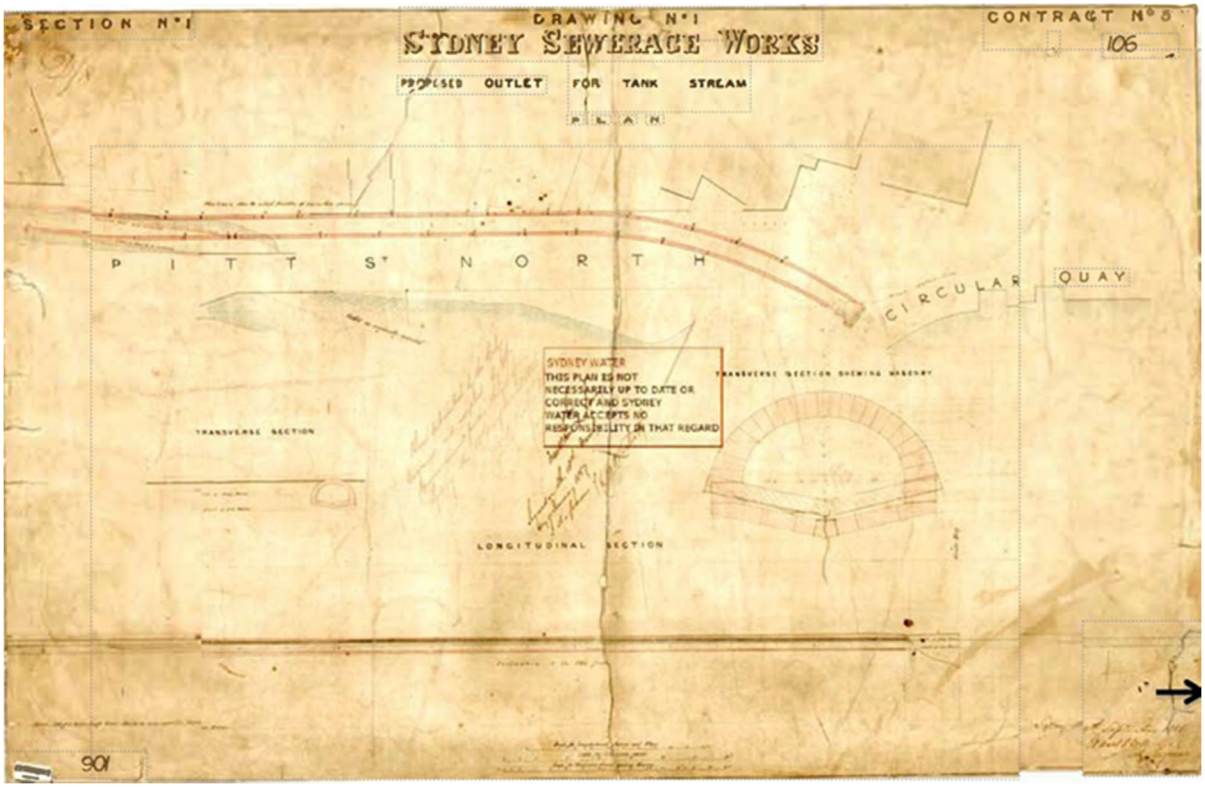

Figure 10. 'Drawing· No 1' of the Sydney Sewerage Works proposed new outlet for the Tank Stream. 1856. In Casey and Lowe (2016) Tank Stream Issues, City of Sydney Planning and Development Committee - 19 July 2016 - Item 6 - AttachmentB18 - Post Exhibition. Accessed online August 19th 2024 at https://meetings.cityofsydney.nsw.gov.au/Data/Planning%20and%20Development%20Committee/20160719140 3/Agenda/160719_PDC_ITEM06_ATTACHMENTB18.pdf.

In 1878, the Tank Stream Sewer was reconstructed, diverting its course under Pitt Street. Control over the sewerage system passed to the Water Supply and Sewerage Board in 1890. The Tank Stream continued to be used as a combined sewer, with measures to prevent sewage from entering the harbour. Over the past century, the Tank Stream has served as a stormwater channel, managed by Sydney Water. Changes in sewerage and drainage requirements, as well as construction activities, have affected its structure, with parts replaced or removed. Today, it remains an operational stormwater channel (Casey and Lowe, 2016).

Establish new values for creative reparation

Unlike the Western Gully and Wheat Creek, the Tank Stream in Sydney has received a lot of attention from historians that has resulted in its documentation through mapping and narration. Consequently, increased awareness has led to urban sculptures and artwork that memorialise its existence.

The Tank Stream Fountain, presented to Sydney by John Fairfax & Sons in 1981, commemorates the 150th anniversary of the Sydney Herald's first publication in 1831. Sculptor Stephen Walker aimed to associate water and bronze, linking the fountain to the Tank Stream, Sydney's first water supply. An inscription notes Walker's intention to connect the fountain with its historic location. Also known as the Children's Fountain, it is dedicated to "all the children who have played around the Tank Stream." An inscription on a plaque by the sculptor Stephen Walker revealed that The Tank Stream fountain recalls humanity's/people's past dependence on this flowing stream and our links with life around this region (City of Sydney, 2004a).

Tankstream – *Into the head of the cove*, installed between 1999 to 2019, is the title of five footpath installations created by Lynne Roberts Goodwin that were markers in the pavement to create a sense of the historic stream flowing beneath the surface of Sydney. Coloured glass modules were embedded in the pavement above the underground stream, angled away from stainless steel lines to mirror the flow of the Tank Stream in relation to Pitt Street. This installation draws a comparison between the city's natural and manufactured energy channels. At Alfred Street, the rods fan out, representing the stream's delta as it merges into Sydney Cove (City of Sydney, 2024b).

According to Coyne (2024) the Tank Stream is emblematic of settler colonial politics. Conventional stormwater designs stem from colonial strategies for waterscapes existing on the lands where Sydney was sited, imposed over First Nations water management systems. The Tank Stream holds potential for anti-colonial hydraulic urban co-design. Using colonial archives and field visits, Coyne is critical of the impact of settler-colonial urban design on contemporary views of watery spaces, concluding that hydro-imperial knowledge must give way to culturally inclusive urban water designs centred on First Nations perspectives.

To further the momentum to explore approaches for de-colonisation of urban infrastructure, we offer a detailed case study for design reparation by Deakin University Master of Architecture Student Juan Alsina. The speculative design project addressed restoring the memory of The Tank Stream, a lost ecosystem to urbanisation through reconnecting people with nature and place, creating environmental awareness, fostering a sense of belonging and a desire to protect. The design proposes a journey along the erased footprint of the Tank Stream that presents its natural and cultural landscape through time, featuring gathering spaces “reclaimed” by nature.

TANK STREAM DESIGN REPARATION - ECHOES A JOURNEY THROUGH TIME AND SENSES ***Student design project by Juan Alsina.***

The environmental debate inspired the concept of “Nature Taking Back Control” in our cities, shaping the project's main research question: How can we restore the memory of an ecosystem lost to urbanization by reconnecting people with nature and enhancing community engagement to foster a sense of belonging.

Analysis of the areas physical and non-physical characteristics suggested the location for a series of nodes highlighting the tension between the urban character and the Tank Stream’s footprint. The project’s design is a multi-layered response to historical, social, and environmental imperatives. Scrutiny of the Tank Stream Valley revealed key cultural, social, environmental, and heritage features. Strategically placed multifunctional nodes in historically significant areas evoke the stream’s history and ecological value while fostering community engagement. The project reintroduces elements of the original ecosystem. Each node enhances social and cultural functions, emphasizing shared spaces that foster community engagement. A sensory journey through five green nodes includes gathering spaces, educational areas, and exhibits featuring native plants and endangered species.

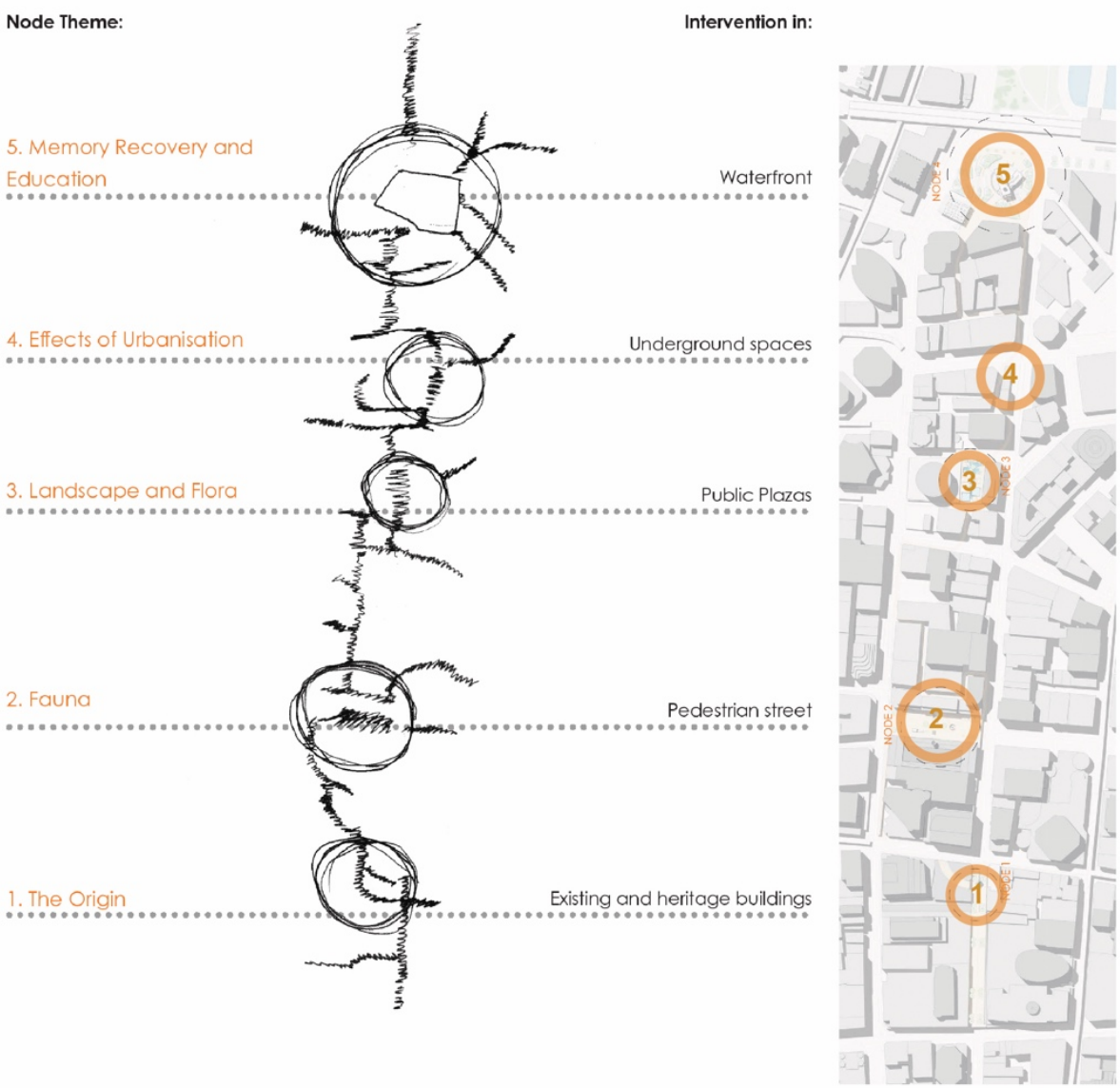

Figure 11. ECHOES A Journey Through Time and Senses. Source: Juan Alsina (2024).

The Journey - Serial Vision through five nodes.

Nodes 1-2 (Figure 12): The user enters the pavilion through a narrow, dark path, creating suspense and mystery. The internal garden is visible from outside through a layered façade but remains enclosed and inaccessible from within. There is no direct view of the outside, but the sounds of people passing by are still audible. The exit opens at the lower end, guiding the user's gaze to a stormwater grate with an organic pattern, referencing the Tank Stream below.

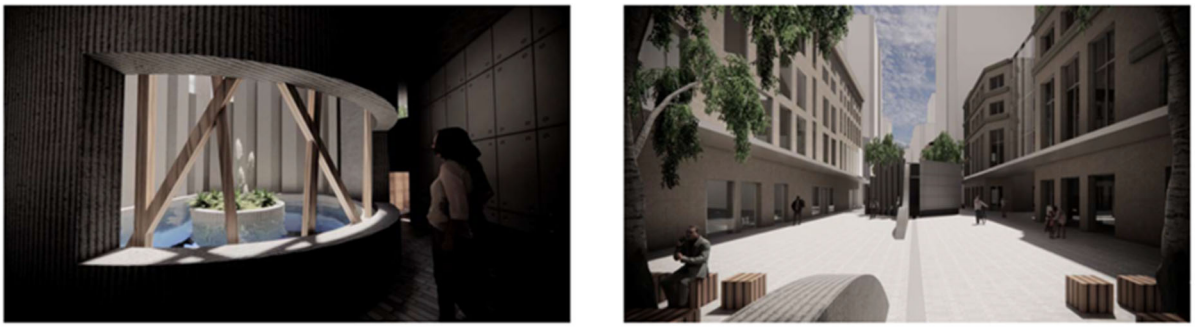

Figure 12. Juan Alsina (2024).

Nodes 2-3 (Figure 13): Approaching from the west end of Martin Place, the user encounters an elevated structure marking the entrance to an underground chamber, where the second node offers an experience of textures and shadows. In the first section, a linear water mirror reflects human shadows cast from above, with an informative wall at ground level. Moving to the second section, the user enters an underground gallery framed by two gardens that receive natural light through floor openings, covered by gathering spaces above. From here, the user can either explore the sewer system as part of the Tank Stream tour or exit via a circular staircase at the plaza's other end.



Figure 14. Juan Alsina (2024).

Nodes 4-5 (Figure 15): Walking down Pitt Street toward Circular Quay, the user encounters a dense green park with tall tree canopies. At its centre stands a lookout with two pavilion structures intertwined like trees. Positioned on a circular pond connected to the sea by a canal that floods at high tide, the lookout is accessed via a circular staircase around a central core, offering 360-degree views of native vegetation from the Tank Stream Valley. The pavilions serve as educational and exhibition spaces, sharing information about the Tank Stream's cultural and natural heritage.



Figure 15. Juan Alsina (2024).

DISCUSSION

In recent years the International Seminar on Urban Form has been striving to encourage a stronger relationship between research and practice (Samuels, 2013; Sanders, 2016) whereby the meticulous study of archival maps that describe past urban and environmental conditions provides documentary evidence upon which designers can interpret, explore and imagine alternative urban approaches and designs towards the re-inscription of and reference to lost waterways.

In this paper we have uncovered the documentation of the pre-colonial existence of three natural waterways that were firstly altered to control the water supply to the new settlements by either a dam or reservoir (Western Gully and Wheat Creek), or by creating tanks (Tank Stream). As each water system became overwhelmed due to the urbanising morphologies and pressures of the new colony, they were each confined into sub-surface drains to control water flows. The substitution of waterways for closed or open sewers indicates the severity of the transformation of the land in the construction of the colonial city. The research approach to focus on the waterways in colonial documentation – maps, surveys, charts – is a small step towards developing a reparative historiography. This method does not aim to alter the colonial documents but to read the documents against their intent, to identify in the documents the spatial, physical and morphological points of substitution of a land 'feature' – in this case waterways – for infrastructure that serves and supports the construction of colonial settlement. Exemplified in the analysis of maps and documentation of the three case studies are the stages of this process of substitution: firstly, the change of value of the waterway between its value from a resource and source of livelihood to an obstacle; secondly, due to increased quantity of colonial settler mobility, the disregard for the waterway as resource renders it an obstruction to the exercise of settlement – it is in the way of 'free settlement'; thirdly, direct investment by the colony to alleviate its 'obstructive' nature, and fourthly, to deploy the technologies of stormwater and sewerage and submit the waterway to an underground infrastructure. This series of exercises chart the process of colonisation as an appropriation of land 'features' /waterways from the custodian role of Indigenous peoples to the practices of colonial settlers.

In Sydney and Brisbane some visible commemorative markers (plaques/ sculptures) of the lost landscape features have been added, however no significant reparation through urban landscape design has occurred. Despite this apparent shortfall, establishing new values of landscape reparation and emerging design protocols for Indigenous led design for building on Country is gaining some urgency. We have shown through a strategic student design speculation project *Echoes: A journey through time and senses* by Juan Alsina how knowledge of site specificities can give visible and meaningful design reparation for lost landscape features, in this case The Tank Stream in Sydney.

However, connecting and designing with Country requires meaningful engagement with First Nations systems of being, knowing and practising. As the lessons embedded within our landscapes are being observed, the built environment is awakening and realizing the rich relationships, stories and ways of First Nations cultures (Gillmer, 2023).

The Australian Indigenous Design Charter guides the respectful and accurate representation of Aboriginal and Torres Strait Islander culture in design and media. It assists both Indigenous and non-

Indigenous designers and helps promote understanding among clients, including governments, businesses, and organizations (Indigenous Architecture and Design Victoria et al 2016). The ten principles of the Charter are as follows:

1. Indigenous led. Ensure Indigenous representation creation in design practice is Indigenous led.

2. Self-determined. Respect for the rights of Indigenous peoples to oversee representation creation of their culture in design practice.

3. Community specific. Ensure respect for the diversity of Aboriginal and Torres Strait Islander culture by following community specific cultural protocols.

4. Deep listening. Ensure respectful, culturally specific, personal engagement behaviors for effective communication and courteous interaction are practiced.

5. Impact of design. Always consider the reception and implications of all designs so that they are respectful to Indigenous culture.

6. Indigenous knowledge. Respectfully ask the client if there is an aspect to the project, in relation to any design brief, that may be improved with Indigenous knowledge.

7. Shared knowledge (collaboration, co-creation, procurement). Develop and implement respectful methods for all levels of engagement and sharing of Indigenous knowledge (collaboration, co-creation, procurement).

8. Legal and moral. Demonstrate respect and honour cultural ownership and intellectual property rights, including moral rights, and obtain appropriate permissions where required.

9. Reconciliation Action Plan (RAP). Develop a RAP incorporating the AIDC:CD.

10. Charter implementation. Ensure the implementation of the AIDC:CD to safeguard Indigenous design integrity.

Indigenous Architecture and Design Victoria et al. (2016)

New projects for the built environment in Australia need to adopt the guidelines of the Australian Indigenous Design Charter to align with protocols for authentic design outcomes.

CONCLUSION

Australia, like other post-settler societies, is grappling with the challenges and consequences of its history. The colonisation of Australia occurred as a military and settler strategy. While one significant strategy was to obtain knowledge of the ‘lie of the land’ and this was executed through mapping, its aim was towards identifying the best sites for colonial settlement. The aim was not to understand or appreciate the natural features of the land or its environmental context. As revealed by the Terra Nullius status – that the land was uninhabited - assigned to Australia, territorial colonisation proceeded alongside practices to eradicate its Aboriginal inhabitants.

Recent efforts towards reconciliation have included political apologies, but the design professions and education sector have been slow to embrace significant change. Nevertheless, advancements by First Nations designers, planners, and architects are leading efforts towards establishing principles and frameworks for the design of cities based on ecological balance and socio-environmental justice (Coyne, 2022).

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Micro territorial Reprogramming: The Metamorphosis of the Olido Gallery and Its Urban Implications

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ABSTRACT

The article analyzes the transformation of Galeria Olido, in downtown São Paulo, from an interstitial corridor into a cultural center. This change has redefined its role in the city, connecting different moments and offering an educational-cultural program. The text discusses the processes of des-territorialization proposed by Deleuze and Guattari, highlighting how places can be modified over time. It also explores the differences between reterritorialization promoted by the State through public policies and that initiated by the population or the market. Thus, it investigates whether the remodelled gallery suggests the creation of a new common public space or a renewal of the urban space's collectivization.

Keywords: Commercial Galleries, Relationship Between Public and Private Space, Public Administration, Reterritorialization and Resignification of Galleries

INTRODUCTION

For a few decades now, there has been talk of overcoming binaries, with profound reverberations and repercussions in the social, political, and urban spheres. On the one hand, we witness undesirable processes of privatization of public spaces, but on the other hand, some situations reveal horizons of hospitable thresholds in the city. In this context, our interest lies in transition territories, an unavoidable topic. However, for at least two centuries, the covered galleries of Paris, the famous "passages," precursors of Modernity for Walter Benjamin, had already introduced the question of a certain blurring between public and private in the metropolis. Thus, we are interested in studying the occurrence in the city of a rather unique territory: the inner block passage galleries, particularly the renewed Olido Gallery and its programmatic and social interactions within the fast-paced transit environment. We are talking about a gallery that has been transformed by the State into a center for cultural production and reception. This aesthetic change has significantly altered the role of this gallery in the urban center, especially considering its existence (and near erasure) in recent decades. We can say it has started to play a connecting role associated with other temporalities of permanence, linked to an intense educational and cultural program. This will raise the issue of processes of de- and

reterritorialization of a territory, a key pair of concepts proposed by Deleuze and Guattari in one of their major works, A Thousand Plateaus: Capitalism and Schizophrenia, or the idea that a place undergoes profound changes in its functioning logic and purposes, its meaning transmuted by the loss and addition of layers of re-signification over time. Such a process can occur spontaneously or be promoted and encouraged by public policies. The question then arises whether, in these places, especially the gallery that has been reterritorialized and gained new urban significance, it indicates a path toward constructing a new common or a renewed process of collectivizing public space through its interstices. Furthermore, we question the differences in the reterritorialization process when triggered by the State, associated with public policies, by actions initiated by the population, or by market interests. The Olido Gallery, located in the center of São Paulo, was chosen as the object of study, conducting a critical analysis of the spatial and programmatic transformation process of this historic interstitial urban corridor.

METHOD

The methodology employed is both empirical and theoretical. Based on theoretical concepts, we sought to interpret reality through an analysis grounded in these concepts, without restricting ourselves solely to theory. Theoretical concepts provide a fundamental framework for a critical reading of reality. However, we acknowledge the importance of confronting them with observed reality. Thus, we conducted surveys and on-site analyses to validate, challenge, and enrich the theoretical positions. This approach offers a complex understanding of the phenomena studied, avoiding overly subjective analysis. With the aim of fostering a discussion about these spaces, particularly the galleries that have been reterritorialized and acquired new urban significance, we ask ourselves: can these interstitial micro territories represent a horizon for the construction of a new commons, or a new process of collectivizing space?

DISCUSSIONS

The territorialization and deterritorialization of the passage galleries of São Paulo

The inner block galleries in São Paulo assume multiple roles, offering a variety of shops and services. Some serve as passages and connections, while others specialize in certain products, attracting customers who linger. However, there is no general rule, as the heavy foot traffic is not necessarily related to the types of products sold. Over time, these galleries have had to adapt their purposes according to new local realities, remaining spaces of diverse commerce, comparable to shopping malls, while also preserving their function as urban passages and connections. These galleries establish unique relationships between public and private, emphasizing the permeability between these two domains. The blurred boundary between these domains, provided by these territories, stimulates and emulates minority agencies that contrast with the binary logic of the city that contains them, becoming micro-territorialities that signal other alliances between public authorities, the market, and the local population—whether they live, work, or simply pass through. Territories with almost no sovereignty, fragile sovereignties in consonant dissonance, a condition of hospitality.

"Based on the idea of agency, the territory comes closer to another possible interpretation of its meaning: the place of conflict, of the struggle for the right to something that gives it existence, of the enunciation of that something which exceeds the codification and stratification imposed by sovereign

power. Territories territorialized by contents and rules linked to sovereign power, State, and Capital can be crossed by deterritorializing lines and forces." (Guatelli, 2022, p.56).

These interstitial architectures play a significant role in the transformation of public and private spaces, influencing the dynamics of street usage as public areas. The degree of access allowed, and the ease of this access are directly related to the level of privacy in these spaces, offering different experiences to visitors. To smooth the transition between public and private spaces, galleries often integrate elements at their entrances, creating a "grey zone" that makes the transition between spaces almost imperceptible. The presence of bars and restaurants in the galleries increases permeability and congestion, offering a sense of access and enjoyment to all. While some galleries are primarily characterized as passageways, offering a variety of shops and services, others stand out for the specialization of services, attracting a specific audience.

However, it is important to note that this pattern can vary between galleries, as the predominant use as a passageway is not necessarily related to the types of products available. Circulation and communication are directed by organizational strategies and serve them. Circulation and communication networks play an essential role in shaping the space-time throughout the territory. These networks are constantly evolving, adapting to the scale determined by the strategies, whether at a broad or local level. The transformation and establishment of this new territory inevitably alter what is considered common in that area. However, even in an ambiguous space between being public and being private, where subtle changes in the environment occur, when examined considering the notion of the commons, boundaries and limits become evident, as this is how the reterritorialization of space is established.

"The commons must have clearly defined limits, as it is important to identify the community to which it pertains; the rules must be well adapted to local needs and conditions and in alignment with its objectives; the individuals to whom these rules apply must regularly participate in the responsible bodies; [...] The commons does not gather market consumers or users of an administration external to production, but co-producers who together establish collective rules for themselves." (Dardot, 2017, p.160)

The processes of deterritorialization and reterritorialization of these places, along with their political and cultural dimensions, are closely intertwined. Deterritorialization can occur symbolically, involving the destruction of symbols, historical landmarks, and identities, or concretely, affecting political and economic aspects, such as the rupture of old ties and population boundaries. Furthermore, individuals, classes, and social groups always absorb, to varying degrees and scales, deterritorialized or deterritorializing perspectives. These processes reflect the complex interactions between power, culture, and identity in the construction and transformation of territories. When addressing these concepts, it is important to highlight the influence of philosophers Deleuze and Guattari, considered pioneers in this field. The galleries deterritorialize and reterritorialize the public-private relationship in urban space. The "gray" becomes a potent third deterritorialized-reterritorialized territory.

"We constructed a concept that I like very much, that of deterritorialization. [...] Sometimes we need to invent a barbaric word to capture a notion with a new ambition. The new notion is that there is no territory without a vector of exit from that territory, and there is no exit from the territory, that is,

deterritorialization, without, at the same time, an effort to reterritorialize elsewhere." (Deleuze, apud. Haesbaert, 2002, p.01)

The case of Galeria Olido

The place known as Galeria Olido originated during the golden age of São Paulo's galleries, in 1957, when it was inaugurated as Cine Olido, the first cinema located inside a gallery. The name "Olido" was created from the fusion of the names Domingos and Olivia, its founder and his wife, respectively. Located at Largo do Paissandu, near major passageways such as the Galeria Comercial (now known as Galeria do Rock), the area was known as São Paulo's Cinelândia, standing out as a privileged space for leisure and cultural gatherings. In the following decades, a significant shift occurred in this region due to the relocation of the city's center to the southeast and the rise of shopping malls. During the 1980s, major financial institutions moved to other parts of São Paulo, while shopping malls began to emerge, offering large parking lots to accommodate the growing use of automobiles by the population. This combination of factors led to the decline of the city center, resulting in the abandonment of movie theaters, which were once frequented by the elite. In response to this economic shift, the company responsible for Cine Olido divided the main auditorium, which previously held 800 spectators, into three smaller theaters. In 1980, the space was renovated to adapt to this new configuration. Cine Olido ceased operations in the late 1990s but was later restored and reopened by the city administration in 2004. (Pereira, 2008)



Ilustrada

Cine Olido volta com mais salas

O cine Olido retorna às origens neste sábado, com o luxo e a pompa que a circunstância exige. Afinal, trata-se de uma tríplice inauguração deste cinema, considerado, no final da década de 50, "o mais luxuoso de São Paulo", agora, dividido em três pequenas salas de projeção: Olido 1 (470 lugares), Olido 2 (300 lugares) e Olido 3 (300 lugares), equipadas com modernos equipamentos — projetores Philips e lâmpadas Xenon.

A clássica casa de espetáculos transformou-se, através de um arrojado projeto do arquiteto alemão Hermann Guettches, há 22 anos construindo cinemas no Brasil, num sofisticado e confortável centro cinematográfico com piso de mármore e paredes espelhadas.

A construção dos três cinemas — a palavra "reforma" seria inadequada, já que tudo é novo no Olido — custou à Empresa Sul Paulista, proprietária de outras 20 salas na cidade, mais de Cr$ 200 milhões, uma fortuna, se se considera o investimento feito pela Gasmont — Cr$ 800 milhões — na compra dos 22 cinemas da Companhia Serrador. Mas o gerente do Departamento de Publicidade da Sul Paulista, Caetano Abruzzini Neto, acha que o dinheiro foi bem aplicado: "O Olido vai concorrer, em luxo, com os cinemas dos Jardins e, como eles, será lançador de grandes produções."

Para ter uma idéia, o primeiro filme a entrar em cartaz no Olido 1 será a superprodução francesa "A Guerra do Fogo" (Quest for Fire), dirigida por Jean-Jacques Arnaud, com duas horas e quarenta minutos de projeção, sobre o período paleolítico, e que custou mais de 15 milhões de dólares. Uma obra para marcar época, exatamente como o filme de estréia, em 1957, do antigo Olido, "Tarde Demais para Esquecer" (An Affair to Remember), do cineasta irlandês Leo McCarey, onde Cary Grant morria de amores por Deborah Kerr, esperando sua amada no topo do Empire States.

Tudo indica que a modernização do Olido, de acordo com o modelo europeu de dividir grandes cinemas em pequenas salas, venha a ser um exemplo seguido pelas outras empresas do mercado em relação às salas centrais. Com a dilatação dos horários — as três salas começam a funcionar às 11 horas e, aos sábados e vésperas de feriados, com sessão extra, às 24 horas — e o agrupamento de salas no mesmo local, as opções dos espectadores crescem e as intermináveis filas tendem a acabar. Uma característica de quase cinquenta cinemas dos Jardins, hoje.

Há, entretanto, alguns detalhes que tornam o Olido diferente dessas salas gêmeas fora do centro. O luxo começa nos luminosos, de neon, e se estende para o interior dos três novos cinemas, todos construídos no mesmo nível do piso do antigo: cores harmoniosas (carpete cinzento e poltronas vermelhas, no Olido 1), escadas de acesso em laído, paredes em Murolflex e telas flutuantes. Os três seguem um projeto arquitetônico bastante semelhante, com pequenas alterações nas cores das paredes e no carpete. Outro detalhe fundamental: o sistema de ar condicionado Lowa, considerado excelente para amplos espaços, é garantido contra eventuais falhas e, desde já, o gerente da empresa adianta que funcionará ininterruptamente.

Única falha do Olido: as três salas não estão equipadas como nos "dolby", a exemplo de dois outros cinemas da Sul Paulista (Paulistano e Iguatemi), porque o sistema exige cópia original do filme e, em alguns casos, isso se torna impossível. Porém o representante da empresa adianta que a instalação do "dolby" está nos planos futuros da Sul Paulista.

Assim, as novas produções prometidas para o Olido — "E.T.", o grande sucesso de Steven Spielberg, entre outras — serão exibidas com cópias processadas em laboratórios nacionais, conforme exigência legal. Para os próximos meses já estão programados outros filmes de igual nível, destacando-se a produção italiana, dirigida por Fulvio Grilli, "Possa Que Ela Seja uma F...", baseada na peça homônima de John Ford, sobre um caso de incesto, com a atriz Charlotte Rampling.

As três salas do cine Olido serão pré-inauguradas com sessão especial para convidados, às 20 horas de hoje. São os seguintes os filmes de estréia: "A Guerra do Fogo" (Olido 1); "Aconteceu no Mar Egeu" (Olido 2); e "Loucamente Apaixonados" (Olido 3).

Uma das salas do novo Olido, a ser pré-inaugurado hoje, para convidados.

Figure 1: News from Folha de São Paulo in 1982. São Paulo, photo credit: da Silva and *Vieira, 2008.*

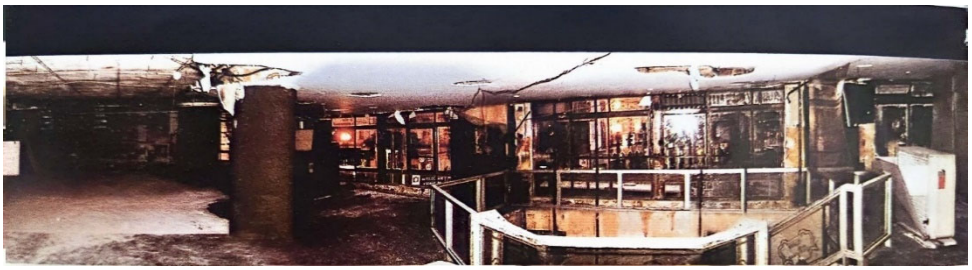

Figure 2: News from Folha de São Paulo in 1982. São Paulo, photo credit: Soares, 2004.

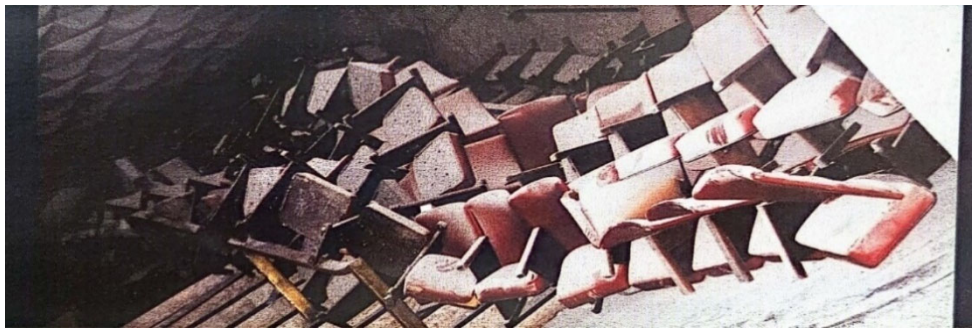

Figure 3: News from Folha de São Paulo in 1982. São Paulo, photo credit: Soares, 2004.

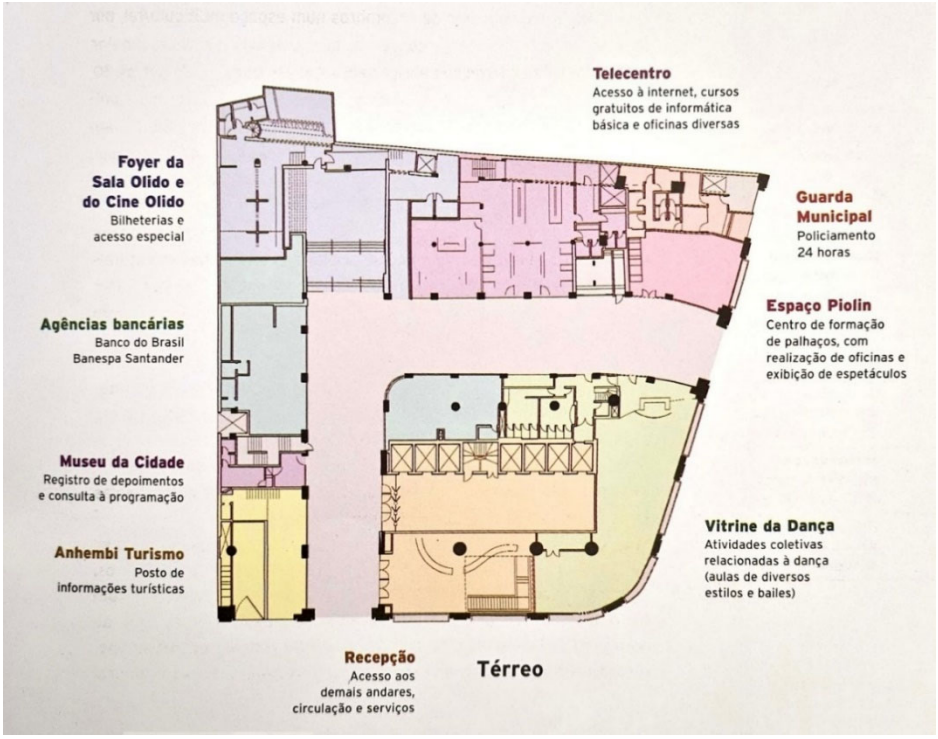

Figure 4: News from Folha de São Paulo in 1982. São Paulo, photo credit: Soares, 2004.



Figure 5: News from Folha de São Paulo in 1982. São Paulo, photo credit: Soares, 2004.

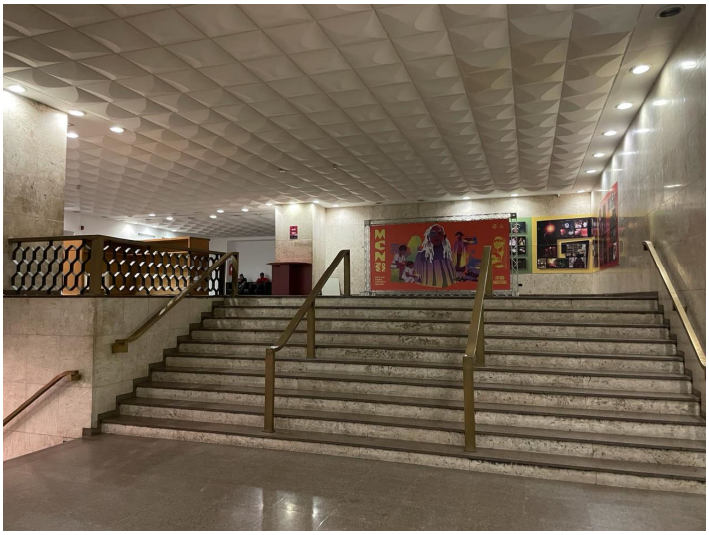

Figure 6: Entrance to the theaters of the former Cine Olido, photo credit: Guatelli, 2023.

Public policies were implemented to revitalize the downtown area and improve the conditions of the space. One such project, launched by the city administration in 2004, was the reopening of the site, now called Galeria Olido, with the goal of restoring its role as a meeting point in the region. An important aspect of this project was that it aimed not only to reopen the cinema and gallery, but also to create a new hub for culture and leisure in conjunction with public engagement. The location introduced a café, a telecentre, and three rooms dedicated to cinema, music, and dance, the latter of which allowed performances to be viewed from the sidewalk as an invitation for social interaction and participation. This was referred to as the "Dance Showcase." (Soares, 2004).

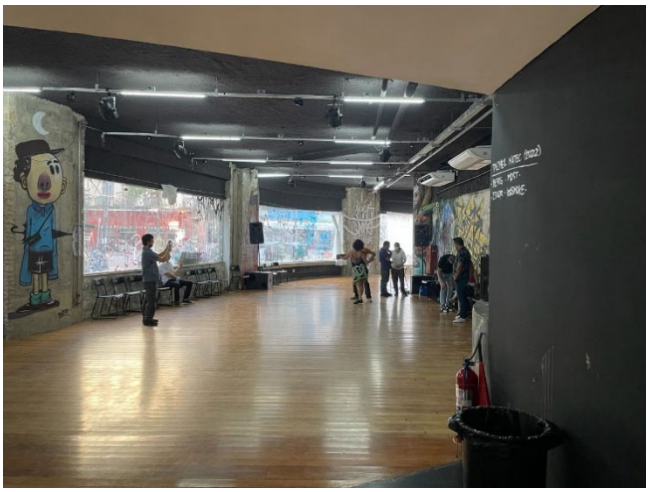

Figure 7: Interior of the Dance Showcase, photo credit: Guatelli, 2023.



Figure 8: Performance on the marquee nicknamed the "Balcony of Laughter", photo credit: Soares, 2004.

Through an agreement with the private sector located on the ground floor, the State implemented public policies aimed at transforming the dynamics and culture of the space's use, occupying the previously vacant building with the installation of three municipal departments to increase occupancy. This approach invites criticism, as an analysis of the resource management by São Paulo's city hall reveals a tendency to create spaces and dynamics through these public policies without investing in the long-term maintenance of these spaces or considering their long-term use to legitimize and expand them as common spaces. An example of this occurred in 2018, when the headquarters of the Department of Culture was moved to a new location in the city center, following the same strategy used at Galeria Olido, without considering the possible consequences for the space after the departure of the public cultural administration from Olido (Prefeitura da Cidade de São Paulo, 2018). This undermines the previous investment and hampers the process of legitimizing the space over time. This situation illustrates the theory of the commons, which emphasizes the importance of collective participation in creating rules for themselves, rather than external administration, since a vertically managed space does not foster plural cultures of appropriation—essential elements for the reterritorialization of the space.

Today, the Olido Cultural Center plays the role of co-producer, managed by individuals closely connected to the project, focusing on stimulating new activities and projects that generate everyday life, constantly expanding the gallery's horizons as a cultural center aligned with social interests.





Figure 9: Posters encouraging the public to submit ideas, photo credit: Autoral, 2024.

Figure 10: Announcement of public meetings to receive suggestions and present the activity schedule, photo credit: Instagram-ccolido, 2024.

In 2019, a new project was implemented to attract an activity already present in the central region, but with a keen approach from the administration, attentive to local dynamics. A space was created within Galeria Olido dedicated to exhibitions, workshops, and permanent activities related to electronic music, which is central to much of contemporary musical production. This space includes electroacoustic experiments, performances exploring the intersection between technology and music, as well as gatherings between DJs and urban dances such as House, Passinho, and Vogue. There is also an intention to transform Galeria Olido into a center of convergence for new media, where the public can access the latest developments in the world of VJs and audiovisual installations. The goal of this center is to give proper recognition to an entire culture that has developed around DJs and electronic music, without making gender distinctions, valuing its importance. After the implementation of this project, the gallery became known as the "DJ Gallery." (Assef, 2019).



Figure 11: Electronic Music Week Event, photo credit: Instagram-ccolido, 2024.

Thus, from a theoretical perspective, the territory is perceived as a delimited and controlled space where the exercise of power is manifested, often related to the political power of the State. Haesbaert (2002) explores the cultural or symbolic-cultural perspective, which emphasizes the symbolic and subjective dimension of the territory, where it is understood as the result of the appropriation and symbolic valuation by a group in relation to its lived space. This creation arises from the daily activities of social appropriation, contributing to the formation of unexpected and unique social interactions in the space. The territory of Galeria Olido is understood as a set of programmatic and social agencies. These agencies are not limited to geographical space, making the authors' concept of territory very broad.

The pandemic triggered a period of intense effort to preserve the culture of use rooted in the space, as the absence of gathering places hindered the desired interactions, demanding extra effort from people to keep alive the hospitable, welcoming, and popular spirit of the location. During this challenging time, the proposed agencies were put to the test, transforming Galeria Olido into a fundamental space for the expression of cultural multiplicity—a true magnet for various groups, especially racial and regional, who used the space to promote their cultural traits. Maintaining this territory beyond the physical space became a significant challenge.

"It is not exactly the space that forms an identity, but the political and cultural strength of the social groups that reproduce within it and their ability to produce a certain scale of identity, territorially mediated." (Haesbaert, 2002, p.01)

After going through a period of closure due to the pandemic and facing the challenges of economic crises, the gallery experienced a reopening marked by significant changes. The Municipal Department of Culture announced the beginning of a new phase for the Olido Cultural Center in 2022 with the inauguration of the Multimedia Showcase, becoming the first public cultural center with an emphasis on digital culture in the city. This space was dedicated to various forms of artistic expression, such as multimedia artistic interventions, video art, interactivity, virtual reality, research, and digital inclusion, valuing diversity and all artistic languages. (Durval, 2022) The intention was to establish the Olido Cultural Center as a public space for the creation and experimentation of innovative projects that not only promote local culture but also explore new possibilities offered by digital culture. In this context, the OLIDO HUB emerged, proposed by the current manager of the space, Luciana Ramin, inspired by the concepts of innovation hubs, aiming to promote and form networks between digital culture and

local cultural practices. This was a multidisciplinary space that addressed the intersection between the arts and new media, encouraging a hybrid and interdisciplinary approach as a catalyst for innovative practices. (São Paulo, 2022)



Figure 12: Entrance to the space dedicated to circus memory, photo credit: Autoral, 2023.



Figure 13: Entrance to the space dedicated to circus memory, photo credit: Autoral, 2023.



Figure 14: The space dedicated to circus memory, photo credit: Autoral, 2023.



Figure 15: Passage of Galeria Olido, photo credit: Autoral, 2023.

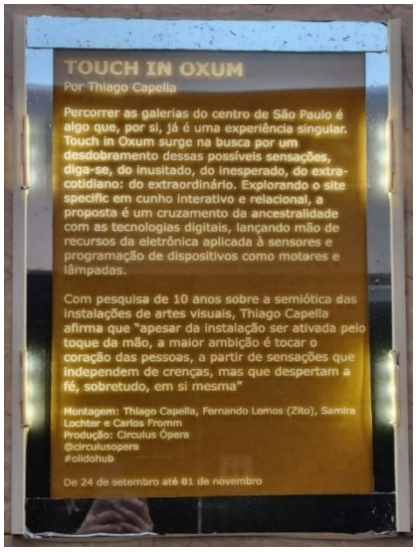

Figure 16: Newsletter introducing the Touch Oxum project, photo credit: Autoral, 2023.

Additionally, the gallery expanded its exhibition spaces to include circus culture, and a room equipped with multimedia resources, the result of a collaboration between the Circulus Ópera and Coletivo Substancial collectives, who worked together in a type of artistic residency. Furthermore, initiatives such as "Forró na Olido" brought together artists, collectives, and traditional forró enthusiasts, attracting a new audience and further reinforcing the cultural role of the space. These were examples of collaborative partnerships, where both sides mutually influenced each other, fostering a connection of thoughts and desires that drove the revitalization of the space, creating a sense of shared belonging. An urban rift of artistic and cultural convergence and radiations, by incorporating these elements of multiculturalism, Galeria Olido reaffirmed its commitment to being a social catalyst and condenser, seeking to expand its role in this regard. (Siqueira, 2023)

"The language of the commons is not only 'descriptive and performative,' but above all inclusive. It enables us to think, under the same framework, about forms of activities, mobilization, and relationships that at first glance seem to have little in common with one another." (Dardot, 2017, p.167)

CONCLUSIONS

The reterritorialization of urban galleries, as exemplified by Galeria Olido, demonstrates that these interstitial microterritories can indeed transform into significant collective spaces. The galleries studied are different in nature, but by identifying the transformations that have occurred within their spaces, it becomes clear that a new common is being created for these interstitial spaces, one that goes beyond the original commercial space, transforming into cultural spaces with the intention of expanding this culture beyond the walls of their passageways. These movements, which seek to form a new common within these spaces, are what connect these galleries.

Galeria Olido found its path through its cultural center, supported both by state legitimization and, most importantly, by the active participation of the people. The continuous interaction of visitors keeps the project dynamic and alive. This phenomenon is also evident in other galleries in downtown São Paulo, such as Galeria do Rock and, especially, Galeria do Reggae. These galleries represent a model for the longevity and vitality of urban spaces, where Black culture has spontaneously found places to gather and express its identity. (Dias, 2020)





Figure 17: Stalls sell fabrics, masks, shirts, and accessories, photo credit: Dias, 2020.

Figure 18: Muslim ceremony with African drums, where men dance and sing to Allah, incorporating elements of the continent's culture, photo credit: Dias, 2020.

Galeria do Reggae, despite its evolution away from its original focus on reggae music, remains an important site of reterritorialization for Black culture in São Paulo. Once home to numerous stores selling records, equipment, and CDs related to reggae, today only a handful of these shops survive. The gallery has transformed into a multicultural space, where immigrants from African countries such as Nigeria, Angola, and Congo have brought new vibrancy and cultural exchange to the location. Although some tension exists between different groups, the gallery remains a meeting point where African and Brazilian communities coexist. (Pacilio, 2023)

This process of reterritorialization in Galeria do Reggae reflects the broader trend seen in other downtown galleries, where spaces once defined by commercial activities have shifted towards becoming centers of cultural expression and social interaction (Pacilio, 2023). Throughout its history, Galeria do Reggae has served as a significant hub for the Black community, hosting gatherings that foster identity and belonging. Even as the physical space evolves, the gallery's cultural significance endures, providing a platform for the expression of African and Afro-Brazilian identities, despite the challenges posed by economic shifts and urban changes.

Much like Galeria Olido, which hosts events and gatherings that celebrate African cultures, Galeria do Reggae has adapted to serve the needs of its visitors. While it no longer serves primarily as a space only for black music, its reterritorialization as a center for cultural exchange—where Black culture continues to thrive—is a testament to its resilience and importance. The spontaneous occupation of this space by African immigrants and the subsequent creation of a new common within its walls have cemented the gallery’s role as a cultural landmark in the city.

The reterritorialization of Galeria do Reggae, as well as Galeria Olido, demonstrates how these urban spaces evolve beyond their original purposes, becoming vital cultural hubs that preserve and foster diverse identities. These galleries not only represent the dynamic processes of cultural adaptation and appropriation, but also highlight the importance of creating inclusive spaces where communities can form new commons and continue to thrive, both culturally and socially.

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Morphological regions and their interpretation

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ABSTRACT

The definition of morphological region, since its first appearance in Conzen's work on Alnwick, has always aroused controversy. The fact that the author presented maps of morphological regions in research on Ludlow, Newcastle and British historical centres and urban landscapes, without defining his methodological procedures, has resulted in numerous interpretations. Various contemporary researchers have investigated the concept and its correct delimitation, applying it to several cities around the world. However, such studies have only served to confirm the ill-defined nature of the term, with one questioning the methods associated with the concept. We researchers at the Landscape Laboratory, (LAP) EAUFMG, consider that Conzen demonstrates how to delimit morphological regions by using the four maps that make up his 1984 work on Ludlow. With the aim of contributing to more precise theoretical and practical definitions, our research has encompassed conceptual discussion and the application of methodological experimentation in contrasting historical-geographical contexts. In order to fulfil the study's core objective, namely the application of the concept in urban planning, Conzen's work on Alnwick (1960) and Ludlow (1975, 1984), together with more recent work are examined. As such, this article concludes that redressing the conceptual imprecision and definition associated with the term could greatly enhance contemporary research, given that the expansion of cities is generating ever larger dimensions of built spaces, in relation to plots and blocks. It is believed that these developments will require new forms of morphological analysis, that may assist in understanding contemporary phenomena across the urban landscape.

Keywords:

INTRODUCTION

Conzen, when disseminating his ideas regarding morphological regions in his work on Alnwick (1960) and in the subsequent articles on Newcastle (1962) and Ludlow (1975, 1988), used his geographical training, acquired in Germany, to theoretically substantiate his application of regionalization in urban morphology. The origin of these studies, according to Whitehand (1981, 2009) were a result of discussions amongst German geographers on the theory of regionalization, from which Conzen

elaborates a retrospective on the concepts and their application. He also notes that the first research, mainly in German-speaking Europe, tended to be based on historical-geographical investigations, carried out in the first half of the 20th century and concludes that throughout the history of the field, the German focus was often referred to as urban landscape or Stadtlandschaft (Passarge, 1930). However, it is contended that these investigations were based more on broader regional sub-divisions carried out by Granö (1929), than on the internal divisions of cities.

Reference to the development of the hierarchy of morphological sub-divisions and the degree of coincidence in the limits between the tri-partite complex of the urban landscape stand out. Thus, Whitehand states that Conzen innovates by studying these regional aspects in internal urban areas. When analysing the similarities between the studies carried out by the German geographer in 1929 and those developed by Conzen in 1960, Whitehand identifies contrasting results, as these early studies culminated in the formulation of more or less uniform and reduced morphological regions, in some cases delineated by non-linear and wide boundaries. He concludes that whilst identifying insignificant similarities, the proposal does not allow expressive hierarchical classification, adding that Conzen establishes the basis for the morphological region adopted by the English school when reflecting on, analysing and mapping several English cities.

The dissemination of the concept and its applications

In his book and articles, Conzen has aroused the interest of researchers in various parts of the world who have sought to use them as inspiration for their own work over the last 60 years. We highlight Whitehand JWR (1981); Slater, T. R. (1990); Baker, N. J. and Slater, T. R. (1992); Kropf K S,(1996) Larkham PJ, Whitehand JWR (1996); Gibson, (2000), Morton N (2002); Barke, M. (2003); Larkham, P. J. and Mmion, N. (2011); Slater, T. R (2018); K. Gu (2019), Pereira Costa et al (2019); Oliveira and Mm: affer Ali Yaygin (2020); Muzaffer Ali Arat,(2022).

The first article that references and discusses morphological region was published by Whitehand in 1981 and entitled The Urban Landscape: historical development and management Papers by M R G Conzen. Chapter 3 contains several explanations about the method used by Conzen in the definition of planning units and morphological regions. Regarding the former, Whitehand explains that these are products of morphological processes and are useful for understanding the urban plan, whilst also contending that methodology should depend on detailed examination of the formation and development of the settlement, subdivision of blocks and plots and analysis of land use and occupation.

Chapter 3 also presents a set of maps created by Conzen in Ludlow and perhaps provides the most enlightening elucidation on the definition of morphological region by explaining that the process may be carried out through overlapping and crossing the three delimitations: the typical area of the urban plan and the typical historical and land use areas. These 3 overlapping maps generate the morphological region. The hierarchy of orders, however, is not mentioned.

In Slater's 1990 The Built Form of Western Cities Essays for M R G Conzen on the occasion of his 80th birthday, two articles contained in section VI, Townscape Conservation, present the morphological regions and discuss their practical purpose in both the field of cultural preservation and urban planning. The first of these (taking as a reference the order of publication in the book) is by Peter J Larkham entitled: Conzen, conservation and management of historical townscapes. He notes that

Conzen's ideas on urban preservation form an important part of his broad approach to urban landscape preservation based on the concept of historicity. Larkham attests as to the tri-partite factors that constitute the historicity of an urban landscape, namely the town plan, urban fabric and use and occupation of the land. The quality of historic urban landscapes and their historicity largely depend on the survival of town plans and the stock of traditional buildings, according to Conzen (1984) - land use being viewed as a minor and indirect aspect of historicity.

In the chapter entitled Townscape management: ideal and reality, Whitehand emphasises the importance of applying the concept in order to preserve an area's historicity, through the definition of morphological regions based on a combination of the above listed components. These constitute a direct reflection of the historicity of the city, whose elusive quality is not distributed uniformly throughout the city, hence the hierarchy of regions. The author questions if the three elements of the tripartite vision: the city plan, the urban fabric and the use and occupation of land are the components of the historicity of the urban landscape and surmises as to what method could be employed when carrying out a systematic examination of these elements.

Whitehand refers to Conzen's article in which he lists possible analyses for defining the same regions and their hierarchy, which are firstly the time interval, and the morphological periods produced by the urban landscape. The spatial distribution of the historical form in each component, including consideration of concentration and mix, used to exemplify the degree of mutual compatibility between the three temporal components, and their adaption, are also observed. Historicity may be affected by obsolescence, building decay, inappropriate "restoration" and local circumstances, such as the use of adjacent areas and landscape settings and the presence of archaeological deposits. (Conzen, 1975, 82-3). Whitehand explains that, despite the importance of this concept of morphological region there is no clear published explanation of how these regions are constructed and no attempt has been made to replicate this detailed study elsewhere to date. This early work summarizes the recurring themes related to morphological regions, the difficulty in defining them, the lack of a common terminology and their applications for public policies both in zoning and the listing of conservation areas necessary for determining land use and occupation laws.

Baker and Slater (1992) addressed the problem of definition when stating that the term morphogenetic regions, originating from Conzen's 1962 study of Newcastle Upon Tyne which, while containing extremely detailed maps, failed to present a methodology for identifying a morphological region. In the article entitled The structure of urban landscapes: strengthening research and practice (2009) Whitehand incorporates into this new text the observations he had already presented in chapter 03 of the book he edited in 1981. Based on the definitions previously presented, he states that the text aims mainly to correct deficiencies and reflect on studies published by other authors noting that the main concern is with Conzen's method of regionalization and its development over the last 20 years. According to Whitehand, this reflection focuses on how structure and space are projected by the landscape, combined with the role that spatial variations play in delimiting areas in order to define the limits of morphological regions. He defines the urban landscape as the product of the combination of geographic units that are articulated in their historical-geographical character and in the temporal process of their formation. He refers to the use of the term urban landscape units and the process to identify them as morphological regionalization. Character and delimitation of such units or regions are considered not only central to urban geographic morphology, but also important in

their application in planning. It is clear that for Whitehand, the importance of the concept lies in its application to urban planning, being that he emphasises that care should be taken in the correct preparation of maps and figures when used in the field.

METHODOLOGY

This text analyses the application of the concept in urban planning and, in order to fulfil the proposed objective, draws on studies undertaken by Conzen in Alnwick (1960) and Ludlow (1975, 1984) as well as other more recent work. A case in point is Barrett's 1992 study on Birmingham city centre which details units of constructed forms and land use that were tabulated, assembled and combined to produce the three maps of the morphological regions (or Townscape) - the method employed by Conzen in Ludlow providing the author's inspiration. However, since Barret fails to explain the process, the reader is prevented from having a full understanding and will perhaps incur problems when delimiting morphological regions.

Whitehand, for his part, further extends the analysis of urban to suburban areas and presents a study carried out by Jones (1987) on urban morphological regions in various Birmingham and London suburbs. It was noted that the three complexes of urban morphological analysis were repeated in suburban areas, the study of which was commissioned to be presented at a public hearing called to draw up a local plan. Items related to this included the presence of suburban roads, adapted rural lanes and the subdivision of plots of private residences and detached houses of greater density. In this suburban regionalization vegetation was taken into consideration in addition to the three components of urban form identified by Conzen in his work on urban centres.

Jeremy and Susan Whitehand's 2005 theoretical comparative study, carried out on two areas whose boundaries were characterized by the same level of resolution, was also cited by the author himself in the 2009 publication. The two essentially suburban areas are both largely products of the 20th century - a part of Lantzville, Vancouver Island, Canada, and Upplands Väsby, north of Stockholm, Sweden. Although the article provides information on the densification process of the two areas, the author himself acknowledges that these are initial studies requiring further research.

Another work cited in the article is the thesis developed by Bienstman (2007) in the Dutch city of Alkmaar and Bromsgrove in Birmingham. Here the author acknowledges the difficulty municipal managers have when defining policies designed for the preservation of historical centres due to their limited conceptual knowledge – the result being inadequate management and preservation of the local character. The innovation of this study lies in the proposal of orders to be used when defining degrees of preservation and also the inclusion of fringe belts and residential areas which are considered to be the main units of the urban plan (the morphological regions).

Other contributions are listed and refer to studies carried out in Asia, principally the study of the Chinese city of Pingyao, where it was possible to measure the triad of elements (streets, plots and block plans) linked to the main development characteristics of the urban plan (Whitehand and Gu, 2007a). A further study carried out by the same authors in a small area near the Forbidden City in Beijing confirmed the capacity for complete morphological regionalization (Whitehand and Gu, 2007b) and its effectiveness in articulating the current urban landscape as a product of centuries of development. In the last section, Whitehand reflects on the applicability of different aspects of

conservation and urban planning, highlighting studies for zoning and citing examples of applications in urban planning and preservation. These include zoning plans and regulations within the Plans d'Occupation des Sols (Land Use Plans) in France (Kropf, 1996b), in the Planes Especiales (Special Plans) in Spain (Barke, 2003) and in the delimitation of 'design areas' in the United Kingdom (Hall, 1997). Muzaffer Ali Arat returned to the topic in his thesis entitled Strengthening the Conzenian Method of Morphological Regionalization (2022) and included other work on morphological regions carried out after Whitehand's article in 2009. In his research, he considers all work on the topic including those previously defined by Whitehand for which he prepared a table listing the author's name, the city where the study was carried out and the time. In addition, the table contains aspects such as the term used to define the region in which the formal complex may be analysed and the number of hierarchies considered, together with the morphological elements that constitute the regions and how these contribute to the definition of hierarchy. The table objectively assists scholars who dedicate themselves to the analysis of the studies elaborated and benefits from the simplification and quality of the themes explored. Regarding morphological regions and their definitions, the thesis, by listing these subsequent works, reinforces the impression that the topic is still characterized by the inconsistencies previously listed by Whitehand (2009), Kai Gu (2019) and Pereira Costa et al (2020)

Pereira Costa et al, drawing on these authors, clarified that when referring to morphogenetic regions, planned units and geographic order, Conzen used examples rather than offering explanation, this in contrast to his approach to the tripartite concepts, burgage plots or fringe belts, in which a full conceptual explanation is provided. In the 1st case there is the possibility of incorrect individual interpretation, statements and conclusions which are deficiencies related to the fact that the concepts, until recently, have not yet been condensed into a single term. As Gu (2019) observes, they are complex and clarification has not contributed to the variety of morphological terminology. This author identifies the use of several terms, such as urban morphological regions that can also be defined as 'urban landscape regions', 'urban landscape', 'urban landscape units', 'morphological units' and 'character areas', concluding that the problem deserves greater systematization.

More recently, Muzaffer Ali Arat (2022) presented a review, identifying the concept's main weaknesses, including the poor relationship between each regionalization and the body of historical-geographical knowledge. He also points out the deficiency in terminology and the lack of definition of options and procedural steps (including the preparation of intermediate and final regional maps). An analysis of the work carried out by the researchers cited further confirms this observation and this aspect will be the next topic of our article.

THE RESULTS OF RESEARCH STUDIES AND THEIR CORRELATION WITH CONZEN

To prepare this analysis, the items listed in table 2.5 of Conzen's article on Ludlow (1984) were used. These outline the following parameters: researchers, date and place where the studies were applied, the terms used to define the area under study, which formal complexes were considered, how many hierarchies were raised in the morphological regions, identification of their morphological components and their contribution to the hierarchy. These items were also listed by Muzaffer Ali Arat (2022) in the table containing a chronology of all work carried out between 1960 and 2022.

Research from 1960 onwards includes Conzen's 1975 and 1984 work on Alnwick and Ludlow and Whitehand's analysis of Amersham after 1997, followed by studies carried out in partnership with Kai

Gu, on the cities of Pingyao and Beijing in 2007. In 2009 the article entitled The Structure of Urban Landscapes: Strengthening Research and Practice was published in which he presented several pieces of work by other scholars, including studies by Jones (1987) on urban morphological regions in the Birmingham and London suburbs, as well as those carried out by Barrett (1996) in Birmingham. In addition to these he cites work on the city of Sibiu, Romania, in 1999, the morphological regions of Barnt Green, near Birmingham, England, in 2005, two other sites in the north-western cities of Lantzville, Vancouver Island, Canada in 2005 and northeastern Upplands Väsby in Sweden in 2008. The article also lists research developed by Bienstman (2007) in the Dutch city of Alkmaar and Bromsgrove in England. Also noteworthy is his 2011 research in Guangzhou, China, carried out jointly with Birkhamshaw and finally the 2012 work on Stratford Upon-Avon. Barke (2003), for his part, applies the concept of morphological regions in the city of Antequera, Spain where two criteria are used to define homogeneous areas. In the first, the analysis focuses on morphological and in the second, on functional aspects related to land use and occupation. No regional hierarchy is observed or studied.

In 2011, Larkham & Morton, developed studies in Edgware and Docklands (London), using the term morphological regions and formal complexes. They consider as morphological constituents the various characteristics of the components of the urban plan, the layout, the division of roads, blocks and plots and land occupation, as well as the occupation rates. Further work includes Vitor Oliveira (2015) in Porto and Alsadaty (2022) in Cairo, whilst Muzaffer Ali Arat lists those developed by Zhang in Shanghai in 2003 and in 2015 in Guangzhou. The studies carried out by Kai Gu in Auckland in 2010 and Chen in the city of Zuoying (Taiwan) in 2018 are also cited. Finally, there is Arat's 2002 thesis entitled Strengthening the Conzenian Method of Morphological Regionalization, in which he explores the concept of morphological region in Antequera and Istanbul. Analysis demonstrates clearly that Whitehand was the most prolific researcher, being that he developed studies on morphological regions in several places around the world, including England, China, Canada, Sweden amongst others.

Although many of the scholars cited refer to Conzen's concepts, interpretation and application are arguably rather vague, and the use of terminology is diverse and therefore fails to provide a unified, standardised or agreed set of definitions. The presentation of solely maps, without an explanation of the results presented also serves to highlight that Conzen's concepts were only partially applied. In line with the many studies, the terms used to designate the object of study also vary and include plan units (twice), urban landscape (once), urban landscape units (twice) and characteristic areas (once).

Regarding the definition of morphological components, the following terms are also used: urban plan (03), urban plan and urban fabric (02) and the tripartite analysis based on Conzen's concepts: urban plan and fabric, land use and occupation (03). In this definition, the author justifies, in some cases, the use of the urban plan in homogeneous areas resulting from planned development that does not present significant morphological variation. The terms, therefore, expand as studies find more developed and defined formal complexes.

In relation to the orders that define the hierarchies, areas analysed only in urban plans naturally do not exist. Moreover, the morphological constituents are subdivided into the orthogonality of the urban plan, the layout of the plots and the types of building and block construction, adjusted according to their function. This characterization of formal complexes (urban plan) is repeated in the study by Zhang, in Shanghai (2003) and Guangzhou (2015). The procedure was also used by Larkham and

Morton (2011) in their studies on Edgware and Docklands in London and their justifications are similar to those provided by Whitehand et al.

With regards to the formal complexes that contain the urban plan and the urban fabric, Whitehand et al (dates) define the number of 03 hierarchies of morphological regions in the study of Upplands Wäsby, Sweden, which are repeated in the work carried out in Lantzville, Canada. To define the morphological constituents, variations in the urban plan were selected, particularly subdivision patterns and housing types in the city centre, residential areas and marginal belts, which contribute directly to the hierarchy as first and second orders. Differences in the implementation of blocks and facades, in relation to their cladding materials, constitute the third order of the hierarchy and are defined in the work on both cities.

For studies that use formal complexes based on Conzen's study in Ludlow, comprising the urban plan and fabric and land use and occupation, it is observed that they were also used by Whitehand and Gu, in Beijing (2007), Whitehand, et al, in Guangzhou, (2011) and in the work carried out by Birkhamshaw and Whitehand in Stratford Upon-Avon (2012), despite the difference in the terms used to define the type of analysis. In the Beijing study, 02 hierarchies of morphological regions are composed of the constituents established by the residential types, original housing complexes, semi-detached and housing transformations and their institutional support amenities. In Guangzhou, Whitehand, et all define a hierarchy of 3 regions, in which the morphological constituents fit only 02 regions in the urban plan containing the layout and the implantation of buildings on the plot over time. These 2 regions are classified as first order, while spatial variations in plot pattern (shape, size and notably plot depth) and their correlation with the building structure and land use may be classified as second order. Buildings, type evolution, land use and occupation contribute to the definition of the first and third order hierarchy.

In Stratford Upon-Avon (2012) two hierarchies of morphological regions were also considered. Their first order constitution is characterized by large residences composed of extensive gardens, suburbs intended for the upper middle class and housing transformation across urban expansion. The second order refers to the transformation of residential models.

Kai Gu's (2010) analysis of morphological regions in Auckland defined three hierarchies. The urban plan containing the subdivision of roads, blocks and plots as morphological constituents are listed and considered to be the first order in the hierarchy. The second-order hierarchy includes the types of buildings and their transformations from their origins to contemporary models, whist the third order includes the elements that are part of the land use and occupation.

For Oliveira (2015) the morphological regions in Porto have four hierarchies. To analyse them he used Conzen's concepts and listed the urban plan and its components as first-order morphological constituents. The buildings, their characteristics, plot occupation and uses contribute to the second and third orders, whilst the transformations of the buildings and their environmental perception are deemed to be fourth-order elements.

Chen's 2018 work in Zuoying (Taiwan), although not highlighting the terms and formal complexes associated with Conzen's concept of hierarchies of morphological regions, does mention the

morphological constitution of the areas and the subdivision of the land, construction typology, land use and occupation over time. The latter items are however not associated with the hierarchy.

Alsadaty (2021) in his work on Cairo uses Conzenian concepts for both the term and the formal complexes to classify two hierarchies of morphological region. He considers the projects implemented before 1920 as first-order hierarchy and the periods between 1920 and 1948 as second-order. The built forms between these periods and the use and occupation of the land are not considered.

Arat´s thesis (2022) argues for a more applicable and explicit method of morphological regionalization and proposes a new approach. His set of criteria which aim to clarify the application of the step-by-step method is, however, reminiscent of the table developed by Conzen in Ludlow. He further develops criteria designed to answer the questions contained in the table and lists the following ten items.

i. the age of the streets/expansion phase of the city, geometry of the streets, layout of the plot (area, width, depth), types of building block plans, building coverage and position of the buildings - based on the urban plan.

ii. architectural style, construction material and building height - based on the structure of the building;

iii. land use. This set of criteria establishes a fundamental basis for the foundation of a more systematic and robust methodology for the identification and delimitation of the morphological region.

Although the author defines it as a more systematic and robust methodology for the identification and delimitation of the morphological region, these seem to us to be merely developments of the aspects contained in Conzenian theory´s tripartite vision

The innovative approach that stands out is the development of the morphological constituents which he distributes according to the criteria listed in the table and the classification to describe them. Explanations for each of the criteria listed and their application to the cities of Antequera and Istanbul are also presented.

CONSIDERATIONS

For Whitehand (1981), despite the conceptual importance of morphological regions, the absence of a clear explanation of how these are constructed may be a cause of numerous misinterpretations. Kai Gu (2019) corroborates these observations by commenting that the terms are complex and clarification has not contributed to the variety of morphological terminology. He identifies the use of several terms, such as ‘urban morphological regions’ that can also be defined as 'urban landscape regions', 'urban landscape', 'urban landscape units', 'morphological units' and 'character areas', concluding that the problem deserves greater systematization (Pereira Costa et al, 2020). In fact, when listing all the work produced and their nomenclature, it is clear that Conzen himself used the term types of plan units in Alnwick, which only evolved into morphological regions in his study on Ludlow. The same procedure may be observed in Whitehand, who uses the term plan units twice. (This terminology was also adopted by Kai Gu and Zhang. The other terms used include urban landscape (once), urban landscape units (03) and characteristic areas (once). On the other hand, Chen, Oliveira,

Larkham, Morton and Alsadaty, adopt the Conzenian concept, in other words the morphological region, related to the following formal complexes: urban plan, urban fabric, land use and occupation.

A summary of the Hierarchy of morphological regions provides the following numbers: 02 orders are found in three studies; 03 orders in 02, 04 orders in 04 and 05 orders in Conzen's with most studies thus considering the regions to be composed of four orders.

However, the definition or classification of each order varies greatly and it is clear that the urban plan, containing the project for subdividing roads, blocks and plots, is considered to be of the first order in its contribution to the hierarchy.

The types of buildings and their transformations from their original to contemporary state can be considered second order.

Third order contribution to the hierarchy includes temporal variations in the land subdivision use and occupation and their impact on the original building format.

For Oliveira (2015), the fourth order resides more in the user's perception of the transformations he or she observes when walking along the street. However, for the other three researchers (including Conzen), the fourth order is characterized by small modifications in the plot dimensions and in the appropriation of the buildings for new uses.

CONCLUSION

In conclusion, it is possible to analyse the same regions and their hierarchy in terms of firstly, the length of time and morphological periods which in turn define the urban landscape (Whitehand). The tri- partite model includes a combination of historical components to exemplify the degree of mutual compatibility between different periods and their adaptation. Historicity can be affected by obsolescence, building decay, inadequate "restoration" and local circumstances, such as the use of adjacent areas and landscape and the presence of archaeological deposits. (Conzen, 1975, 82-3). In fact, when we analyse the process of identifying morphological regions, ranked by the character of the tri- partite model, their usefulness in the application of urban planning proposals can be observed, both in the creation of possible regulations for land use and occupation laws and the management of cultural heritage. In Borges Filho’s thesis Urbs Adamantina (2023) the identification of morphological regions and their characterization through the hierarchical organization of similarities can be used to define the listed polygons according to the degree of importance of the assets to be preserved. He justifies this approach by referring to the 2010 IPHAN standards, which allow for the inclusion of several non-continuous polygons which may contain specific standards in relation to character. According to the author, instead of having a single instrument to regulate all assets, there are therefore morphological regions. Such a strategy allows for greater acuity and better use of the tools necessary for defining character and specificities.

Likewise, the use of morphological regions is useful when defining regulations for land use and occupation according to the specificities of the elements that make up the respective regions. Another relevant aspect is the savings in both time and money, since instead of a case-by-case registration survey, the elements and similarities of each region allow for precise and expeditious 3-dimensional modelling.

The evidence collected from the various scholars cited suggests that their analyses can be considered, in Whitehand's words, unfinished business, underlining that concept and definition may be considered over flexible and open to numerous interpretations, which through dissemination and discussion can and perhaps should be condensed into a more common and agreed conceptual terminology.

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Obscure landscapes: life, city and memory space

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ABSTRACT

The paper proposed here comes from the discussions had at Laboratório de Poéticas Fronteiriças [LabFront - http://labfront.weebly.com], a research, development, and innovation group that aims to investigate further the relationship and possibilities between the fields of art, science, and technology. The exponential technological developments happening in the 21st century, at a pace never seen before in human history, make it so that every sphere of life is permanently affected, needing an adaptation in how things were traditionally perceived. From our day-to-day life to an industrial level, reality as it was has been reshaped to allow for the multiple possibilities presented by technological and scientific advancements. We are currently faced with a paradoxical hidden environment being constructed in front of our very eyes in a digital sphere that can be accessed with the help of mobile cameras, haptics, and stereoscopic devices that are mingling and transforming our understanding of urban spaces. This expansion, created in a space where geographical barriers are easily overcome, makes it easy for highly known cultural environments — such as UNESCO heritage sites across the globe — to be invaded and, therefore, have their existence and meaning altered. We know, from Françoise Choay, how the urban, historical environment works as a mirror to reflect how we construct society. When adding a digital/virtual layer that dialogues and directly alters the structure of existence (life), we face a paradox when dealing with our historical heritage in a post-digital cultural environment. This paper, therefore, aims to discuss how the existence and overcoming of complex objects that are bleeding into every space on Earth through digital means helps to reconfigure our cultural landscape.

Keywords: Digital heritage; digital arts; artificial landscape; digital landscape

INTRODUCTION

In late September 2023, Meta (previously the Facebook company) announced a partnership with Ray-Ban to launch their new generation of smart glasses, Meta Smart Glasses, to be sold in early October of the same year. With a starting selling point of $299, the glasses are filled with many digital features, most noticeable being the glasses' built-in camera, speaker, microphone, and, in particular their Artificial Intelligence (AI) assistant. Although still lacking in many functions, we can understand the Meta Smart Glasses and other smart glasses being launched in the market as a new generation of wearable haptics: technological devices used to access digital layers of our reality.

Lately, especially since the 2010s, we have seen a massive increase in both technologically assisted realities and haptics created to access them. Although the concept of such types of reality was first presented in the 1980s with the creation of the term Virtual Reality (VR) (Netto; Machado; Oliveira; 2002, p. 4), it was only in recent years, from the turn of the 20th to the 21st century, that we had the technological development needed, alongside the significant decrease of their price to allow such dimensions to "escape" industrial and academic contexts and bleed into our daily lives, forever changing the construction and understanding of our landscapes. One of the spheres recently transformed by such transformative technology is the UNESCO heritage sites around the globe. On the premise that such technology allows us to overcome things such as geographical barriers alone, we understand that the digital layer invasion in such places has an effect that needs to be studied as to how and what changes are done to their meaning and existence in itself.

Such discussions are state-of-the-art in regards to the configuration of environments and the creation of mixed landscapes and thus enter the focus of Laboratório de Poéticas Fronteiriças [LabFront - https://linktr.ee/labfront], a research, development, and innovation group based in the Guignard School of Fine Arts in Minas Gerais, Brazil. The group aims to problematize the borders of art, science, and technology and their reverberation. With previous work on how life is being interfaced by technology in various ways, it is of great interest for us to delve further into how the perception of millennial historical sites is faced with challenges and changes due to how life as we know it is in constant change due to fast, constant technological developments.

With such an idea in mind, we present this paper to be divided into two sections, besides this brief introduction and our final considerations. Firstly we will dive into the history and transformation of culturally known landscapes and how our understanding of them and their existence has been altered by the digital technologies we are focusing on to, in the second section, dissect the idea of how cultural heritage is disengaged from life thus creating a paradox when one thinks of living heritage when faces with current technological and scientific developments. Ultimately this paper aims to discuss how a new post-digital cultural landscape is being created and altered in front of our eyes outside of previously delimited spaces.

SMART DIGITAL CITIES

As it is known, cities have been developed, grown, and rearranged accordingly, not only to their population, but to the technology available at the time. Although some things like streets and avenues have seen somewhat relatively few adaptations throughout centuries, especially in European cities, the way we perceive how we utilise the space around us has, undoubtedly, shifted as the population was introduced to new ways in which to perceive reality, interfaced by technological advancements. We understand that:

[...] in the city of the 19th-century field workers already took their places as citizens and congregated socially in spaces where daily life was oriented by industrial logic. That meant an explosive growth in the number of people concentrated in the city had taken place and consequently, new ways to use such space were developed (Benevolo, 1981). [...] The changes in the city [...] are due to the intention of rationalising the relationship between city, citizen and production (Gobira; Silva; Andrade, 2020, p. 3. Our translation).

How technology developed the work is essentially linked to the way the surge for development in our environments shifted.

Not only was it now needed for us to adapt socially to the changes created by technology, here in specific digital technologies, but we also were forced into reshaping our understanding and relationship with our surroundings due to how industries primarily started to accommodate the new developments. Not only that, but the new possibilities in multiple areas, such as agriculture, medicine, biology, etc., due to new technology-aided discoveries have increasingly heightened human life expectancy as well as made for a safer world that now houses more than 7 billion individuals, with some countries such as India and China holding populations of over 1 billion people each. As it is, "Today, more than half of the world's population lives in cities, leading to a lot of problems linked to the explosion of the urban population in towns; to solve these problems, countries are progressively improving the use of new technologies to make cities smart" (Scorpio et al., 2020, p. 1). Those smart cities, although with different specificities to their definition, can be overall understood as:

[...] constellations of instruments across many scales that are connected through multiple networks which provide continuous data regarding the movements of people and materials in terms of the flow of decisions about the physical and social form of the city. Cities, however, can only be smart if there are intelligence functions that are able to integrate and synthesise this data to some purpose, ways of improving the efficiency, equity, sustainability and quality of life in cities (Batty et al., 2012, p. 481).

We can thus understand smart cities as another step in the urbanisation of cities, especially the large ones where we have a concentration of population and an industrial/technological hub. Coined firstly in the 1990s (Söderstrom, 2014, p. 7), it is a:

[...] concept that is created with the demand of making use of technologies through communication networks and the internet for the transformation and use of the urban environment (being a part of urbanisation processes) in an efficient manner, searching, in its essence, to bring equilibrium amongst competition and sustainability. The stimuli to digital development aim to create more [liveable] attractive cities, thus gathering private capital investments (Gobira; Silva; Andrade, 2020, p. 8. Our translation).

We can easily imply then how there would be an industrial push regarding the development (and redevelopment) of urban areas into smart cities, seeing that, as stated here, they are the culmination of technological and financial needs of the post-digital[43] world. As new technologies are created, they can be applied both to our day-to-day lives and on a larger construction scale in the streets, buildings, signs, and other makers of urban spaces. Such use has created a strong movement of capital, in an interconnected way, across the globe, allowing also for better populational control thanks to the use of state-of-the-art technologies aimed to be used in smart cities, such as the Internet of Things (IoT); image processing; Artificial Intelligence (AI); technologically assisted realities, like virtual reality (VR),

[43] We understand post-digital as a moment in time, we are currently living in, where "we can consider that computation has brought new possibilities to society, including for art and technology. With that in mind, [...] [we have] the configuration of a landscape that merges analogue and digital elements" (Gobira, 2018, p. 85. Our translation).

augmented reality (AR) and mixed reality (MR/MX); brain-computer interfaces (BCI); nano-bio-info-cogno-technologies (NBICs).

As stated, such developments, in their use in smart cities, are still somewhat experimental, and that is due not only to the still costly and difficult application but also to the need for a change in the understanding and infrastructure that permeates such environments. That is because smart cities need to be projected by a multidisciplinary team to use technologies to solve urban, social, and economic problems that are created by the growth of the cities and of technology itself. We understand then that smart cities create not only an extrapolation of traditional environments but develop a complete, multidimensional landscape by using software and hardware, and the need for a direct approach to both empirical and digital realities. As of the 2020s, researchers have somewhat agreed that, when it comes to developing smart cities, "challenges include, but are not limited to, environmental issues, air pollution, the heat island effect, the lack of natural resources, and deteriorating infrastructure. Implementing effective policies and strategies for smarter urban growth has received further interest under such scenario" (Jamei et al., 2017, p. 1). One way in which developments are being catered towards, with environmental and cost efficiency questions in mind that is permeating the world around us without being necessarily seen or understood by people other than researchers, developers, or the industry as a whole, is through "invisible" technologies.

While complete reconstructions of cities and ways to interact with our environment are impossible, since the turn of the 21st century, people have been growing accustomed to the use and contact with the digital world. A much more significant, faster, and expanding landscape is being created in laboratories, industries, and research centres, and in the very palm of our hands, though many might need to be made aware. That is because such an environment is somewhat obscured by the difficulty in access and difficulty in the knowledge of how to access. Still, it is, regardless, being steadfastly fed through by millions of people worldwide, especially due to the use of the internet. Although now ubiquitous, some technologies, like our smartphones, tablets, and laptops, are, in reality, haptic devices that connect us to the digital layer of our socially constructed reality (Berger; Luckmann, 1991). The possibilities there, although invisible to the naked eye, are lying in wait for interactions to be developed and put into action, updating our vast landscape. We can see such interactions, for example, in how we use our smartphones as maps, interconnecting the city streets, buildings, urban transport, etc. That is one possibility of mixed reality that is easily accessible to the general population for one. On a deeper, more technologically complex level, we have various research on the use of technologically assisted realities of BCI applications for smart cities for navigation, entertainment, and mobility reasons (Kohli et al., 2022), as well as the use of 3D modelling and VR for research and development of sustainable practices and applications in urban areas (Jamei et al., 2017).

In specific areas of urban life, we have seen more daring uses for the general public: in cultural spaces like museums, we have seen more applied cases of diverse technology and how it can be used and interacted with (Gobira, Silva, 2019; Gobira, Mozelli, 2018). Such discussion is essential for us here seeing that,

[...] at the same time that it preserves, an archive can distance its content from the world around it. To think of an archive in a public institution is to think of it as a needed opening to the world around it, seeing that it can enable the diminishing of the distances that the archived objects tend to keep. The archive can also safeguard and create cultural knowledge of a people and its identity and, with

that, it is open to various interventions, allowing for new configurations and creating new questions (Gobira; Corrêa; Almeida, 2017, p. 270).

As we have proposed here in this paper, the landscape is not simply created by the physical world around us but by its multiple layers, its people, the way it interacts within itself, and, evidently, its social, cultural, and historical context. Thus we cannot overlook heritage sites, be it in the form of cultural institutions or actual historical sites, like, for instance, the ones recognized by UNESCO. Therefore, technological developments will also directly and indirectly affect those places and how we understand and interact with them.

As such, we have seen a surge in research in regards to how we can actively interact and understand cultural heritage sites through the lens and interfaced by technology in this new, still in exploration, obscure landscape. “The growing prevalence of digitization efforts on cultural heritage has elicited widespread international interests regarding their potential implications for the preservation, presentation, and management of cultural heritage assets” (Dang et al., 2023, p. 228). China has appeared as a strong proponent of new techniques and the use of technologies to preserve its cultural heritage sites. As shown by Dang et al., inside its 14th Five-Year Plan, the Chinese government and its researchers are using the notion of digital twin44 to expand its landscape and tap into the digital layer of its environments.

Cultural heritage, subjected to environmental risks, material decay, natural disasters and disturbance of visitors, needs to be comprehensively documented and understood. Simple and “linear” information from manuscript recordings and manual measurements can hardly collect full-scale construction details and performance with high complexity and variability and interpret its invisible interactions with the environment. In addition, the correctness and accuracy of the information are highly dependent on the expertise and responsibility of practitioners. In contrast, digital twin techniques seem to be more reliable. Virtual (p)re-construction is always linked to building information modeling (BIM), that the 3D model reproduces the material characteristics, component types and construction phases of the physical structure with detailed and standardized attribute libraries (Dang et al., 2023, p. 229-230).

However, as we have previously stated, such developments are somewhat recent and still need to be more thoroughly studied and published, with only a few instances out there, as of the writing of this paper, of research in the area of the possibility of digital expansion in cultural heritage sites. Regardless, as we propose, it is merely a question of time before such discussions have a large influx into the academic sphere seeing that they are, undoubtedly and unavoidably being made. What rests for us here, in this paper, as our goal is not to be a case study, is to understand better the literature that makes us able to comprehend how such things can exist and expand.

A LIVING HERITAGE

Just like with the environment around us, as we touched upon in the previous section, we understand that “the layers that make up the museum are created through the work of researchers and

[44] “Typically described as consisting of a physical entity, a virtual counterpart, and the data connections in between, the Digital Twin is increasingly being explored as a means of improving the performance of physical entities through leveraging computational techniques, themselves enabled through the virtual counterpart” (Jones *at al.*, 2020, p. 36)

collaborators throughout time" (Gobira; Rezende, 2022, p. 23). One would not be able to detach a section of reality from its context. Still, it is relevant for us here, faced with the discussion we are proposing in this paper, that we make clear the specificities that make up what constitutes our understanding of reality and, consequently, of heritage. That is because with such markers in mind, we can comprehend the world around us regardless of the way it may (and often does) radically change. As it is, "The remnants of experience still lived in the warmth of tradition, in the silence of custom, in the repetition of the ancestral, have been displaced under the pressure of a fundamentally historical sensibility. Self-consciousness emerges under the sign of that which has already happened as the fulfillment of something that has always already begun. We speak so much of memory because there is so little of it left" (Nora, 1989, p. 7), and technology is one of the leading players in this ever-constant extrapolation and possible replacement of the commonplace.

We have approached and understood the changes that cities have undergone in a practical stance in the previous section. Still, it is vital to us to understand how it allows for the archivist spaces to help in constructing a new cultural landscape in the post-digital context. According to Françoise Choay, it was after 1837 that the understanding of something as heritage changed to accommodate not only constructions but the larger environment as a whole (Choay, 2001, p. 12-13), and that, despite many debates in regards to the specificities of its definitions, it leads to questions in what constitutes as a threat to urban heritages, the field and its researchers have a consensus that it is incredibly pertinent for us to preserve them (Choay, 2001, p. 17). Still based on Choay, "the old formations only reached their heritage identity by obstructing the reorganization of the urban space, transforming the material city into an object of knowledge. The relationship between preservation, heritage, and city incorporates the idea of landscape" (Gobira; Corrêa; Almeida, 2019, p. 272. Our translation). Thus, we can comprehend that despite being a part of the makeup of landscapes, we cannot take the definition of urban heritage and extrapolate it without considering its part and the context as a whole and its need to be preserved. When considering the cultural institutions, we need to change our perspective. That is because,

[...] these hieux de memoire are fundamentally remains, the ultimate embodiments of a memorial consciousness that has barely survived in a historical age that calls out for memory because it has abandoned it. They make their appearance by virtue of the deritualization of our world-producing, manifesting, establishing, constructing, decreeing, and maintaining by artifice and by will a society deeply absorbed in its own transformation and renewal, one that inherently values the new over the ancient, the young over the old, the future over the past. Museums, archives, cemeteries, festivals, anniversaries, treaties, depositions, monuments, sanctuaries, fraternal orders-these are the boundary stones of another age, illusions of eternity. [...] We buttress our identities upon such bastions, but if what they defended were not threatened, there would be no need to build them. Conversely, if the memories that they enclosed were to be set free they would be useless; if history did not besiege memory, deforming and transforming it, penetrating and petrifying it, there would be no lieux de memoire (Nora, 1989, p. 10. Author's emphasis).

Therefore, we can imply the need for such institutions as a part of the landscape created for their enclaved instance that allows for the objects and non-objects to be preserved and role in memory when faced with an ever-constant changing reality and the remains of our memories. Such pertinence can be perceived more clearly when we understand that:

[...] the museum is a legitimation instrument and it, constantly, suffers with changes in reality, but never leaving such reality and its progressive flux. All the events that create the museum do it as part of an illumination instrument of reality. The museum constitutes - and is part of the constitution of - reality between a past shown in the objects (and non-objects) that it is safe keeps, allowing, through the production of knowledge, through its promotion and access, the maintaining of all of its heritage as something contemporary (Gobira; Portugal, 2022, p. 24).

We can thus understand, based on the quote presented and on Choay's descriptions, that despite being held inside the understanding of urban heritage, those institutions do not act according to the dictations of urban heritages as places of memory. That is because the idea of cultural heritage is disarticulated from life and urban heritage, existing in a space removed from time, acting as its preserver.

That is not a discovery. It is known that "in the 19th century [...], the institutional consecration of historical heritage gives it a different temporal status. On one side, it gains the intensity of a concrete presence. On the other, it is installed in a definitive and unequivocal past, built by the collective work of historiography and the (understanding of) historical consciousness of the mutations imposed by the industrial revolution to the abilities of the human beings" (Choay, 2001, p. 206. Our translation. Author's emphasis). What we are facing currently is merely a continuation of how the different understandings of existence come together in the creation of the landscape. An interconnected, constantly evolving landscape. While the discussions and adaptations before took centuries to be able to be perceived in any precise manner, the aid of digital technology has forever transformed our perception by allowing us to understand the reality in which we live and creating a paradox in regards to the sphere in which the cultural heritage, that is the focus of this paper, exists. That is because while existing in a place outside of time in an attempt to be able to preserve a fleeting existence of memory, such places are now being invaded by current, generative technologies, thus creating a direct link that evokes the need for an analysis of living heritage, one that is being constantly updated due to the expansion and bleeding of the digital world into our empirical one. It is in such status that the obscure digital landscape is being formed.

FINAL CONSIDERATIONS

As we have seen throughout this paper and more clearly through our day-to-day lives, ubiquitous and state-of-the-art technology has forever reshaped our socially constructed reality. We are dependent on the digital expansion of our existence in many different degrees to be able to be an active participant in society. From the moment we are born, we are registered into databases, no longer being able to escape having an extension of our bodies that exist online. When analysing it by such close examples, we can perceive that the digital space, which has existed for decades now, is slowly being filled and used and expanded according to our abilities and needs to do so. Seeing the use of digital technologies in constructions, buildings, and the environment around us, we can better understand how the reconfiguration of our post-digital landscape is being formed and why.

Smart cities are the more clearly defined possibilities when severe research and studies have gone into what the changes in technologies might mean to us as a society. Still, they are not the only manner in which we can see and access the different dimensions that make up our landscape. The ease of access and cheap manners in which we can be interconnected with each other, with our homes, with

the world around us, has reshaped the world we live in and our way of occupying it. Looking at a more extensive scope, it is clear that such changes extend to every corner of our existence, including the focus of this paper, which is the cultural heritage sites. The paradox created, and here previously discussed, will be further analysed as more and more intentional advances are made into controlling and safeguarding the digital layer bleeding into those objects and non-objects; We are already seeing the first movements towards such research being done, for example,, in China, a country that has been in recent years very advanced in state-of-the-art discussions. More and more countries are soon to follow in their footsteps, both for cultural and economic purposes, making it so we can, hopefully, shed more of a light on the currently obscure landscape we are just now being able to access and discover.

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Paulo Mendes da Rocha and the ships: morphological analyzes between ideas and metrics

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ABSTRACT

In the Cais das Artes architectural project, could Paulo Mendes da Rocha have designed an architecture as a ship? Added to the influence of industrial and tectonic issues, the proportionality system could be used in a way referenced in the architect's port memories? Published in the reference literature, this project with cultural use is composed of an architectural ensemble formed by three volumes - theater, museum, and administration - organized on a horizontal plane, moored, on the banks of Vitória´s bay (Espirito Santo, Brazil). References to port and nautical structures are frequent in the architect's speech as well more specifically when he talked about projects developed (built or unbuilt) for his hometown Vitória. The objective of this article is to present the results of a morphological analysis to explain the metrics of the Cais das Artes architectural project. To this end, documentary collections were necessary - cartographic, iconographic, and textual -, as well one redesign drawing protocol and the adoption of an “analysis system” composed of three sets: contributing with data from the work and document collection; System #1 aiming to decompose the work into constituent elements, and System #2 with speculations on the architectural composition at constituent levels, namely: spatial, material, and urban surroundings. During the studies, it was possible to register that one of the identified ship proportions is equivalent to the proportion 1/6, and that this same proportion is identified on the architectural composition. The conclusion seems to reflect that the procedures to analysis architectural allows us to appreciate the obvious rules of composition such as rhythms, materials, etc, to the less obvious and more subtle ones such as typological variations, comparative articulations, speculating how much of the discourse is capable of being materialized.

Keywords: Paulo Mendes da Rocha; urban morphology; architecture

INTRODUCTION

All over his career, Paulo Mendes da Rocha talked about the ships as a passion. References to port and nautical structures are frequent in the architect's discourse, as well as the idea that the "[...] nature is not that of a nature purely to be contemplated" (Rocha, In: Wisnik, 2012: 60). On other several occasions, in the readings carried out on the work of Mendes da Rocha, more specifically on those projects developed (built or not) for his hometown Vitória, there are mentions of engineering works on the territory, such as those about "dredged and drained" areas (Wisnik, 2012: 61); or uninterrupted port routines related to "[...] ships, for technical reasons of navigation, sometimes unload at three in the morning or set sail at half past midnight [...]" (Rocha, Wisnik, 2018: 33); or even

about geography and opportunities "I was born in the port of Vitória, State of Espírito Santo [...]. When I think about models for objective things, projects, Vitória's enclosure often appears in my mind. An energetic city that, while you work, can be heard over the noise of the docks. The port is an illuminated powerhouse that refers to the idea of the Universe, the world, schedules and adventure in occupying its spaces. The spatial arrangement appears in memory with the floating part of its territory"[45] (Rocha, In: Wisnik 2012: 38), among others. Could the influence of nautical metrics have entered the metric of architectural design?

The objective of this paper is to present the results of a morphological analysis to explain the metrics of the architectural project Cais das Artes (Vitória, 2007-2011) due to the adoption of an "analysis system" based on the authors Ching (1999), Borie et al. (2008) and Unwin (2013) composed of three sets. Published in the reference literature on the architect, that architectural project with cultural use is composed of an ensemble formed by a theater, museum and administration organized on a horizontal plane, moored on the shores of Vitória´s bay. This paper is structured in two sections. First there are the presentation of the methodological procedures and then the results obtained by the interpretation of this architectural masterpiece.

METHOD

The first adopted procedure in this study, still in the morphological pre-analysis phase, was the formulation of the theoretical framework and bibliographic review from the published works about Mendes da Rocha. Not necessarily focused on the knowledge of Cais das Artes, the activities were focus on reading the texts, listening to interviews and watching films to understand the main ideas of the architect. Subsequently, scientific articles, theses, dissertations, periodicals, and newspaper articles were also selected, and it was possible to quantify: 19 books, 07 scientific articles, 15 articles in journals, 05 theses/dissertations and 05 newspaper articles published between 1996 and 2022 to identify mentions or representations. In this context, and specifically about the Cais das Artes, the first mention that could be identified was in a regional publication called Imagem urbana magazine, from 1998.

Zein (2023: 55) warns that to interpret architecture, "[...] it must be admitted that these works were, in turn, elaborated through customary design methods of the professional field of architects". For the author, "non-textual tools" (drawings, sketches) and "textual tools" meet to compose the reading of a project or the design process for "at least two reasons". The first tools are relevant because the act of projecting involves speech and thoughts; and the second one, disseminate what was researched as well as the drawing. With this notion as a guiding line, there was time to write an analysis protocol composed from the reading of three works selected based on experiences of previous research, namely, Ching (1998), Borie et al. (2008) and Unwin (2013).

From Ching (1998) issues related to the composition, order and decomposition of architecture were worked on, recognizing how to identify the parts of the whole, practicing elementarization, naming the elements and creating vocabulary, as well as addressing principles of composition such as axis, hierarchy, surroundings, and construction system. For the author, there are four systems divided into: space, structure, delimitation, and circulation. By spatial system we intend to understand spaces and

[45] Citations translated by the author.

their programmatic functions; By structure system, columns, beams, slabs and cantilever are searched, observing sizing and positioning; in the delimitation system, compositional elements are registered, such as the vertical planes that contain the external and internal volumes; With the circulation system (of people or vehicles) the connection and connection axes, vertical and horizontal, in the building can be noticed. For Ching (1998) the context component must be analyzed because views, topography, sun, dialogues with forms. In architectural analysis, proportion (systems of proportionality and proportions, for example, of materials), scale (visual and human) and principles of order such as axis, symmetry, hierarchy, repetition, rhythm, etc., can also be observed.

By reading Alain Borie, Pierre Micheloni and Pierre Pinon (2008: 33) it was possible to discuss some issues about the geometry of forms and a particular notion of transformation of architectural and urban objects seeking to "[...] to understand the architectural object as the project or the resulting from its surroundings and not as something with value in ism [...]". When addressing the notion of “deformation”, the authors proposed a System of Analysis of Architectural and Urban Forms composed of three principles: the corpus of analysis, the system or systems of analysis, and the vocabulary employed. Specifically, about the systems, the authors describe two procedures. In the first there are stages: decomposition of the elements, qualification of the nature of the relationships between those elements, quality of the modification or not of the elements. In the second system, the constitutive levels, about architectural forms, are the spatial and the material characterizing surroundings, internal subdivisions, dynamic spaces, static spaces.

It also seemed very opportune to us to observe the methods of studies and how the analysis of buildings could be carried out. Unwin (2013: 5) warns about the need to proceed with one's own analyses, consulting what has been published, but never "blindly" repeating past analyses: "Working from published sources, it is very likely, if not certain, that the analyst will come across inaccuracies in the drawings and may be disoriented by the occasional cases in which the photographs were printed backwards". In doing so, the author defends the consultation of published materials (including textual and non-textual ones), but at the same time advocates the practice of redrawing.

In this article presents the results of the studies are presented according to System #1 and System #2. This interpretation first sought to decompose the object by elementarizing its parts and, subsequently, to observe the logics of composition of the parts with the whole, from the inside out and vice versa.

RESULTS AND DISCUSSIONS

About the architecture and the plot

Cais das Artes, an executive architectural project from 2007, developed by the architect Paulo Mendes da Rocha in partnership with the Metro Arquitetura, is located on the shores of Vitória’s bay, in Enseada do Suá neighborhood (Vitória, Espírito Santo, Brazil). The architectural ensemble facing a cultural center is programmatically diluted and consists of three solids, independent but united by a horizontal plane. Such a design strategy, according to J+S (Wisnik, 2018: 176-177), is "[...] a constant in his work since the gymnasium of the Clube Atlético Paulistano: a certain dissolution of the object, with levels and scales to dominate the volumetry, and allow the open space, the public function".

The composition consists of three main solids. The first and largest housing the facilities of a theater, where artists and visitors can immerse themselves among sets, costumes, and music, in a total of 14,000m² and can house up to 1.300 seats divided into two levels. The second solid, 8,500 m², has the

function of a museum with exhibition rooms, auditorium, and library. This does not sit directly on the ground, being seated on 6 reinforced concrete pillars, spaced 54 meters apart, making the ground, as is characteristic of the architect's work, public and the block elevated and traversable by visitors. In this solid, the visitor will be able to discover worlds and "other seas" without leaving the port. The smallest of the solids, almost a perfect cube, has the function of conducting the complex housing employees related to management and the collection. In addition to this function, it also houses the plumb of public toilets, thus allowing the architect's initial desire to suspend the museum from the ground, integrating it into the landscape. After all, what would a ship be without a tugboat?

During an interview with Wisnik (2012), Mendes da Rocha exposes design decisions in the case of this project and, specifically, how he deals with the different solutions adopted for the solids that houses the functions of museum and theater. More than a mere justification, the architect's speech allows us to explore the historical layers of the territory and the actions of engineering in the transformation of the place over time.

In this non-linear timeline of the territory´s history from the cove of calm waters that attracted foreigners to the materiality of the rectangular plot of 300 by 70 meters, it is possible to register formal intermediate stages of the plot that influences the architect's thoughts. It is thus understood to identify 4 formal periods: water between islands, land in islands, striation between islands and solids.

The first stage has primitive characteristics of the site known as Vitória´s bay or a geographical enclosure of seawater that advances through the interior of the continent. Generally, concave in shape, the bay referred here currently has a linear shape resulting from several engineering actions that dredged, rectified, grounded its contour, artificialized its edge over four hundred years. With 120 meters wide and 7,500 meters long, this bay has to the north the city of Vitória, to the south, Vila Velha, to the east the infinite horizon the Atlantic Ocean and Africa, to the west the Port of Vitória, an enclosure that receives ships from different parts of the planet.

The ships, that came from all over and enter this enclosure day and night, has maximum size rules, such as the Cosco-Shipping cargo ships, with their 189 x 32.25 meters, and Log-in, with 218.45 x 29.8 meters, and oil tankers, such as the Robert Maersk, measuring 171.2 x 27.4 meters. Accompanying the ship from the attraction on the high seas to the port are smaller vessels called tugboats, with 34.2 x 12.6 meters, with the function of guiding and avoiding impediments or obstacles along the way (Figure 1). In addition to the oil explored off the coast of the state, the other cargoes arrive stored in containers with a standard of 6.1 x 2.44 x 2.6 meters.

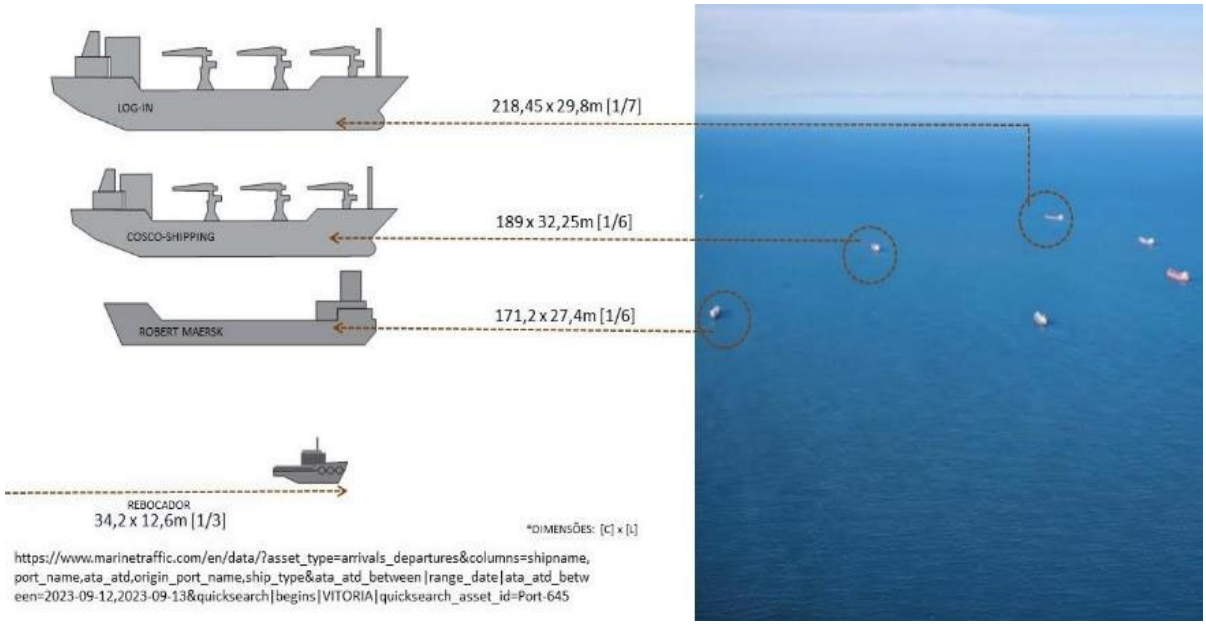

Figure 1 - Metrics of tugboat vessels transiting the bay of Vitória (Source: marinetraffic, adapted by the author, 2023).

In the second formal stage, during the 1960s, for multiple reasons that involved actors from the public and private initiative, the bay was dredged, and its natural concave shape was definitively changed to a linear shape given by a riprap. About 1.2 km² is equivalent to the created soil that unites few islands; both the larger islands, already occupied by neighborhoods, and the smaller islands occupied by animals and vegetation.

In the next stage – third – the urban plan was designed when the smooth soil is changed to a striated soil with demarcation of properties in a two-dimensional composition. It is proposed a set of blocks in different trapezoidal and rectangular formats, from 60 by 120 meters to 240 by 420 meters, and an urban tissue in scales formed by local streets with 7 meters large and main streets of 21 meters, promoting interconnection between the central area and the seafront.

In the fourth formal stage, the layer of the three-dimensional is added. The soil is used and occupied by buildings and increasingly by human beings in a replacement of non-human inhabitants: stones, vegetation, birds, reptiles, amphibians, and fishes. The buildings have prismatic shapes from 10x15x4 meters in one of their smallest formats to the other ones configuring profiles of 100 meters and bases with a tendency to rectangles around 20 by 80 meters.

There is also a height configuration given by the construction of the Deputado Darcy Castello de Mendonça Bridge, "Third Bridge", started in the late 1970s with 70 meters high in the central span, and 3.3 km long connecting two neighboring municipalities separated by the bay. When it comes to talking about landscape of Vitória´s bay, one cannot fail to mention the presence of the chapel Convento da Penha, from 1568, located on a hill 154 meters high. Although located at a distance from Vitória´s limits, the presence of this monument promotes debates and influences the creation of public policies at the local level. According to Otondo (2013: 174) during the development of the architecture project and "As part of the model, Paulo Mendes da Rocha made some cargo ships, exquisitely made of colored paper, in different sizes, from different origins of the globe, the Greek and Russian ships".

System #1

The building form of the probable "anchored ship" Cais das Artes can be read in four sets - spatial, structural, delimitation, circulation - based on the principle that a whole can be subdivided into parts and if this is done it is an abstraction for the purposes of studies (Ching, 1998). In System #1, elements that make up the project are identified. So the graphic analysis and the action of redesigning the architectural projects are taken as an instrument of interpretation (Figure 2).

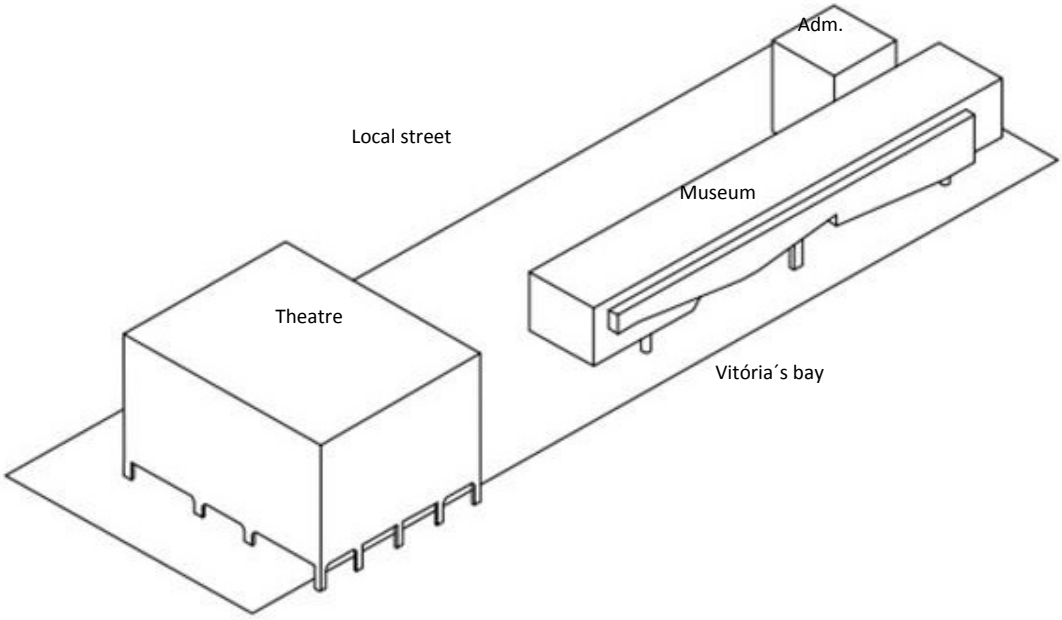

Figure 2 – Cais das Artes: architectonic composition (Source: author based on modeling developed by Uliana, 2023)[46].

The first set of System #1 contemplates spatial aspects. It is "a set of bodies" (Pisani, 2013) composed of three independent solids that approach each other without touching, "[...] pure solids, loose from the ground, which are articulated by aerial passages" (Otondo, 2013: 173). Two of the solids tends to the cube and a third to a parallelepiped with the base cut out. The first and smallest "almost cube" has bases equivalent to 22x22 meters, the second is larger with bases of 70x58 meters. Between these two there is the third solid 6 times as deep as it is wide, 50 meters away from the 32-meter-high solid and 3 meters from the 24-meter solid. Its dimensions are 26x144 meters at the base and a height of 15 meters, being elevated 3 meters from the ground. This third solid of the composition is central and by format hierarchy stands out from the others. On the side facing the ground, it has cutouts and diagonals cutting the linearity of the edge of the solid.

As protagonist as the solids, the surface on which they are arranged is a prominent compositional horizontal element, gaining the strategy of connecting the solids giving a sense of the whole (while keeping them independent). This surface can be related to: "At ground level, the freed space is configured as a square, also the result of an embankment, which opens up over that representative place of human ingenuity that is the port" (Pisani, 2017: 167). In the second set, the structural aspects

[46] These architecture modeling were made by Antônio Uliana (graduated student in architecture and urbanism, Ufes).

of the architectural work are highlighted, such as pillars, beams, slabs, and construction system (Figure 3).

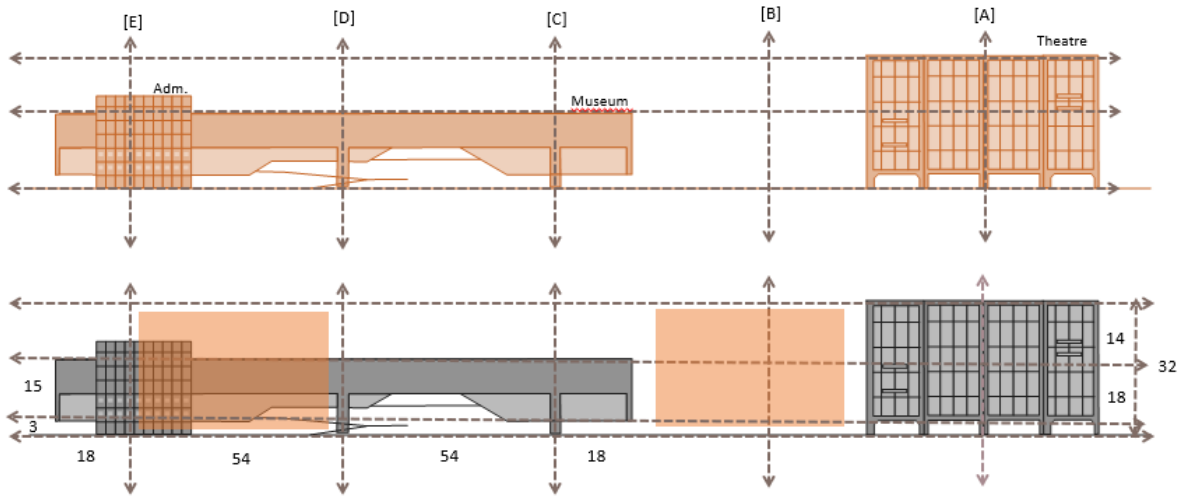

Figure 3. Structural elements of architectural composition (Source: author, 2023).

The smaller solid is made up of metal pillars and beams. The pillars in profile “I” are 8 in number, and are next to the perimeter walls, except for one of them. The slabs, in steel deck structure composed of galvanized steel panel in trapezoidal shape covered by reinforced concrete, are occupied by a set of administrative rooms and public bathrooms having between these two programs the vertical circulation system formed by elevator and stairs.

About 3 meters away is, in parallel, the solid supported by 6 concrete pillars in the horizontal plane. Such reinforced concrete pillars are 54 meters apart from each other in span. In the composition of the elevated solid, the ends are cantilevered of 18 meters. The constancy of the metric equivalent to the number 6. It is impossible not to notice the presence of the 7-meter-high beam supported by the six pillars. On the support of the steel deck slabs there are 1-meter-high transverse metal beams and the slabs in turn are mismatched at level and half level, making the possibility of rooms with double height ceilings a reality.

The larger solid, in turn, is composed of 32 reinforced concrete pillars, with the 4 pillars at the edges in trapezoidal shape, 6 in circular shape and the others in rectangular shape. Of these, 20 pillars are aligned to the face of the outer and peripheral box. Reinforced concrete slabs and beams complete the structure of this speaker because for Mendes da Rocha (Rocha; Wisnik, 2018: 211-212) "[...] It is impractical to imagine the suspended theater, we did it on the floor. However, under the audience, which necessarily must rise from the stage to a background, we precisely imagine the theater's living room opening to the sea, to the same parade of ships, but already with its tectonic installations, that is, its pillars entirely in the water, à la Venice. After all, it must be considered that in that place there is no difference between building directly in the water or in the landfill [...]".

The third set includes aspects related to delimitation. Such aspect, in what specifically configures here the external limits, is carried out by concrete slabs. In the smaller one, it takes on a width of 1.2 meters and 15 cm thick. Each face of the cube has modulation for 70 plates. The 144 meters long are subdivided into 6-meter modules contemplating 3 precast concrete plates.

The larger solid will receive as external delimitation precast concrete plates in the modulation of 1.50 x 3 meters and thickness of 10 cm, in addition to frames in aluminum and tempered glass. As it is a “music box” there are specifications related to the delimitation with acoustic properties such as structural masonry, rock wool, mechanical protection, and acoustic masonry. The question about the foundation of these buildings on landfill from the 1970s once identified by Pisani (2017: 167) were not reported here (Figure 4).

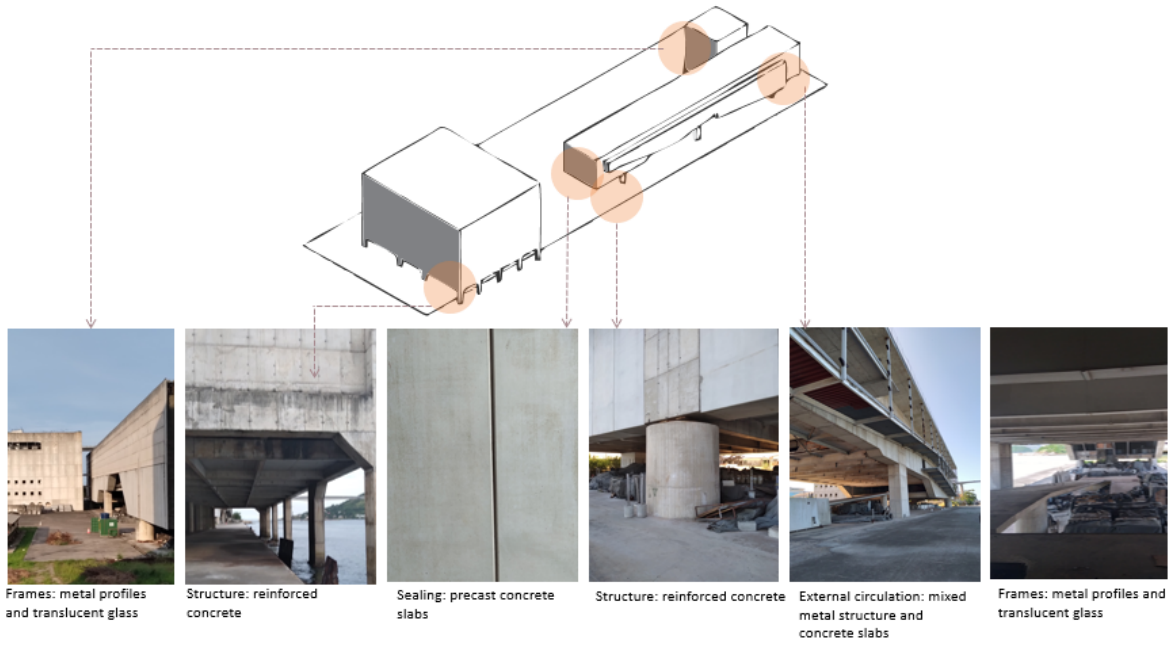

Figure 4. Materiality of architectural composition (Source: author, 2023).

Circulation is a theme of decomposition along with the last set proposed in this System. All solids, with ground floor at the plaza level, have elevators and stairs. The smaller solid has a set formed by a cargo elevator and stairs, the larger solid by 2 sets of elevators, stairs and other 2 sets of elevators and stairs arranged in the northern portion of the solid facing the circulation of artists and technical backstage. Between the north and south portions is arranged, in the center of the composition, the foyer provokes the access of the public at level and necessarily through the horizontal plane.

In particular, the museum's project, for having been "conceived loose from the ground" (Otondo, 2013: 177), 8 meters from the limit of the bay of Vitória and 20 meters from the road curb, requires a specific design to reach the main access meters high in relation to the ground: "[...] The architect designs the circulation with great care: the entrance to the museum is made by a large ramp whose intermediate landing is almost a square (8x8 meters) [...]" (Otondo, 2013: 179). The horizontal and internal circulation of the museum promotes the inevitable displacement so that the visitor can interact with the future collection. In addition to the main access ramp, this solid has 2 sets of elevators and stairs arranged to the east and west, also having an external ramp in metal structure, reinforced concrete and coating in concrete slabs measuring three meters wide. This ramp allows connection between the three levels of the internal slabs, in the internal solid of 14 meters high, without reaching the ground and stands out for the volumetry in the composition of the south elevation (Figure 5).

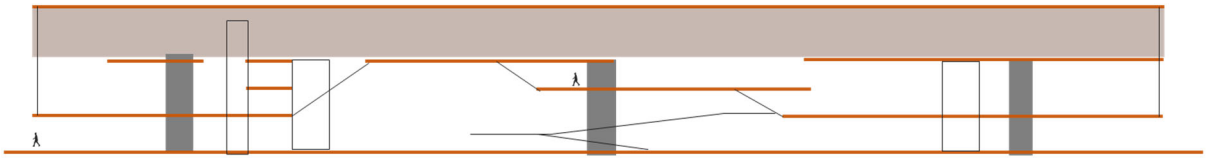

Figure 5. Sectional levels of the solid that houses the museum function (Source: author, 2023).

System #2

In system 2 the rules of composition were studied, speculating intrinsic parameters, and related to the documentary analysis of the executive architectural project. In this system, it is important to say that there is a lot of interpretation, which means, in turn, that the rules observed are not those that the architect uses or used to design, but those that the observer was able to identify.

To this end, the analysis was carried out, the redesign of the floor plan, sections, and elevations, also considering the three-dimensional modeling using digital tools, and then proceeded with the description of the architectural object from 3 constitutive levels - spatial, material, and urban surroundings - previously observed in the literature. So, spatial parameters were observed as the axis; symmetry; hierarchy; given [organizational resource]; rhythm and repetition (Figure 6).

The first two north-south and east-west axes can be noted, subdividing the lot into four quadrants. The east-west connects the square and the urban tissue, interconnecting the vertical circulation axis of the theater with a hypothetical circulation channel formed by the approximation between the solids of the museum and administration. Then, enhancing the north-south axis, it is possible to replicate it in 54-meter modules, forming 5 transversal axes to the lot [A, B, C, D, E], connecting street and water: 2 axes and that cause symmetry in the theater and administration; 1 axis connects directly with a set of pillars in the museum; 1 axis divides the museum to the center, but does not cause symmetry. The metric of 54 meters is a multiples of the unit 6 meters.

In the east-west direction there are 4 longitudinal axes to the lot connecting square and street: 1 axis divides the solid of the museum to the center and whose extension extends to the elements of vertical circulation of the theater. There seems to be a 2-1-2 compositional logic here. This same sequence provokes a reading of the project in reference to the sectorization of uses in compositional band administrative use, horizontal and vertical circulations and, in parallel to water, the main use of the architectural complex (in this case housing theater and museum).

In the identification of the compositional axes in the east-west direction from the south elevation and the street, it is possible to record the metric of 54 meters by 32 meters in height, including the spacing between museum and theater, a kind of invisible rectangle recorded by Otondo (2013: 177) (Figure 3).

As for the hierarchy of the set, the solid of the museum for its hierarchy of implantation (in the center) and format (in horizontal bar). In hierarchy one can also verify what Ching (1999) calls "form within form" with the two boxes of the theater, two (imperfect) cubes one inside the other. The same occurs in the museum's solid, which also contains a trapezoidal-based prism.

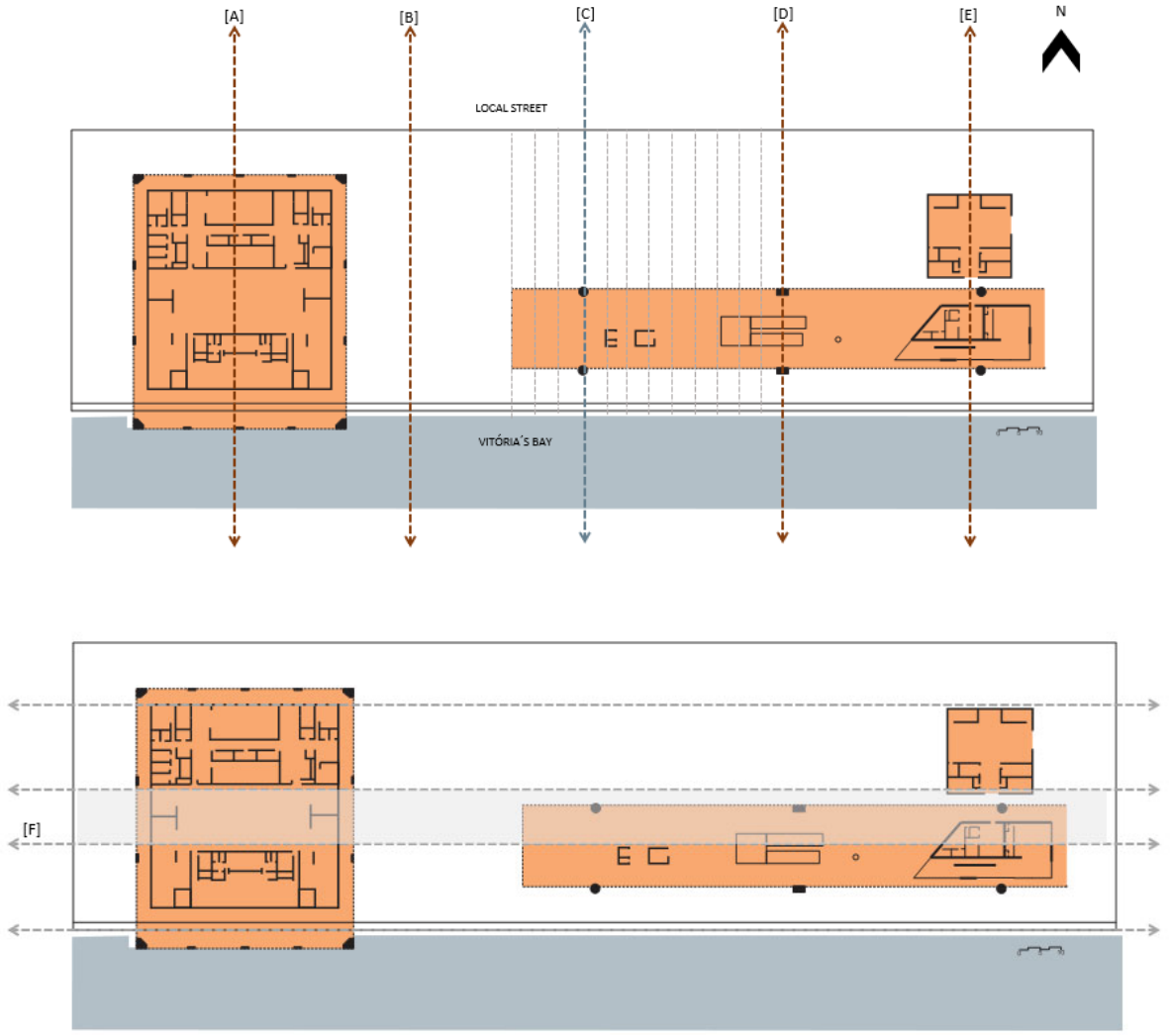

Figure 6. Composition system and spatial parameters transversal to the plot (Source: author, 2023).

By organizational resource was taken the identification of the horizontal plane. It is this rectangle that gives meaning to the whole, enhances the public function, makes the transition between city and water, in addition to promoting a support for observation of the landscape. In addition to these issues, other resources were noted: [1] space within space; [2] space connected by common element; [3] linear organization with a sequence of repetitive spaces; [4] Mesh as an organizing principle. The composition with the mesh and the "space within the space" immediately leads to visualizing "project within the project" in an overlap that goes beyond time and space, the built and the unbuilt.

Parameters related to rhythm and repetition were also noted. From the decomposition of the floor plan, two exercises were carried out. At this level, materiality parameters were observed to understand the proportion system and materials (structure, fence, and frames) (Figure 7). Before describing the observed proportions, it is important to return to the metrics of solids. The solid of the theater observes 32 meters of height, the solid of the museum 18 meters of height (being raised 3 meters from the ground), the solid of the administrative was thus designed with 23 meters of height.

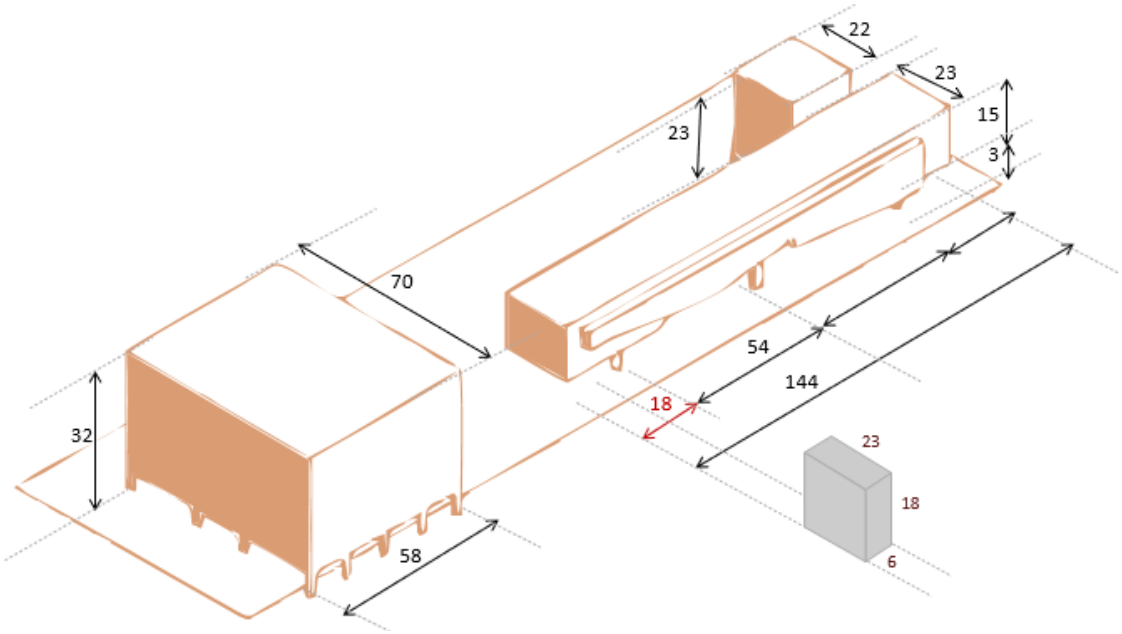

Figure 7. Composition system and the parameters of materiality and proportion (Source: author based on modeling developed by Uliana, 2023).

Among the proportions in architecture enumerated – Fibonacci sequence, golden section, regulating lines, Ken, modulor, anthropometry, visual scale, human scale – its possible to argue that the Cais das Artes project is at the intersection of the proportions of visual scale and regulating lines, the latter defined as: "If the diagonals of two triangles are parallel or perpendicular to each other, They indicate that the two rectangles have similar proportions. These diagonals, as well as the lines that indicate the common alignment of the elements, are called regulating lines" (Ching, 1999: 290).

Added to the influence of industrial and tectonic issues, the system of proportionality used in a way could be referenced in the architect's port memories? Permission is requested here to record merely speculative impressions, seeking to place side by side the nautical proportions of the ships and the architecture. It is thus noted that one of the ship proportions identified is 1/6, as well as that of the solid that houses the museum function in its metric 23/144 or approximately 1/6.

In addition to the possible ways of seeing the proportion of a container, an element extremely associated with the world's cargo ships. From this metric of 2.44 by 6.1 by 2.6 in height, it can be said that the total volume of the museum's solid (except for the issue that there are cutouts in the base) corresponds to 1,680 containers; The solid of the theater corresponds to 3,306 containers and the solid of the administration to approximately 285 containers (although in the latter case the equivalence is not integer and the resulting numbers are fractional). The ships can hold from 5,000 to 20,000 containers. To close this reasoning: 1,680 divided by 285 results in 6 (or 1/6), and 1,680 divided by 3,306 in 0.5 (or 1/2).

CONCLUSIONS

The decomposition of the architectural work allows us to appreciate from the obvious rules of composition such as rhythms, materials, full, empty, to the less obvious and more subtle as typological variations, comparative articulations, speculating how much of the discourse is capable of being materialized. This is so, as Zein (2023: 57) reflects, because the "[...] a work of critical and referenced

recognition of a work of architecture will certainly deal, at every moment of its steps, with forms of representation and non-verbal/non-textual studies (drawings, diagrams, sketches, schemes, etc.); just as it will necessarily deal with verbal or textual forms". It is understood that with the studies developed, many other research perspectives were opened about the design process in architecture.

Acknowledgements

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Permanence and transience in the Florianópolis Urban Agglomeration, Brazil: a configurational analysis in the neighbourhoods of Pedra Branca and Jurerê

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ABSTRACT

In the Florianópolis Urban Agglomeration, tourism-driven urbanization has led to neighbourhoods with a high concentration of occasional residences, while traditional urban growth persists. This dual process accelerates urban sprawling, creates social boundaries, and reshapes the urban fabric. Pedra Branca, characterized as a permanent neighbourhood, contrasts with Jurerê, considered a transient one. Both neighbourhoods have become highly valued within the settlement. This study surveys and compares the socio-spatial features of these neighbourhoods, focusing on how urban form, permanent and transient spaces and income levels can influence urban development. The study then analyses the spatial attributes of both neighbourhoods mainly using the "integration value", from Spatial Syntax Theory, which evaluates the integration of the road system within the global and local context. Building typologies were also considered for the spatial analysis. To characterize the neighbourhoods as permanent or transient spaces, census data (IBGE, 2022) on housing were analysed, focusing on the proportion of occasional and permanent residences. That information was crossed with income distribution to understand the socio-spatial attributes of both neighbourhoods. The results allow a comparison of growth processes, the qualities of permanent and transient spaces in Florianópolis Urban Agglomeration, besides the interactions between these neighbourhoods and their surrounding areas.

Keywords: growth process, permanent spaces, transient spaces, socio-spatial configuration.

INTRODUCTION

Florianópolis Urban Agglomeration is the largest urbanized area in Santa Catarina state, with a population of 1.193.507 inhabitants (IBGE, 2022) and is located on the coast of Santa Catarina state, Brazil. Its urban fabric is organized by a continental and an island portion, where in the continental one prevails conventional urban fabric and in the island the tourist urbanization has an expressive role in the urban sprawl process.

Mainly from the 1970s onwards, the spatial reorganization of the settlement was characterized by what Solà-Morales (1997) identifies as a combination of new morphological arrangements and their locational implications regarding uses and socio-economic aspects. This urban dynamic was led by two main vectors of development: the intensification of tourist activities in the coastal areas of the island, at the same time in which growth originated from a higher accessibility - due to the road investments promoted by the state - was guaranteed in the continental portion (Sugai, 2002). Meanwhile the coastal areas the tourist urbanization occasioned, in terms of use, a high concentration of hotels establishments and summer residences, characterizing this space as a transience space, in other areas the conventional urbanization promoted residential occupancy and the emergence of subcentralities, concentrating job activities and permanent residences.

In spatial terms, distinctly from the recurrent pattern of the urban fabric growth, consolidated based on the progressive division and urbanization of agricultural land – under a layout known as the "fishbone model", where local streets are connected perpendicularly through a main road – and by expansion of the foundational grid (Reis, 2002), the new urban growth vectors had as their main premises the fragmented grid pattern, where land subdivision and urban infrastructure are consolidated at the same time. This form of urban sprawl, however, has been resulting in an increase of urban segregation, both by road disconnections with the surrounding area such as geographic isolation, especially when regard to urban tourist spaces.

The segregation of the new areas has been increasing pockets of poverty while leading to occupation by the high-income population in monitored strongholds, often accessible only by car. Two emblematic examples are the case of Pedra Branca, a neighbourhood belonging to the city of Palhoça, and Jurerê, a coastal neighbourhood located on the north portion of Santa Catarina Island, in the city of Florianópolis. The interaction between these spaces with the surroundings is mainly due to economic dynamics, as they concentrate a large supply of jobs. Regarding morphology, they rarely engage with their surroundings, exacerbating social and economic issues through a silent segregation orchestrated by dominant groups (Sugai, 2002), process also known as commodification, where there is a transformation of space urban in commodities, with public power taken over by the private sector (Romero, Mendes, 2023).

How are these two neighbourhoods configured, considering their functional and the urban form characteristics? What impacts do they generate in the (re)structuration of the surroundings and in the urban growth process?

Metropolisation, tourist urbanization and new dynamics of urban growth: an approach in Florianopolis Urban Agglomeration

The search for innovation constitutes the essence of metropolitan dynamics, becoming a dimension subject to analysis and observation under the constant pressure of uninterrupted growth induced by industrial capitalism. This process leads to the transformation of the modern metropolis, which adopts a new configuration through emerging patterns of modernization (Meyer, 2000).

However, it is important to highlight that the contemporary metropolis – a product of post-modernity – does not arise solely from the unfolding of the industrial metropolis, but is also the result of an urban restructuring that explodes, implodes, establishes or re-establishes new spaces; the contemporary

metropolis is, in general, polycentric, fragmented, discontinuous and kaleidoscopic, in which its limits become practically undefined (Soja, 2008). In this context, it tends to break traditional urban continuities, creating diffuse and isolated centres of activities (Meyer, 2000).

In terms of function, the contemporary metropolis does not replace, for example, the industrial activities by service activities; on the contrary, it expands “its attributions within the new stage at all levels and aspects of the productive stage called post-industrial” (Meyer, 2000, p. 7, our translation). Consequently, the contemporary metropolis tends to present greater functional dynamism. This dynamism partly arises from the expansion of pre-existing configurational conditions and partly from urbanization efforts to accommodate the demand for urban sprawl. The spatial-functional reorganization is fuelled by class dispute and based on the locational advantages afforded to high-income groups, which tend to create segregation within urban spaces (Villaça, 2001).

Accessibility is one of the most important locational values which guarantee a high valuation of a place (Hillier, 1999, Villaça, 2001). In the urban sprawl process, the improvement of accessibility is conditioned by high-income people's needs and specific economic interests. In the process, more valued become certain areas and routes in the urban fabric, while others lose value over time (Santos, 1993).

In addition to accessibility, other factors have become significant for urban sprawl in the contemporary metropolis, one of which is the economic exploitation of the landscape. Within this context, tourism plays a key role in configuring new urban spaces. Tourism is not defined merely as an economic activity, but a spatial one that induces and generates various economic activities (Vera et al., 1997). The sun-and-sea segment of tourism is particularly vital in this urban development model.

Macedo (1998) identifies two recurring patterns in urban-tourist occupation in Brazil, naming classic subdivisions the ones with a main street along the sand strip, and contemporary subdivisions the configuration based on streets that promote access only to residential areas, perpendicular to the sand strip. The patterns he identified, however, are not inherent to tourist urbanization. They also occur in other parts of the city, with adaptations being made depending on the maritime limits and the scenic potential of the tourist areas. On the other hand, an important observation made by the author refers to the lack of connection between the owner and the city in which his properties are located. In general, they occupy these residences only during the seasons, reinforcing the seasonal character of tourist urbanization.

For Pereira (2014), in addition to factors related to economic and land use, the creation of urban tourist space is characterized by the integration of leisure activities associated with the sea into daily life. The author points out a behavioural change, as the maritime area, previously only focused on fishing and port activities, with the bad smell of waste thrown into the sea constantly present, becomes attractive for walks on the beach and sunbathing. Consequently, they also become attractive for urbanization, functioning as new hubs of centrality.

Most cities are not prepared to deal with the spatial, social, economic and cultural effects generated by tourist urbanization. We can mention, among the various consequences generated, the lack of infrastructure and urban planning, the overcrowding of public spaces and, even more damaging, the transformation of residential neighbourhoods, causing residents to be expelled and replaced by new

and more affluent inhabitants (generally high-income tourists), in a process known as gentrification (Bobic, Akhavan, 2002).

Gentrification is an urban phenomenon that materializes class dispute in contemporary urban space. The socio-spatial dynamics arising from gentrification are related to the structures of capitalism, which operate to strengthen and perpetuate the wealth and power of the dominant class, being this process achieved through accumulation, dispossession, expropriation, displacement and expulsion of the less favoured social classes (Mendes, 2015). The gentrification process often happens in places where tourism urbanization is present, involving selling properties and replacing them by higher-standard residences.

On the other hand, segregation is a phenomenon that happens in new urban tourist areas and also in spaces originated from the "conventional" processes of sprawl, that is, from the demographic growth with high real estate speculation. In those cases, there is the emergence of new barrios spatially segregated from the pre-existent urban fabric, most of the time primarily accessed by car. These areas are also known as fortified enclaves, that is, "privatized, enclosed, and monitored spaces for residence, consumption, leisure, and work" (Caldeira, 1996, p. 303, our translation).

METHOD

To identify the permanent and transient spaces of the Urban Agglomeration of Florianópolis, we surveyed the proportion of vacant and occasional-use residences in the settlement, that is, those that do not have inhabitants or that have residents for a period regardless of the purpose (holidays, work, season, etc.), and the proportion of permanent residences. Transient spaces were those that have more than 50% of vacant housing and for occasional use. These data were obtained from IBGE census sectors (2022). They were spatialized on the urban agglomeration map, in a procedure carried out throughout QGIS software, version 3.12.22.

Transient spaces do not necessarily happen only in urban tourist areas. However, urban tourist spaces - considered here the urban fabric directly connected to bath areas and with a high predominance of occasional residences - corresponds to the most relevant portion of transient spaces, as conceptually pointed out by Macedo (1998).

In the second stage, we considered two neighbourhoods for analysis (figure 1), the first one is Pedra Branca, located at the continental portion of Florianópolis Urban Agglomeration, and classified as a permanent space. The second one is Jurerê, a neighbourhood located on the island portion, classified as a transient space. Both neighbourhoods originated from the process of metropolisation and intense urban sprawl that occurred from the 1970s onwards, differing significantly from the growth process originating from traditional subdivision.

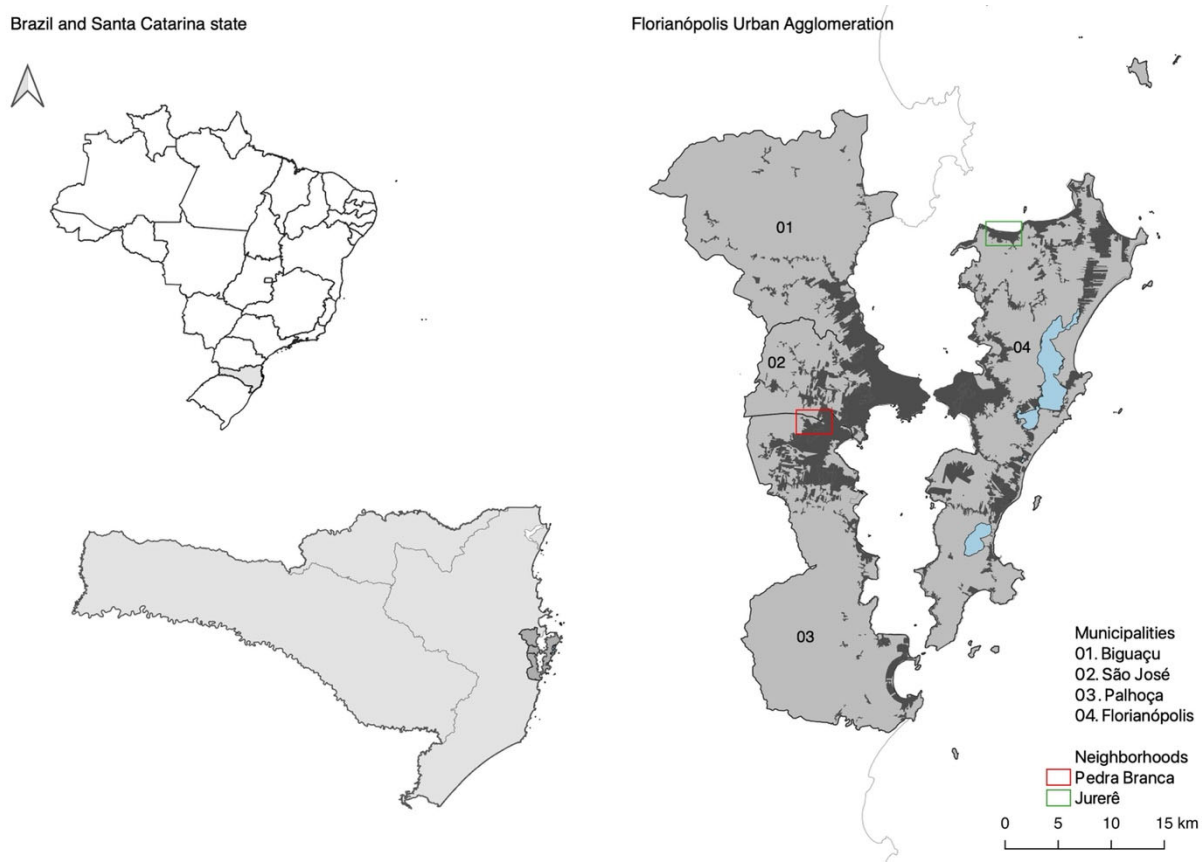

Figure 1. Jurerê and Pedra Branca neighborhoods in the context of Florianópolis Urban Agglomeration. Source: prepared by the authors based on the IBGE cartographic base (2022).

For the configurational analysis, the urban forma characteristics were correlated with functional and social aspects, among which were considered: a) the relation between accessibility, based on layout, and land use, finding how central in the neighborhood for the surroundings; b) the characteristics of the neighborhood and the surrounding buildings correlated with income levels, understanding if there is a trend towards gentrification or segregation; c) the connectivity between the road system and the surroundings, surveying the level of segregation present in both neighbourhoods.

For the first aspect, we linked Space Syntax Theory, specifically the global and local integration value, with the concentration of commerce and services. We measured local integration within an 800-meter radius, representing a 10-20-minute walking distance (Bueno, Reis, Saboya, 2017), and analysed the concentration of commercial and service establishments based on Areas of Interest identified in Google Maps, following the approach of Reis and Almeida (2023). To create the maps and define centrality areas, we used tools like the DepthMap plugin and the Google Terrain complement, both available in QGIS.

For the second procedure, we used Mapbox and Google Earth to identify the predominant building types in the neighbourhoods and in their surroundings. Additionally, we mapped income rates using census data from IBGE (2010) and spatialized this information on a QGIS map. By analysing the obtained information, we could assess the current levels of gentrification or segregation in Pedra Branca and Jurerê.

The last aspect we evaluated the connectivity level between both neighbourhoods to their surroundings. We surveyed the number of connections to Pedra Branca and Jurerê, through the connectivity index obtained using Space Syntax Theory, together with the walkability of these accesses, through photographic surveys. With this information we could understand how fragmented neighbourhoods are.

The purpose of this set of analyses is to verify how the permanent and transient spaces in the Florianópolis Urban Agglomeration, especially those of great relevance in the process of contemporary urban sprawl, interact with the building forms and the pre-existing urban fabric, observing and understanding configurational aspects inherent to the new context of urban sprawl. It is important to highlight that the qualitative analysis on the levels of centrality, the presence or absence of gentrification and segregation and how fragmented they have as a parameter the comparison between both locations.

RESULTS AND DISCUSSIONS

The Pedra Branca neighbourhood and its consolidation process

The Cidade Pedra Branca project, implemented in Palhoça, a municipality in the Florianópolis Urban Agglomeration, Santa Catarina, situated in the continental portion of the Agglomeration, as observed in the figure 2. Its consolidation became at the end of the nineties (1999), with the transformation of a family farm into a subdivision aimed at high-income classes out of the main upper-class axes of the metropolitan area.



Figure 2. The urban ambience (on left) and the urban fabric (on right) of Pedra Branca neighbourhood. Source: photo from authors and map prepared from cartographic bases from Prefeitura Municipal de Palhoça and satellite images from Google Earth (2022).

The monofunctional zoning with well-defined urban functions for work, housing, leisure and circulation prevailed in the first years of existence of the neighbourhood. Within the project, small and medium-sized industrial zones were also defined, thus meeting the high demand for this type of activity throughout the metropolitan region. Mixed use will only appear from 2013, in the so-called last stage (the biggest one), with the development of the central sector. The neighbourhood, planned

under the premises of multifunctional zoning, was inaugurated under a development aligned with the principles of New Urbanism (Reis, Menezes, 2015).

The Cidade Pedra Branca project was designed with the primary goal of utilizing human-scale principles to seamlessly connect public and private spaces, fostering a high quality of life that encourages the full use of public areas. Its form is composed of a radial grid, which starts from a square where the building blocks are clustered around it, thus configuring the road system. Regarding the occupation and land use, each block was designed to house buildings with up to 12 floors, where commercial units are distributed on the first floor, while the upper ones are destined for residential use. According to Reis and Menezes (2015), the designed public spaces have defined and continuous boundaries, with dimensions that match the intended activities. The boundaries of the streets and squares create a clear separation between public and private areas, connecting indoor activities, such as commerce, services, housing, with exterior collective spaces.

With the great real estate expectations generated, the neighbourhood presented, after its consolidation, as a centrality structure for the surroundings, as well as in the settlement. Aimed to guide urban sprawling, the neighbourhood improvement process relies on numerous contributions and compatibility of principles, with renowned consultants such as the urban planners Jaime Lerner and Jan Gehl.

Intense advertising promoted the sale of the neighbourhood, being mainly governed by the ideas of an alternative urbanism to the pre-established structures in the dispersed and fragmented surrounding territory. According to its creators, the space's configurational pillars include: a) walkable structure, where the number of blocks were designed to serve high-standard real estate developments, including housing, educational structures, services and essential businesses, b) sustainable city, with most of the buildings presenting ecological systems in their infrastructure, attracting investors and residents who are interested in this performance, c) neighbourhood for people, aimed to integrate the scale system between person and car, d) mixed uses and safe public spaces, offering shopping and leisure services at all times.

The Jurerê neighborhood and its consolidation process

Jurerê is a neighbourhood in the north of Santa Catarina Island, region where most part of the Florianópolis tourist urban space is situated. The communal lands that existed in the island, not useful for agriculture, gradually acquired economic importance and were privatized, with tourism having an important role in the appreciation of these lands (Reis, 2002).

The Jurerê urbanization project had as its main goal the consolidation of a region that is essentially aimed at the high-income population, with high-standard properties and a private offer of commerce and services (Siqueira, 2021). Its distinct urbanization model regarding other regions of the Santa Catarina`s island – where growth predominates based on the foundational grid and local roads with a herringbone layout (Reis, 2002) – can be considered one of the first resorts with planned urbanization in Santa Catarina.

Regarding the subdivisions, it refers to a configuration of "garden cities", composed of rectangular and large lots that are permeated by green areas among the buildings, as shown in figure 3. For Henrique (2005), some streets are located on a flat site (a marine terrace), causing problems of

drainage during rainy periods, which is incompatible with the project's propaganda, based on the combination between nature, infrastructure and several options and entertainment.



Figure 3. The urban ambience (on left) and the urban fabric (on right) of the Jurerê neighborhood. Source: photo from authors and map prepared from cartographic bases from Prefeitura Municipal de Florianópolis and satellite images from Google Earth (2022).

According to Mezzomo (2009), the urbanization process of the neighbourhood began with the division of its land into lots along the sand strip (east-west direction) and up to the Ratones river (north-south direction). Jurerê's urban fabric is structured into two portions. On the east side, the region is known as Jurerê Tradicional. The orthogonal grid urban layout was designed by the architect Oscar Niemeyer in the 1950s. The area is limited to the east by a hill (morro de Canajurê) and by a winding road from the colonial rural subdivision. On the west side, Jurerê Tradicional is currently integrated with the more recent portion, known as Jurerê Internacional. The subdivision of the urban fabric, also in a grid, occurred in the 1980s and was carried out by Grupo Habitasul.

The land use is predominantly residential, with a high concentration of commerce and services in two main regions: the first is in Jurerê Internacional, in Avenida das Raias (located in the north-south direction), which was specifically designed to be an open Mall, being accessed only by pedestrian. The second commercial area is in Jurerê Tradicional, where commerce is distributed along a set of streets and emerged in a more organic way compared to the first case.

The permanent and transient spaces in the neighborhoods of Pedra Branca and Jurerê

In the Urban Agglomeration of Florianópolis, areas with a high concentration of permanent residences are primarily situated on the mainland and parts of the island near the historic centre of Florianópolis, extending into its surroundings between the north and south bays of Santa Catarina Island and further inland. In contrast, coastal bathing areas are marked by a significant presence of occasional residences, predominantly located on the northern coast of the island, with the Jurerê neighbourhood standing out as a key area for these types of properties.

Figure 4 illustrates that, according to IBGE (2022), the 16 census sectors within the Jurerê neighbourhood have an average of 55.4% occasional residences. This percentage peaks at 78.3% in the central census sector, particularly in the area known as Jurerê Internacional. This seasonal

population pattern results in substantial fluctuations in the use of public spaces throughout the year, with a large influx of people during the summer and a significant decline in the winter. Seasonality causes a turnover of commercial establishments, as some are unable to maintain themselves during low season periods. Some establishments remain closed and only open in the summer which, on the other hand, means that the demand from people eventually exceeds the services offered in the region.

Pedra Branca exhibits a more permanent residential condition. Its six census sectors (figure 4) have an average rate of occasional residences of 12.3%, with the highest rate at 28.9%, in the residential portion, and the lowest at 6% (IBGE, 2022). The lowest concentration of occasional residences corresponds to the "heart" of the neighbourhood, where mixed use can be found, with a variety of commerce and services. Unlike Jurerê, in the Pedra Branca neighbourhood, commerce remains at an intense pace throughout the year, with a high flow of people, especially on weekends. Commerce has less turnover, highlighting the constant expansion of the neighbourhood's centrality.

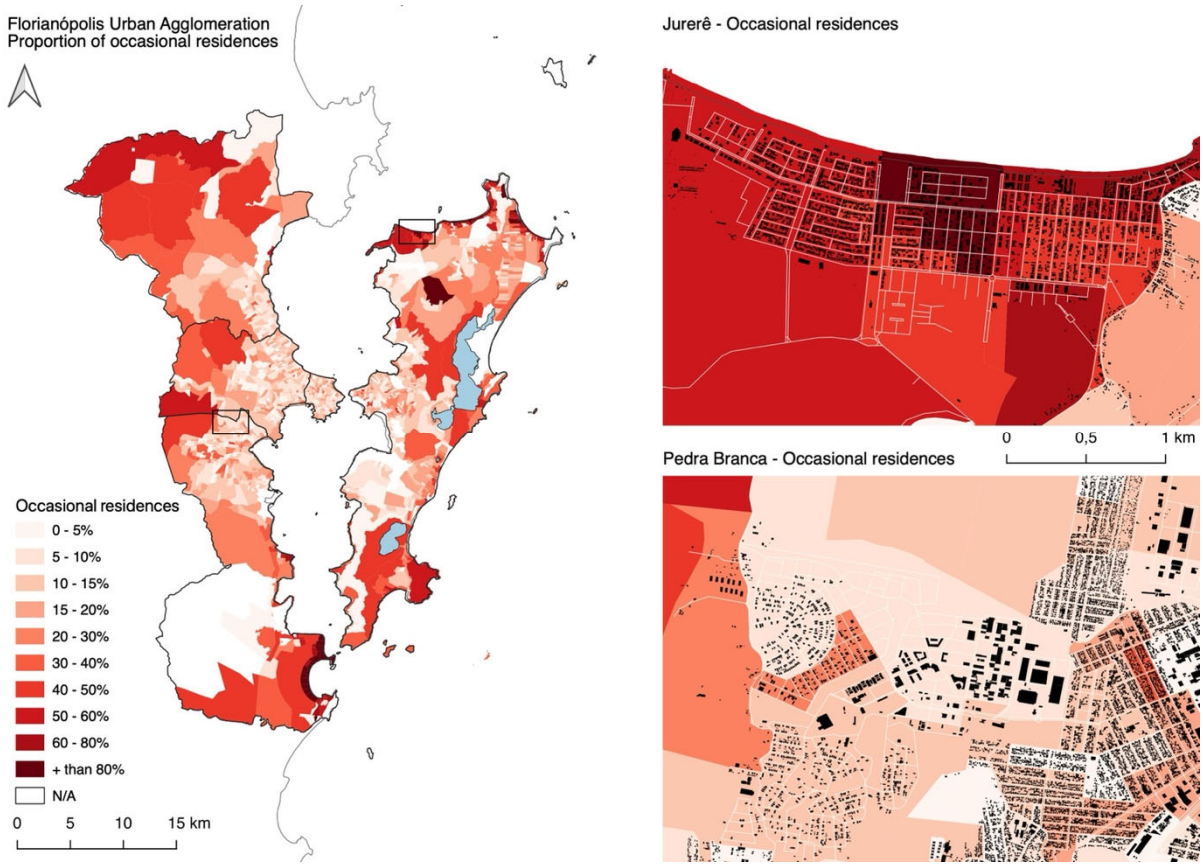

Figure 4. Proportion of permanent and occasional residences in Florianópolis Urban Agglomeration (on left), in Jurerê (on right-above) and in Pedra Branca (on right-below). Source: map prepared from cartographic bases from municipal records (Florianópolis, São José, Palhoça and Biguaçu) and from IBGE (2022).

The accessibility in the neighbourhoods of Pedra Branca and Jurerê

As shown in the map of figure 5 (on left), the integrating nucleus of the Florianópolis Urban Agglomeration, representing the 10% most accessible axial lines in the settlement - based on global integration value - is strategically located at the intersection of the BR-101 and BR-282 highways. This area extends the adjacent urban fabric on the continental portion of the settlement, characterized by a grid-like structure. However, when examining areas with high local integration value, within an 800m radius, shown on figure 5 (on right), high accessibility is not conditioned only to this region. Instead, it

appears in a dispersed manner across the island and other parts of the continental portion, in various dimensions, highlighting the process of polycentric development (Almeida, Reis, 2023).

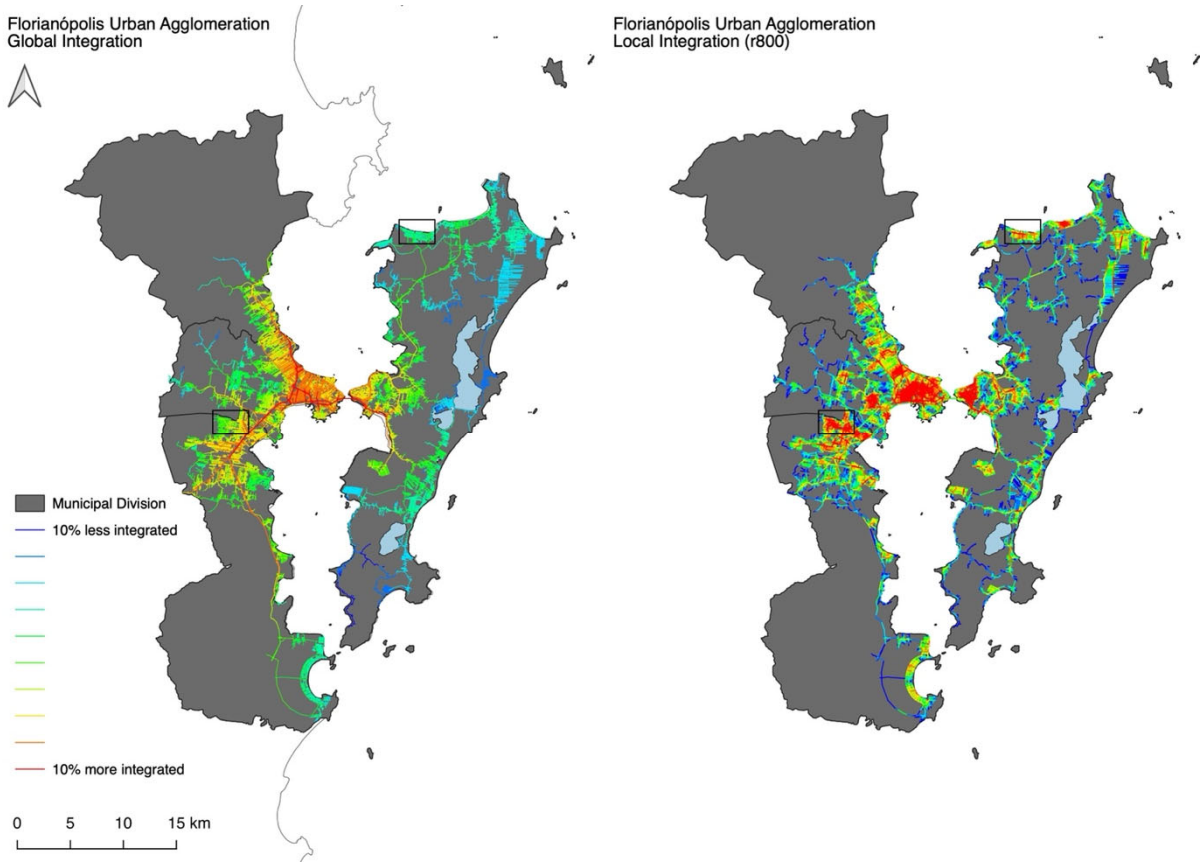

Figure 5. Global integration map (on left) and local integration map using an 800 meter-radius (on right). Source: map prepared from cartographic bases from municipal records (Florianópolis, São José, Palhoça and Biguaçu).

Both Pedra Branca and Jurerê, though not situated in the integrating nucleus of the Florianópolis Urban Agglomeration, feature an axial system that largely falls within the top 30% of locally integrated structures, based on an 800-meter radius. The axial lines in these neighbourhoods typically range between 66 and 131 on a scale of 0 to 255, where lines closer to 0 are the least integrated and those near 255 are the most integrated.

This spatial configuration indicates that Pedra Branca and Jurerê neighbourhoods have a strong potential to develop local centralities, as evidenced by the high concentration of commerce and services observed in Google Earth's Areas of Interest, indicated in figure 6. Unlike other parts of the city, where centrality evolved gradually, these purposefully designed neighbourhoods stand out in terms of layout, building volumetry, and income levels, making them more conducive to economic dynamism.

In Pedra Branca, while the surrounding areas also exhibit high local integration, the concentration of commercial establishments is particularly notable in the neighbourhood's core, where it also presents institutional use, with the presence of a private university. The surrounding regions are primarily residential, with some industrial zones. Here, accessibility is on par with other socio-spatial factors, such as income levels, population density, and the design of the core buildings, which feature

commercial spaces on the ground floor and residential units above. In contrast, Jurerê's geographic isolation makes accessibility the key factor for the concentration of commerce in its central area, despite its "central region" being designed with a similar building layout and mixed-use distribution as in Pedra Branca.

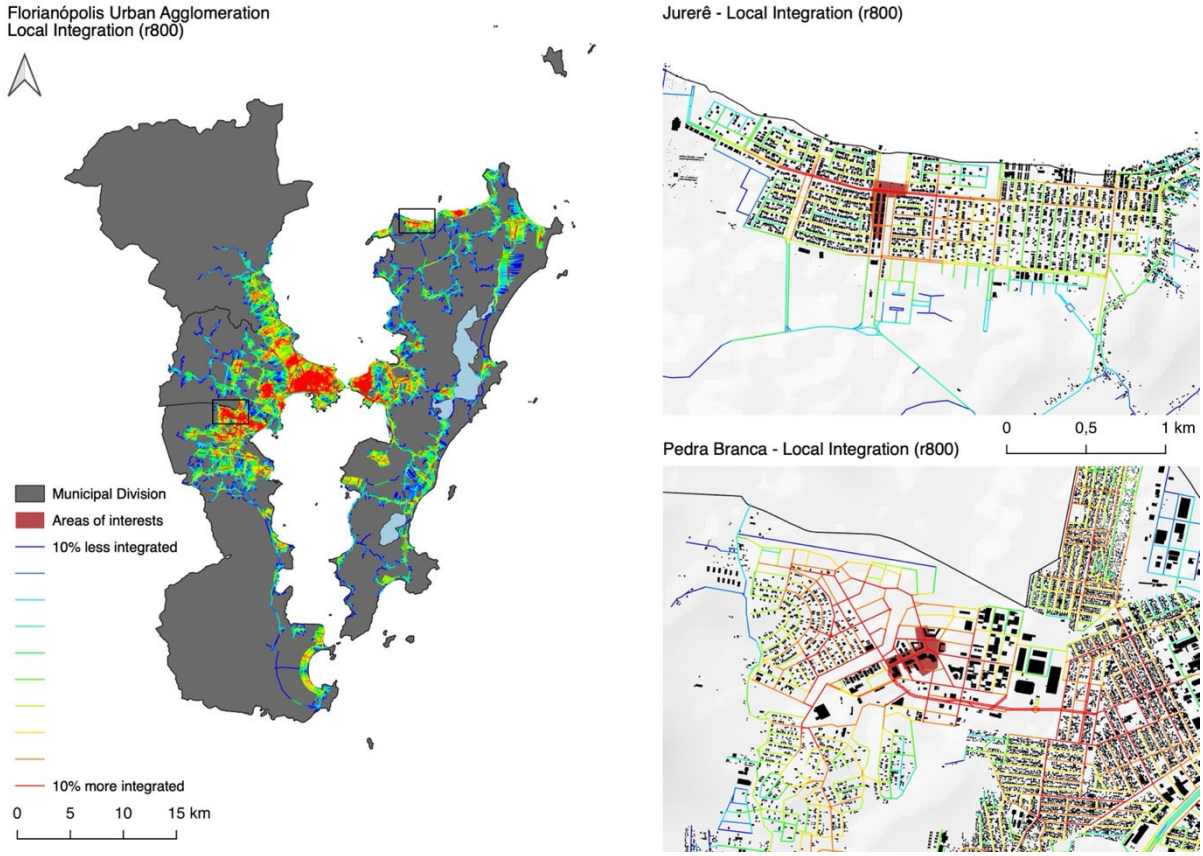

Figure 6. Local integration map (on left) and local integration map in Jurerê and Pedra Branca(on right). Source: map prepared from cartographic bases from municipal records (Florianópolis, São José, Palhoça and Biguaçu).

Urban form and income in the neighborhoods of Pedra Branca and Jurerê

The income map (Figure 7), based on IBGE census sectors (2010), shows that in the Florianópolis Urban Agglomeration, the highest concentration of high-income groups is found on the island portion. While the island's urban area has an average income of R$ 10,818, the mainland portion has an average income of R$7,042. Florianópolis has the highest incomes due to a large portion of its territory being concentrated on Santa Catarina Island, combined with its status as the state capital – factors that attract high-income groups to choose this location for permanent residence and/or real estate investments.

However, this "locational advantage" of Florianópolis does not impede high-income populations from being concentrated in the continental portion. According to the income map of the Florianópolis Urban Agglomeration (IBGE, 2010), the census sectors that make up the Pedra Branca neighbourhood have an average household income of R$20,452, while the average in Jurerê is R$10,256. Despite Pedra Branca having an average income twice as high as Jurerê, both neighborhoods are among the wealthiest regions of the Florianópolis Urban Agglomeration, which, in turn, has a household income range that varies between R$848 to R$46,233 across the urban census sectors.

The concentration of high socioeconomic strata in these neighbourhoods creates a clear socioeconomic barrier between them and their surrounding areas. This phenomenon is particularly pronounced in Pedra Branca, where low-income regions are found nearby. For instance, the Frei Damião community, located just 200 meters away from the centre of Pedra Branca, is one of the poorest areas in the Florianópolis Urban Agglomeration, with an average income of only R$1,985 in its poorest census sector (IBGE, 2010). Jurerê, geographically isolated, borders areas primarily consisting of fishermen's residences. In both cases, there is minimal interaction between social classes, a division that is further deepened by the transient nature of the higher-income population in Jurerê.

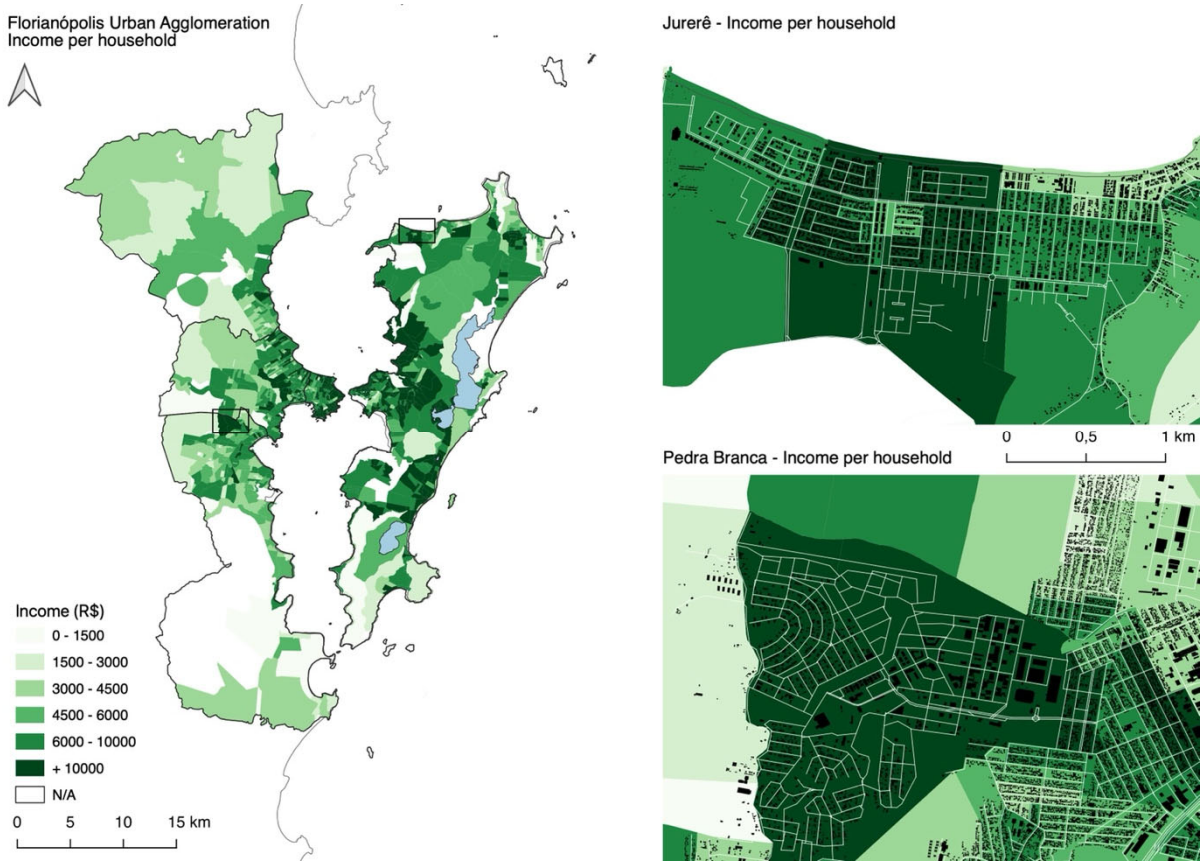

Figure 7. Income distribution map in Florianópolis Urban Agglomeration (on left), in Jurerê (on right-above) and in Pedra Branca (on right-below). Source: map prepared from cartographic bases from municipal records (Florianópolis, São José, Palhoça and Biguaçu) and from IBGE (2022).

The configurational attributes in Pedra Branca and Jurerê neighborhoods: synthesis of the analysis

When considering the characteristics of the urban form, permanence and transience, and income conditions in Pedra Branca and Jurerê, we can observe some similarities and differences in the socio-spatial configuration of these neighbourhoods. Table 1 outlines the main conditions related to the analysed attributes:

Table 1. Main socio-spatial attributes of the neighbourhoods of Pedra Branca and Jurerê. Source: prepared by the authors.

Neighbourhoods	Urban form	Land use	Permanent and transient spaces	Income profile
Pedra Branca	High local integration and low global integration, urban layout in a radial grid (from its centre) and volumetry composed of high-standard residences and multifamily and mixed-use buildings in the neighbourhood centre.	Predominantly residential neighbourhood, with the presence of mixed and institutional use in its centre.	Neighbourhood composed predominantly of permanent-use residences, representing 88.7% of the residences. The neighbourhood has low seasonality.	High-income neighbourhood, with an average income of R$20,452 per residence. It is almost twice the average of Jurerê.
Jurerê	High local integration and low global integration, layout in an orthogonal grid, volumetry composed of high-standard residences and multifamily and mixed-use buildings in the neighbourhood centre.	Predominantly residential neighbourhood, with the presence of mixed-use in its centre.	Neighbourhood composed predominantly of occasional-use residences, representing 55.4% of the residences. The neighbourhood has high seasonality.	High-income neighbourhood, with an average income of R$10,256 per residence. It is comparable to the average of the Island of Santa Catarina.

CONCLUSIONS

In the context of the Florianópolis Urban Agglomeration, Pedra Branca and Jurerê are neighbourhoods with low global integration. Both are high-income areas but differ in some characteristics: Pedra Branca is oriented towards local activities with many permanent residences, while Jurerê is primarily transient and focused on tourism activities.

Their configurational structures result in well-succeeded functional performance, with concentration of commerce and services, creating important local hubs. However, they also have high socio-spatial segregation, Pedra Branca due to its minimal road connections with surrounding areas, and Jurerê because of its geographic isolation.

The layout and initial plans for Pedra Branca and Jurerê reflect the preferences of the dominant classes, who seek high-quality housing, leisure, services and security. This dynamic highlight the socio-spatial division: high-income areas have high local integration with good services and amenities, while their surroundings often face infrastructure issues, intensifying urban segregation.

Although the Pedra Branca neighbourhood sells the proposal of integration between the different uses by several social classes, there are factors that must be presented as contrary: such as the disconnection of the surroundings, especially the urban mobility, giving scope to urban voids, which are being valued by real estate speculation. Jurerê, on the other hand, was deliberately designed as an “oasis” within the urban environment, where its seclusion and commercial establishments focused on high-income strata restrict, somewhat, the access to the beach, a space considered public under Brazilian law.

It is essential to consider integrating these neighbourhoods with their surroundings, as they have favourable configurational characteristics compared to other city areas. Public policies that incorporate less privileged groups both in terms of housing and the use of their public spaces could enhance urban diversity and reduce inequalities driven by the real estate market.

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Precarious Occupations in Brazil: dialogues between urban form and nomenclatures

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ABSTRACT

This article broadens the discussion on the relationship between nomenclature and urban form in precarious occupations in Brazilian cities. The aim is to analyses whether the terms "Favelas" and "Urban Communities," recently adopted by the Brazilian Institute of Geography and Statistics, can be applied generically considering the diversity of these areas. The study conducts a comparative analysis between an "Área Livre" in Osasco, São Paulo, and a "Ressaca" in Macapá, Amapá. The methodology involves mapping data such as location, occupation duration, built environment characteristics, housing typologies, and urban infrastructure into an analytical matrix to assess their alignment with the locally used nomenclature. The findings suggest that a specific nomenclature, recognized by both residents and municipal administration, can improve the identification and quantification of these areas, aiding in the development of public policies aimed at enhancing living conditions in precarious occupations.

Keywords:

INTRODUCTION

Precarious and informal occupation in urban areas, often referred to as "favela", is a phenomenon rooted in Brazil's history, reflecting the social and urban complexities that have developed over more than a century. From the end of the 19th century, favelas began to form in large Brazilian cities, such as Rio de Janeiro, highlighting both the lack of urban planning and the persistent social exclusion that affected a large part of the population. Over time, the terminology for these areas has evolved, significantly influencing how these occupations are perceived and treated both by society in general and by public policies.

This study critically analyses the different names used to describe precarious occupations in Brazilian cities, examining how the terms "favelas" and "urban communities", recently adopted by the Brazilian Institute of Geography and Statistics (IBGE), do or do not capture the diversity and complexity of these territories. The three-dimensional analysis methodology proposed by Tessari (2016) is used to

demonstrate that the generalization of the term "favela" can obscure the regional and cultural particularities of these occupations, making it difficult to formulate appropriate public policies.

Through the case study of two different areas - Jardim Vicentina, an occupation of public areas in eight allotments in the Jardim Roberto district in Osasco, SP, in the Southeast region, and *Ressaca* Chico Dias, an occupation of public areas in the Amazon, made up of stilt houses in Macapá, AP, in the North region - the aim is to establish a deeper understanding of the socio-spatial dynamics that characterize precarious occupations in different regional contexts in Brazil, contributing to the formulation of public policies that are more aligned with the needs of the resident populations.

The article is structured in several sections. Firstly, it presents a summary of the evolution of the term "favela" in Brazil; then it analyses the specificities of precarious areas in the cities studied, addressing aspects such as location, time of occupation, structure of the built environment, housing typologies, urban infrastructure and origin of the population. In the third part, an analytical matrix is used to compare the divergences and convergences between the nomenclatures used by the population and the municipal authorities, relating them to the terms adopted by the IBGE.

The comparative analysis of the two cases suggests that the nomenclature, when established by the municipal administration and adopted by the population, directly reflects the territory occupied, facilitating the formulation of public policies and the development of projects aimed at improving the lives of the population of these settlements.

FAVELAS IN BRAZIL: Terminologies and relationships with urban form

Precarious occupation in urban areas, commonly known as "favela", is a complex and historically rooted phenomenon in Brazil. Since the end of the 19th century, these occupations have been consolidated in large cities such as Rio de Janeiro, reflecting the lack of urban planning and the social exclusion of a large majority of the population.

The term "favela" originated in the context of the accelerated urbanization of Rio de Janeiro, and was initially associated with Morro da Favela, where ex-combatants from the Canudos War settled. As detailed by Backheuser (1906), the housing conditions of the poor in Rio de Janeiro in 1906 were extremely precarious, with many living in overcrowded tenements in the city centre. Modernization policies, such as the Pereira Passos Plan (1902-1906), resulted in the demolition of tenements and the forced migration of the poor, encouraging the occupation of the hillsides that formed the physical structure of the city, and thus the creation of the first favelas.

Although the term "favela" originated in Rio de Janeiro, this form of occupation spread to several Brazilian cities, such as Salvador, Recife, Belo Horizonte and, later, São Paulo and Brasília. The IBGE (2011) adds that these occupations are called in various ways in different municipalities, including terms such as "invasão", "grota", "baixada", "comunidade", "palafita", among others, becoming synonymous with precarious housing for the poor, perpetuating stigmas that have directly influenced public policies.

In the 1950 Demographic Census, the Brazilian Institute of Geography and Statistics (IBGE) proposed the official definition of favelas, a term used to describe irregular settlements in urban areas, characterized by unauthorized occupation of the land, lack of basic infrastructure and precarious housing (Valladares, 2012). During this same period, engineer Passos Guimarães played a key role in

defining the favela and associating it, for the first time, with the idea of irregular land ownership. Guimarães described favelas as areas of popular housing on illegally occupied land, without proper land regularization, and with improvised constructions, without access to essential urban services such as water, sewage and electricity. This direct link between favelas and irregular ownership reinforced the social and institutional stigma that came to accompany these areas, consolidating the view that favelas were an urban 'anomaly' to be combated.

Based on this definition, consolidated in the 1950s, land irregularity became one of the main criteria for characterizing slums, in addition to precarious physical and infrastructural conditions. In the 1991 Census, the IBGE continued to use the term 'subnormal agglomerations', classifying them as areas with at least 51 housing units that simultaneously lacked essential public services and had irregular land occupation. This concept continued to be used in the 2010 Census, but new debates arose about the appropriateness of the term, as different regions and municipalities adopted alternative names, seeking to avoid the stigma associated with favelas. Pasternak (2008) argues that despite the evolution of nomenclatures, the term "favela" continued to be widely used, perpetuating prejudices and negatively influencing the formulation of public policies. As research progressed, the specificities of precarious occupations were recognized and, depending on the location and the physical and legal characteristics of each area, occupations were given different names by public bodies.

The terminology has evolved, and many municipalities have opted to use other names to avoid the stigma associated with the term "favela". Costa and Nascimento (2005) documented the various nomenclatures adopted in the main Brazilian capitals, which vary according to local policies and the characteristics of the areas.

In 2007, the Ministry of Cities (Marques, 2007) adopted the generic term "precarious settlement", highlighting the spatial peculiarities and precariousness of these occupations. Regardless of the methodology adopted, based on the way in which the municipalities and resident populations called the occupations, the adjective alluding to precariousness remained, denoting the need to act on the physical, social and land needs of each one.

Despite the publication of this document and the debate on it, which served as a reference for the creation of this type of action within the Programa de Aceleração do Crescimento (BRAZIL, 2007), the IBGE continued to use the term Subnormal Agglomerations and the same methodology for surveying and quantifying the population and living conditions in precarious occupations in Brazil.

In 2022, the Ministry of Cities' Peripheral Territories Secretariat organized a working group to review the conceptualization of precarious occupations in cities. The aim was to recognize these areas as an integral part of the city and to differentiate between the autonomous and collective strategies of the population to meet their housing needs in the face of insufficient public policies.

The results of the study confirmed the diversity of names for precarious occupations, such as "favelas", "comunidades", "quebradas", "vilas", among others, reflecting geographical, historical and cultural differences. The IBGE therefore revised the nomenclature of these areas, proposing "favelas" and "urban communities" as broader and more inclusive terms (IBGE, 2022). However, the ability of these terms to capture the complexity of Brazilian urban realities, especially considering regional and cultural variations, remains a matter of open debate.

The spatial diversity of Brazil's precarious occupations and their different urban forms demand continuous reflection on how nomenclatures can help or hinder the formulation of policies that truly respond to the needs of their residents.

Consolidating the terms "favelas" and "urban communities" as broad concepts that incorporate the multiplicity of names given to territories seems to us to be a standardization that does not consider the form and regional and cultural characteristics of each location.

According to IBGE data from 2019, Brazil had 13,151 subnormal settlements, housing 5,127,747 households, currently known as favelas. The Northern region, where Amapá is located, showed the greatest proportional growth in the number of households in favelas compared to 2010, with an increase of 48.6%. In 2019, the region was home to 299,262 households in subnormal settlements. Macapá, for example, registers a peculiarity in its informal occupations, known as "*ressacas*", made up of dwellings on stilts in flooded areas, which differ significantly from the traditional favelas found in the Southeast region, where the absolute number of households in favelas is the highest in the country, with 3,093,760 units. The Southeast, despite having registered a lower growth in percentage terms (12.2 per cent), is still the region with the highest number of slum dwellings in Brazil. These regional differences reflect the different adaptations to the environment and the cultural and economic specificities of each area.

Understanding urban form and how the nomenclature used to describe it influences social perception and the formulation of public policies is one of the aims of this research. Tessari (2016) proposes that the urban form of favelas can be analyzed based mainly on three dimensions: public space, plot and building. Each of these dimensions offers a unique perspective for understanding how favelas are structured and function, as well as how the different nomenclatures used to describe them influence perception and intervention. How can analyzing these three dimensions contribute to a more appropriate nomenclature that captures the complexities and specificities of favelas? How can the definition of terms affect urban development and public policies aimed at these areas?

Despite this attempt at unification, the debate about the suitability of these terms to capture the complexity of Brazilian urban realities continues, especially in the face of regional variations, such as the "*ressacas*" in Macapá and the "palafitas" in the Amazon. It is argued that the use of two terms can return to the difficulty of definition and quantification, negatively impacting the formulation of public policies. A single term, established through an in-depth study that considers the specificities of each municipality, could avoid generalization and promote more effective interventions aligned with local needs.

These variations in terminology not only reflect Brazil's geographical and cultural diversity, but also have implications for the urban form of these occupations. Do the different names influence the perception of the spatial organization of favelas? How do these nomenclatures impact on the way public spaces, plots and buildings are viewed and treated by public policies? To what extent do these terminological changes reflect a reconfiguration of the urban form of these areas? And by changing the name of a settlement, do we also change its spatial perception and the solutions proposed for its regularization?

It is understood that the nomenclature used to describe precarious occupations is not just a technical issue, but also reflects the power relations that structure urban space. As Pasternak (2008) observes,

the choice of terms such as "favelas", "subnormal agglomerations" and "precarious settlements" directly influences public policies and the social perception of these areas. The language used to describe these urban phenomena has the power to shape social realities, legitimizing or delegitimizing ways of life and, consequently, impacting urban intervention and inclusion in the urban fabric. So how does the urban form of these favelas influence and is influenced by the terminology used? How does the spatial organization of favelas impact urbanization and land regularization policies?

Jardim Vicentina: One of the cases of precarious occupation in Osasco, SP

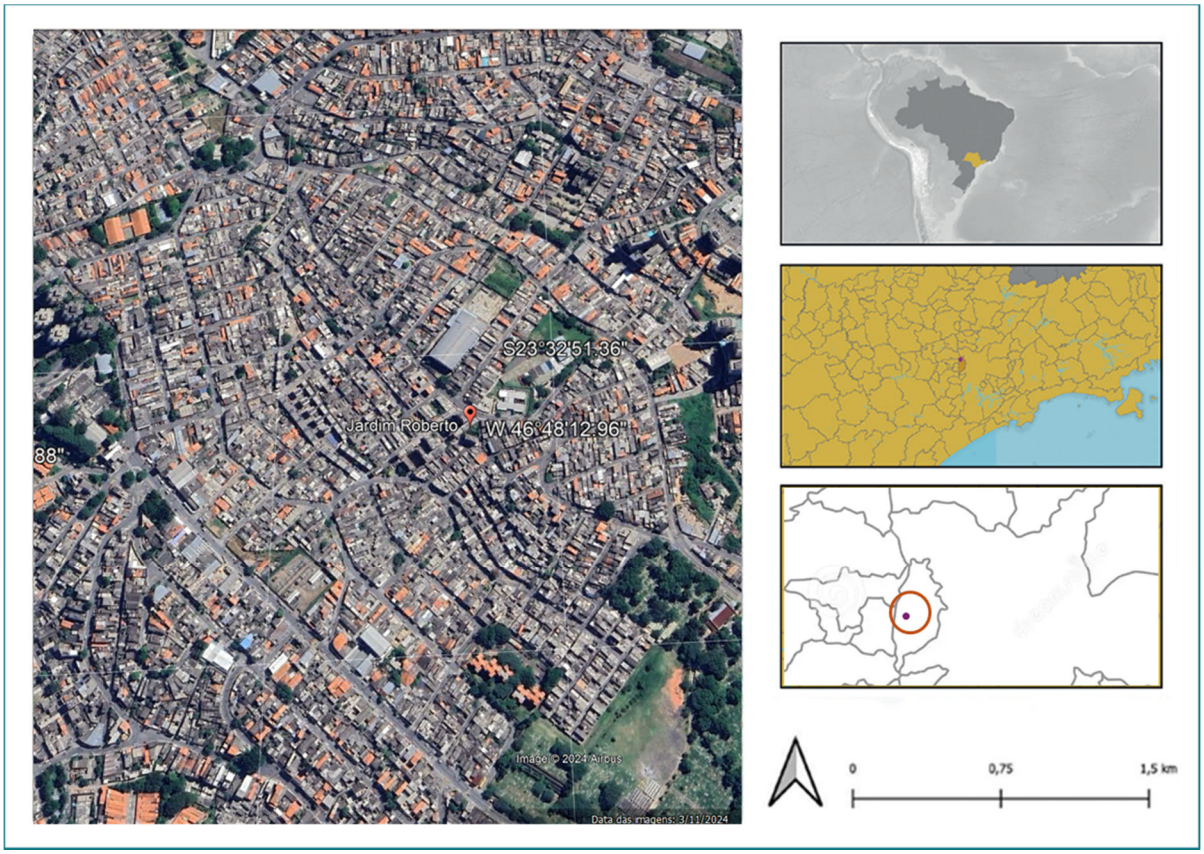

Figure 1: Location of Osasco in the São Paulo Metropolitan Region. Image credit: Prepared by Ivan Alves Pereira from BC 250 IBGE (2019) on Google photo (2020) in Alvim and Rubio, 2022

Located in Osasco, Jardim Vicentina is an emblematic example of the challenges faced by the municipality in terms of precarious occupation and housing policies. Osasco, which was emancipated from São Paulo in 1962 and quickly became an industrial hub in the São Paulo Metropolitan Region (RMSP), inherited uneven development patterns and significant shortcomings. The city's rapid growth, driven by industrialization and internal migration, resulted in disordered urbanization, especially in areas unsuitable for formal urbanization.

The occupation arose in the midst of the city's accelerated growth and urbanization. Classified as a "free area", it has occupied the public areas of eight allotments in the Jardim Roberto district since the 1970s (SEHDU/PMO, 2012).

The "free areas", as defined by the municipality of Osasco, are public lands intended for common use, but which, due to a lack of supervision and pressure for housing, were gradually occupied by low-

income populations. The lack of urban infrastructure, combined with the location on a valley floor and proximity to watercourses, created a highly vulnerable scenario for residents, who faced constant risks of landslides and flooding.

Urban Form of Jardim Vicentina

The urban form of Jardim Vicentina is marked by disorderly occupation and the absence of formal urban planning, consisting of a fragmented structure where plots are irregular and often located on risky land. Access roads are narrow and poorly defined, with alleys that make it difficult for vehicles to circulate, including emergency vehicles. The lack of paving and proper drainage contributes to the degradation of urban conditions, especially during the rainy season, when there is frequent flooding. The urban form of Jardim Vicentina has a direct impact on residents' quality of life.



Figure 2: Shape of occupation in Sections 1 and 3 of Jardim Vicentina, Osasco in 2006. Image credit: RUBIO, 2017

The occupation along the valley floor and on the banks of the stream defines the morphology of the occupation, which is segmented into three main sectors:

Section 01: located in a more elevated and less vulnerable area, it has relatively regular spatial organization, with plots of varying size, but with some regularity in the layout of the houses. The buildings are predominantly masonry, but despite being the most consolidated in the district, they still face challenges such as insufficient sanitation infrastructure and a lack of adequate public spaces.

Section 02: located in an area of steep slopes, this sector has a chaotic spatial organization, with houses built without following a defined pattern or orientation. The steepness of the terrain

aggravates the problems of instability, resulting in frequent landslides. Most of the houses are built with precarious materials and without adequate foundations, which compromises structural safety.

Section 03: located at the bottom of the valley and close to the stream, it has the most critical urban form. The chaotic layout of the housing, especially in the most vulnerable sectors, contributes to unhealthy conditions and makes it difficult to provide essential public services such as rubbish collection and medical care. Improvised dwellings, built with scraps of wood and fiber cement roof tiles, occupy narrow alleyways, often encroaching on areas that should be set aside for environmental preservation. The unhealthiness was exacerbated by the direct discharge of sewage into the stream and the accumulation of rubbish, which was often deposited in the watercourse by the residents themselves (RUBIO, 2017).

In 2005, the Área Livre was home to approximately 865 households, with an estimated population of 3,148 residents, most of whom were migrants from the Northeast. Of the total number of residents, 31 per cent had bought the land and built their homes, while another 17 per cent had bought homes that had already been built. The disorderly occupation resulted in a occupation with a high population density, poor infrastructure and significant environmental risks (SEHDU/DTS, 2007).

In addition, the lack of public spaces and communal areas reduced opportunities for social interaction and community development. The lack of green areas and the disorderly occupation of the valley floor compromise the environmental sustainability of the occupation, exacerbating the problems of pollution and soil degradation.

The Comprehensive Urbanization Project

In response to the challenges posed by the urban form of Jardim Vicentina, the Osasco city council drew up and implemented a comprehensive urbanization project in 2007. This project included the canalization of the stream with the installation of a road, organizing the occupation along it, the installation of basic sanitation infrastructure, such as water supply, sewage and electricity supply networks, and the construction of housing units to resettle the families who lived in the risk areas and the creation of leisure and living areas.

The urbanization work and the entire process of removing and resettling families was carried out with funds from the Federal Government's Growth Acceleration Programme (PAC), supplemented by municipal funds between 2010 and 2015, with the aim of not only improving the occupation’s infrastructure, but also mitigating environmental risks and promoting the social integration of residents.

Despite the progress made with the comprehensive urbanization project, numerous challenges remain, such as the extremely complex land regularization process, which is hampered by the historical disorderly occupation and the lack of proper land documentation. In addition, the maintenance of the infrastructures put in place requires continuous investment and the active participation of the community to guarantee the sustainability of the improvements made.

As such, Jardim Vicentina remains a symbol of the challenges faced by Osasco in its housing policy, and although the living conditions of many residents have improved significantly, the need to complete the land regularization process, as well as the need for additional urban interventions,

remains crucial to the effective transformation of this and other precarious settlements in the city (RUBIO, 2017).

Ressaca Chico Dias: A Portrait of Precarious Occupation in Macapá, AP

Located in the city of Macapá, the capital of the state of Amapá, the *Ressaca* Chico Dias is a clear example of the urban challenges faced in the Brazilian Amazon. The occupation of the Amazon has been shaped by a series of economic and governmental factors over time, from the first contacts with external societies to major natural resource exploitation projects. These processes have often overlooked traditional populations and resulted in urban areas deeply marked by social exclusion and a lack of planning. Macapá, like many other Amazonian cities, emerged from this context of exploitation and colonization, and the *ressacas* represent a peculiar form of precarious occupation in this region (CARVALHO, 2020).

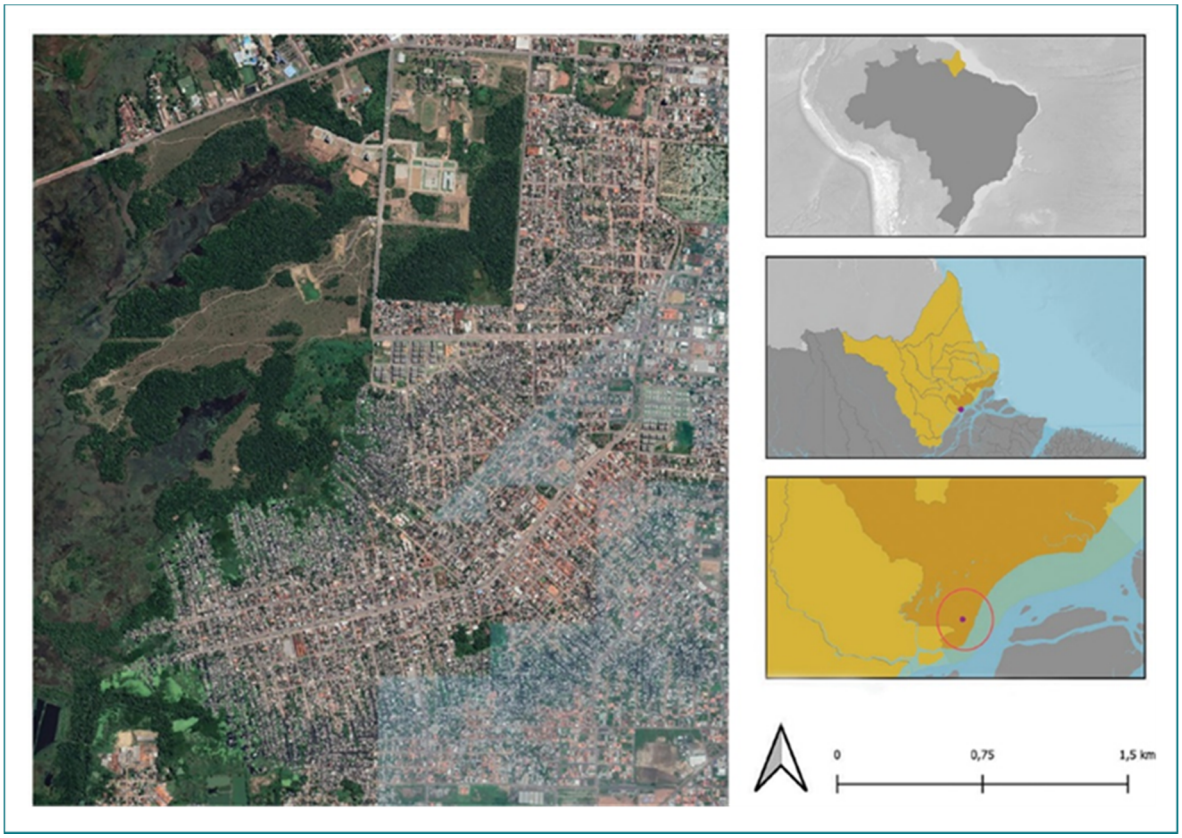

Figure 3: Location of the Chico Dias ressaca from BC 250 IBGE (2019) on Google photo (2020). Image credit: Prepared by Ivan Alves Pereira from BC 250 IBGE (2019) on Google photo (2020) in Alvim e Rubio, 2022.

Macapá's Context and Development

Macapá, located at the mouth of the Amazon River and part of the Legal Amazon, is one of the few Brazilian capitals without a direct road link to other capitals, accessible only by air and water (DRUMMOND; PEREIRA, 2007). This unique geographical location, combined with rapid population growth since the 1990s, has brought significant challenges for the city's urbanization. Disorganized expansion and the irregular occupation of land, especially in *ressaca* areas - naturally flooded zones close to the best urban infrastructure - became commonplace as immigrants from various parts of

Brazil, especially the Northeast and Pará, arrived in search of better living conditions (ANDRADE, 2005).

Urban Form of the Ressaca Chico Dias

Chico Dias, located in an environmental protection area, represents a microcosm of the complex social, economic and environmental interactions that permeate the lives of its inhabitants. Situated in the districts of *Novo Buritizal* and *Congós*, next to the Fortaleza Igarapé, it exemplifies the peculiar urban form of *ressacas* in Macapá. These areas are characterized by stilt houses, built on flooded land and connected by wooden bridges. The lack of basic infrastructure, such as sanitation and water supply, contributes to the proliferation of diseases such as dengue fever and malaria, as well as high rates of hepatitis. The urban form of Chico Dias is defined by a linear spatial organization, where the houses, mostly made of wood, line up transversally from the access bridges, occupying a flooded area (AGUIAR, SILVA, 2003).

This spatial arrangement reflects the need to adapt to the flooded environment, but also exacerbates the conditions of insalubrity and social isolation. According to data from, around 82.2 per cent of residents access their homes via bridges, while 12.3 per cent arrive by dry roads, and a small percentage (2.7 per cent) have to cross flooded paths. The prevalence of stilts and the lack of proper urban planning result in a high population density in vulnerable areas, where buildings are often made of improvised materials such as wood and fiber cement tiles.

The Chico Dias *ressaca* is home of a population that depends mostly on informal activities for its livelihood. With a high unemployment rate, 63 per cent of families have at least one unemployed member, and most residents earn no more than a minimum wage. This precarious economic reality is reflected in the infrastructure of homes, which are often built with cheap materials and lack the minimum conditions for habitability. Around 79.5 per cent of homes are made entirely of wood and are in flooded areas, which contributes to the deterioration of living conditions (CARVALHO, 2020).



Figure 4: The urban form of Ressaca Chico Dias. Images credit: CARVALHO, 2020 in ALVIM and RUBIO, 2022

In addition to precarious housing, the urban form of the *Ressaca* Chico Dias also negatively affects access to essential public services. Rubbish collection, although considered satisfactory by 64.4 per cent of residents, contrasts with the critical situation of sanitation and water supply. With 74 per cent of households having no access to sewage treatment and water quality often considered poor, residents are forced to seek alternative and often unsanitary solutions for their basic needs.

Education and health in Chico Dias also face significant challenges. While 57.5 per cent of residents consider local schools to be of reasonable quality, the situation regarding health services is more worrying, with 45.2 per cent of citizens evaluating their quality as regular. Inadequate access to medical care and limited educational infrastructure aggravates already precarious living conditions, perpetuating a cycle of poverty and social exclusion (CARVALHO, 2020).

Although there are isolated efforts to improve living conditions in Chico Dias, such as the construction of some basic infrastructure and the limited provision of government assistance programmes, the need for a comprehensive urbanization project is urgent. This project should include land regularization, the restructuring of the urban form to reduce the vulnerability of housing to flooding and the implementation of essential public services such as sanitation, water supply and rubbish collection, as well as actions that address the precariousness of housing in order to improve living conditions. Without planned and continuous intervention, the disorganized urban form and living conditions in the Chico Dias lagoon will continue to perpetuate the social and environmental vulnerability of its population.

URBAN FORM AND NOMENCLATURES: a discussion of case studies

By analyzing the data for the Jardim Vicentina occupations in Osasco and the *Ressaca* Chico Dias occupations in Macapá shown in tableau 1, we can identify both points of similarity and specificities

that reflect the geographical, social and cultural conditions of each region. These elements are crucial to understanding local dynamics and urban form.

Tableau 1: Aspects of the settlements. Data credits: Rubio, Alvim and Carvalho, 2024

ASPECTS	SETTLEMENT	
	JARDIM VICENTINA	CHICO DIAS
Country Region	Southeast Brazil	Norte do Brasil
Localization	Urban area	Urban area
Climate	subtropical	equatorial
Resident Population	3,148 residents	De 400 a 500 residents
Population origin	Northeastern migrants	Migrants of Belém do Pará
Time of occupation	30 years	40 years
Form of occupation	Valley bottom inserted in the formal city grid	Flooded areas within the urban grid
Housing Type	Self-built housing, predominantly in masonry	Self-built dwellings, predominantly made of wood
	in many cases overlapping.	on stilts (palafitas)
Public Space	Fragmented, with narrow paved streets and alleys and staircases	Bridges connecting the accesses to the houses. There are no public facilities. The difference between public and private spaces is made possible by a portal installed at the entrance to the houses.
Land Situation	Occupation of public areas in 8 allotments	Occupation of an environmentally protected public wetland area
Block/Lot	The blocks and lots are not defined and are irregularly installed on slopes and valley bottoms, with dense and disorderly occupation.	Lots adapted to flooded areas, with linear layout within the Igarapés
Urban infrastructure	Precarious and insufficient	Precarious and insufficient
Environmental Risk	Areas at risk of landslides and flooding	Risk of flooding and proliferation of water-borne and endemic diseases diseases such as malaria and dengue fever
Social Conditions	Population with an average income of 1 to 2 minimum wages and low level of education	Population with an average income of 1 minimum wage and low level of education
Public Intervention	Comprehensive urbanisation works	One-off works to pave the main access roads
		and improving the bridges that provide access to the houses.
Nomenclature Used by the City Hall	Precarious slum settlements of the favela type	Ressaca (subnormal settlement))

Approximations between the settlements

Although both occupations are considered precarious and present difficulties in terms of infrastructure and living conditions, the similarities between them are limited due to their regional and environmental specificities.

1. **precariousness and vulnerability** (public space, block/lot, building):

Both Jardim Vicentina and *Ressaca* Chico Dias are marked by significant precariousness, but nature differs according to regional characteristics. In Jardim Vicentina, the disorderly occupation of valley bottom areas subject to landslides and flooding creates an environment of high vulnerability. In *Ressaca* Chico Dias, vulnerability is linked to the occupation of wetlands, where houses on stilts are a response to periodic flooding, but remain vulnerable to the lack of adequate infrastructure and unsanitary conditions and the risk of water-borne diseases due to water contamination.

2. **Geographical and Social Isolation** (Public Space, Block/Plot):

There is no physical isolation in Jardim Vicentina, since it is part of an occupation and thus integrated into the formal urban fabric, despite the geography of the valley floor and the fragmentation of public space. Exclusion there is a social issue, given that the majority of residents are on low incomes. In *Ressaca* Chico Dias, isolation is caused by the fact that it is located in flooded areas, accessible only by wooden bridges, which creates both physical and social barriers for residents. This isolation is a

common factor that contributes to social exclusion and limits opportunities for economic and social development.

Settlement specificities *- based on Tessari (2016)*

1. Adaptation to the Environment (Public Space, Block/Lot, Building):

The specificities of the two settlements are strongly influenced by local environmental conditions. In Jardim Vicentina, adaptation to the slopes and valley bottoms occurs in an improvised way, with self-built houses on irregular land and often in risk areas. This adaptation is limited and aggravates the structural problems of the houses. In *Ressaca* Chico Dias, adaptation to the flooded environment is visible in the construction of houses on stilts, a traditional solution in the Amazon region. However, this form of occupation also brings specific challenges, such as the difficulty of integrating these areas with the rest of the city and continuous exposure to unhealthy living conditions.

2. Public Intervention and Impact on Urban Form (Public Space, Building):

The impact of public interventions varies significantly between the two locations. In Jardim Vicentina, there was a process of urbanization that included investments in infrastructure, the construction of housing units and the reconfiguration of the road system. These interventions have resulted in improvements in living conditions, but many structural problems persist due to the complexity of the land and the irregularity of property ownership. In *Ressaca* Chico Dias, the absence of adequate public interventions perpetuates the precariousness of the settlement. The houses continue to be built in an improvised way, with low-quality materials, and the basic infrastructure is practically non-existent, which drastically limits the possibilities of improving the residents' quality of life.

Reflection on Nomenclature and Implications for Public Policy

1. Nomenclature and Social Perception (Public Space, Block/Lot, Building):

The nomenclature used to describe settlements plays a crucial role in how these places are perceived and addressed by public policies. Jardim Vicentina, initially known as Área Livre, is a type of "favela" that carries with it a series of stigmas associated with precariousness and social exclusion. This nomenclature, although appropriate for describing the reality of this dense and irregular occupation, may not capture the nuances of the origin of the occupation and the population's perception of the urban interventions that have already been carried out. In *Ressaca* Chico Dias, the term *ressaca* is used to describe a very specific precarious occupation in the Amazon region, where houses are built on stilts in wetlands areas. This nomenclature is more appropriate for reflecting the local environmental and cultural conditions; however, being classified as a "subnormal settlement" carries a connotation of precariousness that does not accurately reflect the specific characteristics of the region

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FINAL CONSIDERATIONS

The urban form of the Jardim Vicentina and *Ressaca* Chico Dias occupations exemplifies how urban precariousness can manifest itself in different ways in different regional contexts in Brazil. Although they share common aspects of vulnerability and marginalization, the geographical, climatic and cultural specificities of each location determine unique urban forms that require different approaches to both public policies and urban interventions. The nomenclature adopted by city halls has a significant influence on the perception and the way in which public authorities intervene in these areas. Generalizing the term "Favela" is not an ideal solution, as this neglects regional particularities, which are essential for formulating effective public policies. Nomenclatures that reflect the specificities of each location, such as the term *Ressaca* in Macapá, provide a more accurate and richer view, facilitating more appropriate and inclusive interventions. It is therefore essential that the choice of nomenclature is made carefully, in order to accurately reflect the reality of each community and to promote policies that respect and respond to the unique needs of each urban context.

Looking at the information presented, it is possible to identify several points of similarity between the two settlements, despite the diversity in the form of occupation and the characteristics of the housing. The similarities stand out especially in the social characteristics, such as the length of occupation, the origin of the population, the level of education and income, elements that are closely linked to urban precariousness and social vulnerability in both contexts.

The land situation of the two settlements is also similar: in Jardim Vicentina, occupation takes place in public areas along a watercourse (APP) that crosses eight allotments; in *Ressaca* Chico Dias, occupation takes place in a public wetland area of environmental protection. However, the characteristics of the houses differ considerably: in *Ressaca* Chico Dias, the houses are mostly built of wood, with larger internal dimensions; in Jardim Vicentina, the houses are predominantly made of masonry, with smaller rooms and greater density.

Both typologies studied represent precarious occupations of urban areas that are unsuitable for families to live in, and without the action of public authorities to mitigate precariousness, guaranteeing decent housing conditions is practically impossible. Labelling and generically grouping them as "favelas" or "urban communities" doesn't change the way families identify with their place of residence and life. Max Weber (1973), quoted by Peruzzo (2009), defines community as a broad concept that covers heterogeneous situations, but which is based on affective, emotional and traditional foundations. In both cases, the population identifies strongly with their place of residence and the form of occupation, making any attempt at simplistic categorization that disregards the complexity and specificity of each area ineffective.

Recognizing the specificities of the Jardim Vicentina and Chico Dias settlements is essential for formulating effective public policies adapted to local realities. Analyzing the urban form, considering public space, plots and buildings, reveals that although both face significant challenges, solutions to improve living conditions must be specific to each context. The nomenclature used to describe these settlements must accurately reflect regional and cultural particularities, avoiding generalizations that could result in inappropriate public policies. The ultimate goal should be to promote inclusive and sustainable urbanization that respects the particularities of each region and effectively improves the quality of life of residents.

Finally, it's important to recognize that a "favela" can be an urban community, but not every urban community is a favela. It can be an *Área Livre*, a *Ressaca*, a *Mocambo*, a *Cortiço*, or any other type of occupation, if the people who live there identify with the place. Therefore, instead of focusing on labels, the bodies responsible for delimitation and quantification, by the IBGE or the municipal government, should concentrate on developing methodologies that get closer to the specific realities of each occupation, in order to help shape public policies that address the precariousness and vulnerability present in all forms of precarious occupation in the city, respecting the particularities and promoting the inclusion and dignity of the inhabitants**.**

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Radical Reframing: Modern Transformations of the Rio de Janeiro City Center Morphology

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ABSTRACT

These guidelines provide instructions to format your paper. It is advised to write directly into the template and use the formatting styles, indicated in light grey that should be deleted before final submission. The full paper must be between 12 and 14 pages, including figures, tables and references. The abstract should be a single paragraph and should follow the style of structured abstracts, but without headings: 1) Background: Place the question addressed in a broad context, present the research problem, and highlight the purpose of the study; 2) Aims and objectives of the study, 3) Methods: Describe briefly the main methods applied. 4) Findings: Summarize the article's main findings; and 5) Conclusion and implications: Indicate the main conclusions or interpretations.

The contemporary morphology of Rio de Janeiro's city center is a many-layered system. Its current form was decisively shaped by radical transformations in the first half of the twentieth century. Modern urbanism aimed at a gradual substitution and broad restructuring of the inherited colonial and nineteenth-century fabrics. The new framework relied on tools such as increased density, functional restrictions, autonomous objects, a new role for the street system and large-scale arrangements of the urban block. In contrast to the autonomous plans often associated with modern urbanism, these transformations took place at the heart of the historic morphology. While the piecemeal implementation often resulted in a fragmented, incongruent whole, the partial reframing also established new directions for development. This paper examines the different historic strategies of modern urbanism in the central area of Rio de Janeiro, their impact on the preexisting fabric and the persisting issues related to the contrasting morphologies. Modern strategies are categorized by type and better understood through comparative analysis within the modern repertoire. Recent attempts to transform the inherited contradictions shed light on the nature of the city center's hybrid morphology. An assessment of future possibilities is discussed through the contemporary interpretations of the city block and through the restructuring of interstitial space.

Keywords: Modern Urbanism, Rio de Janeiro Morphology, Alfred Agache, Pereira Passos, Eduardo Reidy

INTRODUCTION

A series of modernizing initiatives in the first half of the twentieth century extensively transformed the colonial and nineteenth-century urban fabric of Rio de Janeiro's city center. These transformations

responded to the demands of urban expansion and the symbolic consolidation of the city as the capital of the Republic. Modeled primarily after French urban planning experiences, the initiatives ultimately sought to rationalize the city's streets and blocks, creating overarching frameworks to unify the dispersed historic developments.

Four pivotal moments define the urban transformations within the examined historical arc. First, an initiative modeled after Haussmann's Parisian interventions was carried out in the early 1900s under Mayor Pereira Passos and the Federal Government. Second, French architect and urbanist Alfred Agache's extensive plan for the city center aimed to consolidate the changes initiated by the Passos Reform and introduced new structuring elements, from the urban block to the metropolitan scale. The third phase, strongly influenced by Le Corbusier in the 1930s, marked a fundamental shift toward canonical CIAM modernism, proposing a new role for the architectural object. Lastly, a post-war plan by architect Eduardo Reidy for a large-scale Civic Center on a newly leveled area sought to radically transform the central city with its emphasis on infrastructure and monumental characteristics.

Each of these moments, which have been studied individually, represents a complex set of urban tools and concepts, often experimental in their time. Developed in the context of European cities, their application was complicated by Rio de Janeiro's colonial morphology and its peculiar geography between mountain and sea.

The present work thus proposes to examine the above sequence of historic urban interventions as a layered system, through its conflicts and continuities. The inherited colonial morphology, often schematically characterized both historically and historiographically, will be reappraised through its structural significance and permanence throughout the modern period. Furthermore, the city's geographical characteristics will be analyzed in light of the challenges they posed to the application of European urban planning tools. Their interrelationship is examined through comparative analysis of tools and concepts.

METHODOLOGICAL DISCUSSION

To understand the layering process in Rio de Janeiro and the relationship between its successive morphologies the present works employs the comparative analysis of historical planning strategies.

The utopian image of "Enlightenment space," which Anthony Vidler describes as "geometrical, rational, gridded, and above all transparent, universal and seamless, equally illuminated and illuminating" (Vidler, 2011: 131), translates into more mundane realities in the nineteenth century. The Enlightenment's notion of "clearly defined entities, separate from each other, taxonomically organized in series and hierarchies, as known and knowable as the space that surrounds them" persists as a horizon of identifiable parts waiting to be built, understood, and transformed. This concept perhaps forms the historical basis of the idea of types within an increasingly complex system of rearranged elements.

This is also the basis of the modern project of transparency. The urban block, for example, as a recognizable entity within a larger framework and, within the block, the mechanics of its internal parts. Gradually, the system will acquire new elements: functional, spatial and technical, as well as different densities. The clear reading of its parts will give way to a process of differentiation, as observes Panerai, Castex and Depaule.

Vidler's reading is thus both a description of physical objects and a reflection on the foundational practices within the field of urbanism. The utopian horizon he describes becomes a symptom of the search for a commanding framework, where urban components are presented as recognizable units, accessible to both the planner and the public.

According to Panerai, Castex, and DePaul, the primary objective of their study on the urban block was to describe spatial models, aiming to go beyond the empirical developments of physical objects. Their work engages with historical discussions and theoretical insights related to the formation of urban models, contributing to broader efforts to stabilize and unify the field of urban morphology.

Our work thus examines the gradual process of rearranging urban elements in search of a coherent framework. It also seeks to uncover less evident structures in developments often portrayed as uncoordinated, such as the colonial fabric of Rio de Janeiro. As we will see, the urban block played an uneven role in the early stages of the city center's development. Its prominence emerges for a relatively brief period, before being questioned again by the modern canon.

EARLY MODERN TRANSFORMATIONS

Modeled after the Haussmann reforms, the early twentieth-century transformations carried out by Mayor Pereira Passos (1902-1906) and the Brazilian federal government aimed to modernize Rio de Janeiro's central area. The plan included a broad range of interventions: 1) opening major connective thoroughfares such as Avenida Central boulevard; 2) leveling of two prominent hills (Castello and Santo Antonio); 3) expanding the central area into the sea; 4) expanding and regularizing the street system; and 5) transforming the center's functional profile from a heavily residential area into one focused on business, commerce and administrative buildings, with increased density. These extensive reforms, both symbolic and economic, as historian Mauricio de Abreu observes, spanned the next decades and responded to Rio de Janeiro's new role as the capital of the Republic, industrial center, and major shipping port (Abreu, 1987).

The pronounced topography played a fundamental role in the morphological development of Rio de Janeiro, particularly the two large hills in the central area, each occupying around 30 hectares. Paulo Santos describes how the city grew on and around these and other geographic features, gradually spreading into the available lowlands (Santos, 1968). Santos notes that, in its early stages, 'there was no difference between military architecture and town planning' (Santos, 1968: 88). The high ground remained a crucial element of the city's defense strategy during the colonial period, as envisioned by the Portuguese, and held strong structural and symbolic significance in its spatial planning.

The colonial city, over which early modern reforms were overlaid, is often described in terms of its restrictive qualities by both historians and contemporary figures. Mayor Carlos Sampaio (1920-1922), as cited by historian Sonia Gomes Pereira, claimed that 'the city center was suffocating between the hills and the sea.' (Pereira, 1996). Similarly, Abreu describes a 'cramped city, limited by the hills of Castelo, São Bento, Santo Antônio, and Conceição' and highlights the inadequacy of its street system, with 'narrow and dark streets.' He considers that 'the Passos Reform represents a moment of fundamental break in the relationship between State and Urban' (Abreu, 1987: 73). The historian thus sees a major shift characterized by concerted actions aimed at unifying the dispersed colonial fragments.

There is, nevertheless, an ordered framework within the colonial city, one that continues to manifest itself within the superimposed developments of the twentieth century. This framework involves the concept of local clusters, shaped by the fragmented geography. These clusters have their own internal logic, organized around the structuring role of public space. Santos emphasizes the importance of the public square in Portuguese urbanism as 'the meeting center of urban life' (Santos, 1968: 64), while Gomes Pereira, drawing on Kevin Lynch, views the Largo do Carmo, the city's main founding colonial square, as a special type of node, one that 'radiates its influence' and functions as a symbolic core for its surrounding area (Pereira, 1996: 74).

Thus, a more complex relationship between colonial and modern frameworks emerges beyond the idea of substitution or simple superposition. Paulo Santos speaks of the 'organicity' of colonial development – in contrast to the term 'organic' – (Santos, 1968). There is, here, an implied systemic framework that orders the somewhat dispersed development of local clusters in response to the contingencies of the geography. This theme recurs throughout the twentieth century, as the city expands, occupying the available patches between mountain and sea, connected through an increasingly autonomous network of infrastructural lines – an idea that would be later recognized by Agache, Le Corbusier and Reidy, as will be discussed further on.

Within this framework, the restrictive qualities of the colonial street system often played a secondary role. While the narrow streets did present problems for the city's development at specific points, their influence remained confined to the ambit of the local cluster. The colonial grid was largely preserved in many areas throughout both early and late modern developments, despite a major increase in density brought about by the gradual replacement of its historic buildings.

The permanence of parts of the colonial streets and the continued logic of cluster areas called into question the role of the grid and the urban block as dominant tools in early modern remodeling. Santos observes that the street system was relatively regular, though not as geometrically precise as the Pombaline grid in Lisbon (Santos, 1968: 95). The colonial block, with its heavily fragmented parceling, was gradually adapted through the widening of streets and the merging of its narrow, elongated plots, which allowed for an increase in density with new, higher buildings.

An entirely rectified grid system would await the leveling of Castelo Hill and the expansion of the center into the newly opened area in the 1920s. This laid the groundwork for a more significant role of the urban block, as would be proposed by Alfred Agache. The problem then became one of compatibility between the nineteenth century clusters and the rectified expansion areas.

During Pereira Passos's term, the main accomplishment remains the opening of the Central Avenue boulevard. Its infrastructural role, connecting the newly built seaside avenue to the port area, has been noted by Abreu (Abreu, 1987), while Gomes Pereira highlights the intention to create a modern, civilized, and cosmopolitan space, following the model of the great European capitals (Pereira, 1996). The avenue begins at a large open plaza where the republic's most important government and cultural buildings were located, conforming a new focal point that would structure the city's expansion toward the sea and into the area opened by the leveling of the Castelo hill. (Figure 1) The plan thus aligns itself with the logic of the radiating local cluster.



Figure 1. Central Avenue and Plaza. Rio de Janeiro, photo credit: Augusto Malta. Instituto Moreira Salles.

ALFRED AGACHE: TOWARDS A COMPOSITIONAL FRAMEWORK

In late 1927, architect and urbanist Donat Alfred Agache, then General Secretary of the 'Société Française des Urbanistes,' was hired by Antonio Prado Junior, mayor of the Federal District, to develop an extensive plan for the city of Rio de Janeiro, coordinating it with the ongoing projects initiated under Pereira Passos. Agache's comprehensive proposal, titled City of Rio de Janeiro: Remodelling, Extension and Embellishment, aimed to address the city's complexity and employed a wide range of tools to provide a unified plan.

The proposal, which came to be known as the Plan Agache, acknowledges the key features of the preexisting colonial framework. An introductory chapter titled Anthropo-Geographic Factors presents the city's historic development through high-ground panoramas, depicted in paintings and drawings, revealing the importance of public squares, street spaces, and the relationship between the stretches of flatland, where the city had expanded, and the surrounding hills.

Agache also acknowledges the city's 'particularly special topography,' which he states 'imposes undisputed solutions' (Agache, 1930: 135). He seeks to understand its physical nature and impact on the contemporary urban situation through a cartographic sequence that illustrates the evolution of the city center and its relationship to the surrounding topography, including the recent changes to the central hills. (Figure 2) The gradual urban growth depicted in these images reinforces the idea of extension lines connecting local clusters, while also reiterates the local role of the street grid in addressing the city's fragmented complexity.

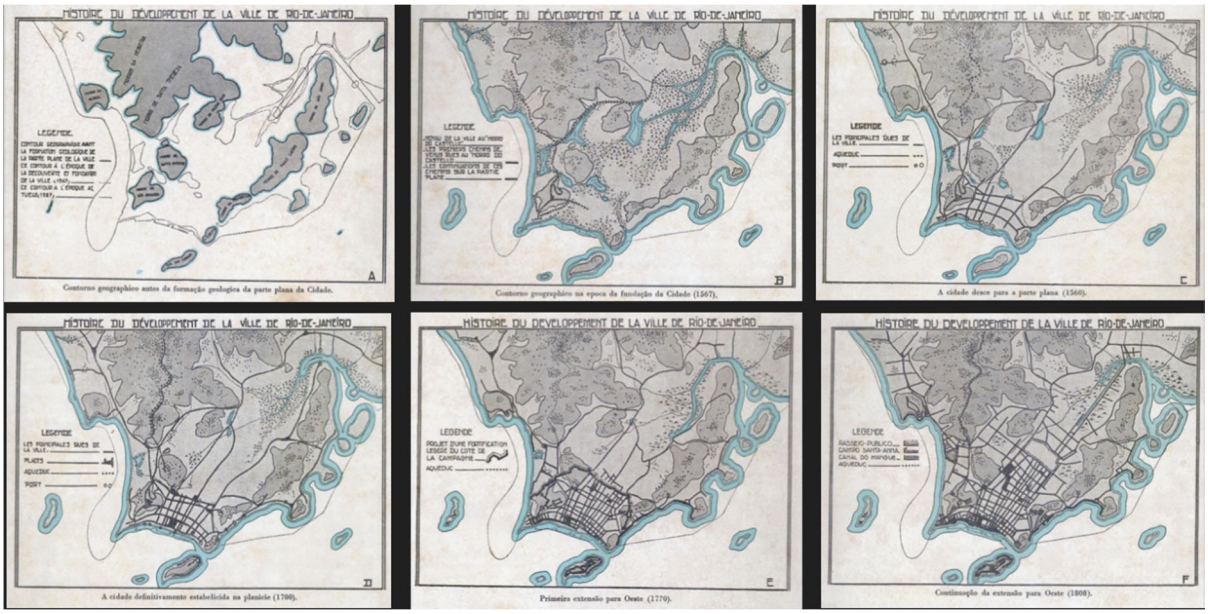

Figure 2. Sequence of maps presented by Agache showing the historical development of Rio de Janeiro in relationship to the geography. Agache. Plan.1930.

The plan's title encapsulates the various tools introduced by Agache. The concept of extension applies to scenarios such as the leveling of hills and the reclamation of land from the sea. It also relates to the grid system: the structuring capacity of the street grid, the increasing importance of transportation in urban planning, and the role of the block within the grid. The concept of remodeling, in turn, pertains to the ongoing transformations of existing clusters, including the reform of the colonial street grid and the adaptation of historic blocks through increased density, new alignments, and the reconfiguration of plots, as we have seen. Remodeling also involves reinterpreting already-established structural lines and incorporating them into a coherent plan. Lastly, the idea of embellishment addresses the symbolic significance of the structuring boulevards and, more broadly, the new governmental and business functions of the central area, including the modern expression of its architecture.

His previous work with Eugène Hénard consolidated two fundamental ideas. First, the importance of a rational circulation system, subdivided into distinct categories based on their nature (such as pedestrian, economic, or professional movement) and their relationship to centrality (convergent/divergent) (Hénard, 1982). This approach led to a better understanding of planning instruments according to their scale and purpose. Agache, in his proposal for Rio de Janeiro, writes: 'The broad lines and characteristic points required by the project must be considered. The remodeling project is, in effect, contained within a framework whose generating coordinates we will quickly analyze, and which responds to the needs of urban traffic' (Figure. 3) (Agache, 1930: 135).

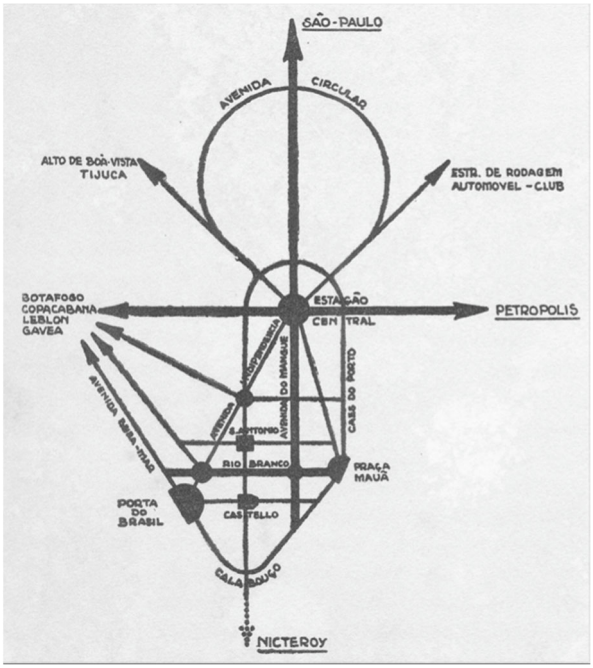

Figure 3. Metropolitan Structure, termed Ossature (Bone Structure) constituting a system of infrastructural lines. Agache. Plan.1930.

A second idea, expressed in Projet d'Ensemble des Parcs et Jardins à Établir dans Paris (Hénard, 1982), posits that parks and squares can serve a structuring function for the city as a whole. This idea resonates with the role of the public square within the historic fabric of Rio de Janeiro, as we have seen. It also counterbalances the role of the street as a structuring element, favoring the compositional strategy that characterizes Agache's Beaux Arts approach and its alignment with the development of Rio de Janeiro's central area. Agache included a map of 'parks, squares, and playing fields' within the proposal, detailing their respective radii of influence. (Agache 1930: 206)

Perhaps the central focus of Agache's proposal is his extensive study of a new role for the urban block as a coordinating element within the plan. He approaches this on two fronts: first, by systematizing the block as an instrument to occupy the newly opened expanse where Castelo Hill once stood; and second, through the gradual adaptation of blocks within the historic fabric. (Figure 4) In both cases, the urban block is conceived as a complex system incorporating various spatial and functional elements developed since the mid-nineteenth century. This includes internal courtyards, a pilotis-arcade system mediating between urban life and the building, the gradual tapering of overall volume to allow light to reach the city ground, increased density, and legislative instruments that lend a sense of unity to the overall block form. (Figure 5). The effort marks a gradual shift away from the cluster morphology of the colonial period, although it retains some of its spatial aspects, particularly the role of public space.

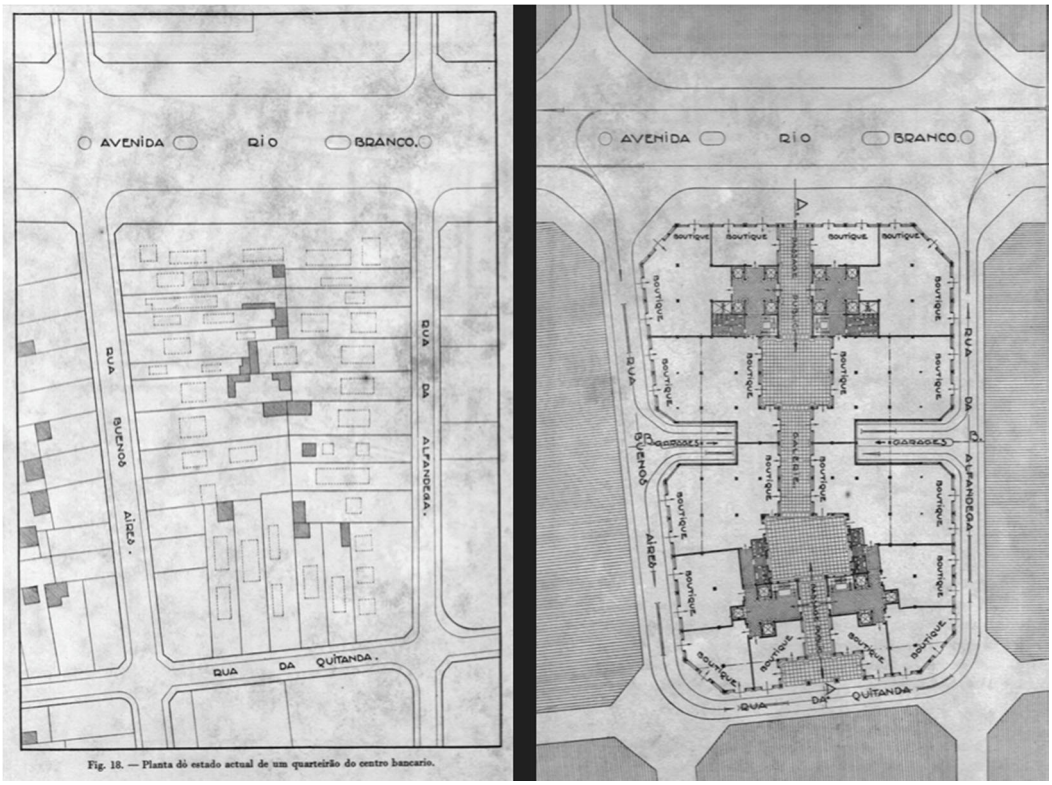

Figure 4. Proposal for the gradual transformation of the existing colonial block, including widening of the street and substitution of its historica buildings. Agache Plan.1930.

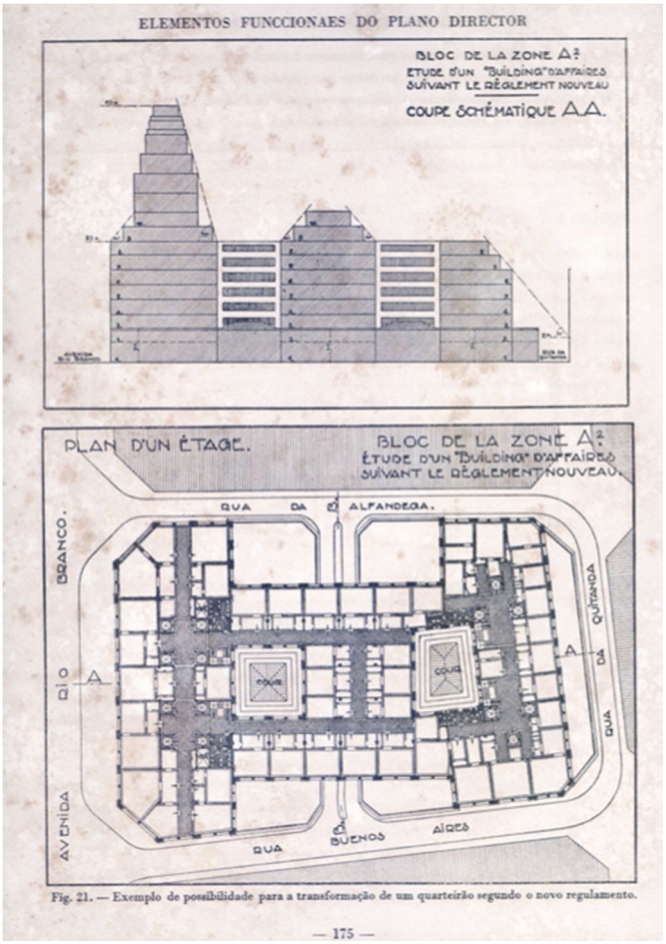

Figure 5. Plan and Section for new block in the the newly developed Castelo Esplanade, showing new density, tapering and internal courts. Agache Plan.1930.

The effort marks a gradual shift away from the clustered morphology of the colonial period toward a more continuous fabric and sense of unity. It nevertheless retains some of the spatial qualities of the historic development, particularly the role of public space in shaping local differentiation within the city center. This approach facilitates the transition between historical layers and newly planned extensions. Though the grid system is now clearly in play, Agache does not pursue a Cartesian regularity. The result is a series of negotiated spatial interactions.

THE URBAN BLOCK AND ARCHITECTURAL AUTONOMY

A new site for the Ministry of Education and Health was planned in the newly opened area of Castelo Hill, which had already been partially occupied during the late 1920s and early 1930s. The building was intended to play a symbolic role in the development of this area, marking its significance in relation to the nearby square which was already home to key governmental buildings. As is well-known, the Brazilian team, composed of soon-to-become prominent figures in Brazilian modernism, including Lucio Costa, Oscar Niemeyer, and Affonso Eduardo Reidy, among others, was joined by Le Corbusier in 1936, on his second visit to Rio de Janeiro.

The effort resulted in what is considered the first realization of the Cartesian high-rise, a landmark in modern architectural development (Segre, 2013). The final version comprised a main vertical block containing office spaces and a horizontal block housing an auditorium, foyer, galleries, and a terrace.

The building would be almost entirely detached from the ground through pilotis, forming an open square that could be traversed by the public. Although it would be free-standing, the building was set within the Agachian block system that characterized the extension plan, thus surrounded by a continuous wall of buildings that would eventually line the borders of their blocks.

Despite Le Corbusier's insistence on relocating the building near the waterfront to emphasize its panoramic view of the bay and mountainous landscape, the project remained within the originally planned extension area, as shown by the historic correspondence between the Swiss architect and the Ministry of Education and Health, organized by historian Maurício Lissovsky (Lissovsky, 1996: 108-114). The unbuilt version would have reaffirmed the modern building's role as an autonomous object, underscoring its relationship to the idea of a continuous ground and to the surrounding landscape. The initial version for the open terrain was published alongside the design that would ultimately be built, done in collaboration with the Brazilian team. (Le Corbusier, 1939)

Significantly, the circumstances of Le Corbusier's insistence reveal his personal feud with the traditional block system, to which the project would ultimately have to adapt. In the same edition where he publishes the plans for the Ministry of Education building, a comparative figure-ground diagram contrasts his proposed residential area for the Ville Radieuse with the dense block patterns of Paris, New York, and Buenos Aires, which he termed Villes Pêle-Mêle (jumbled cities). 'These four city diagrams, on the same scale,' Le Corbusier writes, 'reveal the true revolution in urban land use' (Le Corbusier 1939: 30).

A schematic diagram also accompanies the documents for the Ministry of Education building in the same edition (the 1934-38 works). It compares the contiguous blocks, titled 'traditional use of land in Rio,' with the 'new method realized'—the free-standing building, now in its definitive plot within the Agachian grid. (Figure 5) The idea of a liberated ground and the autonomy of the object remained intact (Le Corbusier, 1939: 81). The result was a partial victory.

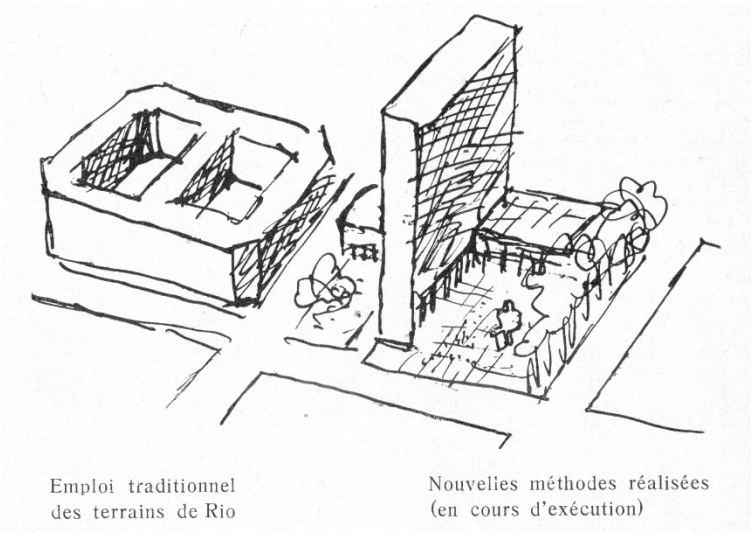

Figure 5 Comparative diagram of proposal for the Ministry of Education and existing urban block in the Castelo Esplanade, photo credit: Le Corbusier.

Le Corbusier's argument illustrates a shift in focus from the rue corridor, with its narrow, meandering path, to a broader opposition to the gridded system of the urban block and its repetitive framework.

This shift not only envisions an increasingly central role for the autonomous architectural object but also introduces a new spatial perspective that defies the planar qualities of the grid. This stance had a particular impact on Reidy, who recognized a paradigm shift from the block as the fundamental unit of the city to an open system – perhaps with implied block-scale subdivisions, or rather, rhythms – but framed by an external infrastructure, an idea similar to Agache's metropolitan ossature.

Interestingly, the Ministry of Education reaffirms the concept of the local cluster, as the open space on which it is situated functions as a core square, redefining the surrounding blocks. It thus signals a new role for the architectural object within the block system.

RADICAL DISSOLUTION OF THE URBAN BLOCK

In the late 1930s, Eduardo Reidy, who had worked as an assistant to Agache, evaluated the role of the block system as a fundamental framework for the development of the city center: "Although this system had already been abandoned in more advanced countries, it undoubtedly represented a significant step forward for us, compared to the precarious conditions in which our capital had been built until then" (Bonduki, 2000: 63). For Reidy, the system represented a necessary intermediate phase transitioning from the dense and fragmented colonial fabric toward the full expression of a contemporary modern urbanism.

His unrealized plan for the Castelo esplanade (1938), adjacent to the recently completed plans for the Ministry of Education – then under construction – serves as a precursor to the future plan for a downtown Civic Center (1948). These proposals follow Le Corbusier's urban principles, some of which had been discussed in relation to the Ministry building and its relationship to the surrounding blocks, particularly the fundamental modern concepts of continuous ground and autonomy of the detached architectural object.

Other characteristics of the 1938 plan included the "separation of local access and high-speed traffic," the "reduction of the number of streets," the design of "green open spaces," and the implementation of "level crossings" for pedestrians. The area was envisioned as an "urban nucleus planned to provide collective well-being." Furthermore, the plan aimed to infiltrate the old city at its borders, where "it presented insufficient scale" or a "disorganized structure". (Bonduki, 2000: 64)

These characteristics reappeared in the 1948 design for a Civic Center, planned to occupy the large central space left open by the leveling of Saint Antônio Hill, an area of nearly forty hectares. Reidy describes this operation as "the last chance to introduce a completely new element into [the Capital's] center of gravity" (Bonduki, 2000: 118).

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Recognizing similarity between cities using Internet celebrity Spots from an urban design perspective: a case of 9 Chinese cities

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ABSTRACT

This paper addresses a phenomenon increasingly discussed in China, referred to as 'thousand cities one face'. There exist worries that as social-media-driven economies influence cities, they will become more similar to one another. To test whether such a phenomenon exists and develop a comprehensive understanding, this paper takes a quantitative approach, identifying cities' Internet-Celebrity Spots (ICS) – top-ranked hotspots on social media, compiling data on their type and morphology, and using statistical tests to answer the following questions: i) Concerning the types and spatial configurations of ICSs, are Chinese cities becoming similar or not? ii) Which cities are more similar or unique? What is the degree of similarity between them?

A total of 413 scenic spots and 1800 restaurants are identified as ICSs for a total of 9 cities from 3 of China's geographical regions. ICS types are labeled, and 16 indicators describe the morphology of each, regarding physical form, cultural services, and consumer activity. Cosine similarity is used to test the similarity of ICS type, while the Kruskal-Wallis test and Mann-Whitney U-test are used for evaluating ICS morphology similarity.

Similarity is obtained for the overall group, all city pairs, as well as each city, and results are analyzed with reference to real-world phenomena. Results show that regarding both ICS type and ICS morphology, similarity of cities exists, but only for a portion of cities sampled here. This confirms the 'thousand cities one face' phenomenon can be reflected in data, but also shows that the phenomenon is not as widespread as commonly described. Driving factors for similarity including geographical location, economic development, etc. are also analyzed. It is hoped that this study will not only address public discussion, but also help policy makers better understand the public's perspective, and lead to better development of cities overall.

Keywords: Internet Celebrity Spots, similarity, urban morphology, data mining

INTRODUCTION

As urbanization proliferates within a country, and as modernization progresses within cities, it is speculated that urban morphologies will converge into more homogenized forms. In recent years, with the rapid development of social media and the emergence of the internet-celebrity-economy

(ICE), the so-called 'thousand cities one face' phenomenon is an increasingly discussed topic online. This can be recognized as studying the same phenomenon as topics of homogenization and similarity commonly discussed in fields of urban planning, landscape ecology, geography, etc. In this paper, the effect of ICE on similarity between cities is studied through a quantitative approach.

Current urban morphology research has covered similarity for aspects including urban expansion and urban environment etc. Studies have been conducted for the cross-city comparison of urban morphology expansion (Jia et al., 2020; Lemoine-Rodríguez et al., 2020; Cai et al., 2022), as well as the correlation between urban morphology and sustainable development (Cao et al., 2021; Stuhlmacher et al., 2022). Under its rapid urbanization and the regulation of its unique municipality administrative structure, China is subject to controversy regarding its urban form becoming increasingly similar, and this similarity has been verified at the city-level and block-level (Song et al., 2018; Ding et al., 2022).

Although the overall trend of increased urban morphology similarity has been verified in multiple aspects, it can be argued that cities are multifaceted. Thus, different perspectives may lead to different conclusions. For the topic of 'thousand cities one face', a city's policymakers tend to focus more on the macro-scale phenomena in their cities, such as urban expansion(Pili et al., 2017), urban function distribution(Tian et al., 2010), etc. However, as the internet becomes an increasingly integral part of society and life, information flow, including those about cities, is increasingly affected by social media (Zhou et al., 2023). By shaping the flow of information, social media implicitly determines which areas in a city are searched for and visited by more people, thus constraining the public's perception of cities within these areas. Such areas can be perceived as emerging hotspots of increased activity birthed by internet influence and are studied in this paper under the term "internet celebrity spots" (ICS). Studying urban morphologies through the perspective of ICSs to give more accurate insight into the public's ICE-driven perception of cities is the primary goal and novelty of this paper.

ICSs are a product of the ICE, thus as a derivative of the 'thousand cities one face' argument, it can be hypothesized that policies and natural developments following ICS growth will cause cities to lose their cultural features and experience excessive commercialization of hotspots, leading to increased similarity of cities. Studies have discussed how the ICE builds cities' ICSs through social media and in turn builds internet-celebrity-cities, and how this brings both significant opportunities and challenges for city development (Che et al., 2022). This also shows how ICSs are currently a prominent component of city development. ICSs act as the main site at which cities are connected with both tourists and residents and the surrounding spatial configuration in their vicinity plays a key role in shaping cities' image and reputation (Nolasco-Cirugeda et al., 2020; Iranmanesh and Abokhamis Mousavi, 2023). Most studies have used two-dimensional metrics for describing spatial configuration, but several studies using three-dimensional approaches have also been introduced in recent years (Cao et al., 2021; Yang et al., 2022). In addition, ICSs not only carry basic physical morphology characterizes, but are also closely tied with human commercial activity as well as cultural services and facilities (Ye et al., 2018; Zhang et al., 2022). Therefore, this study augments fundamental morphology indicators with additional indicators on three-dimensional information and urban function when characterizing urban areas.

In this paper, 2213 ICSs from 9 provincial capitals are characterized using type and morphology data, in order to test the hypothesis that within the perspective of ICE, cities in China display significant similarity. On one hand, we use cosine similarity to quantify the similarity between ICS types between

cities, and on the other hand, we use 16 indicators characterizing the physical, cultural, and consumer activity aspects of ICSs to quantify urban morphology, using the Kruskal-Wallis Test and Mann-Whitney U Test as mathematical tools to test the similarity of cities' ICSs. This study strives to answer the following two questions: i) With respect to the types and spatial configurations of ICS, are Chinese cities becoming homogeneous or not? ii) Which cities are more similar or unique? What is the degree of similarity between them?

METHOD

The overall methodology used in this paper is summarized in Figure 1. This includes selection of cities, selection of internet celebrity spots including scenic spots and restaurants, collection of type and morphological data, indicator selection, as well as analysis of results.

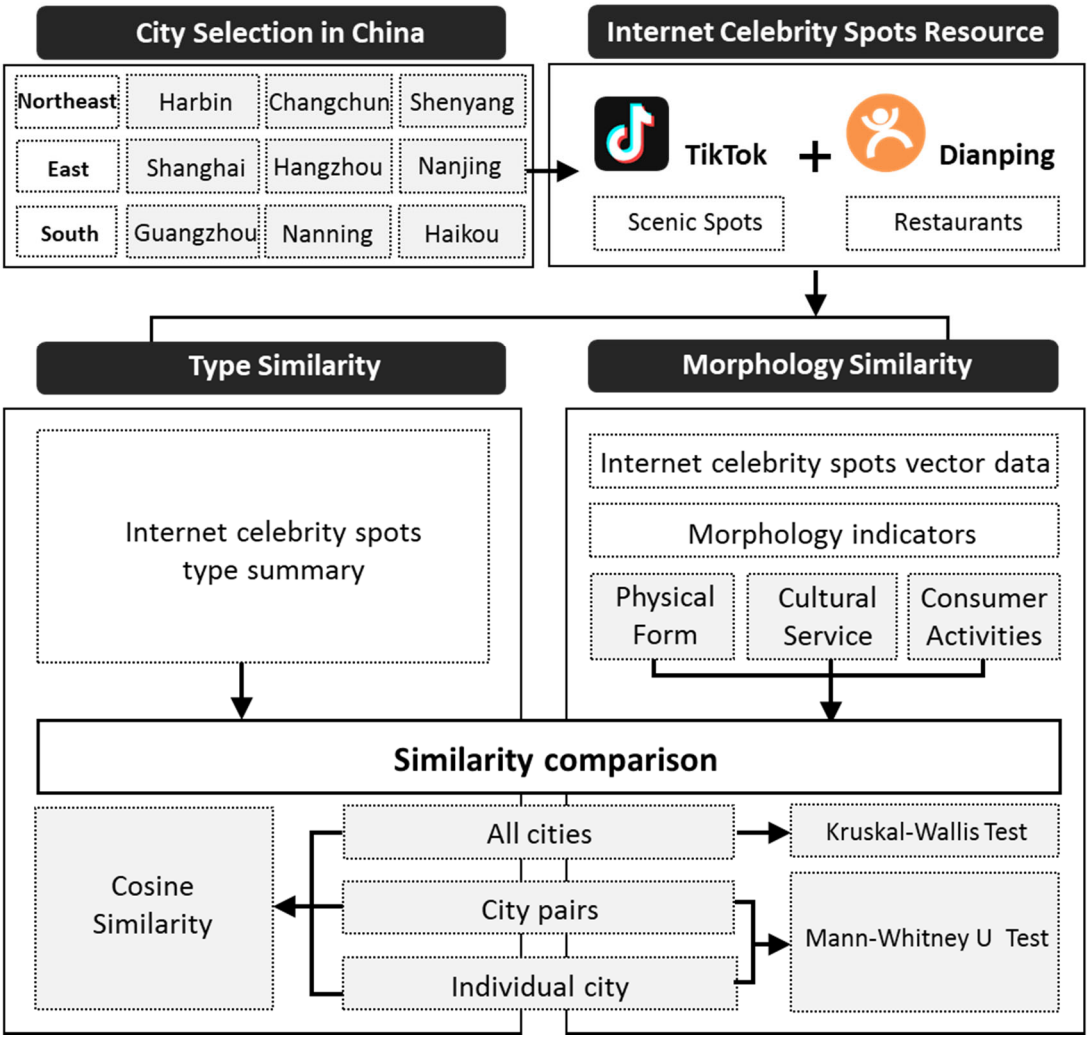


Figure 1. Overview of the methodology adopted in this study.

Selection of case cities

The 9 cities in this study were selected according to geographical location and climate, as well as population and socio-economic development etc. They are 9 provincial capitals from 3 primary Chinese geographical regions: East China (Shanghai, Nanjing, Hangzhou), South China, (Guangzhou, Haikou, Nanning) and Northeast China (Harbin, Changchun, Shenyang). In East China, summer months

are humid and hot, while winter months are moderately humid and moderately cold. The general economic development of East China is relatively high. South China is warm all year round, with no snowfall and high humidity. Guangzhou is one of the economic and commerce centres of the region. Northeast China has long winter months with harsh cold, and rainfall is concentrated in the short summer months. It is the traditional centre of heavy industry in China.

Selection of Internet Celebrity Spots

Two types of ICSs are considered here: scenic spots and restaurants. These are selected according to TikTok and Dianping data respectively. ByteDance's TikTok is one of the major social media platforms which shape the public's perception of cities. Its content as well as corresponding geotagging have been shown to be valuable for understanding the geography (Lin et al., 2023), public image (Wang and Feng, 2023), and tourist visit activity (Zhang et al., 2022) of China's cities. Dianping (https://www.dianping.com/) is the largest Chinese-language third-party online platform for customer reviews (equivalent to Yelp), and its content has been widely used for relevant studies on cities (Guo et al., 2018).

Regarding the selection of scenic spot ICSs, this study takes into account the fact that public preference shifts with season change. Data is obtained from Ocean Engine's list of the most popular scenic spots on TikTok between April 2023 and March 2024. The top 20 attractions of each month are selected, and information includes attraction names. Preprocessing of attraction data includes removing duplicate entries with identical geographical boundaries, non-tourist-attraction entries (stations, hospitals, residential areas, etc.), entries with ambiguous non-specific addresses, and large rivers (e.g. Songhua River). In total, 413 scenic spot ICSs were chosen for the 9 cities.

Restaurant ICSs were selected from the restaurant ranking list extracted from Dianping's website API, retrieved 23rd February 2024. The top 200 restaurants which satisfy qualifiers including being open, having more than 50 comments, and rated higher than 4.0 points were selected. Collected information includes name and type, as well as longitude and latitude. In total, 1800 restaurant ICSs were chosen for the cities.

Type data source

As the Ocean Engine platform does not include specific type data on every scenic spot, this information is supplemented by data retrieved from corresponding entries on Dianping's website. Type data for restaurants are according to classification displayed online by Dianping. However, as redundant categories exist, merging of categories must be carried out, e.g. merging 'wildlife zoo' and 'zoo', merging 'leisure district' and 'recreational district', or merging 'Japanese food' and 'Japanese cuisine'. After processing, 32 scenic spot types and 41 restaurant types are adopted.

Morphological data source and preprocessing

This study uses morphological data collected from multiple sources. The name, source, year and preprocessing of each data is listed in Table 1.

Table 1. Morphological data type, source, year and preprocessing.

Data type	Data source	Year	Data description and processing
Boundaries of the administrative	Chinese Academy of Sciences Resource and	2022	Extract urban boundary.

divisions of cities in China	Environmental Science Data Platform (https://www.resdc.cn/) (Xu, 2023)		
Building footprint	Zenodo (https://zenodo.org/) (Shi et al., 2023)	2024	Filter out building footprints larger than 20 square-meters in each city.
Building height	Zenodo (https://zenodo.org/) (Wu, 2022)	2020	Rasterized data for building height at 10-meter resolution.
Road network	OpenStreetMap (https://www.openstreetmap.org)	2024	Select motorway, trunk, primary, secondary, tertiary, residential, unclassified layer, all for city roads, set up 40 m, 20 m or 10 m buffer according to road type and extract the centre line of the buffer as a road network data.
Point of interest	Amap (https://www.amap.com/)	2022	Point data with attached name, type as well as longitude and latitude. Extract points for food and beverages, shopping, accommodation service, along with recreation as points for consumer activities. Extract points for tourist attractions as well as science, education and culture (only consider subcategories relevant for ICE, including museums, expositions, science museums, art exhibits, planetariums, cultural centres etc.) as points relevant to cultural activities. All point data are converted to the GCS_WGS_1984 geographic coordinate system.
Area of Interest	Baidu Map (https://www.baidu.com/)	2024	Extract ICS boundary according to name. ICSs with missing boundary data are supplemented using information from other map website and satellite imagery (Amap, National Platform for Common GeoSpatial Information Services etc.) and merged using ArcGIS Pro 3.0.1. software. All area data are converted to the GCS_WGS_1984 geographic coordinate system.

The calculation areas for ICS morphological data are obtained using a methodology described in Figure 2. First, raw data for ICSs include two vector data types: point data with single geographical coordinates for restaurant ICSs, and polygonal boundary data for scenic spot ICSs from Baidu maps. For both data types, a 300-meter buffer zone is created using ArcGIS Pro 3.0.1 under the justification that 300 meters is the average 5-minute walking distance within which people visiting ICSs are likely to also traverse. The buffer zone area is added to point and area data and considered as part of the ICS area when calculating morphological data. Furthermore, when ICS areas encounter city boundaries, it is cropped using the city boundary by Boolean operation between the two areas, i.e. any ICS areas beyond city boundaries are removed. City boundaries are according to data from the Chinese Academy of Sciences Resource and Environmental Science Data Platform.

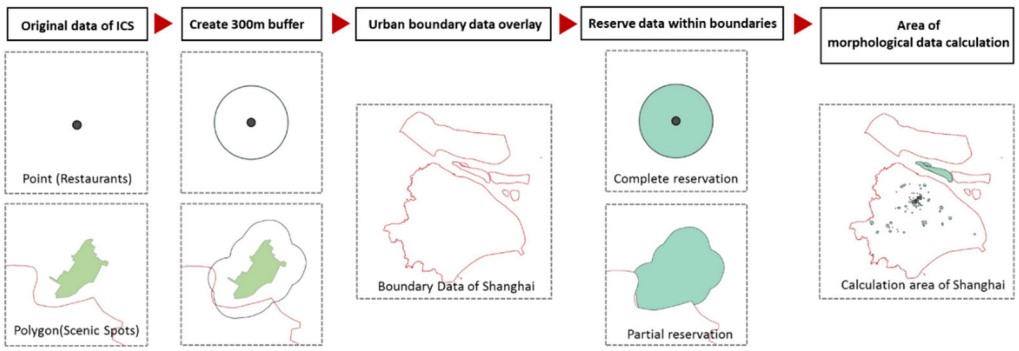


Figure 3. The calculation area of ICSs.

Indicator selection

According to a report jointly published in August 2022 by Ipsos Ltd. and multiple platforms (Oceanengine， 2022), uniqueness of cities is the primary attractor for Chinese tourists, and specific destinations include boutique commercial areas, natural scenic areas, cultural and historical sites, local cuisine, large shopping centres, and landmark buildings. From this it can be seen that compared to traditional theories such as Kevin Lynch's work on the perceptual form of urban environments, and M. R. G. Conzen's theories on urban morphology, tourists' cognition of city features are much more limited, and that the architectural form, consumer environment and cultural features are what tourists place focus on. Therefore, this study describes the configuration surrounding ICSs, using three perspectives: physical form, cultural services and consumer activities. Table 2 defines the 16 indicators used for quantifying the different aspects of urban morphology and generating a comprehensive overall description. The detailed mathematical formulation for each indicator is given in Appendix A.

Table 2. Morphological indicators.

Indicator	Dimension	Abbreviation	Description
Road network density	Physical Form	RND	Traffic accessibility
Building density		BD	Surrounding development intensity
Building footprint ratio		BFR	Surrounding development intensity
Average building height		MEAN	3D architectural feature
Maximum building height		MAX	3D architectural feature
Standard deviation of building height		STD	3D architectural feature
POI proportion of science ,education & culture service	Cultural Service	P_SEC	Cultural space composition
POI proportion of tourist attraction		P_TOURISM	Cultural space composition
Cultural service POI density		D_CU	Density of cultural spatial distribution
Cultural Service POI diversity		SHDI_CU	Complexity of cultural space types
POI proportion of food & beverages	Consumer Activities	P_FOOD	Consumption space composition
POI proportion of shopping		P_SHOPPING	Consumption space composition
POI proportion of accommodation service		P_HOTEL	Consumption space composition
POI proportion of recreation		P_RECREATION	Consumption space composition
Consumer activities POI density		D_CS	Density of consumption spatial distribution
Consumer activities POI diversity		SHDI_CS	Complexity of consumption space types

RESULTS AND DISCUSSIONS

Type similarity

Type similarity is quantified using cosine similarity. A total of 36 similarity results are created for pairs between the 9 cities selected here and are listed in Table 3. It should be note that, data for scenic spot and restaurant are of different nature and size, so should not be compared to each other. Comparison is only made within scenic spot data and restaurant data. The most similar city pair for scenic spots is Harbin and Shenyang (0.897), and the most dissimilar is Nanjing and Shanghai (0.290). The city pair with highest similarity for restaurant is Changchun and Shenyang (0.953), while the lowest is Guangzhou and Harbin (0.106). Overall, there is a significant disparity in the similarity between cities,

meaning when the public views cities from the perspective of ICSs, similarity exists for a portion of cities within the sample here.

Table 3. The overall average, maximum, and minimum of the pair values

Type	Mean	Max	Min
Scenic Spots Type Similarity	0.679	0.897	0.290
Restaurant Type Similarity	0.372	0.954	0.107

Figures 4 and 5 illustrate the cosine similarity results between city pairs for scenic spot and restaurant data respectively. Figures 6 and 7 display the average similarity ranking for each city, where the average similarity of a city refers to the average of cosine similarity values between it and all other cities. Corresponding radar plots are also included in Figures 6 and 7 to visualize the proportion of each type of scenic spot or restaurant within each city and reveal the type compositions of each city.

Regarding the comparison of city pairs, the maximum similarity pair of both scenic spot and restaurant data are between cities of the same geographical area. This means the ICS type of cities studied here is still most prominently influenced by geographical location, and corresponding climate conditions. For example, Harbin and Shenyang have highest scenic area similarity as Figure 4 shows, and they are both from Northeast China. Figure 6 indicates that City Parks (A07) and Theme Parks (A27) are the two highest proportion ICS types in both cities. This is presumed to be due to cities Northeast China putting emphasis on developing winter tourism in recent years, making winter-themed parks a hot destination for the public. Examples include Harbin's Ice Snow World and Polarland, as well as Shenyang's In Box Container Village and Peace Bay Ice Snow World. The correlation between restaurant type similarity and geographical location is observed to be even greater, especially for the three cities in Northeast China and East China, where the minimum similarity within the two geographical areas are 0.716 (Changchun and Harbin) and 0.625 (Nanjing and Shanghai) respectively, both far higher than the overall average of 0.372. This can be explained through the cuisines in Northeast China and East China being more unified throughout history. Meanwhile, dissimilarity of restaurant types between the north and south of China is also reflected by the data.

It is notable that, the minimum value for scenic area type similarity is generated within Nanjing and Shanghai (Figure 4), which are both from East China. Nanjing possesses abundant natural scenery resources, along with a rich history and cultural heritage. It is known for and advertised with such features, thus popular tourist destinations mostly include Natural Scenery(A23), Historical Sites(A14) and City Parks(A07). On the other hand, Shanghai is situated on the Huangpu River and has developed numerous site-seeing spots and routs within the city. In addition, Shanghai has the advantage of being one of China's largest economic and commerce centres, thus has attracted theme parks and themed districts from multiple leading IPs. These attractions have all grown to be Shanghai's representative ICSs. From the real-world situation of these two cities, it can be seen that when analyzing cities from an ICE perspective, the causes for similarity can be more complex, and each city's resources, economics and development strategy are all important factors in addition to geographical location.

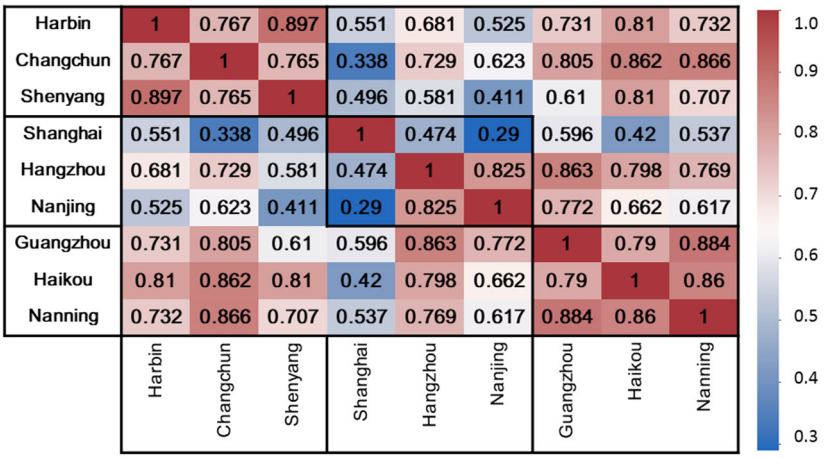


Figure 4. Similarity matrix of scenic spot types.

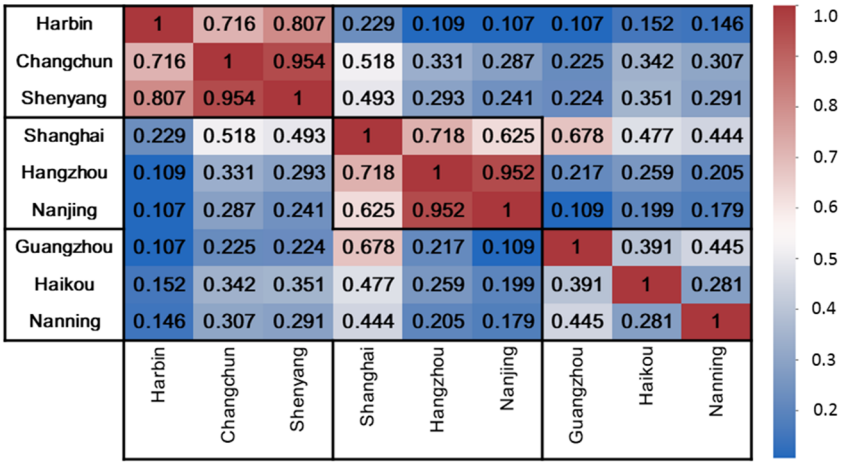


Figure 5. Similarity matrix of restaurant types.

Regarding the average similarity of individual cities, Figure 6 shows that Guangzhou is the most similar for scenic spot types. As illustrated in Figure 6, Natural Scenery (A23) and City Park (A07) are the majority types popular in most cities. Guangzhou follows this trend, and along with its other minor scenic spot types, it is at a position of highest average cosine similarity with other cities.

Meanwhile, it can also be seen in Figure 6 that Shanghai has the most unique scenic spot types. Half its ICSs are composed of City Sightseeing(A08), Ancient Villages(A02), Leisure District(A08), Theme Park(A27) and Landmark Building(A18). People often perceive Shanghai as a big city which lacks its own uniqueness, but from the data results it can be seen that Shanghai in actuality displays a more diverse range of ICS types, making it unique from other cities. This is an example of ICE-driven cognition showing deviation from reality. In terms of data, Shanghai is at a direction away from the majority of cities, thus has lowest cosine similarity.

On the other hand, Figure 7 shows that Shanghai has the highest similarity in restaurant ICS types, showing Shanghai's popular restaurants overlap with many restaurants in other cities. This suggests that consumers visiting internet celebrity restaurants in Shanghai are more likely to find a similar experience with that of other cities, and means that compared to scenic spots, restaurant and food

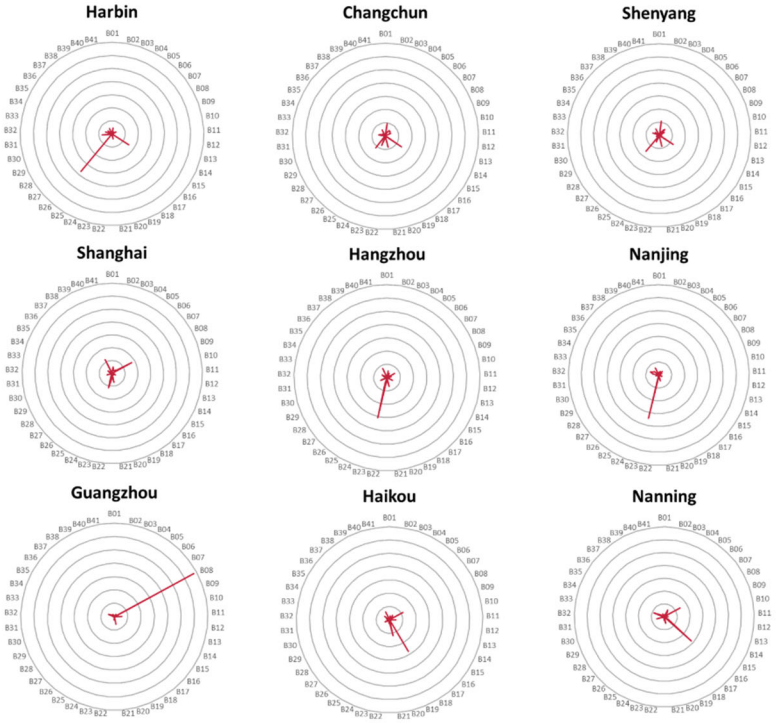
are easier to replicate between cities. Restaurant ICS type data shows most cities have several unique majority types, while Shanghai has a wider range of types, thus its middle position leads to higher average similarity. The data here corroborates the common intuition that Shanghai is an open, diverse and inclusive metropolis, while explaining the duality of Shanghai's scenic spot type uniqueness and restaurant type similarity.

Also in Figure 7, Nanning has the lowest average restaurant similarity. It has very unique cuisine, consisting mostly of Guangxi Cuisine (B16) and Cantonese Cuisine (B08). Other cities rarely possess Guangxi Cuisine, making it unique. Again, note that data for scenic spot types and restaurant types should not be cross-compared.



Ranking	City	Average Similarity (Scenic Spots)
1	Guangzhou	0.756
2	Haikou	0.752
3	Nanning	0.746
4	Changchun	0.720
5	Hangzhou	0.715
6	Harbin	0.712
7	Shenyang	0.660
8	Nanjing	0.591
9	Shanghai	0.463

Figure 6. Average similarity for scenic spot.



Ranking	City	Average Similarity (Restaurant)
1	Shanghai	0.523
2	Changchun	0.460
3	Shenyang	0.457
4	Hangzhou	0.385
5	Nanjing	0.337
6	Haikou	0.307
7	Guangzhou	0.299
8	Harbin	0.297
9	Nanning	0.287

Figure 7. Average similarity for restaurant.

Urban Morphology Similarity

Similarity of morphology for the 9 selected cities is discussed in three levels: the overall group, all city pairs, and individual cities. The ArcGIS Pro 3.0.1 software is used for geo-spatial data manipulation while tools including the SciPy library and SPSS 26 were used for statistical analysis. Regarding data form, all ICSs in cities are characterized using the 16 indicators for physical form, cultural services and commercial activity, giving each city 16 data distributions. All indicators have non-negative values, which is important for understanding analysis results. Normality of all distributions are tested using the Kolmogorov-Smirnov test, and found to not be satisfied, thus non-parametric tests are used instead of parametric tests such as ANOVA and T-tests.

First, the overall similarity of the 9 cities is analyzed using the Kruskal–Wallis test, a non-parametric counterpart of one-way ANOVA which considers the ranks of numerical values to accommodate distributions which cannot be assumed to be normal (Sá and P, 2007). Specifically, a single ranking is assigned to data across all distributions, and significant difference in the median ranking of all distributions is analyzed. This is implemented in Statistical Package SPSS 26 software, testing whether similarity exists respectively for each of the 16 morphological indicators. The null hypothesis H0 is the distributions corresponding to each city all originate from the same distribution. The Kruskal–Wallis test returned significance levels (P-values) of 0.000 for all 16 indicators, thus the null hypothesis is rejected. This result shows that for all morphological indicators, at least one city shows significant differences with other cities in the group, and from a ICE perspective, an overall similarity does not exist for the morphology of these 9 cities.

Second, similarity between each city is analyzed. This study uses the Mann-Whitney U-test, which is the equivalent of the Kruskal-Wallis test for individual pairs. It uses the ranking approach for two data distributions, and tests whether there is a significant difference in median (Mann and Whitney, 1947;

Okoye and Hosseini, 2024). This is implemented using Python 3.9 and the SciPy library's default Mann-Whitney test function. P-values produced by the U-test are equivalent to conventional T-tests, and refer to the probability that two samples are of the same distribution (PEARSON, 1914). In the context here, it indicates the probability that two cities are considered similar.

Figure 8 displays the P-values for all 16 indicators in descending order, revealing the overall trend for each indicator. It can be observed that only less than half of cities display significant similarity (non-negligible P-value), and most cities are dissimilar (P-value approximately zero). This means that the 'thousand cities one face' phenomenon only exists within a subset of cities, and corroborates findings from type similarity analysis, i.e. There does exist highly similar city pairs within the cities selected in this study, but this is far from all city pairs. Regarding specific indicators, the descending trend for P-values of BD, BFR, D_CS, MEAN, P_FOOD, P_HOTEL, P_RECREATION, P_SEC, P_SHOPPING, P_TOURISM, RND and SHDI_CS are relatively consistent, but for 3 specific indicators, D_CU, MAX and STD, P-value descends significantly more rapidly. This indicates that for these 3 indicators, only very few city pairs show similarity. The indicators MAX and STD are driven by building height, thus its dissimilarity can be attributed to cities' natural random disparities in building height, as well as inevitable random errors such as resolution-driven rounding errors introduced in the satellite telemetry data used here. The indicator D_CU is driven by cultural POIs (see Appendix A.), thus compared to other indicators, such as D_CS which is driven by consumer POIs, the total number of POIs driving D_CU is significantly smaller, and more prone to random disparity between cities, leading to dissimilarity. For D_CU, only Guangzhou and Hangzhou, Hangzhou and Nanjing, as well as Guangzhou and Nanjing have a P-value larger than 0.7. This shows that in the context of ICE, compared to other cities, these 3 cities are more likely to give visitors similar experiences with regard to cultural service POI configuration, such as the density of scenic areas, museums and memorials. These three cities are all relatively economically developed eastern and southern cities where natural and cultural tourist attraction resources are more abundant, thus similar economic development and environment will lead to similar cultural POI density within ICS hotspots within the cities.

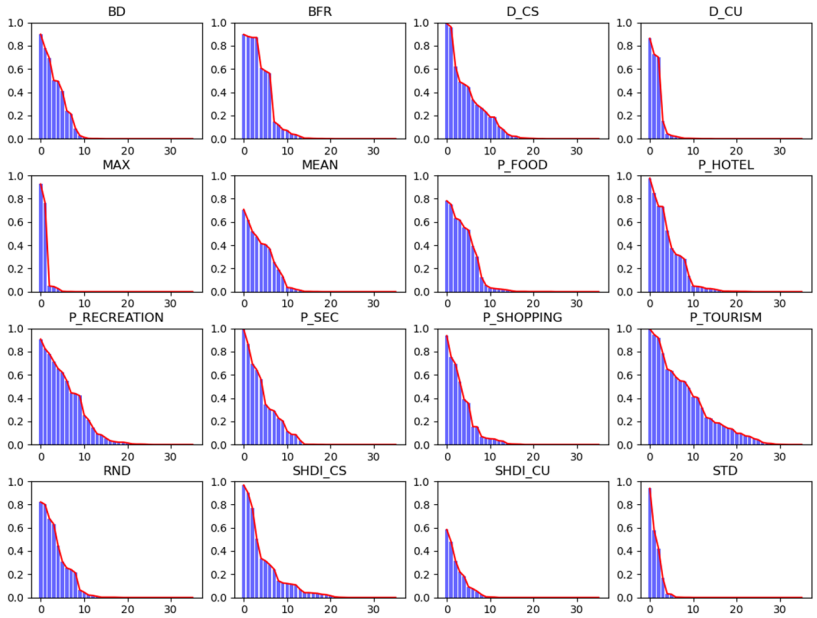


Figure 8. P value trend generated by Mann-Whitney U Test.

This study averages the P-values of each city to characterize its similarity with other cities, i.e. adding the P-values between it and each other city and dividing the number of other cities. The addition of P-values carries meaning here, which could be explained through expected value. Consider city i, which is compared to other cities j≠i . Each outcome of similarity for city j leads to 1 more similar city, with probability Pj, while dissimilarity leads to 0 more cities, with probability (1-Pj). Thus, the expected total number of cities similar with city i is

$$EX_{total,i} = \sum_{j \neq i} 1 \times P_j + 0 \times (1 - P_j) = \sum_{j \neq i} P_j$$

where Pj is the P-value between city j and city i. Furthermore, averaging P-values can be interpreted as the expected increase of cities similar with city i with each additional city, or in other words, the probability that the next city will be similar with city i, based on knowledge from current cities. This is considered as

$$EX_{average,i} = \frac{\sum_{j \neq i} 1 \times P_j + 0 \times (1 - P_j)}{N - 1} = \frac{\sum_{j \neq i} P_j}{N - 1}$$

where N is the total number of cities (including city i). Note how $EX_{average}$ is a measure of similarity which is independent of total city number.

Figure 7 displays the average expected similarity for all 9 cities and all 16 indicators. When considering geographical location, no significant correlation is observed with overall maximum and minimum values of average similarity. On the other hand, Shanghai, Nanjing and Guangzhou are the three cities with higher economic development. Shanghai shows uniqueness, i.e. dissimilarity in many aspects, while Nanjing and Guangzhou show similarity in many indicators. For Shanghai, its MEAN and STD, the three-dimensional building characteristic indicators, show significant difference with other cities. This can be understood through the original data, Shanghai has a higher coverage of taller buildings, raising the mean and standard deviation values of its building height data. This also fits the common perception that Shanghai is a highly urbanized city with many skyscrapers and unique city skyline. The other unique city is Haikou, which holds the lowest similarity in 6 indicators, especially concentrated in cultural services. From the original data it can be observed that Haikou has sparse cultural POIs around its ICSs, and also lacks in the diversity of such POIs, falling far behind other cities. This is speculated to be due to Hainan province having Sanya, another more prominent city for tourism. Also, Hainan is a geographically isolated island with a less extensive history. These facts combined may contribute to Haikou not having developed similar levels of cultural services as other cities.

Looking at all three groups of indicators, Nanjing stands out with its high average expected similarity. By principle of the U-test, as well as the form of the original data, it can be seen that Nanjing's data is most evenly distributed on either side of the overall median for each indicator, leading to its data distribution being closest on average to other distributions. Guangzhou similarly shows a significant level of similarity. In contrast, regarding the groups of indicators, Changchun and Shenyang show most significant dissimilarity in physical form indicators, Haikou and Harbin are most unique in cultural service indicators, and Changchun and Shenyang are again the least similar in consumer activity indicators. Analyzing the data from a real-world perspective, Nanjing is geographically centered in

latitude within China, and its economic development is also at a medium level within the 9 cities here, leading to its high average similarity. Conversely, Northeast China, where Changchun, Harbin and Shenyang are from, is the northernmost area in China. In fact, Changchun, Harbin and Shenyang are the 3 northernmost provincial capitals in China. Furthermore, the economic development of Northeast China is a commonly observed phenomenon in recent years, and this also drives the significant difference in city morphology.

		Harbin	Changchun	Shenyang	Shanghai	Hangzhou	Nanjing	Guangzhou	Haikou	Nanning
Physical Form	RND	0.1028	0.2145	0.1498	0.1026	0.2120	0.0531	0.2221	0.0084	0.0748
	BD	0.0343	0.0818	0.0560	0.0998	0.0628	0.2461	0.2260	0.0649	0.2213
	BFR	0.3036	0.2381	0.1265	0.2996	0.0050	0.2933	0.0300	0.0000	0.1549
	MAX	0.0004	0.0000	0.0004	0.0063	0.0089	0.1211	0.1018	0.1191	0.0959
	MEAN	0.0929	0.0000	0.0674	0.0000	0.1658	0.1878	0.0685	0.2164	0.2469
	STD	0.0208	0.0208	0.0529	0.0000	0.0601	0.1210	0.0726	0.1218	0.0721

		Harbin	Changchun	Shenyang	Shanghai	Hangzhou	Nanjing	Guangzhou	Haikou	Nanning
Cultural Service	P_SEC	0.0776	0.1621	0.1499	0.1695	0.2139	0.1701	0.2679	0.0004	0.1529
	P_TOURISM	0.3354	0.2019	0.0868	0.3764	0.2753	0.3441	0.4359	0.0105	0.4231
	D_CU	0.0046	0.0081	0.0248	0.0020	0.2006	0.1793	0.1960	0.0025	0.0226
	SHDI_CU	0.0263	0.0499	0.0920	0.0123	0.0796	0.1013	0.0456	0.0005	0.1026

		Harbin	Changchun	Shenyang	Shanghai	Hangzhou	Nanjing	Guangzhou	Haikou	Nanning
Consumer Activities	P_FOOD	0.1173	0.0719	0.1050	0.0048	0.2170	0.2198	0.2229	0.0921	0.1681
	P_SHOPPING	0.0000	0.0891	0.0551	0.1039	0.2103	0.2153	0.1905	0.1128	0.0934
	P_HOTEL	0.3061	0.0008	0.1098	0.0515	0.1896	0.2535	0.2546	0.1311	0.0713
	P_RECREATION	0.1605	0.3035	0.0000	0.2558	0.2051	0.2778	0.1973	0.2528	0.1814
	D_CS	0.2635	0.0035	0.2374	0.0194	0.2430	0.2876	0.1055	0.0004	0.2818
	SHDI_CS	0.1309	0.1130	0.1764	0.1401	0.1405	0.1508	0.1534	0.1760	0.1250

1 2 3 4 5 6 7 8 9 Average Expected Value Ranking

Figure 9. Average expected value of individual cities.

CONCLUSIONS

This study discusses the hotly debated topic of 'thousand cities one face' from the novel perspective of Internet-Celebrity-Economy, conducting similarity quantification and tests for the type and morphology characteristics of Internet-Celebrity-Spots in 9 provincial capital cities in China.

Based on data for the 9 cities selected in this study, and separately approaching the two branches of type similarity and morphological similarity, the similarity between cities is discussed for cities overall, city pairs, and individual cities. The conclusions which could be drawn include: 1) Regarding all cities and city pairs, significant similarity between the characteristic indicators of cities can be observed, but exist between a portion of the samples here. 2) Regarding individual cities, Shanghai shows noteworthy difference in its type similarity. As a typical internationalized metropolis, when compared to other cities, it simultaneously possesses more dissimilar scenic area ICS types, and more similar restaurant ICS types. This points to the significant advantage which large cities hold in tourism development, i.e. they have more diverse tourist destinations not available elsewhere, as well as more diverse restaurants which cover cuisines of other cities. Meanwhile, Nanjing is a city with a medium placement in geographical location and economic development, thus displays corresponding similarity

in many indicators. In contrast, Harbin, Changchun and Shenyang have more marginalized placement in both geography and economics, displaying corresponding dissimilarity in certain indicators.

The results from this quantitative analysis can bring insights for city policy makers, aiding them in raising cities' uniqueness or benchmarking and replicating other cities. It is hoped that the approach taken here, collecting and analysing urban morphology data with the perspective of ICE and ICS, can allow a better understanding of the public's interests as well as their cognition of city images. As a topic of debate, the 'thousand cities one face' phenomenon is verified in the quantitative results, showing its importance. Meanwhile however, it has also been shown that numerous cities are able to retain their uniqueness. As the Internet-Celebrity-Economy continues to grow, how to correctly understand its effects and incorporating it into urban design studies and policy making will be an important direction of research.

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Appendix

Appendix A. Morphological indicators calculation equation and description.

Equation	Description
$RND = \frac{L}{AREA}$	L =Total length of road network within the calculation area of each ICS $AREA$ =Area of each ICS and its buffer zone
$BD = \frac{N}{AREA}$	N =Number of buildings within the calculation area of each ICS $AREA$ =Area of the ICS and its buffer zone
$BFR = \frac{A}{AREA}$	A =Building footprint within the calculation area of each ICS $AREA$ =Area of the ICS and its buffer zone
$MEAN = \frac{H}{n}$	H =Total building heights within the calculation area of each ICS n = Number of grids within the calculation area of each ICS
MAX	MAX = Maximum building height within the calculation area of each ICS
$STD = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(h_i - MEAN)}$	n =Number of grids within the calculation area of each ICS h_i =Building height represented by the i th grid
$P_SEC = \frac{N_{\text{sec}}}{N_{cul}} \times 100\%$	N_{sec} =Number of science, education and culture POI within the calculation area of each ICS N_{cul} =Number of cultural service POI within the calculation area of each ICS
$P_TOURISM = \frac{N_{tourism}}{N_{cul}} \times 100\%$	$N_{tourism}$ = Number of tourist attraction POI within the calculation area of each ICS N_{cul} =Number of cultural service POI within the calculation area of each ICS
$D_CU = \frac{N_{cul}}{AREA}$	N_{cul} =Number of cultural service POI within the calculation area of each ICS $AREA$ =Area of each ICS and its buffer zone
$SHDI_CU = -\sum_{j=1}^{N_{cul}} P_j \times \ln P_j$	P_j =Proportion of the number of POIs in this subcategory to the number of POIs in all cultural service categories within the calculation area of each ICS (Cultural service POI has 17 subcategories, which are Museum, Exhibition, Science and Technology Museum, Art Exhibition, Planetarium, Cultural Palace, Zoo, Park, Square, Red Tourism, Memorial Hall, Scenic Spot, World Heritage, Aquarium, Botanical Garden, Religion, Others)
$P_FOOD = \frac{N_{food}}{N_{cs}} \times 100\%$	N_{food} = Number of food and beverages POI within the calculation area of each ICS N_{cs} = Number of consumer activities POI within the calculation area of each ICS
$P_SHOPPING = \frac{N_{shopping}}{N_{cs}} \times 100\%$	$N_{shopping}$ = Number of shopping POI within the calculation area of each ICS N_{cs} = Number of consumer activities POI within the calculation area of each ICS
$P_HOTEL = \frac{N_{hotel}}{N_{cs}} \times 100\%$	N_{hotel} = Number of accommodation service POI within the calculation area of each ICS N_{cs} = Number of consumer activities POI within the calculation area of each ICS
$P_RECREATION = \frac{N_{recreation}}{N_{cs}} \times 100\%$	$N_{recreation}$ = Number of recreation POI within the calculation area of each ICS N_{cs} = Number of consumer activities POI within the calculation area of each ICS
$D_CS = \frac{N_{cs}}{AREA}$	N_{cs} = Number of consumer activities POI within the calculation area of each ICS $AREA$ =Area of each ICS and its buffer zone

$SHDI_CS = -\sum_{j=1}^{N_{cs}} P_j \times \ln P_j$	P_j =Proportion of the number of POIs in this subcategory to the number of POIs in all consumer activities categories within the calculation area of each ICS (Consumer activities POI has 36 subcategories, which are Tea House, Cake and Dessert Shop, Coffee, Others-food & beverages, Foreign Cuisine, Snacks and Fast Food, Chinese Cuisine, Department Store, Convenience Store, Supermarket, Shopping Centre, Flora and Fauna Market, Home Appliances and Digital Products, Home Furnishing and Building Materials, Duty-Free Shop, Commercial Street, Market, Sports and Stationery Supplies, Others-shopping, Budget Chain Hotel, Inn, Youth Hostel, Three-Star Hotel, Four-Star Hotel, Five-Star Hotel, Others-accommodation service, KTV, Cinema, Vacation and Retirement, Bar, Theatre, Agritourism, Chess and Card Room, Internet Café, Amusement Park, Others- recreation)

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Reimagining urban fabric: formal analogies between informal settlements and ottoman mahalle

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ABSTRACT

An intriguing formal analogy emerges when comparing the urban fabric of late Ottoman mahalle (residential neighborhood) with the contemporary informal settlements of 21st-century Ankara on urban scale. Despite both embodying a form of organic development, they diverge significantly in terms of urban continuity. While the former is esteemed as a foundational element worthy of conservation, the latter often faces condemnation and imminent transformation. This research posits the existence of a controlled and systematized organicity inherent in the evolutionary trajectory of 19th-century Ottoman mahalle as an archetype, stemming from their regulatory framework. Employing a comparative methodology, this study seeks to offer a novel lens through which to perceive the concept of "informal." Proposing an analogy through morphological analysis between late Ottoman mahalle and contemporary informal settlements, while bypassing considerations of legality, prompts critical inquiry into urban transformation and regeneration processes. To substantiate the analogy between the two urban fabrics, this study endeavors to synthesize the Typology as Themes of O.M Ungers with Caniggia and Maffei's process-based approach to morphological study. Its objective is to generate a three-column matrix comparing the urban fabric typologies of 19th-century Ottoman settlements with contemporary informal settlements and to show typological compatibility between them as well as thematic relation between them. Ultimately, this study reinterprets the building clusters of Ottoman mahalle as urban block typologies as well as the mixed clusters of gecekondu (informal units). Despite their deviation from pure geometric principles, these clusters offer a pathway for transformative processes. Embracing them as urban block typologies presents an opportunity for thematic urbanization rooted in formative analogy, steering away from wholesale destruction. Such formative comparison of urban form holds promise in shifting local transformation strategies towards more sustainable and inclusive urban regeneration through the generative side of thematic typology.

Keywords: Ottoman mahalle, informal settlements, typology as theme, urban fabric, urban block

INTRODUCTION: READING ORGANIC SETTLEMENTS

Despite extensive demolitions and urban transformations, a formal connection between distinct urban tissues persists, offering significant insights for future urban design interventions. Existing morphological studies of informal settlements often overlook how these areas adapt to and penetrate existing urban fabrics. Understanding the morphology of informal settlements is crucial for ensuring a sustainable continuity of urban form. This research posits that there is a meaningful analogy and

interconnection between the organic urban fabric of the Ottoman mahalle and the gecekondus that emerged adjacent to mahalles in Ankara's Altındağ district. By examining these relationships through the frameworks of "organism" (Caniggia and Maffei, 1979) and "Grossform" (Hattasch, 2016), this study aims to demonstrate how informal settlements and historical urban forms can constitute a cohesive whole through their morphological adaptations. This approach raises critical questions about how informal settlements can be integrated into urban design without resorting to total demolition or drastic transformations. The research seeks to address the following questions: How can we enhance our understanding of the urban morphology of informal settlements to anticipate their contributions to urban development and identify sustainable continuity strategies? To what extent can informal settlements be considered adaptable to existing urban tissues? How can informal settlements be conceptualized in relation to different urban fabrics-historical fabric in this case-irrespective of their legal status? Can a morphological analysis of informal settlements within historical urban contexts offer new perspectives on informality and state-led transformations? To explore these questions, this study first reviews relevant literature on informal settlements, urban morphology, and the urban history of Ankara. It then conducts a detailed morphological analysis to elucidate the findings.

The Literature on Informal Settlements

The term "informal" refers to settlements that develop outside the formal regulations of a state concerning land tenure, urban planning, design, and construction (Dovey and Kamalipour, 2017). This term also encompasses various labels such as slum and squatter (Dovey, 2012), shanty towns (Rodwin, 2022), popular settlements (Hernandez, 2009) and self-help settlements (Ward, 2015), unifying them under one heading to avoid overlapping meanings (Dovey and Kamalipour, 2017). In summary, informal settlements can be broadly defined as urban areas that have arisen independently of governmental oversight regarding urban design, planning, and construction (Kamalipour and Dovey, 2019: 63).

Numerous scholars have investigated the urbanity of informal settlements through diverse research questions (Roy and AlSayyad, 2004; Neuwirth, 2005; Davis, 2006; Dovey, 2012; Tonkiss, 2013). Despite the advancement of methodologies for examining urban form (Hillier, 1984; Moudon, 1994; Gauthier & Gilliland, 2006; Marshall, 2009; Sima & Zang, 2009; Whitehand, 2009), the morphology of informal settlements has remained largely underexplored.

As Kamalipour (2016) notes, Davis (2006) conducted a typological study focusing on the proximity of job opportunities, which led to the development of a taxonomy of informal settlements. In order to move the gaze from formal to informal in morphoplogical studies, Dovey and King (2011) aimed to define and categorize the typology of informal settlements based on growth processes, including settling, inserting, or attaching. Kamalipour (2016) also investigated the urban interfaces of informal settlements, focusing on their spatial relationships and connectivity to nearby public spaces. McCartney and Krishnamurthy (2018) sought to bridge the terminological divide in the literature between formal and informal settlements by categorizing the morphological structures of slums based on site factors, building typologies, and configurations of circulation space.

These studies show that informal settlements contribute to the sustainability of most developing cities despite their lack of formal regulations (Dovey, 2012). Regarding this, informal settlements show great

potential of incremental adaptation within the mixture of different urban fabrics (Kamalipour, 2016). Self-organization is the key and dominant typological mode (Kamalipour and Dovey, 2019) contributing to this adaptation. Furthermore, because of their spontaneous development, they have been considered as “modern vernacular environments” (Lapping, 1973). On the other hand, there is a need of process for the cities to achieve the sustainable mix (Jacobs, 1961), while these settlements develop in the city. Van den Hoek (2008) defines this process as “cyclical transformation”. However, existing depictions of informal settlements are inadequate in capturing the complexity of their morphology, which is necessary to justify and facilitate their cyclical transformation (McCartney and Krishnamurthy, 2018).

Towards a Comprehensive Morphological Characterization of Informal Settlements

A healthy cyclical transformation for a city requires well-organized design interventions. Marshall and Çalışkan (2011) emphasize that poorly described urban morphology can lead to inadequate design interventions. Despite the existence of studies on the urban morphology of informal settlements, the current findings contribute minimally to design interventions, calling into question the methodologies used in these studies. Therefore, this study posits that a morphological characterization synthesizing two different approaches in urban morphology—process-based typology and typological theme—is necessary for a comprehensive understanding of informal settlements.

The development of morphological characterization has been maintained through different approaches (Kropf, 2011). Yet, the roots date back to the study of architectural typology. The idea of the categorization of typologies extends back to Durand, who first, introduced the concept of “model” which is equal to “type”, while systematizing a methodology: cataloging types, classification of formative constraints, and recomposition of constraints (Petruccioli, 1998). Cataloging types, in Durand’s manner, was the categorization of buildings first according to their function (church, temple, theatre), then their geometric and compositional constraints (footprint on: round shape, rectangular shape, horizontals). Following the works of Saverio Muratori, process-based typology (Caniggia and Maffei, 1979) has developed a substantial discourse in morphological characterization that adheres to the concept of urban form as a series of aggregations (Kropf, 2014). Caniggian approach analyzes urban form by representing hierarchical relationships (from part to whole on building footprints, the system of routes/streets, and topography) between and within different districts/towns (Kropf, 2009).

On the other hand, Aldo Rossi (1966) took a step further of Durand’s approach, prioritizing geometric and compositional constraints over function while putting forward the “autonomy” and “persistence” of form through the term “urban artifact” (Marzot, 2014). Rowe and Koetter (1978), furthermore, brought a new perspective through Collage City, which categorizes autonomous urban entities instead of independent buildings, based on their stimulative character in the city (such as memorable streets, stabilizers, the garden, and nostalgia-producing elements). The typological theme (Schrijver, 2021), which Ungers initially suggested and developed under the influence of Rowe (Hertweck and Marot, 2013), has the ability to bring together these concepts under a single heading: "theme". The term "theme" is an abstract concept used to encapsulate all initial ideas, illustrations, and content related to an architectural form—whether it be a building, a building ensemble, or an entire city—under a single analogous figurative object, irrespective of its scale (Güngör, 2022). Although the idea first appeared to categorize architectural elements (buildings) through the term Grossform (megaform), it then began to show up in a kind of morphological characterization of cities (Dialectic City, 1999; City Metaphors, 1982; The City in The City: Berlin as an Archipelago, 1977). To better understand the

interaction and typological relationship between Ottoman mahalle and informal settlements in Ankara, a synthesis of typological theme and process-based typology is necessary.

Urban history of Ankara: The Ottoman *mahalle* and informal settlements

As it was already mentioned, this research analyses the interaction between the urban fabrics of Ottoman mahalle and informal settlements, both situated adjacent to each other in the city center, atop two hills separated by the Bent stream (Figure 1).

The Ottoman mahalle plays a crucial role in defining urban form, functioning historically as both a physical and political unit. Cerasi (2001) describes the mahalle as a cluster of row garden-houses organized around a central public building or monument, such as a mosque, fountain, or medrese, with houses aligned along organic, winding streets. The 1924 military plan of Ankara depicts these clusters as distinct urban islands, each corresponding to a mahalle (Figure 1). This representation reinforces the idea that the mahalle can be viewed as a typological unit akin to an organic urban block in Ottoman settlements, underscoring its significance in understanding the urban fabric of historical Ankara.

Although the mahalle's evolution dates to the fifteenth century, the earliest document on Ottoman settlements in Ankara is from 1924, produced for military purposes (Cengizkan, 2004). Despite transformations since the early twentieth century, the urban fabric of mahalle remains recognizable due to planning decisions and conservation policies in Ankara's history. The first modern master plan of Ankara, Jansen Plan, maintained a deliberate separation between traditional and modern urban fabrics, aiding in preserving the Ottoman mahalle's form (Tankut, 1988). In the 1980s, documentation of Ulus's historical districts and the Ulus Historical Center Conservation Planning Competition (Çakır, Altınöz and Özüduru, 2019) reinforced this separation and heightened awareness of Ottoman mahalle typologies. Although post-2000 regulations have been controversial (Çakır, Altınöz and Özüduru, 2019), the urban fabric of Ottoman settlements has largely retained its historical characteristics, evidenced by street networks, building footprints, urban islands, and plot patterns.

Özdemirli (2019) notes that squatters or "gecekondus" in Turkish, on the other hand, began to emerge in Ankara primarily after World War II, during a period of rapid urbanization and migration. These makeshift settlements, lacking formal planning and infrastructure, were constructed so quickly they were referred to as "gecekondu," meaning "built overnight" (Özdemirli, 2019). Although many have been demolished, gecekondus represent a significant part of Ankara's housing history. Over time, gecekondus in Ankara have undergone various stages of transformation through informal upgrading, government interventions, and policy changes. These stages include the authorization of demolition, pardoning of existing gecekondus, recognition of their political power and formalization, and eventually the criminalization and demolition of gecekondus as part of urban transformation initiatives (Özdemirli, 2019) (Figure 2). Unconventionally, there was a period when gecekondus in Turkey were formally recognized and granted construction rights, significantly influencing the current urban form, including building footprints, urban islands, and plot patterns. However, since the 2000s, government policies have re-informalized and demolished many gecekondus, replacing them with high-rise apartment blocks through controversial urban transformation projects.

Regarding the aforementioned information, this research argues that despite the demolition and replacement of informal settlements, there is a clear formal connection between the urban tissues of the Ottoman mahalle and the gecekondus. This connection can inform future design interventions, providing potential insights towards urban transformation strategies.



Figure 1. The images in order: A part of 1924 military map of Ankara (Source: Günel and Kılıcı, 2015:80), figure-ground map of whole Ankara and focus area (Ulus) in 2015).

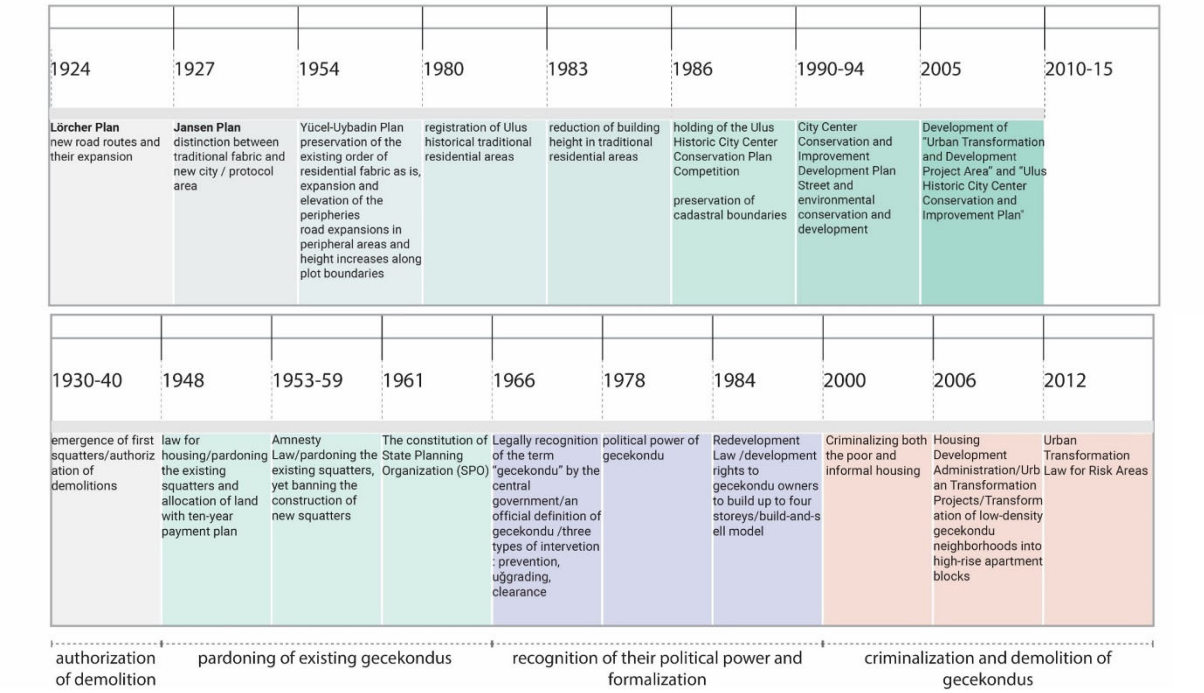

Figure 2. Regulatory timeline addressing the transformation and maintenance of historical and informal settlements in Ankara (Generated by the author. Sources: Tankut, 1988; Cengizkan, 2004; Çakır, Altınöz and Özüduru, 2019; Özdemirli, 2019)

METHODOLOGY : THE SYNTHESIS OF MORPHOLOGICAL APPROACH

To elucidate the formal analogy between informal and historical settlements, this paper posits that a morphological characterization of both informal and historical urban fabrics is essential. Given the variations and ambiguities in morphological characterization within urban form literature (Kropf, 2014), this research aims to synthesize process-based typology and typological theme to achieve a specific objective: thematic and compositional characterization.

The typological theme approach can be observed in a series of Ungers' works, including "Grossform," "Dialectic City," "Architecture as Theme," "The City in the City: Berlin as a Green Archipelago," and

"City Metaphors" (Schrijver, 2021). Among these, "Grossform" and "The City in the City: Berlin as a Green Archipelago" provide a clear set of definitions and methodologies, which this study interprets for synthesis. These works refer to “megaforms” not in a literal sense, but metaphorically, as mature forms that have achieved self-sufficient complexity in their geometry and form, regardless of scale (whether a building, an urban block, or an urban district). To achieve thematic characterization, this study adopts Ungers' four criteria of self-sufficient complexity as described via Grossforms: the presence of an over-accentuated element, a connecting element, the existence of figure and theme, and an ordered principle (Schrijver, 2021).

The process-based typological approach is employed initially to reveal the ordered principles of informal and historical settlements in Ankara. Furthermore, Ungers' definition of ordered principles is insufficiently clear and can be better described through the hierarchical relations delineated by Caniggia. Consequently, this research adopts Caniggia's compositional terminology and analytical system, focusing on building and street layers: unit, structure, system, organism, and route; matrix route, planned building route, and break-through route.

Although Caniggia's system is inherently applied to gridded settlements, this study extends its application to organic settlements to uncover analogies between the figure and theme of informal and formal settlements. Unlike Ungers' approach-which does not apply scalar hierarchy-, this study synthesizes typological themes and process-based typological methods by thematizing the hierarchical components described by Caniggia (1979) (unit, structure, system, and organism).

The analysis involves the diagrammatic representation of Ottoman settlements and informal settlements in the Altındağ district of Ankara. The morphological characterization is carried out by analyzing six distinct periods using a range of historical data, including the 1924 military map, the Jansen Plan, the 1944 map, the 1953 map, as well as GIS data from 2015 and 2024. Unlike other historical studies of Ankara's urban form, this research does not focus specifically on each planning period. Instead, it emphasizes selected periods that reflect significant changes in laws and regulations concerning gecekondus, aiming to provide clear depictions of the figure-ground data of Ottoman settlements across different periods since founding of Turkish Republic. First, the analysis compares the differences between each period. It then conducts a morphological characterization on various scales (organism, system, and structure) using thematic analysis. To establish an analogy between the formative components on different layers (building footprints and street systems), this study creates a typological sequence matrix, inspired by "The City in the City: Berlin as a Green Archipelago."

RESULTS AND DISCUSSIONS

Results

The initial development of Ottoman settlements exhibits an organic progression in structural scale. However, the typology of these structures cannot be determined due to the lack of information or maps documenting building development from that period. The Ottoman mahalle, influenced by the steep topography, displays a distribution characterized by a homogeneous structure that shows an unfolding distribution. Although the Jansen Plan proposed converting a significant portion of Ottoman settlements into elongated urban blocks, which would have compromised the unfolding nature of these historical settlements as an organism, these plans were not executed. This is evidenced by the

1944 map, which clearly shows the expansion of the settlement, maintaining its original boundaries (Figure 3).

The 1953 map marks the initial emergence of informal settlements on the other side of the hill, which is divided by Bent Stream (Bentderesi). This area had remained undeveloped, likely due to its steep slope. The distinct topography of the small hill and the gradual establishment of gecekondus resulted in the formation of an organism constituted by the meeting of the two halves of the divided hill. While it may seem tenuous to describe this as an encounter solely based on the cellular development of informal and historical settlements, the 1953 map also allows for the observation of the structural and unit development of buildings. The buildings' scales, as elementary units, are remarkably similar in both the informal and Ottoman settlements, which justifies the notion of defining this development as an encounter (Figure 3).

The urban data acquired in 2015 indicates that the interaction between the two urban halves reached its own spatial boundaries, which were defined by the lowest sidehill isohips. The topography shaped this urban organism into a distinct encirclement, clearly illustrated in the organism diagram. At this juncture, the southwest half of the hill was predominantly occupied by Ottoman mahalle, while the north half consisted exclusively of informal settlements. The transformation of the southern part into macro-scale dispersed building campuses significantly altered the urban fabric from smaller cells to larger ones, reinforcing the encircling. This change is evident in the street diagram, where the street pattern's evolution from the 1953 map to the 2015 data is distinctly observable. The development of informal settlements based on the 1953 map suggested a potential second tangential encirclement. However, this potential was nullified by urban transformation projects initiated in the 2000s.

While the streets emerging in 1953 displayed an organic layout parallel to both Ottoman and informal settlements, a part of (northeast) 2015 street layout revealed a markedly different urban fabric. The building footprints and the large point blocks from 2015 do not exhibit any logical or parallel alignment with the previous urban fabric, indicating a significant shift. By 2024, urban data reveals the complete erasure of the north half of the hill, as buildings were demolished in accordance with urban transformation regulations. Nevertheless, original street layout remains intact. Together with the new street layout on the northeast for the point blocks and demolished north halve, the urban fabric evolve into a state of confusion (Figure 3).

Due to the absence of maps showing building footprints from the periods of 1924 and the Jansen plan, a comparative analysis of the structural systems with subsequent periods is not feasible. However, data from later periods provides significant insights into the typologies of mahalle-gecekondu urban fabric. Based on the 1944 map, the Ottoman mahalle was the predominant urban form, whereas a systematic presence of gecekondus was not evident at that time. The urban systems displayed an organic layout, with the elementary units—historical Ottoman housing—exhibiting a recurring pattern. This repetition creates what Pettruccioli (2007) describes as an "occasional seriality," where the organic layout of each mahalle is interspersed with repeated units, forming a serial system. In

contrast, the gecekondus did not conform to either an organic or serial group layout. Instead, they were sparsely scattered along the isohips on the hillside, lacking any cohesive pattern (Figure 4).

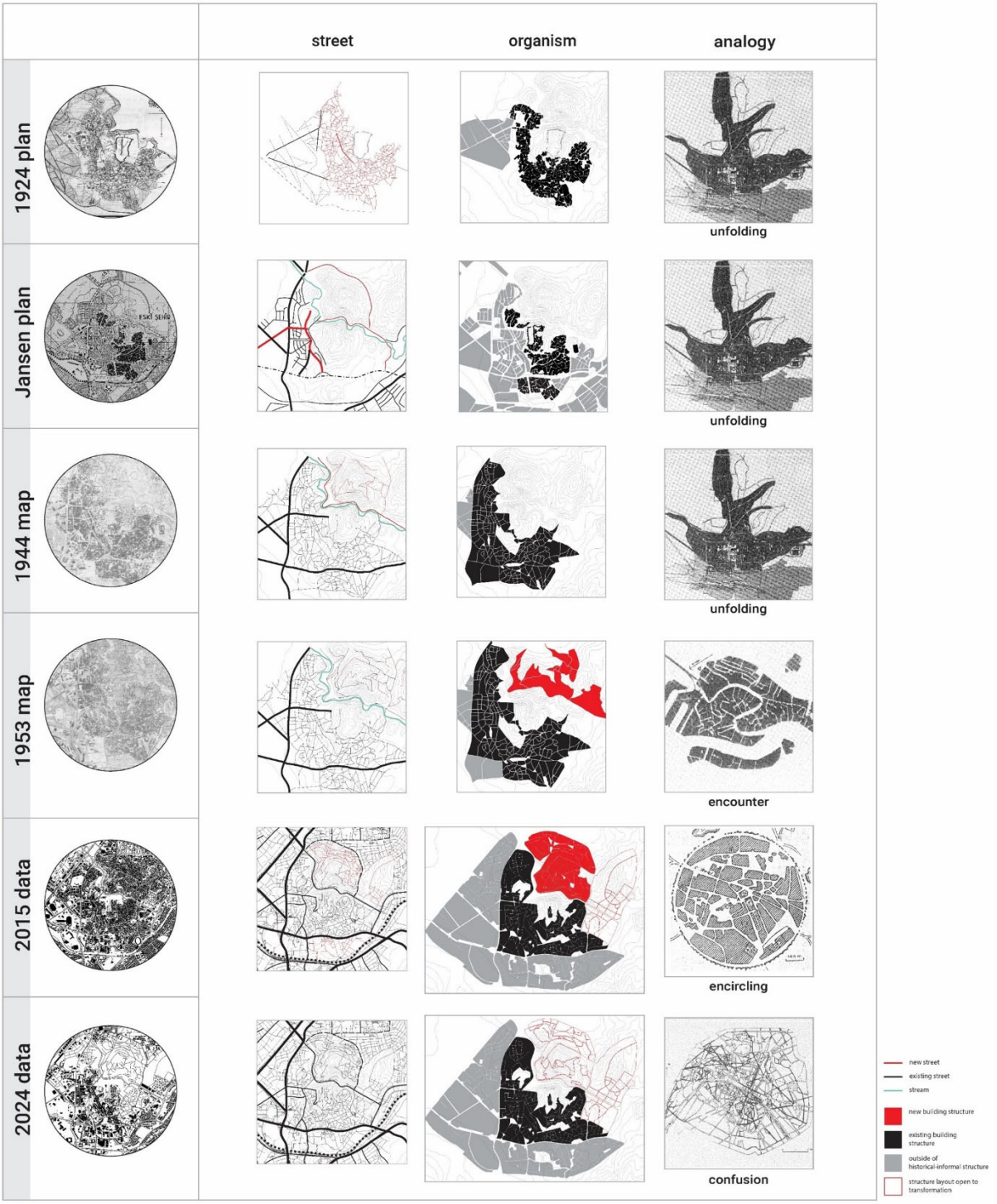

Figure 3 Transformation matrix of the morphological relationship between the traditional mahalle and the gecekondu in Ankara over time. (Diagrams generated by the author based on maps. Source: VEKAM Locloud Collection, TU Berlin Data Collection)

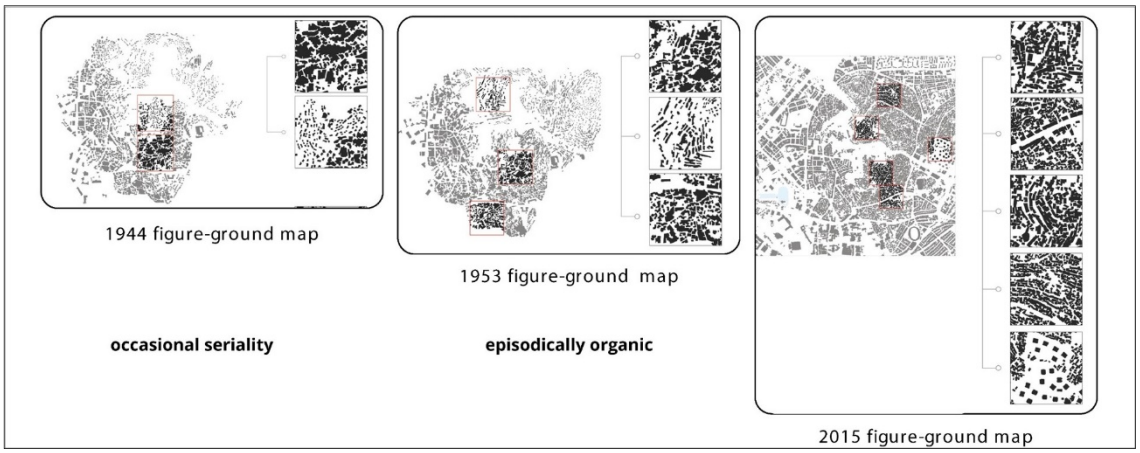

Figure 4. Structural systems of mahalle and gecekondu over time

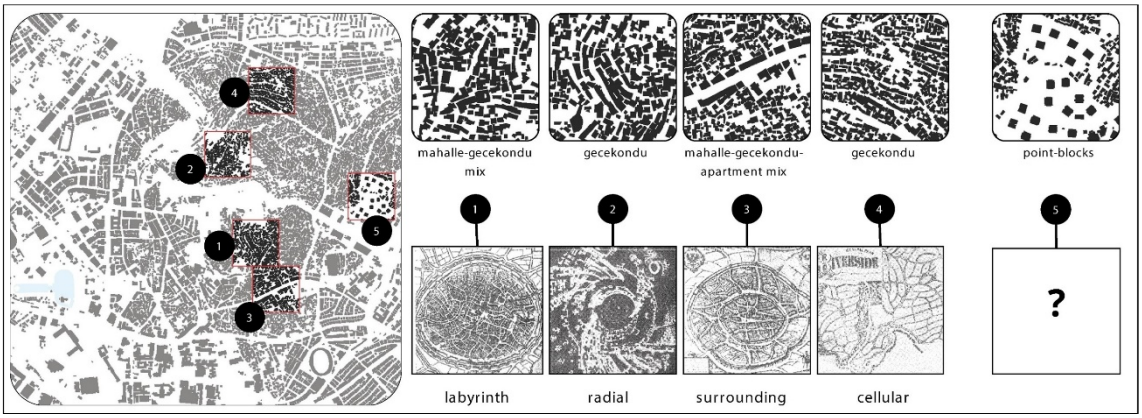

Figure 5. Morphological comparison of the structural systems of the mahalle and gecekondu in 2015

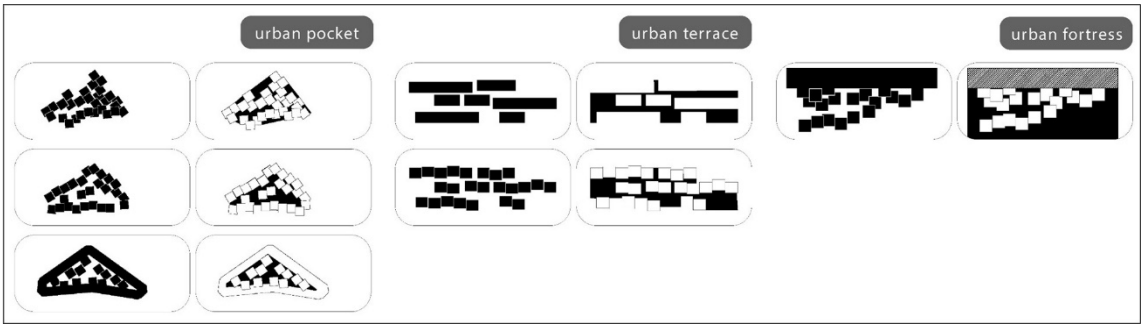

Figure 6. Potential transformative themes of elementary structures derived from the morphological combinations of mahalle and gecekondu units

The 1953 map reveals that the Ottoman mahalle maintained its characteristic occasional seriality, while the gecekondu units began to penetrate the organic layout of mahalle cells on the southwest half of the hill. Initially scattered on the north half, the gecekondu units started forming a serial repetition by attaching to each other linearly along the isohips. This development suggests the emergence of a new structural typology, which Pettruccioli (2017) refers to as "*episodically organic*." In this context, the elements themselves reflects organic growth patterns but occurs in distinct episodes rather than as a continuous process. This hybrid form represents a significant shift from the purely organic or scattered layouts observed in earlier periods (Figure 4).

The 2015 data indicates that the density of gecekondus and their structural system reached a level where the two halves of the hill could be perceived as a unified organism, characterized by similar unit and structure scales in the urban fabric. However, there are nuanced differences between the systemic composition of gecekondus and Ottoman mahalle.

The linear aggregation of gecekondus on the northern hillside resulted in the emergence of a *cellular* structure. In contrast, on the southern hillside, the aggregation of gecekondu units produced a *radial* structure. The Ottoman mahalle meanwhile, maintained its occasionally serial structure with the encroachment of gecekondu units, leading into a mixed structure which can be interpreted as a *labyrinth* form. The modern linear apartment blocks constructed since the 1957 Yücel Uybadin Master Plan of Ankara thickened the boundaries of Ottoman mahalles along the lowest isohips of the southern half of the hill (now Ulucanlar Avenue). This thickening can be interpreted as a *surrounding* form, reinforcing the concept of encirclement and emphasizing the reading of the hill as a single organism composed of Ottoman and informal settlements (Figure 5).

High-rise point apartment blocks, constructed adjacent to the hillside border, on the other hand, do not generate a consistent typology with either the Ottoman or informal settlements, nor with the rest of the city (Figure 5). These high-rises were intended to relocate gecekondu residents from the northern half of the hill, but their vague typology caused significant ambiguity after 2015, effectively resetting the urban fabric of the organism to its initial state when half of the hill was empty. This regression is clearly shown in the 2024 urban data.

On the other hand, the elementary structures of the aforementioned forms—namely the mix of gecekondu-mahalle, apartment-mahalle, and gecekondu structures—exhibit variations in spatial identities that can inform future urban transformations. They also highlight the significance of the spatial themes created by these structures within the urban context. The combination of gecekondu-mahalle can be interpreted as an urban pocket, offering potential access points to an organic block that can accommodate urban activities in spatially dynamic ways for future transformations. The elementary structures composed solely of gecekondus reveal a terrace configuration, which can be seen as urban terraces ripe for future interventions. Moreover, the combination of mahalle, gecekondu, and apartment structures generates a theme reminiscent of a fortress, where gecekondu-mahalle units are integrated with thick substantial apartment buildings. This arrangement conceals the organic open spaces between the gecekondu-mahalle units that lie behind the apartments. Thus, this configuration can be interpreted as an urban fortress that opens up to open-air activity spaces, providing opportunities for future interventions (Figure 6).

Discussion

The synthesis of typological theme and process typological approach while analysing the informal and ottoman settlements reveal several facts in organism scale. Regardless of their legality and the occurrence of demolitions, the aggregation of gecekondus generates a distinct urban tissue. This urban tissue shares significant similarities with Ottoman settlements, with minor differences at the structural scale, resulting from historical preservation implementations. According to Petruccioli (2007, p.184), different urban typologies can be integrated into a cohesive whole if they respect and adapt to each other's spatial logic, leading to typological compatibility. This compatibility is evident at both macro and micro scales when comparing Ottoman and informal settlements.

The analysis reveals five distinct typological themes concerning the reciprocal formation of Ottoman mahalle and gecekondu urban fabric on a macro scale: unfolding, encounter, encirclement, and confusion. Up until the theme of confusion, the temporal transformation of these typological themes shows how the interconnection between Ottoman mahalle and gecekondus adapts over time, culminating in an encirclement. This adaptation is also evident in the encroachment of gecekondus into the inner courtyards of Ottoman mahalle urban blocks. Thus, gecekondus not only dominate the northeast half of the hill but also penetrate the structural system of the Ottoman mahalle. Comparison of conservation timeline and urban fabric analysis reveals this fact clearly.

The analysis of both mahalle and gecekondu reveals notable similarities and differences. On an urban scale, the elementary units and their structural systems share similarities, while the structures of these elements exhibit slight differences. Both Ottoman houses and gecekondus are nearly identical in proportion, contributing to their similar appearance. However, the aggregation patterns of elementary units to constitute a structure differ: gecekondus align linearly along the isohips without providing interior courtyards between buildings, whereas Ottoman houses follow a trapezoidal arrangement along the street edges, adhering to the primary property distribution layout established during Ottoman times. This consistency in following plot edges is likely rooted in Ottoman regulations regarding house construction.

Despite differences in structural organization, both systems exhibit an organic pattern. This research posits that the steep slope of the hill significantly influences this similarity. From this perspective, the research suggests that the spontaneous consciousness emerging during the Ottoman period and after the 1950s, when gecekondus were constructed, shares a similarity. Both periods emphasize topography through the organic system, highlighting the impact of the hill's topography on the settlement patterns. However, there is a key distinction: in the evolution of Ottoman mahalle, the street and plot patterns were established first, whereas in the evolution of informal settlements, construction of gecekondus played a primary role with street patterns developing subsequently. This causes an essential difference in structural formation within the two halves of the hill.

Regarding these observations, the primary difference between Ottoman and informal settlements lies in the emergence of their elementary structures. The elementary structure of an Ottoman mahalle adheres to a set of rules that create defined street edges and internal courtyards, contributing to consistent spatial qualities. In contrast, gecekondus do not follow a prescribed pattern but instead develop organically in response to natural conditions, resulting in a lack of consistent spatial quality. Yet, since they follow the isohips in different levels, there is a recognizable radiality that offers a potential spatial quality for future urban transformation. From this perspective, this research asserts that, despite its organic nature, the occasionally organic structure of the Ottoman mahalle creates a type of organic urban block with distinct spatial qualities, which is not clearly visible/differentiable in informal settlements.

Another vital fact concerning the difference between occasional seriality of mahalle and episodically organic structure of gecekondu is related to the consistency of the elementary unit types: the Ottoman house and the gecekondu. Despite the similarity in unit scale, gecekondus lack a repeating unit type at the architectural level because they were constructed independently and without mastery. Conversely, the Ottoman house has consistent types—with features such as cumba/loggia, avlu/internal courtyard, and two-storey construction—that exhibit synchronic variations across the

southwest half of the hill. Regarding these findings, this research asserts following points that could be important to understand formative relations between Ottoman and informal settlements:

1. There is a typological compatibility between ottoman and informal settlements despite the differences arising from the system of evolution.

2. The informal urban tissue composed of gecekondu generates an encroachment tissue, which generates a mix of gecekondu-mahalle units with thematic potentials for urban transformation strategies.

3. Gecekondus create a distinct urban fabric alongside mahalles, which helps define the combined characteristics of Ottoman and informal settlements. This composition reflects four principles of Ungers' Grossforms: a) the presence of an over-accentuated element, represented by organic urban blocks formed by a mix of gecekondu and mahalle units; b) a connecting element, such as the isohips of the topography; c) the existence of both figure and theme, characterized by encircling and interlocking elements; and d) an ordered principle as organic serial development. In this context, the interconnection of mahalle and gecekondu structures on either side of a hill can be seen as a unique Grossform. The typological compatibility and overlap of informal urban fabrics further support the concept of Grossform by weaving together Ottoman mahalle and gecekondu urban elements.

4. Typological thematization of urban tissues offers new compatible urban transformation strategies for future implications on different scales (organism, system, structure), which brings a new perspective to the continuity process of informal settlements through a formative approach.

CONCLUSIONS

In conclusion, this research elucidates the morphological parallels between Ottoman mahalle and gecekondus in Ankara, revealing a typological compatibility that transcends their legal and historical differences. Despite the challenges posed by urban transformation initiatives, the study shows that both settlement types share a consistent spatial logic influenced by the topography of the hills they occupy. The synthesis of process-based typology and typological themes provides a nuanced understanding of these urban fabrics, offering a framework for future urban interventions that respect and integrate the spatial qualities of both formal and informal settlements.

By identifying five distinct typological themes—unfolding, encounter, encirclement, and confusion—this research underscores the dynamic interaction between Ottoman and informal urban forms. These themes highlight the potential for creating a cohesive Grossform, referred to as the Encircling-Interlock form, integrating different urban typologies into a harmonious whole. This compatibility suggests new avenues for urban transformation strategies that can enhance the continuity and sustainability of informal settlements, leveraging their inherent adaptability and spatial coherence.

Due to the scale and detail of accessible data, the morphological characterization is limited to the organism, system, and structural scales, omitting the elementary scale, which requires detailed floor plans. Additionally, the plot patterns are not clearly visible in the maps used, leading to an oversight of this aspect. Future analyses should aim to integrate plot patterns for a more comprehensive

morphological characterization. The findings of this study suggest that understanding the Grossform of informal and historical settlements can be beneficial for future urban transformation projects, especially in areas like Altındağ where remnants of street layouts and some gecekondus are still recognizable. Moreover, reading informal settlements through their typological compatibility could contribute to a global understanding of informal settlements, potentially redefining the term "informal" in morphological studies and emphasizing its value in design developments and interventions. Ultimately, recognizing and preserving the formal connections between historical and informal urban tissues is vital for developing more inclusive and sustainable urban environments. This study advocates for design interventions that build on the identified typological themes, promoting a more holistic and integrated approach to urban transformation in Ankara and similar contexts.

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Research on Evaluation Factors of Traditional Commercial Streets Pedestrian Comfort: A Comparative View between Experts and Travelers

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ABSTRACT

The perceived pedestrian system is not equivalent to the objective physical built environment due to multifaceted reasons, such as instantaneous traffic conditions and personal travel habits. Evaluating the comfort of a pedestrian system proves challenging when relying solely on a top-down expert perspective, as it may struggle to encompass the nuanced perceptions of individuals within the immersive environment. Conversely, adopting a bottom-up pedestrian viewpoint presents difficulties in comprehensively examining the interplay between neighbourhood spaces and traffic from a more generalized standpoint. Consequently, the actual comfort of the built environment often exhibits a gap from design expectations in diverse situations. The research employed the semi-structured interviews to gather evaluation factors of pedestrian comfort on a traditional commercial street. Factors were considered respectively from the perspectives of urban design experts and ordinary residents engaged in everyday travel. Interviewees and the evaluated street were selected from a typical 15-minute neighbourhood in Shanghai, China. Compared to the two perspectives on the evaluation factors of pedestrian comfort, the findings suggested that physiological responses, emotional perceptions and travel characteristics significantly influence on travellers' perceived comfort. In contrast to the experts' concentration on the objectivity of cause and effect of the travel, residents prioritized experiential facets, giving greater consideration to emotional perceptions such as perceived safety and convenience conveyed by physical elements. The study established a comprehensive framework for the elements and criteria of pedestrian comfort evaluation. A multifaceted perspective is advantageous in addressing the process of urban space gentrification and enhancing the neighbourhood's performance in urban transportation and travel.

Keywords: Pedestrian Comfort, Evaluation Factors, Comparative View

INTRODUCTION

Since 2023, Shanghai has adopted the 15-minute community life circle as the core concept for organizing residential spaces throughout the city. This approach seeks to reorganize urban spaces based on walking time and distance. As the physical embodiment of the 15-minute community life circle, the community pedestrian system is closely connected to daily urban life and the public

transportation network. Pedestrian comfort in traditional commercial streets is a critical factor that significantly influences urban vitality, economic sustainability, and social interaction. These streets, often rich in historical and cultural significance, serve not only as commercial hubs but also as important public spaces where people engage in a variety of activities. Increasing evidence reveals that the improvements in the built environment can facilitate pedestrians by providing more convenient transportation (Ball et al., 2001), accessible destinations (Owen et al., 2007), and well-maintained footpaths (McCormack et al., 2010), etc.

The comfort experienced by pedestrians in these environments is shaped by a complex interplay of factors, including the physical elements of the community pedestrian system (Ewing, 2009), personal characteristics of residents (Bean et al., 2008), walking behaviours and habits (Alfonzo, 2005), physiological perceptions (Wankhede et al., 2016), and psychological perceptions (Singh,2016). While the importance and relevance of different influencing factors are combined into evaluation indexes such as Walkability Index (Frank, 2009), Pedestrian Environment Index (Peiravian, 2014), and Neighbourhood Environment Walkability Scale (Cerin, 2009), there remains a gap in the comparative evaluation of these factors from the perspectives of both experts and travellers. This divergence in perspectives can lead to differing priorities and outcomes in designing and managing traditional commercial streets.

Additionally, several recent studies have linked walking with the diverse demands, activities, and purposes of residents during their travels. Individual characteristics and travel behaviours of pedestrians are closely related to the study of walking comfort. The field of architecture often focuses on the social or physiological characteristics of pedestrians, such as the elderly (Tournier et al., 2016), and children (Rothman et al., 2014). These studies typically explore the walking behaviours of specific groups and corresponding built environment design strategies. As travellers, pedestrians' travel purposes (Bohte and Maat, 2009), time of travel (Moiseeva et al., 2010), duration of travel (Ding et al., 2016), and modes of travel (Rasmussen et al., 2015) significantly influence their behaviours and perceptions while walking. Integrating walking as part of the overall travel process allows for a more systematic understanding and integration of urban public spaces, ultimately enhancing the efficiency and quality of community pedestrian systems.

This paper seeks to bridge these gaps by conducting a comprehensive analysis of the evaluation factors that influence pedestrian comfort in traditional commercial streets, comparing the views of experts and travellers. The study selected the commercial streets of the Kongjiang sub-district in Shanghai, China, as the focus for researching pedestrian comfort. By systematically reviewing previous studies on pedestrian comfort and conducting field research and design analysis, the study constructed semi-structured interviews with residents and experts who live in or near the neighborhood. The findings enabled the collection of detailed explanations and descriptions of factors affecting pedestrian comfort within the neighborhood, and provided valuable insights for the development of more inclusive and user-centered urban design strategies.

LITERATURE REVIEW

Elements of Chinese 15-min neighbourhood pedestrian system

The modern community pedestrian system is an integral part of both the road and public space networks within a community. Since 2018, China's Planning and Design Standards of Urban Residential

Area (Ministry of Housing and Urban-Rural Development of the People's Republic of China, 2018) have adopted the 15-min, 10-min, and 5-min pedestrian-scale neighbourhoods as the basis for organizing residential area. Cities such as Beijing, Shanghai, Jinan, Changsha, and Zhengzhou have incorporated 15-minute community life circle into their master plans as the fundamental unit for urban and rural resident area. In Shanghai, most 15-minute community life circles are delineated according to the administrative boundaries of sub-districts.

The community pedestrian system serves dual functions of pedestrian transportation and recreational walking. It includes roads suitable for walking and non-motorized travel, as well as pedestrian zones, paths, and public space nodes such as plazas, green spaces, and enclosed or open interaction spaces. Natural, artificial, and cultural landscape elements, along with transportation and recreational facilities and other amenities, cater to the aesthetic needs of pedestrians and support walking activities. The interaction and coordination of these networks, environments, and facilities are often reflected in the quality of pedestrian paths, road landscapes, and public spaces, thereby creating a sense of place, belonging, and participation for community residents and forming a complete community pedestrian system (Sun, 2011). Based on 15-minute community life circle, a slow traffic network comprising urban roads, greenways, and public passages needs to be constructed, to enhance the safety and comfort of pedestrian movement (Ministry of Natural Resources of the People's Republic of China, 2021).

Pedestrian comfort and its determinants

Walking, as a mode of travel in any part of a journey, is significantly influenced by factors such as distance, duration, and the quality of the walking environment, all of which impact the overall travel experience. An increasing number of scholars are now focusing on the comfort of walking behaviour and its interaction with other stages of the travel process, conducting more targeted and dynamic evaluations. A meta-analysis of factors affecting walking comfort has revealed that spatial qualities of the community pedestrian system—such as sociability, compactness, convenience, and aesthetics—as well as perceived safety and well-being, all influence walking comfort (Dadpour et al., 2016). While both subjective perceptions of pedestrians and the measurable physical qualities of the community pedestrian system can reflect walking comfort to some extent, the degree and pathways through which these factors influence walking comfort may differ.

In terms of influence degree, some scholars argue that the perceived quality of urban design may be more important for walking comfort than measurable physical characteristics themselves (Johansson et al., 2016). Perceived walkability is positively correlated with walking behaviour, while the impact of spatially measured walkability on walking behaviour is relatively small (Van der Vlugt et al., 2022). Other scholars suggest that the correlation between spatial quality and travel comfort is stronger than that of perceived spatial quality (Lin and Moudon, 2010). For vulnerable groups, destination connectivity is directly and positively related to the duration of utilitarian walking but negatively related to the duration of recreational walking, with walking behaviour being unrelated to individual perceptions of the environment (Van Dyck et al., 2013).

In terms of influence pathways, spatial quality often affects pedestrian perception, leading to different travel behaviours, which in turn result in variations in walking comfort (Ewing and Handy, 2009). More recent research, combining mobile signaling and POI data, suggests that factors such as the functional

amenities, quantity, and distance of walking destinations can indirectly influence pedestrian perception, thereby affecting travel behaviour (Qiao and Yeh, 2023). At the start and end points of a travel chain, good walkability characteristics of the pedestrian system can reduce the burden of walking and encourage low-income commuters to use public transportation more frequently (Ha et al., 2023). During the transfer stage of the travel chain, some scholars have studied the relationship between the types of roads on Bus Rapid Transit routes and citizens' perceptions of walkability and the distance walked to bus stops (Jiang et al., 2012). Others have collected environmental factors of the walking areas around subway stations at a micro-scale through citizen satisfaction surveys, analysing how the objective design quality of the pedestrian environment (Gupta et al., 2022) or the perceived subjective walkability (Gan et al., 2021) promotes subway usage.

METHOD

Through an exploratory qualitative design, semi-structured interviews were conducted from March to April 2024. We recruited a sample of individuals aged 19 to 45 who lived in the selected Kongjiang sub-district in Shanghai, China. All interviewees had participated in the Kongjiang sub-district 15-minute community life circle initiative in 2023 and had extensive and detailed knowledge of all the roads and communities within the site.

Site selection

The Kongjiang sub-district is located in the central part of Yangpu District, covering an area of 2.15 square kilometres and comprising 25 neighbourhoods (Figure 1). According to data from China's Seventh National Census, the Kongjiang sub-district has a registered population of 85,100 people across 32,500 households, with a resident population of 102,800 people (Figure 2). It represents a complete 15-minute community life circle.



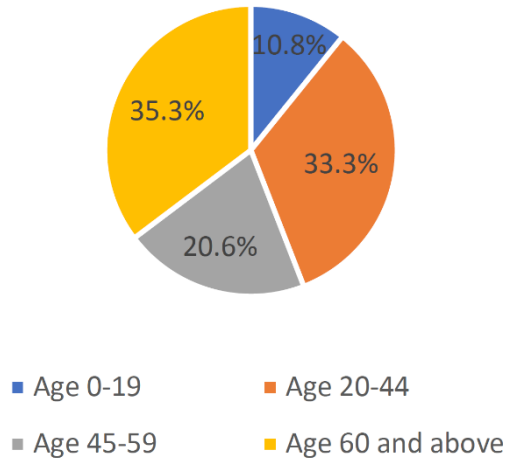

Figure 1. Location and scope of Kangjiang sub-district. Shanghai, photo credit: Author's illustration.

Figure 2. Population composition of Kangjiang sub-district. Shanghai, photo credit: Author's illustration.

The Kongjiang sub-district is intersected by Shanghai's inner ring road and contains 20 roads, with two major arterial roads running both north-south and east-west. In terms of public transportation, the sub-district is served by dozens of bus routes, and two metro lines have stations within the area. The buildings in the region are relatively small in scale, with public service facilities evenly distributed. The

land use is primarily residential, with a significant presence of commercial buildings along the streets (Figure 3). Overall, it represents a typical modern 15-minute community life circle in China.



Figure 3. Status of Kangjiang sub-district. Shanghai, photo credit: Author's illustration.

Sampling and recruitment

The study recruited two types of interviewees: experts and residents. Given that the Kongjiang sub-district includes two communities with dormitories for Tongji University students, the experts interviewed consisted of urban design scholars and urban design students, who, as residents, also brought a professional perspective. The residents interviewed included government officials and ordinary citizens, with government officials increasingly involved in community planning due to the promotion of the 15-minute community life circle.

During the preliminary 15-minute community life circle project, our design team found that residents under 18 and over 60 years of age typically have more singular travel needs, which do not cover a range of scenarios such as commuting, shopping, medical visits, and leisure activities. Therefore, the sample included 5 experts and 5 residents, aged between 25 and 60 years. All interviewees held a university degree or higher. More than half of the interviewees averaged between 5,000 and 10,000 steps or more per day (n=7). Further details of the sample are shown in Table 1.

Table 1. Participant characteristics. Source:

Number	Identity	Sexual	Age	Daily steps
No.1	Urban design student	Female	25	5000-10000
No.2	Urban design student	Male	25	0-5000
No.3	Urban design expert	Male	37	0-5000
No.4	Urban design expert	Female	35	5000-10000
No.5	Urban design expert	Male	32	5000-10000
No.6	Resident	Male	29	5000-10000
No.7	Resident	Female	32	0-5000
No.8	Government staff	Male	36	5000-10000
No.9	Government staff	Female	56	10000-15000
No.10	Government staff	Female	48	5000-10000

Data collection and analysis

The study's semi-structured interviews were designed with 10 questions regarding pedestrian comfort during the travel process in the Kongjiang sub-district. Each question required the interviewees to answer individually. Interviewers strictly followed the outlined questions during the interviews but could adjust the approach depending on the interviewees ' specific situations.

Data were collected through face-to-face and telephone interviews conducted by the authors, who had prior training and experience in qualitative interviewing. During the interviews, the author informed interviewees of the necessity of recording and obtained their consent. It was assured that respondents' identities would be replaced with letters, and any sensitive information would be deleted during the later stages of data use. Within 24 hours after each interview, the recordings were transcribed, and the author organized the records, thereby completing the initial interview process.

The study utilized Colaizzi's seven-step phenomenological method to analyse the interview data (Colaizzi, 1978). This process involved carefully reading the interview transcripts to identify statements of significant meaning, coding recurring significant statements, and summarizing the coded points. Using detailed and comprehensive descriptions, similar viewpoints were identified, and key thematic concepts were refined. Any ambiguous points were verified by returning to the interviewees for clarification. The interview content from the same respondent was independently analysed by two authors, and the results were compared and synthesized to summarize the themes.

RESULTS AND DISCUSSIONS

Theme one: Public transport-led travel mode choice

Interviewees described their daily travel modes for different purposes such as commuting or school, shopping, medical visits, and leisure, and they identified the stages where walking most frequently occurred within these various travel modes. The interviewees consistently reported that the subway and private cars remained the dominant modes of transportation, with walking often serving as a means to access these other modes of travel. Additionally, for traditional Chinese communities, electric scooters were also highlighted by respondents as an essential tool for daily travel.

"The electric scooter parking is right below my building, and the weather in Shanghai always doesn't motivate me to walk. I only walk when heading to the subway station or a designated pick-up point,

and usually for no more than 3-5 minutes." (No.3, Urban design expert, male, daily step count: 0-5,000)

"I believe health is essential, so I choose to commute by bike, usually taking 10 minutes to get from my dormitory to the studio. The distance and time needed to find a shared bike while walking are quite variable, but I find it healthier this way. I only choose ride-hailing services when in a hurry, such as when going to the doctor." (No.1, Urban design student, female, daily step count: 5,000-10,000)

"Ever since I got an electric vehicle, all my various trips have been by car, and walking only occurs when getting in and out of the car. However, in my work, there are many times when I have to walk to communities." (No.8, Government official, male, daily step count: 5,000-10,000)

"I specifically rent a house close to my company or a subway station, so I can control my arrival time at the office by walking. If it's within one subway stop, I usually opt for a shared bike, and if it's farther, I only take a taxi." (No.6, Resident, male, daily step count: 5,000-10,000)

In the choice of travel modes, there was no significant difference between interviewees; the decision to walk or not was primarily influenced by the availability of vehicles and commuting distance. Walking in the community often occurred while heading to or transferring between public transportation, highlighting the importance of paying attention to pedestrian comfort on these routes.

Theme two: Safe, shaded and convenient places for pedestrian

Interviewees described the types of places where walking typically occurred in their daily routines and identified locations and reasons that contributed to uncomfortable walking experiences. For most daily travel, urban roads outside the community were primarily used, but for interviewees who seldom walk for travel (n=4), sidewalks and public spaces within the community were significant walking areas. The most frequently mentioned causes of discomfort during walking included chaotic and unsafe traffic conditions (n=7), a lack of shade (n=6), and the need to navigate stairs (n=5).

"I don't find it necessary to walk within the community and even tend to dislike it. If I must walk, I prefer public spaces outside the community that offer higher spatial quality." (No.3, Urban design expert, male, daily step count: 0-5,000)

"My walking is always purposeful, so I mainly walk along sidewalks inside and outside the community. I think safety and efficiency are most important, and I particularly dislike having vehicles pass by when I'm walking." (No.7, Resident, female, daily step count: 5,000-10,000)

"Since my daily routine is a straight line between work and home, my walking occurs only within the community. Our community has great landscaping, and I enjoy strolling within it. However, I find it very unpleasant when cars occupy the open space in front of buildings." (No.9, Government official, female, daily step count: 10,000-15,000)

When describing the reasons for discomfort, urban design experts were noticeably quicker and more accurate in identifying specific causes compared to ordinary travellers. However, both groups shared a primary concern for pedestrian safety at crosswalks. Moreover, crosswalks, subway transfer

corridors, overpasses, and similar locations should remain focal points for improving walking comfort, supporting the previous theme that walking primarily occurs near public transportation.

Theme three: The divergence in perspectives of pedestrian comfort's evaluation factors

Interviewees were asked to describe the importance of various evaluation factors related to pedestrian comfort. According to the literature review, these evaluation factors includen emotional perceptions during walking, physiological responses during walking, walking characteristics, physical spatial features of the community, personal characteristics, and travel characteristics.

Walking characteristics (such as distance, duration, and whether walking alone) were considered the most important evaluation factors by the majority of interviewees (n=6). In contrast, personal characteristics (such as attitudes towards walking and physical condition) were deemed the least important by most interviewees (n=6). Additionally, interviewees consistently prioritized physiological responses over emotional perceptions in terms of their impact on comfort. Interestingly, the spatial features of the community (such as convenience, aesthetics, and cleanliness) were rated as moderately important (n=6), with interviewees offering somewhat ambiguous negative evaluations.

"If the walking distance exceeds my psychological expectation, I will choose another mode of transportation... this threshold is about 5-10 minutes." (No.6, Resident, male, 5,000-10,000 steps)

"I don't intentionally focus on the surrounding environment because my mood and body will tell me whether I'm comfortable. The purpose of the walk subconsciously shapes my expectations, leading me to either a good or bad mood." (No.1, Urban design student, female, daily step count: 5,000-10,000)

To better understand the differences in opinions between residents and experts, the study assigned importance scores weighting from 6 (most important) to 1 (least important) based on the rankings. The importance score for each evaluation factor was then calculated (Formula 1). Further details of the sample are shown in Table 2.

$$\text{Influence factor importance score} = (\Sigma \text{ frequency} \times \text{weight}) / 10 \quad \text{(Formula 1)}$$

Table 2. Influence factor importance score.

Influence factor	Comprehensive score	Resident score	Expert score
walking characteristics	5	5	5
physiological responses	4.2	4.6	3.8
travel characteristics	3.5	2.2	4.8
emotional perceptions	3.4	4.2	2.6
spatial features	2.8	2.8	2.8
personal characteristics	2.1	2.2	2.0

Before the interviews began, participants were informed to consider walking as a segment of the overall travel experience. Despite this, differences remained between experts and residents in their understanding of travel characteristics and the role they play. Residents believed that physiological responses and emotional perceptions during walking had a greater impact on comfort, but they generally did not consider travel characteristics to be important. They repeatedly mentioned physical

spatial elements such as greenery, noise, and shade in the walking environment, but their focus was on the personal perceptions these elements elicited rather than the elements themselves.

"As long as there's enough shade and little noise during my walk, I can remain physically and mentally comfortable." (No.10, Government staff, female, daily step count: 5,000-10,000)

"What I hate most is sweating during a walk, so I try to walk as little as possible in an environment that's as pleasant as possible……walking with someone I like greatly influences my comfort." (No.7, Resident, female, daily step count 0-5,000)

Experts, on the other hand, were more focused on travel characteristics and physiological responses but paid less attention to emotional perceptions. They generally agreed that studying the impact of travel characteristics on walking comfort is necessary, as experience suggests that these characteristics subconsciously influence perceptions even before the walk begins.

"Before setting out, I make sure to note which parts of the journey will involve walking, and whether my trip is for something positive or negative affects my view of the walk. In short, my mood is predetermined before I start walking, but my physiological responses may vary." (No.2, Urban design student, female, daily step count: 0-5,000)

"I also have some preconceived notions about walking before I set out, but I'm open to enjoying the walk and observing the positive features of the road and environment, which may lead to new emotions." (No.4, Urban design expert, female, daily step count: 5,000-10,000)

Notably, in addition to the six categories of influencing factors provided to participants, weather conditions (n=6), such as temperature and humidity, were most frequently mentioned by both groups as important factors affecting walking comfort. This underscores that physiological comfort is a fundamental aspect of participants' understanding of walking comfort.

Theme four: The most comfortable commercial street

The study selected 12 iconic roads from the Kongjiang sub-district, including main roads, secondary roads, and internal community roads (Figure 4). Interviewees were shown street-view images of these roads in pairs and were asked to recall their walking experiences on each. In the paired comparison, the more comfortable road was assigned a value of 1, while the other was assigned a value of 0. The comfort ratings for all roads were then compiled based on these comparisons (Table 3).

Table 3. Influence factor importance score.

Roads	Comprehensive score	Variance(s^2)	Experts' average	Variance(s^2)	Residents' average	Variance(s^2)
Huangxing road	2.2	0.40	2.2	0.7	2.2	0.2
Songhuajiang road	0.8	0.40	1	0.5	0.6	0.3
Jiangpu road	1.2	1.07	0.8	0.7	1.6	1.3
Kongjiang road	1.8	1.51	2	2	1.6	1.3
Changling road	1.3	1.79	1.4	2.3	1.2	1.7
Shuangyang road	1.9	1.21	1.2	0.7	2.6	0.8
Yanjixi road	1.3	0.90	1.8	0.7	0.8	0.7
Yuanquan road	1.5	0.94	1.6	1.8	1.4	0.3
The First Kongjiang Cun	1.4	0.71	1.4	0.8	1.4	0.8

Wang Chun Jia Yuan	0.7	0.68	0.6	0.8	0.8	0.8
The new fengcheng	2.7	0.23	2.8	0.2	2.6	0.2
The second fengcheng cun	1.2	0.84	1.2	0.7	1.2	0.7



Figure 4. The selected subjects for the comfort evaluation. Shanghai, photo credit: Author's illustration.

Subtheme: Main road

Both the expert and resident participants consistently identified Huangxing Road as the most comfortable main road (s^2=0.4), particularly among the majority of residents. The difference between the two groups emerged in identifying the least comfortable road: experts pointed to Jiangpu Road (s^2=0.7), while residents considered Songhuajiang Road to be the least comfortable (s^2=0.3). Overall, Songhuajiang Road was regarded as the least comfortable by the respondents (Figure 5).

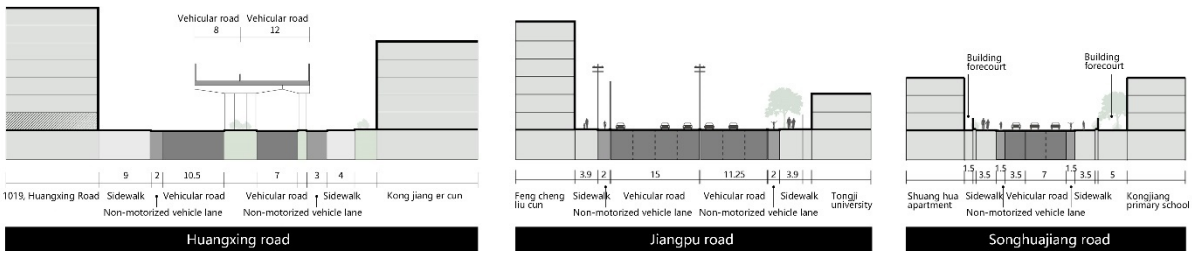

Figure 5. Three representative main roads. Shanghai, photo credit: Author's illustration.

"The sanitation on Songhuajiang Road is quite poor; I often step on something dirty on my way to and from work." (No.9, Government official, female, daily step count: 10,000-15,000)

"Huangxing Road may have an overpass, but the greenery is well-maintained, and I can barely see the overpass in my line of sight … Jiangpu Road feels too open, almost deserted." (No.7, Resident, female, daily step count: 0-5000)

Subtheme: Secondary main road and branch road

When considering experts and residents as a whole, the comfort of the four selected secondary main roads and branch roads were quite similar. However, the majority of residents identified Shuangyang Road as the most comfortable (Figure 6).

"The comfort of Shuangyang Road comes from a sense of familiarity, which is the most important spirit in our Chinese communities... Good neighbourly relationships are very important." (No.5, Urban design expert, female, daily step count: 5,000-10,000)



Figure 6. Shuangyang road. Shanghai, photo credit: Author's illustration.

Shuangyang Road is lined with numerous grocery stores located on the ground floor of residential buildings, providing considerable convenience to residents. At several key intersections, small landscape features have been installed at street corners, offering visual comfort to pedestrians. Additionally, certain sections of the road have been equipped with reversible lanes, which help prevent congestion during peak hours, keeping noise levels relatively low. The Chinese-style neighbourhood relations are largely fostered by the close connection between these grocery stores and residents' daily lives. The shop owners and residents are often neighbours, and this repetitive commercial interaction has shaped a modern Chinese community commercial street.

Subtheme: Intra-community road

The study selected four communities— the First Kongjiang Cun, Xin Feng Cheng, Wangchun Jiayuan, and the Second Fengcheng Cun—each differing in their time of construction and population composition. Both the interviewed experts and residents unanimously found the internal roads of Xin Feng Cheng to be the most comfortable for walking (s^2=0.23), while the internal roads of the Second Feng Cheng Cun were deemed the least comfortable (s^2=0.68) (Figure 7).

"During our work on the 15-minute community life circle project, we found that in communities named with cun, the internal roads are often uneven, and there is a common occurrence of mixed traffic between pedestrians and vehicles. The outdated building facades along the roadsides and poorly managed greenery also fail to provide visual comfort within the pedestrian's line of sight," (No. 4, Urban design expert, female, daily steps 5,000–10,000).



Figure 7. Two differentiated intra-community road. Shanghai, photo credit: Author's illustration.

The New Fengcheng community is one of the few mixed-type communities within the Shanghai inner ring road, featuring townhouses, high-rise buildings, and hotel-style apartments. Completed in 2005, it is considered one of the higher-quality residential developments in Yangpu District. The section of Kongjiang Road where this community is located is quiet, with lush greenery that provides a tranquil environment amidst the bustling city.

The Second Fengcheng Cun community is a typical worker's new community built in Shanghai during the 1950s. Yangpu District, being a hub for industry with a large working-class population, hosted four of the nine worker's new community sites in the city's "20,000 Workers' Housing Units" project, with a total of 10,000 units in Yangpu alone. From the first through the fourth Fengcheng Cun are exemplary of this type of community. When these workers' new communities were built, housing was arranged in clusters of 100-200 units, with 4-5 acres of open space reserved for public green areas and activity spaces; each new community of 1,000-2,000 units was equipped with comprehensive public facilities. However, due to the age of these developments, the living environment in such communities has become relatively outdated compared to current living standards. During the 15-minute community life circle renovation process, there have been numerous complaints from residents regarding the quality of the community environment.

Discussion

The semi-structured interviews revealed several key insights into pedestrian comfort within the Kongjiang neighborhood, highlighting the interplay between travel mode choices, the crucial quality of comfort pedestrian places, and the divergence in pedestrian comfort evaluation factors between experts and residents. Respondents also rated the streets they thought were the most and least comfortable. A significant finding is that pedestrians usually connect between transportation modes like subways, private cars, and electric vehicles. This reliance on motorized and public transport highlights the urgent need for enhancing the comfort of pedestrian infrastructure, particularly in areas around transport hubs and crosswalks. Due to the lack of consideration for safety, convenience, and shade, these interviewees rated these transfer places near the transportation hubs as the most uncomfortable places at present.

The divergence in evaluation factors between the two groups is particularly telling. While residents prioritize immediate, sensory experiences—such as the impact of greenery, noise, and weather—experts lean towards objectivity of cause and effect like travel characteristics and physiological responses. Residents considered the most comfortable commercial streets to be those characterized by a strong sense of community spirit and well-maintained greenery. This gap underscores the importance of integrating both subjective and objective elements in urban planning to create pedestrian environments that are not only functional but also emotionally satisfying.

CONCLUSIONS

This study explored the evaluation factors of pedestrian comfort on traditional commercial streets within a 15-minute neighbourhood in Shanghai, comparing the perspectives of urban design experts and residents. By utilizing semi-structured interviews, the findings highlight that walking characteristics and physiological responses significantly influence perceived comfort among travellers. Experts tend to focus more on the travel characteristics and physiological response in walking, while traveling residents prioritize experiential factors, such as perceived safety and convenience.

The research underscores the importance of considering both expert and travellers' viewpoints to create a more comprehensive evaluation framework for pedestrian comfort. By bridging the gap between these perspectives, urban planners can develop more effective, inclusive, and user-centered strategies for the design and management of traditional commercial streets. This approach not only enhances the pedestrian experience but also supports the broader goals of urban vitality, economic sustainability, and social interaction in these culturally and historically significant spaces.

Future research could extend this study by exploring pedestrian comfort in different types of travel destinations to understand how different contexts influence comfort perceptions. Additionally, quantitative methods, such as large-scale surveys or sensor-based assessments of pedestrian movement and behaviour, could complement the qualitative findings, providing a more comprehensive understanding of pedestrian comfort.

Acknowledgements

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Research on the evaluation of pedestrian friendliness in the living street space: A case study of two open residential districts in Shenzhen

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ABSTRACT

Streets, as an important component of urban public space, have received increasing attention for their spatial quality. Pedestrian-friendliness is one of the core connotations of street spatial quality in the street design guidelines issued in major cities around the world, such as London, New York, Shanghai and Shenzhen (Jiang et al.,2012; Chen et al.,2017). Scholars in different fields have developed frameworks of evaluating and analysing the pedestrian-oriented street spatial quality in the overall city scale and proposed reference for design strategies (Long & Tang, 2019; Marvin et al.,2019; Lu & Tan, 2019; Istrate & Chen, 2022). Meanwhile, living street is one typical street carrying the daily activities of local residents. It is of great importance to study the relationship between the physical environment of living street space and people's walking behaviours for contributing a walking-friendly city.

This paper aims to explore the interaction between the psychological perceptions of residents and the built environment of the living streets. Two typical open residential areas in Shenzhen, totalling 18 streets, were selected. It firstly develops a morphological framework of measuring the physical environment of street space, which includes twenty indicators in four categories: street morphology, street function, street traffic and street greening. Meanwhile, semantic differential (SD), structured Interviews and Questionnaires are used to investigate the psychological perceptions of the residents. 17 pairs of adjectives are used in the SD questionnaire. Factor analysis is used to extract the common metrics in the SD evaluation. Correlation analysis is then adopted to explain the relationship between the indicators of living streets morphology and resident's perceptions. Based on this, suggestions could be provided to enhance street built environment that could be more vibrant and pedestrian-friendly. It is hoped that the improved understandings of this underlying relationship would provide reference for proposing pedestrian-friendliness design strategies for living street space in the future.

Keywords: Living street space, Open residential district, Pedestrian friendliness, Street morphology, Semantic differential

INTRODUCTION

Recently, the quality of pedestrian-oriented street spaces has garnered increasing attention. Cities such as London, New York, Shanghai, and Shenzhen have successively issued urban design guidelines, street design manuals, and relevant policies that emphasize the importance of enhancing street quality (Jiang et al., 2012; Chen et al., 2017). Living street refers to an urban road within a residential area where more than 60% of the land on both sides of the street is used for residential purposes, and the shops on both sides of the street are mainly focused on catering and lifestyle services. These living streets, as the most frequently utilized spatial carriers for residents' daily commutes, leisure travel, and various life activities, not only fulfill the function of facilitating traffic but also create socially significant spaces for community interaction. However, many streets face issues such as unreasonable scales, monotonous spatial experiences, and uncomfortable pedestrian environments. Given the current shift in urban environmental construction from "incremental development" to "stock renewal," exploring street space environment issues in residential blocks based on residents' subjective perceptions is of great theoretical and practical significance for creating pedestrian-friendly street spaces and pedestrian-friendly cities.

Pedestrian friendliness is a crucial attribute for measuring street space quality. Experts and scholars from various fields have explored methods for evaluating and optimizing street space pedestrian environments from multiple perspectives. Many studies on street walkability focus on the meso- and macro-levels, examining how walkable environmental factors and built environment elements affect residents' walking behavior (Cervero et al., 1997; Koohsari et al., 2015). Other researchers have delved into the micro-level, investigating how street space forms, scales, streetscape features, and municipal facilities impact pedestrian behavior (Jaskiewicz et al., 2000; Dover et al., 2014; Yin et al., 2016). Given that living streets in residential blocks are crucial public spaces and important carriers of public activities, it is essential to study the relationship between street space form elements and pedestrian behavior from the perspective of urban design, based on residents' subjective perceptions and at the meso- and micro-scales. Unlike residential areas in other Chinese cities that, before the 1980s, experienced closed management due to the planned economy’s danwei (work unit) courtyard model, Shenzhen’s residential neighborhoods during this period did not fully implement property management and gated access control. Consequently, some residential neighborhood streets can be shared with the city, and the well-developed surrounding retail commercial facilities make these open residential areas more vibrant and dynamic. Therefore, this paper focuses on the type of open residential districts in Shenzhen, aiming to study the impact mechanisms of the built environment of living streets on residents' subjective perceptions. The goal is to provide recommendations for creating pedestrian-friendly street spaces and building pedestrian-friendly cities.

METHODOLOGICAL FRAMEWORK

This paper firstly conducts field research and resident interviews on open residential areas in Shenzhen, and conducts preliminary data collection. Next, a framework for measuring the built environment of living streets in open residential districts in Shenzhen was constructed, including street morphology, street function, street traffic and street greening. And then the semantic

differential method is used to analyse residents' psychological subjective perception evaluations. Evaluation factors are firstly selected, and adjustments are made based on the pre-survey results from residents' on-site questionnaires and the subjective evaluation factors for pedestrian-friendliness are determined. Factor analysis is then further applied to cluster the evaluation factors, leading to the identification of the principal components of residents' perception evaluations. Finally the relationship between pedestrian's psychological perceptions and the physical environment of street space was explored. Key environmental factors influencing residents' walking experiences were identified, which could provide reference for design strategies to enhance the walkability of living streets.

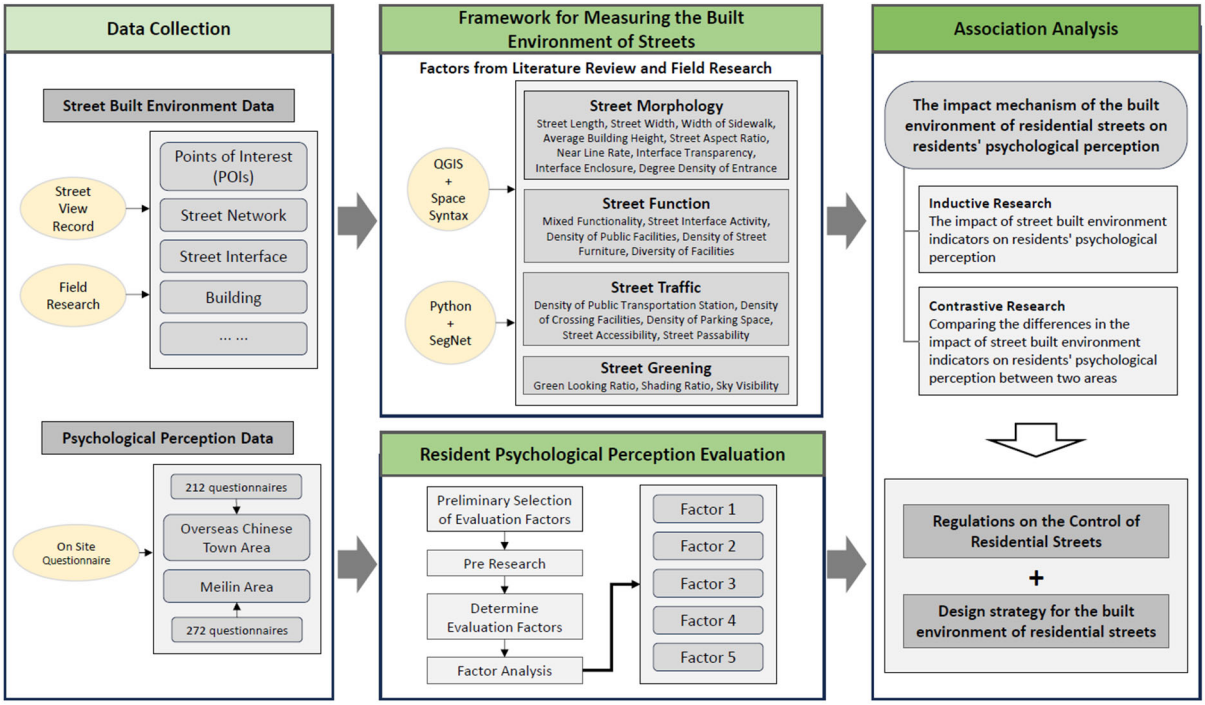

Figure 1. The framework of the study.

Psychological perceptions of pedestrian friendliness

A questionnaire survey was conducted using the semantic differential method (SD) to assess pedestrians' psychological perceptions. Semantic differential Proposed by Charles E. Osgood in the 1950s, it measures attitudes using bipolar adjective scales. It is usually used to measure people's experience with a product or a scenario (Osgood et al., 1957). Factor analysis was employed to determine the psychological evaluation structure of pedestrians regarding the streets and to calculate evaluation scores for each street based on common factors, thereby quantifying residents' subjective assessments of the streets at different levels. Factor analysis is a statistical method used to extract common factors from a group of variables with overlapping information. It is primarily applied when the number of variables is large and there is a certain degree of correlation among them. By studying the relationships between these variables, it groups strongly correlated variables into categories, thereby significantly reducing the number of variables and summarizing new factors that reflect the majority of the original information (Bartholomew, D. J.,1995) .

Based on the characteristics of open residential districts in Shenzhen, this study considers the impact of street spatial environment, atmosphere creation, and attractiveness on pedestrian behavior and

psychology. Drawing on the research of several scholars (Zhang, 2000; Dover et al., 2014; Yin et al., 2016) and through a pre-survey questionnaire, 17 adjective pairs were ultimately selected as subjective evaluation factors. These factors include: Satisfaction level, Walking Comfort, Quietness, Sense of Liveliness, Attractiveness, Space Openness, Convenience, Continuity, Greening Richness, Activity Richness, Interface Neatness, Functional Completeness, Safety, Tree Shading Coverage, Facility Completeness, Willingness to Linger, and Daily Communication Frequency. Each evaluation factor was assigned a 5-point rating scale: very poor, poor, average, good, and very good, corresponding to scores of -2, -1, 0, 1, and 2, respectively.The survey was conducted using an interview-style questionnaire approach. A total of 25 questionnaires were planned for each street, amounting to 450 questionnaires in total. Ultimately, 212 valid questionnaires were collected from the OCT area and 272 from the Meilin area, achieving a response rate of 97%. The demographic structure of the respondents in both areas was similar, with each demographic proportion closely aligning with the overall statistical averages.

Physical environment of street space

The framework for measuring the built environment of streets includes data on four spatial attributes: street morphology, street function, street traffic, and street greening (Li et al.,2019; Shi et al.,2020). The definition and quantification methods of various built environment indicators are shown in Table2. For the built environment survey, data on spatial elements were obtained by using CAD topographic maps as the base material, supplemented by field surveys for data correction. The survey content covers four sub-indicators: street morphology, street traffic, street function, and street greening.

Table 2. Definition and quantification of built environment indicators

Dimension	Indicator	Concept Definition	Measurement Method
Street Morphology	Street Length	Pedestrian average crossing width.	——
	Street Width	Total street segment length of the sample street.	____
	Width of Sidewalk	Sidewalk width of the sample street.	$w_a = S_a \,/\, 2L$ S_a represents the effective sidewalk area. L is the street segment length.
	Average Building Height	Average facade height of street interface.	$H_a = \frac{\sum_{i=1}^{n} s_i}{2L}$ S_i represents the street-facing facade area of building i. L is the street segment length.
	Street Aspect Ratio	Weighted ratio of building height to street width.	$P_i = \sum_{i=1}^{n} h_i \times l_i \,/\, d_i \times L$ h_i represents the height of building i along the street, l_i is the street-facing length of building i, d_i is the distance from the building i to the road centerline, and L is the street segment length.
	Near Line Rate	Represents the proximity of the street interface to the street boundary, or the degree of concavity and convexity of the interface.	$N' = \frac{\sum_{g=1}^{n} s_g}{\sum_{j=1}^{m} s_j + \sum_{g=1}^{n} s_g} \times 100\%$ n is the number of street segments divided by the variation in distance between the street-side interface and the boundary, s_g i is the area between the smallest boundary distance interface and the boundary across segments. m is the number of segments with the smallest distance between the interface

			and boundary, s_i is the area between the side interface and the nearest interface in different segments.
	Interface Transparency	The visual openness or closure of the buildings or enclosed interface on both sides of the street to pedestrian.	$C = \frac{0 \times a_1 + 0.5 \times a_2 + 1 \times a_3}{L}$ a_1, a_2, and a_3 represent the lengths of closed, semi-closed, and open interfaces. L is the street segment length.
	Interface Enclosure Degree	Calculate the proportion of buildings, walls, columns, and fences in the street view image.	$V_e = \frac{B_n + W_n + S_n + F_n}{A_n}$ B_n is the number of pixels for buildings in the image, W_n is the number of pixels for walls, S_n is the number of pixels for columns, F_n is the number of pixels for fences, and A_n represents the total number of pixels in the image.
	Density of Entrance	Ratio of the number of entrances along the street to the street length.	$D_e = S_e / L$ S_e is the number of entrances. L is the street segment length.
Street Function	Mixed Functionality	The balance of types and quantities of functional facilities along the street; quantified using the information entropy of functions.	$J = \frac{H}{H_m} = -\frac{\sum_{i=1}^{n} P_i \ln P_i}{\ln N}$ J represents the mixed functionality index, P_i is the percentage of different functional areas of street-facing buildings relative to the total area, and N is the number of functional categories.
	Street Interface Activity	Percentage of commercial interface length along the street.	$P_C = L_C / 2L$ L_C is the total length of commercial building facades on both sides. L is the street segment length.
	Density of Public Facilities	Number of public activity facilities per unit length of the street.	$D_f = N_f / 2L$ N_f represents the number of public activity facilities along the street, including outdoor spaces such as plazas, parks, courtyards adjacent to the street boundary. L is the street segment length.
	Density of Street Furniture	Density of functional street furniture per unit length of street, including seating, phone booths, vending machines, and sanitation facilities.	$D_sf = N_sf / 2L$ N_{sf} is the number of street furniture within the street area. L is the street segment length.
	Diversity of Facilities	Calculate the variety and number of different types of facilities to obtain a comprehensive evaluation value.	$H' = -\sum_{i=1}^{S} \frac{n_i}{N} \cdot \log_2\left(\frac{n_i}{N}\right)$ s is the total number of facility types, n_i is the quantity of the i-th facility type, and N is the total number of all facility types.
Street Traffic	Density of Public Transportation Station	Number of public transportation stations per unit length of street.	$D_t = N_t / L$ N_t is the number of bus stops and entrances of rail transit stations in the street. L is the street segment length.
	Street Accessibility	Measure of street network accessibility using 800-meter angular integration from space syntax.	$NAIN = \frac{NC\text{^}1.2}{TD + 2}$ NC is T1024 Node Count R800 metric. TD is T1024 Total Depth R800 metric.
	Street Passability	Measure of street network passability using 800-meter angular choice from space syntax.	$NACH = \frac{\log_2(Ch + 1)}{\log_2(TD + 3)}$ Ch is T1024 Choice R800 metric. TD is T1024 Total Depth R800 metric.
	Density of Crossing Facilities	Number of crossing facilities such as pedestrian crosswalks per unit length of street	$D_c = N_c / L$ N_c represents the number of crossing facilities, and L is the street segment length.
	Density of Parking Space	Number of parking spaces per unit length of street.	$D_p = N_p / L$ N_p is the number of parking areas along the street. L is the street segment length.
Street Greening	Green Looking Ratio	Based on street view image data, use image semantic segmentation with Segnet technology to extract the average proportion of greenery elements in pedestrian recognition	$V_g = \sum_{i=1}^{N} P_g / P$ P_g represents the greenery elements in pedestrian view images. P represents all elements in the pedestrian view images.

	images taken at 21-meter intervals on each street.	
Shading Ratio	Shading area ratio of tree canopy vertical projection along the street.	$D_s = S_S / S$ S_S is the shading area of tree canopy vertical projection. S is the street area.
Sky Visibility	Based on street view image data, use image semantic segmentation with Segnet technology to extract the average proportion of sky elements in pedestrian recognition images taken at 21-meter intervals on each street	$V_s = \sum_{i=1}^{N} P_S/P$ P_S is the sky elements in pedestrian view images. P is all elements in the pedestrian view images.

Correlation analysis between psychological perceptions of pedestrian friendliness and built environment

This study first employed principal component analysis (PCA) to simplify the multiple variables related to residents' perceptions of pedestrian friendliness. As a type of factor analysis, PCA reduces the dimensionality of the original variables by extracting uncorrelated principal components, thereby simplifying the data structure while retaining the main information of the original data and effectively avoiding multicollinearity issues. Compared to other factor analysis methods, PCA is more data-driven and does not require assumptions about latent factors. Therefore, by analyzing the SD factor data on residents' pedestrian friendliness, this study extracted several principal components that reflect residents' perceptions of pedestrian friendliness, which served as the dependent variables for the subsequent correlation analysis.

Following this, Pearson correlation analysis was used to explore the relationship between built environment indicators of livable streets and the principal components of residents' perceptions of pedestrian friendliness. Pearson correlation analysis quantifies the strength and direction of the linear relationships between these variables by calculating the correlation coefficient between each street environment indicator and the principal components of pedestrian friendliness. This analysis helped identify key street environment factors that significantly influence perceptions of pedestrian friendliness. These factors provide further insights into how the built environment affects residents' walking experiences, offering guidance for optimizing street design and improving pedestrian environments.

Case: two residential districts

This paper focuses on the type of open residential districts in Shenzhen. The first one, Overseas Chinese Town (OCT) area, is located in Nanshan District, Shenzhen. It was built in the 1980s and underwent large-scale planning, design, and unified construction in the early stages of construction. The residential area is shown in Figure 1, covering approximately 70 hectares. The residential buildings in each plot are mainly 7-9 story multi story buildings with high building density. This article selected 8 residential streets with typical spatial characteristics as research samples (A1-A8, see Figure 1,2 and Table 1).The second one, Meilin District, is located in Futian District, Shenzhen. It was built in the late 1980s to early 1990s and was one of the urban construction projects carried out during the early stages of Shenzhen's reform and opening up. The residential area is shown in Figure 2, covering approximately 130 hectares. Unlike the OCT area, the Meilin area is influenced by multiple developers

who develop and construct land parcels and time periods, and has more diverse contact information with other residential areas. This article selected 10 residential streets with typical spatial characteristics as research samples (B1-B10, see Figure 3,4 and Table 1).

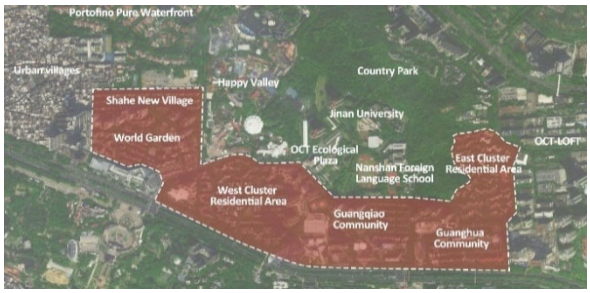

Figure 1. Overseas Chinese Town Residential Area.

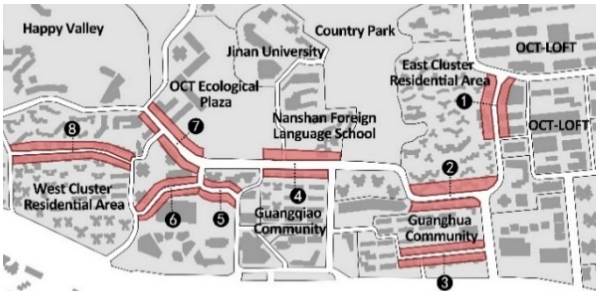

Figure 2. Research object in OCT Area.



Figure 3. Meilin Residential Districts.

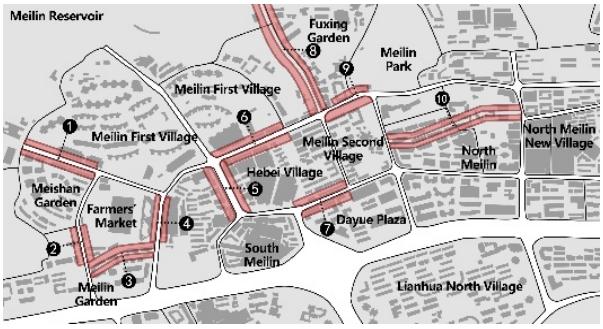

Figure 4. Research object in Meilin Districts.

Table 3. Research Streets in Two Residential Districts.

Number	A1	A2	A3	A4	A5	A6
Street View Image						
Number	**A7**	**A8**	**B1**	**B2**	**B3**	**B4**
Street View Image						
Number	**B5**	**B6**	**B7**	**B8**	**B8**	**B10**
Street View Image						

DATA STATISTICS AND PRELIMINARY ANALYSIS

Psychological perceptions assessment of pedestrian friendliness

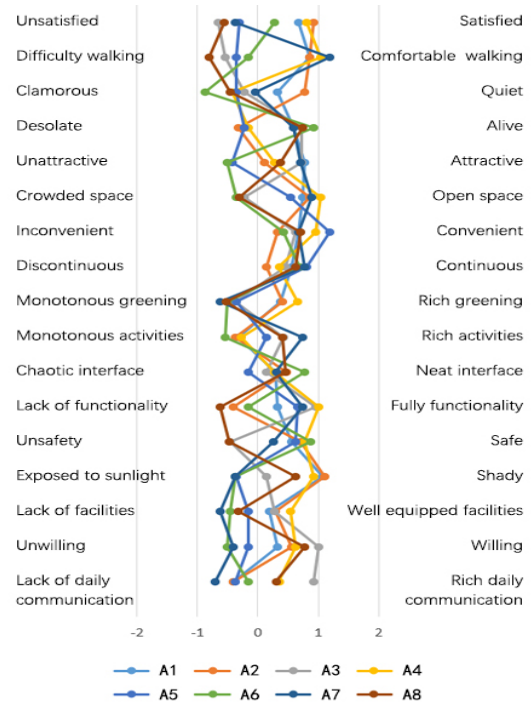

Figure 5. Evaluation curve of street design in sample Streets of the OCT district (SD)

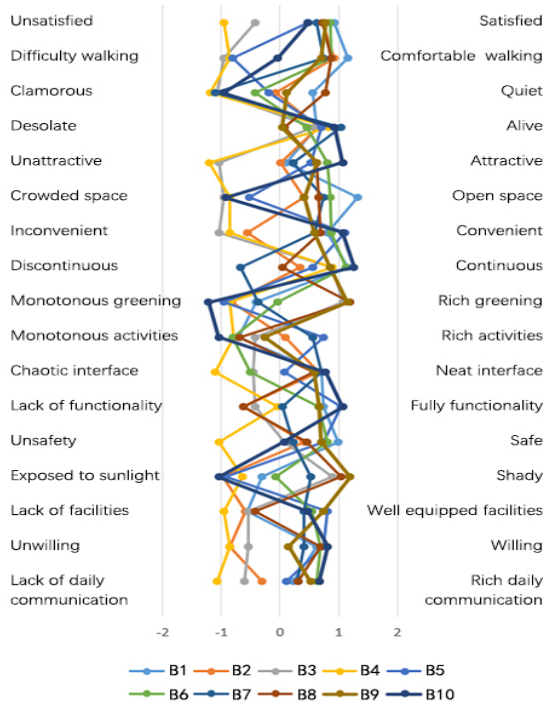

Figure 6. Evaluation curve of street design in sample Streets of the Meilin district (SD)

The statistical analysis of the survey data resulted in the SD measurement tables for pedestrians' spatial perceptions of each street (Figures 6 and 7). The average scores for various attributes mostly range between 0 and 1, indicating that the subjective perception of walkability in the livable streets within the study area is generally at a moderately favorable level. By comparing the scores of streets in the two areas, it is evident that pedestrian satisfaction in the Meilin area is slightly higher than in the OCT area. Specifically, Meilin scores slightly higher in attributes such as attractiveness, space openness, convenience, continuity, landscape richness, safety, and tree shading coverage, reflecting a certain level of recognition for Meilin's efforts in pedestrian space scale and streetscape construction. On the other hand, the OCT area scores slightly higher in factors such as walking comfort, quietness, sense of liveliness, activity richness, interface neatness, functional completeness, facility completeness, willingness to linger, and daily communication frequency. This suggests that the OCT area has some advantages in terms of resident participation in activities and the adequacy of living facilities. Additionally, there is considerable variation in the spatial characteristics and levels of recognition among the streets within Meilin.

Furthermore, a longitudinal comparison of the evaluation attributes reveals a noticeable differentiation among them, with some attributes exhibiting relatively high or low values. For instance, despite being renowned for its greenery, the OCT area has a negative mean score for greening richness. These results indicate that the influence of the built street environment on residents' psychological perceptions requires further investigation.

Built environment measurement

For the data of built environment, after sorting out the built environment data of all streets, it was found that the streets in the two areas were quite different in terms of construction scale and size.

The overall street scale of OCT was larger, the buildings were low, and it was relatively open. The street scale of Meilin area was relatively narrow, but the layout of store functions, public facilities, street furniture, etc. was richer.

In terms of street greening, the overall green looking rate and shading rate of OCT Area are higher than those of Mei-lin Area, while the overall sky visibility is slightly lower than that of Meilin Area. A1 and B8 are the streets with the highest green view rate in the area, while A6 and B6 are the streets with the lowest green view rate in the area. From their street view images, you can clearly feel the difference in the experience of walking in them. The same is true for the analysis of sky view rate.

RESULTS AND DISCUSSIONS

SD factor analysis of pedestrian friendliness

In this study, sixteen variables, excluding satisfaction, were distilled into five principal components with eigenvalues greater than 1 (Table 3). Using SPSS software, the initial eigenvalues, variances, and cumulative variances of the five factors were calculated. The results show that these five principal components explain a cumulative variance of 72.494%, indicating that the five factors extracted from the 16 original variables can reasonably explain the perception of walkability in the living streets.

Factor 1 includes six evaluation variables: daily communication frequency, willingness to linger, facility completeness, functional completeness, attractiveness, and convenience. This factor primarily describes the degree to which various functional attributes and facilities support residents' social interactions and engagement, and is thus named the "Social Interaction" factor. Factor 2 includes five evaluation variables: walking comfort, space openness, quietness, safety, and interface neatness. This factor focuses on the overall pedestrian experience within the street environment, encompassing both psychological safety and physical comfort, and is therefore named the "Pedestrian Environment" factor. Factor 3 includes two evaluation variables: landscape richness and tree shading coverage. This

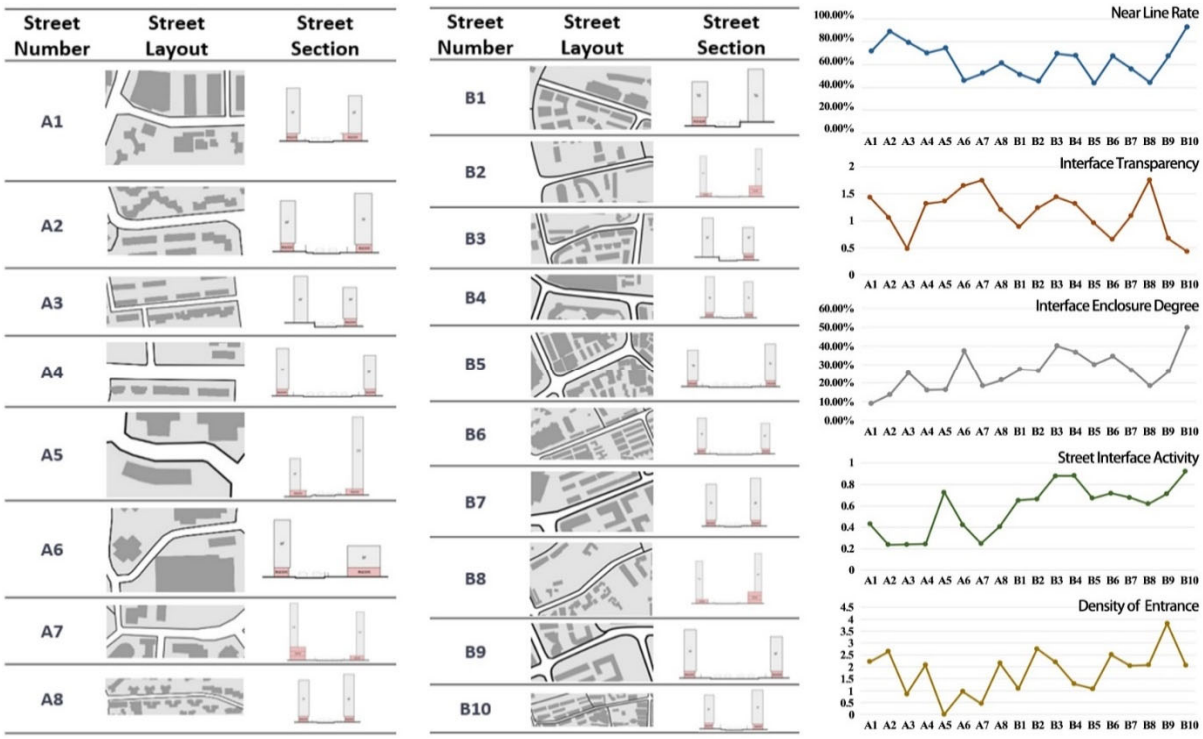

Figure 7. Analysis of the Built Environment of the Street

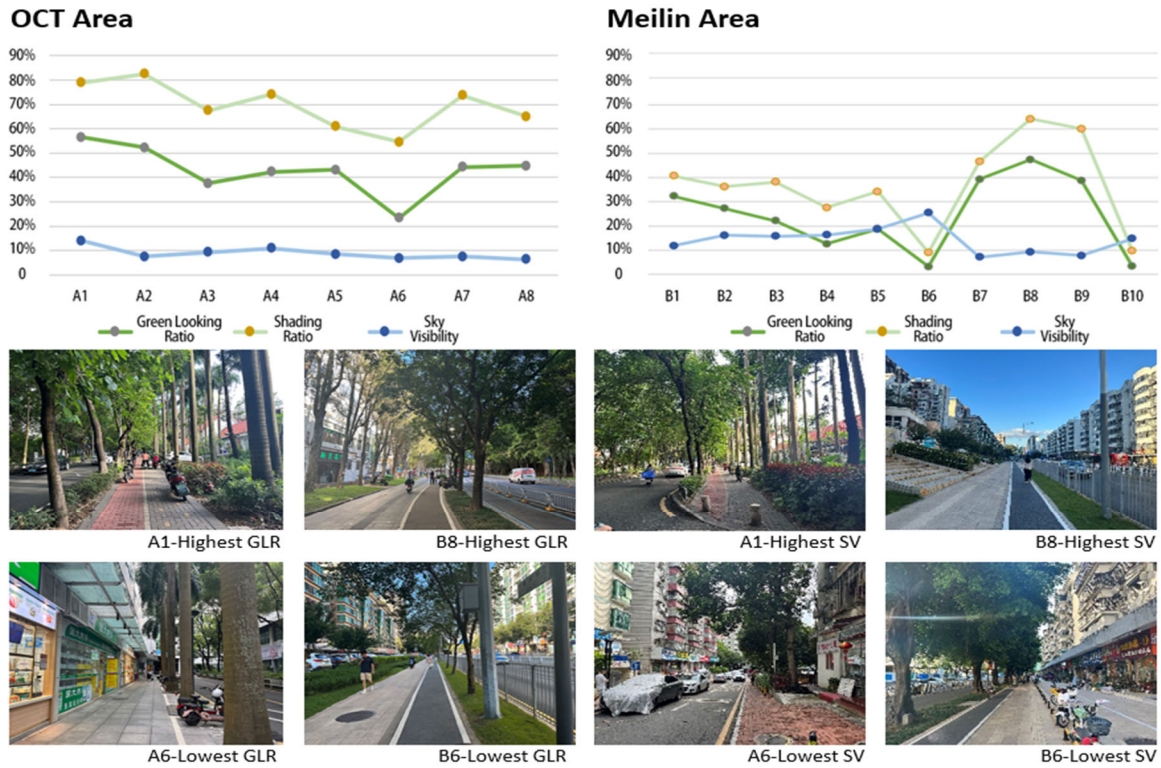

Figure 8. Analysis of the Built Environment of the Street

factor mainly describes the characteristics of the street's greening environment, reflecting the quality of the ecological environment, and is named the "Landscape and Greening" factor. Factor 4 includes two evaluation variables: sense of liveliness and activity richness. This factor primarily describes the

level of street activity and the diversity of events, and is named the "Street Vitality" factor. Factor 5 includes one evaluation variable: continuity. This factor focuses on reflecting the continuity and consistency of buildings on both sides of the street, and is named the "Interface Continuity" factor.

Table 3. Component matrix after factor load rotation

SD Factor	Principal Component Factor				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Daily communication frequency	.805	.112	.213	.152	
Willingness to Linger	.779	.195	.237	.150	
Facility Completeness	.733	.249	.329		
Functional Completeness	.693	.332			.320
Attractiveness	.669	.457		.152	
Convenience	.630	.498			.196
Walking Comfort	.209	.839	.175		
Space Openness	.196	.817	.200		
Quietness	.174	.703	.308		.147
Safety	.302	.671	.227		.138
Interface Neatness	.337	.568	.123	.207	-.103
Greening Richness	.145	.316	.846		.117
Tree Shading Coverage	.234	.277	.838		
Sense of Liveliness	.121			.894	.219
Activity Richness	.479	.223	.140	.491	-.394
Continuity	.326	.198	.154	.259	.742

Extraction method: Principal Component Analysis
Rotation method: Kaiser standardized maximum variance method
Rotation has converged after 9 iterations
Note: Blank cells indicate that the absolute value of the value is less than 0.1

Table 4. Factor score coefficient matrix

SD Factor	Principal Component Factor				
	Social Interaction	Pedestrian Environment	Landscape and Greening	Street Vitality	Interface Continuity
Walking Comfort	-.137	.379	-.097	-.014	-.065
Quietness	-.151	.264	.046	.009	.077
Sense of Liveliness	-.170	-.035	-.040	.846	.168
Attractiveness	.185	.067	-.138	.000	-.043
Space Openness	-.147	.363	-.073	.022	-.064
Convenience	.178	.106	-.180	-.160	.103
Continuity	-.037	-.089	.035	.124	.794
Greening Richness	-.105	-.084	.573	-.041	.093
Activity Richness	.126	.005	-.024	.410	-.577
Interface Neatness	-.011	.217	-.091	.130	-.234
Functional Completeness	.231	-.004	-.193	-.112	.253
Safety	-.045	.237	-.015	-.125	.061
Tree Shading Coverage	-.036	-.114	.566	-.029	-.069
Facility Completeness	.270	-.137	.131	-.150	-.007
Willingness to Linger	.293	-.157	.060	-.032	-.032
Daily communication frequency	.340	-.195	.059	-.026	-.134

The common factors were described through linear combination functions of the original variables, and the factor coefficients of each principal component factor were calculated using regression under the least squares criterion (Table 4). When calculating the "Social Interaction" factor, evaluation attributes such as "Daily Communication Frequency" and "Willingness to Linger," which describe residents' social interactions, were assigned higher weights, while most other adjectives received negative weights, consistent with the actual representation of the factor. Similarly, the evaluation attributes with higher weights in the "Pedestrian Environment," "Landscape and Greening," "Street Vitality," and "Interface Continuity" factors also align with their respective actual representations.

Based on the factor score coefficients and the values of each variable, the evaluation scores for each sample street based on the common factors were obtained (Table 5), as well as the evaluation scores for each area (Table 6). The tables indicate that in terms of social interaction, the OCT area slightly outperforms the Meilin area, suggesting that OCT has a slight advantage in the layout of social spaces or the configuration of social facilities. However, the difference between the two areas is not significant. In terms of the pedestrian environment, the OCT area has a noticeably higher score than the Meilin area, indicating that pedestrians in the OCT area experience a more comfortable and safer walking environment. Although the landscape and greening scores for both areas are negative, the OCT area scores relatively higher, suggesting that its greening level is slightly better than that of the Meilin area, though both areas have room for improvement in this regard. Regarding street vitality, the Meilin area scores higher, indicating that its streets likely have more commercial activities, attracting more foot traffic. In terms of interface continuity, the Meilin area scores significantly higher than the OCT area, suggesting that the street design in Meilin is more cohesive, allowing for a smoother pedestrian flow. Overall, the OCT area performs better in social interaction, pedestrian environment, and landscape greening, while the Meilin area excels in street vitality and interface continuity. It is evident that the OCT area places greater emphasis on pedestrian comfort and safety, whereas the Meilin area focuses more on street vitality and spatial continuity. The strengths of each area provide valuable insights for further street design and urban planning.

Table 5. Street factor score table

Street Number	Social Interaction	Pedestrian Environment	Landscape and Greening	Street Vitality	Interface Continuity
A1	-0.19515	1.24492	0.39313	0.49654	0.74352
A2	-0.38768	1.00467	0.77967	-0.23533	0.08
A3	1.25374	-0.29732	-0.35215	0.39833	0.28698
A4	0.50589	0.75424	0.41119	-0.00717	0.4925
A5	0.14317	0.05171	-0.71468	-0.1538	-0.90556
A6	-0.40107	-0.17067	-0.66168	1.18688	0.89774
A7	-0.3678	1.72321	-1.30636	0.63234	0.40413
A8	0.4645	-0.47046	0.05168	0.30891	0.0296
B1	-0.23021	1.48526	-0.96069	0.77548	1.40545
B2	-0.94888	1.07783	-1.16098	0.88399	-0.04938
B3	-0.88055	-1.89829	1.56489	0.28093	1.1736
B4	-0.93825	-1.83016	-0.54017	0.20227	1.61176
B5	1.27677	-0.02602	-1.32758	0.59149	0.52121
B6	0.58775	0.58775	-0.40825	0.05029	1.56952
B7	0.36632	0.36632	-0.28831	1.07088	-1.07674
B8	-0.3354	-0.3354	1.04277	0.1996	0.16194
B9	0.35152	0.35152	1.02409	0.22812	0.82138
B10	1.33551	1.33551	-1.69602	0.88908	1.74086

Table 6. Area factor score table

Area	Social Interaction	Pedestrian Environment	Landscape and Greening	Street Vitality	Interface Continuity
OCT	0.11908	0.49979	-0.17799	0.32771	0.47206
Meilin	0.05846	0.21292	-0.27503	0.51721	0.78796

Correlation analysis between pedestrian friendliness and built environment

The correlation analysis between the street evaluation factor scores of the two residential areas and the various indicators of the built environment across four dimensions is presented in Table 7.

Street Morphology: Street Length, Width of Sidewalk, Average Building Height, and Near Line Rate did not show any correlation with the five evaluation factors. Street Width exhibited a moderate positive correlation with the "Pedestrian Environment" factor (.563*). Interface Enclosure Degree showed a positive correlation with the "Interface Continuity" factor (.590**). Density of Entrance was positively correlated with the "Social Interaction" factor (.643*) and also with the "Landscape and Greening" factor (.527*). This correlation was not anticipated; a potential reason could be that higher Density of Entrance increases the visual diversity of the street and makes green landscapes more visible and easier to experience. Street Aspect Ratio showed a negative correlation with the "Interface Continuity" factor (-.566*), which contrasts with previous understanding. The reason for this might be that higher Street Aspect Ratios are usually associated with taller and more spaced-out buildings, leading to a reduced perception of interface continuity. Additionally, Interface Transparency was negatively correlated with the "Social Interaction" factor (-.683**). High transparency in street interfaces implies less shielding or privacy protection, making residents feel exposed in public spaces and reducing their willingness to engage in social interaction. Moreover, the lack of correlation between Width of Sidewalk and the evaluation factors suggests that the sidewalk width in these two areas may sufficiently meet pedestrian needs, resulting in unclear correlation analysis outcomes.

Street Functionality: Street Interface Activity did not show any correlation with the five evaluation factors. Mixed Functionality was positively correlated with the "Street Vitality" factor (.520*). Density of Public Facilities and Density of Street Furniture were positively correlated with the "Social Interaction" factor (.603*, .565*). Diversity of Facilities showed a positive correlation with the "Pedestrian Environment" factor (.799*). However, Street Interface Activity, Density of Public Facilities, Density of Street Furniture, and Diversity of Facilities did not show a correlation with the "Street Vitality" factor, which was contrary to the hypothesis. These built environment characteristics, while enhancing the quality of public spaces, did not significantly influence resident social behavior patterns

Table 7. Correlation analysis results between street built environment indicators and evaluation factor scores（OCT Area and Meilin Area）

First level indicator	Second level indicator	Social Interaction		Pedestrian Environment		Landscape and Greening		Street Vitality		Interface Continuity	
		r	P -	r	P -	r	P -	r	P -	r	P -
Street Morphology	Street Length	.378	.122	.074	.770	-.292	.240	.292	.240	.201	.423
	Street Width	.071	.781	**.563***	.015	-.119	.637	-.020	.939	.297	.231
	Width of Sidewalk	-.325	.188	.271	.277	-.325	.188	.330	.181	.035	.889

	Average Building Height	-.265	.287	-.055	.829	-.250	.317	.030	.907	-.365	.136
	Street Aspect Ratio	-.092	.717	-.211	.400	-.155	.539	-.129	.609	**-.566***	.014
	Near Line Rate	.295	.235	.038	.881	.171	.497	-.-456	.057	.172	.495
	Interface Transparency	**-.683****	.022	-.180	.474	.222	.376	.004	.988	-.278	.264
	Interface Enclosure Degree	.141	.576	-.327	.186	-.318	.198	.430	.075	**.590****	.010
	Density of Entrance	**.643***	.016	.069	.785	**.527***	.025	-.129	.609	.148	.558
Street Function	Mixed Functionality	.069	.787	-.122	.630	.236	.345	**.520***	.027	.028	.911
	Street Interface Activity	-.083	.743	-.355	.148	.107	.673	.132	.603	.332	.178
	Density of Public Facilities	**.603***	.017	.464	.053	-.164	.516	.197	.434	-.063	.803
	Density of Street Furniture	**.565***	.014	-.465	.052	-.293	.254	-.227	.365	-.291	.242
	Diversity of Facilities	.353	.151	**.799***	.001	-.429	.076	-.383	.117	-.157	.534
Street Traffic	Density of Public Transportation Station	-.380	.120	-.054	.831	.218	.386	-.076	.765	.233	.352
	Density of Crossing Facilities	-.091	.720	.098	.700	.167	.507	.172	.496	.061	.811
	Density of Parking Space	-.083	.743	**-.564***	.015	.077	.762	.035	.890	.203	.420
	Street Accessibility	**.660****	.003	.099	.697	-.190	.451	.127	.616	-.127	.615
	Street Passability	.407	.094	**.540***	.021	-.067	.793	.112	.659	.186	.459
Street Greening	Green Looking Ratio	-.181	.472	.235	.347	**.635***	.005	-.263	.291	-.446	.063
	Shading Ratio	-.151	.549	**.558***	.014	**.521***	.026	-.297	.231	**-.525***	.025
	Sky Visibility	.071	.779	-.087	.732	-.207	.410	-.069	.786	.163	.519

**. At the 0.01 level (double tailed), the correlation is significant.
*. At the 0.05 level (double tailed), the correlation is significant.
r: Correlation coefficient; P - : Significance

or interaction frequency. Street vitality is often driven by a combination of social, cultural, and economic factors, such as community social networks and the prosperity of commercial activities.

Street Traffic: Density of Parking Space was negatively correlated with the "Pedestrian Environment" factor (-.564*), while the other street traffic-related indicators did not show any correlation with the five evaluation factors.

Street Traffic: Density of Parking Space showed a negative correlation with the "Pedestrian Environment" factor (-.564*), Street Accessibility exhibited a highly positive correlation with the "Social Interaction" factor (.660**), and Street Passability was positively correlated with the "Pedestrian Environment" factor (.540*). The remaining street traffic-related indicators did not show any correlation with the five evaluation factors. The data results show that a higher density of parking spaces occupies pedestrian areas and restricts walking paths, negatively impacting residents' walking experience. Higher street accessibility implies stronger connections between neighborhoods, making it easier for pedestrians to access various public facilities, which promotes social interaction. Additionally, higher street passability enhances pedestrians' ability to move quickly and conveniently.

Street Greening: Sky Visibility did not show any correlation with the five evaluation factors. Green Looking Ratio was positively correlated with the "Landscape and Greening" factor (.635*). Shading Ratio showed a positive correlation with the "Pedestrian Environment" factor (.558*), and with the "Landscape and Greening" factor (.521*), but a negative correlation with the "Interface Continuity" factor (-.525*). This suggests that the more orderly and continuous the interface morphology, the less conducive it is to the formation of a shaded environment.

CONCLUSIONS

The study conducted a factor analysis on the pedestrian psychological evaluation data for the sample streets, summarizing the psychological evaluation structure into five principal components: Social Interaction, Pedestrian Environment, Landscape and Greening, Street Vitality, and Interface Continuity.

From an urban design perspective, based on built environment data and correlation analysis results, we propose the following strategies to enhance the walkability of livable streets in open residential districts:

(1) Optimize Public Facilities and Street Functionality to Enhance Mixed Functionality: By increasing the diversity of functions along the street and enriching the configuration of public facilities, the perception of social interaction and street vitality among residents can be effectively enhanced. Improved Mixed Functionality promotes interaction between different activities, thereby increasing the overall friendliness of the street.

(2) Improve Interface Design and Spatial Enclosure to Enhance Street Comfort: Thoughtful design of the street interface and spatial enclosure, especially when Interface Transparency is within the range of 1.00 to 1.30, can significantly enhance residents' positive perception of street vitality. This suggests that residents have specific preferences for street space, and a moderate degree of spatial enclosure can provide a more comfortable walking experience, as overly open spaces are not necessarily better.

(3) Strengthen the Design of Residential Entrances and Street Node Public Spaces to Provide Diverse Activity Spaces: By optimizing the design of residential entrance spaces and public spaces at street nodes, and enhancing the behavioral guidance function of these areas, more activity opportunities can be provided for residents. Moderately increasing the Density of Entrance can help boost street vitality, but excessively high density may lead to negative experiences. Therefore, in the design process, it is essential to appropriately configure public spaces such as node plazas to further enhance street activity and friendliness.

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Research on downscaling population estimation method based on texture morphology types and location information of residential areas in the old town of Nanjing, China

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ABSTRACT

Many major Chinese cities have entered a phase of urban renewal to address the shifting spatial needs driven by changes in population structure. Effective updates to urban spaces require finer-scale population data. However, publicly available data is often limited to the "Jiedao (an administrative unit under the district)" level, which includes multiple communities, making it challenging to access more granular population data—an obstacle for urban renewal planning. This study focuses on an overlapping area of Nanjing Old Town and Qinhuai District, to explore a downscaling population estimation method based on residential morphology and location characteristics. The method refined population data from the Jiedao level to residential plots and buildings. Firstly, a synthetic population with residential information for the study area was generated using a Bayesian network (BN) and iterative proportional fitting (IPF). This synthetic population then guided the initial classification of residential buildings, resulting in nine types. Each type was further subdivided into 30 clusters using a Gaussian mixture model (GMM). Gaussian distributions were constructed based on the household unit area within each cluster. The distribution probability of the synthetic population across different household unit ranges within these clusters was calculated to derive the population. Finally, this population was redistributed to individual buildings based on each building's total area and the POI (Point of interest) density. The study revealed that the building with the highest population was a 7-story slab-type building. High population density (≥10 people per 100㎡) was found only in buildings with 2-7 floors, while 72.9% of high-rise buildings had low population densities (0-2 people per 100㎡). The findings suggested that high floor area ratios did not necessarily correlate with high residential density and might even result in low population densities. Therefore, re-establishing the relationship between population and residential morphology is crucial.

Keywords: population estimation、residential morphology、synthetic population、clustering algorithms、population density

INTRODUCTION

Urban renewal strategies are widely adopted by cities both domestically and internationally during periods of slowed urbanization, primarily to mitigate the negative impacts of significant demographic shifts at the socio-economic level (Rose et al., 2012). On the physical level, these strategies focus on

revitalizing small, fragmented spaces that emerged during rapid urban expansion (Zhou and Ding, 2022). Consequently, this stage has highlighted the correlation between urban spatial forms and population characteristics (Patino and Duque, 2013; Wang and Ren, 2019; Li and Li, 2024). For example, there is a strong connection between aging residential communities and an aging population, as well as between urban spaces and the distribution of the floating population. However, most of these studies have either been qualitative or conducted at a large scale. From the perspective of urban renewal, there remains a lack of analytical tools that directly link small-scale urban morphology with population data.

Census data serves as the primary source of population information across the country (Zhang and Ming, 2022). However, current census data cannot reliably provide direct population at small geographic unit levels (Calka et al., 2017; Hecht et al., 2018). Therefore, many studies have constructed estimation models using auxiliary data that reflect regional population density variations to allocate census data to smaller estimation units. This approach is commonly known as "population spatialization"(Wang et al., 2016; Han et al., 2019) or " population downscaling"(Rubinyi et al., 2021; Wan et al., 2023).

The core of existing research has been centered on achieving more accurate population data, with the quality and precision of auxiliary data being critical factors (Beck et al., 2018; Qiu et al., 2020). For instance, many studies that use remote sensing imagery as auxiliary data initially relied on land cover and land use data to identify habitable areas (Mennis and Hultgren, 2006) and estimate population based on land type zoning. However, the limited variety and low resolution of land use data, along with the heterogeneity of population distribution within the same land type, have made it difficult to achieve refined population distribution (Bai et al., 2015; Wang et al., 2016). In response, subsequent studies have utilized higher-resolution remote sensing imagery to differentiate between residential and non-residential land directly associated with census populations (Balakrishnan, 2019). Today, LIDAR data can capture building heights, prompting many researchers to develop 3D building models (Chen et al., 2021). Thus, the ongoing emphasis on residential spatial morphology through remote sensing imagery has revealed that the form of residential buildings directly influences the accuracy of population estimation.

Although the importance of residential building information for population estimation has been well recognized, the expansion of regional scale leads to morphological differences in residential buildings, which in turn cause variations in population density (Alahmadi et al., 2016; Rubinyi et al., 2021; Mei et al., 2022). Currently, remote sensing imagery alone is insufficient for detailed identification. Future research should include more precise and comprehensive building type information, combined with architectural morphology knowledge, to enhance the accuracy of population estimation (Wan et al., 2023). Therefore, by classifying residential building types and studying population density from an urban morphology perspective, we can explore the relationship between population and residential morphology, and provide more comprehensive data on residential patterns to support urban renewal efforts.

In reality, residential areas often experience housing vacancies, which can increase errors in population estimation. Many studies have utilized nighttime light data to represent actual population

density and reduce estimation errors (Han et al., 2019). However, the low resolution of nighttime light data and the inability to identify light sources lead to significant errors in small-scale population estimates (Yang et al., 2019). As vector point data, POI data provide precise location and type information. Although POI types are not directly related to population distribution, the actual population capacity of residential buildings can be inferred from the quantity and diversity of surrounding POIs (Sadeghi et al., 2023).

Using census data as the control total for population estimation may have led to the overestimation or underestimation of certain categories when subdivided by different land or residential types. Synthetic populations, however, can replace census data as the control total, offering an advantage by including additional statistical indicators like the construction year and number of floors of residential buildings. This may make them better suited for matching with residential building types compared to census data. Synthetic populations have often been employed in large-scale analyses and simulations, such as transportation modeling and forecasting (Zhou and Ding, 2022). With the growing research on synthetic populations in recent years, their application has expanded to smaller spatial scales, providing more accurate and valuable data for various urban decision-making processes. Thus, in small-scale population estimation, beyond focusing on the quality of auxiliary data, using synthetic populations as the primary data source to control population estimation may be a more effective method for improving accuracy.

This study focuses on urban renewal needs by classifying residential forms to estimate population characteristics, assessing the actual utilization of residential space resources, and reconstructing the relationship between population and residential forms. This study aims to address several key issues: First, what method should be used to classify residential forms? Second, what approach should be adopted for creating synthetic populations? Third, how can a matching mechanism between synthetic populations and residential buildings be effectively established?

STUDY AREA AND DATA

Nanjing has a history of over 2000 years of city construction and currently has a permanent population of more than 9 million. In recent years, as the focus of construction has shifted from the old city to the new districts, the urban form and landscape of the old city have remained relatively stable. Furthermore, census data is relatively comprehensive and accessible. Therefore, the research area has been selected as Qinhuai District within the old city, which includes 7 Jiedao(an administrative unit under the district). Since this study involved population downscaling estimates based on census data, the research subjects should match the census scope and pertain to residential plots. Consequently, all residential plots within the research area have been compiled (Figure 1). The data used in this study are categorized into three types: morphological data, population data, and POI data (table 1). population data includes 1% national sampling data from 2015 and census statistics from Qinhuai District in 2020. POI data includes 18 types, with 12 POI types selected for the study based on Pearson correlation analysis.

Table 1. Datasets used in this study.

Data type	Data	Year	Source
Population Data	Census population data	2020	Nanjing Municipal Bureau Statistics, Qinhuai District Bureau Statistics,
Morphological Data	Building footprint	2021	Nanjing Municipal Planning and Natural Resources Bureau

	Boundary maps	2015	https://www.resdc.cn/
POI Data	Point of interest	2020	https://ditu.amap.com/

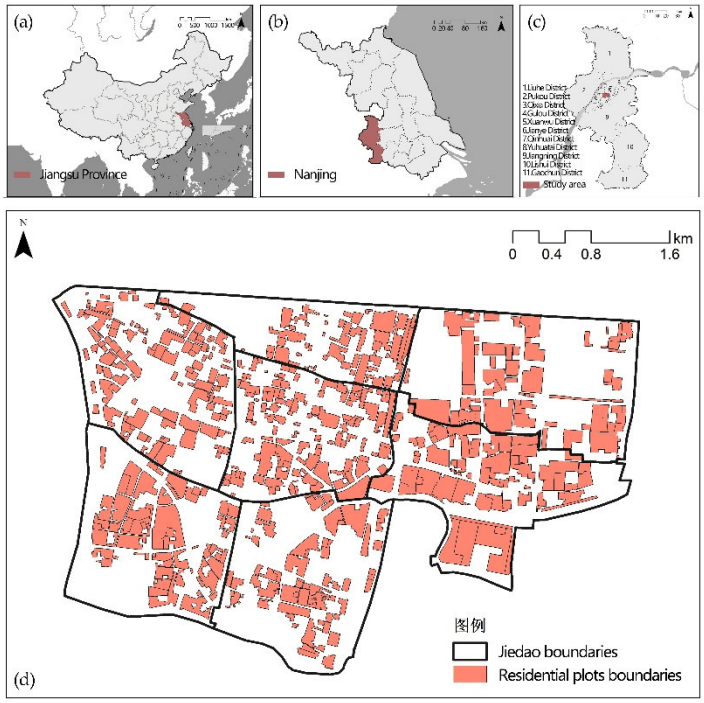

Figure 1. Geographical distribution of all residential plots within the study area. (a) Location of Jiangsu Province; (b) Location of Nanjing City; (c) Boundary of Qinhuai District within the old city; (d) All residential plots within Qinhuai District in the old city.

METHOD

Figure 2 shows the research process, which was divided into three main parts: synthetic population generation, residential building classification, and population-building matching. The first part involved generating a synthetic population for the study area using Bayesian networks (BN) and the Iterative Proportional Fitting (IPF) algorithm. The second part included two stages of residential building classification: the first was based on construction year and the number of floors, and the second involved further subdivision using selected morphological indicators and clustering algorithms. The third part assigned the synthetic population to different building types and estimated the population count for individual buildings accordingly.

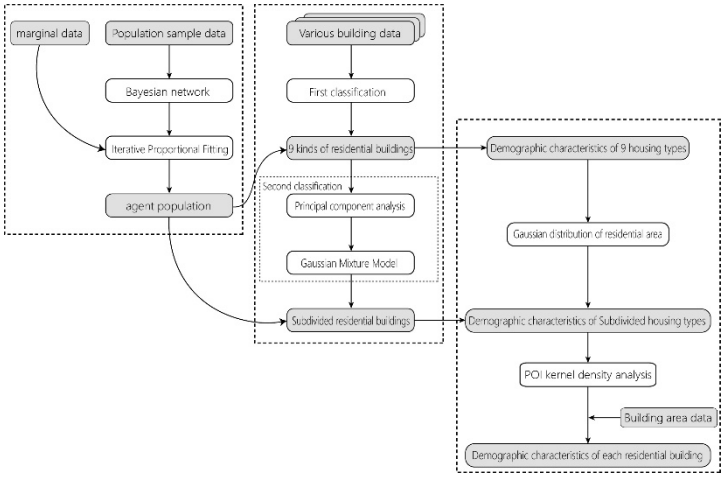

Figure 2. Flowchart for disaggregating Jiedao population into residential buildings population studies.

The model construction for synthetic population generation

There are three main methods for creating a synthetic population: Synthetic Reconstruction (SR), Combinatorial Optimization (CO), and Statistical Learning (SL) (Sun et al., 2018). The choice of method primarily depends on the type, scale, and quality of the available data. In this study, the sample data represented only 0.1% of the population, along with accessible marginal data. Therefore, based on the decision tree tool(Fabrice Yaméogo et al., 2020), a combination of SL and SR was deemed the most appropriate. Consequently, the synthetic population was constructed using BN for SL and IPF algorithm for SR. First, the study used the Tabu search algorithm and the Akaike Information Criterion (AIC) to construct and select the optimal BN. Six indicators from the sample data were used as network nodes: household size, number of residential rooms, number of floors, residential building construction year, age, and per capita housing area (Table 2). Then, the IPF algorithm was applied to adjust the synthetic population, ensuring a better fit to the census data.

Table 2. Nodes and their values in the Bayesian network.

Variable	Definition	Values
HS	Household size	1、2、3、4、5、6、7、8
NRR	Number of residential rooms	1、2、3、4
NF	Number of floors	Bungalow、2—6、7 floors and above
RBCY	Residential building construction year	1979 and before、1980—1989、1990—1999、2000—2009、2010 and after
AGE	Age	0—14、15—64、65 and above
PCHA	Per capita housing area	8 and below, 9—12, 13—16, 17—19, 20—29, 30—39, 40—49, 50—59, 60—69, 70 and above

Classification of residential buildings

The population sample data identified three key attributes: construction year, number of floors, and household unit area (calculated as the product of per capita housing area and household size). These three variables formed the basis for classifying residential buildings. First, an initial classification was conducted using the construction year and number of floors. Then, the Gaussian Mixture Model (GMM) was employed to subdivide the typologies further. This process involved dimensionality reduction of the morphological indicator dataset (Table 3), followed by clustering with the GMM algorithm. Finally, manual adjustments were made to some clusters with significant morphological differences, ensuring that buildings within the same type had similar morphological characteristics.

Table 3. Residential building morphology indicators.

Attribute	Description
Building footprint area	Building floor area
Total building area	The total area of each floor
Shape index	The relationship between the building's perimeter and footprint area
Aspect ratio	The aspect ratio of the building's minimum bounding rectangle
Area ratio	The ratio of the building's footprint area to the area of its minimum bounding rectangle
Number of floors	Number of building floors
The side surface area ratio of the building	The ratio of the building's side surface area to its total surface area.

Population estimation for residential buildings

The matching of population and buildings was discussed at different levels of building classification：first, the matching of population with residential building types classified by construction year and number of floors; second, the matching of population with more finely subdivided residential building types, aiming to estimate the population of individual buildings. In the first level, the corresponding synthetic population was directly assigned to each building type. In the second level, the population assigned in the first step was further subdivided to align with the clustered residential building types. This subdivision was achieved by using the household unit area variable to link the population with the buildings. First, a sufficient number of building samples was drawn from the building clusters to calculate the area of individual housing units, yielding the mean and standard deviation for each type. A Gaussian distribution was then constructed based on these values. Next, the probability density values for different household unit area intervals within the synthetic population were calculated across the various Gaussian distributions. These probability densities were then normalized so that the sum of probabilities for each residential area interval across different building types equaled one. Finally, the synthetic population for each building type was calculated based on the relative probabilities. The calculation formulas used were as follows:

$$f_t(\mathrm{A}) = \frac{1}{\sigma_t\sqrt{2\pi}}\exp\left(-\frac{(A-\mu_t)^2}{2{\sigma_t}^2}\right) \quad (1)$$

$$P_t(\mathrm{A}_k) = \int_{A_{k1}}^{A_{k2}} f_t(\mathrm{A})dA \quad (2)$$

$$\tilde{P}_t(A_k) = \frac{P_t(A_k)}{\sum_{t=1}^{T} P_t(A_k)} \quad (3)$$

$$O_t = \sum_{k=1}^{\mathrm{n}} o_k \times \tilde{P}_t(A_k) \quad (4)$$

In the formula, $f_t(\mathrm{A})$ represents the Gaussian distribution for the subdivided building type t, A_k represents the residential area interval for the synthetic population, $P_t(\mathrm{A}_k)$ denotes the probability density of the residential area interval [Ak1,Ak2] within the Gaussian distribution of building type t, $\tilde{P}_t(A_k)$ represents the relative probability of the residential area interval [Ak1,Ak2] within the Gaussian distribution of building type t, T denotes the total number of building types, O_t is the population count for building type t, and o_k is the synthetic population for residential area interval Ak.

After assigning the corresponding synthetic population to the subdivided building types, the population was further distributed to the individual building level, with the allocation weighted by each building's area and POI (Point of Interest) density. The formula used was as follows:

$$O_i = O_t \times \frac{s_i d_i}{\sum_{i=1}^{j} s_i d_i} \tag{5}$$

In the formula, O_i represents the estimated population for building i, s_i represents the total area of building i, and d_i represents the POI density for building i. The POI density was determined through a series of steps: first, Pearson correlation analysis was used to identify the optimal bandwidth for each type of POI (Table 4). Next, kernel density analysis was applied to generate POI density grids for each type. Finally, principal component analysis was used to integrate these grids into a composite POI density layer, which was then used to calculate the POI density for each building.

Table 4. The Pearson correlation coefficients and optimal bandwidths for each POI type.

Types of POIs	Pearson correlation coefficient	Optimal bandwidth（m）
science and education culture	0.951	700
transportation facilities	0.861	300
living facilities	0.825	1500
healthcare	0.816	2500
shopping services	0.795	3000
recreational sports	0.782	2500
food services	0.776	2500
public facilities	0.755	3000
government agencies	0.752	7000
lodging facilities	0.736	4000
companies and enterprises	0.728	6000
financial services	0.726	5000

RESULTS AND DISCUSSIONS

Clustering Results of Residential Buildings and Gaussian Distribution of Housing Area for Each Type

Residential buildings were classified into nine typologies based on the construction year and number of floors. Figure 3 highlights the distribution characteristics and quantities of each typology. Typology 1 encompasses the largest number of buildings, representing traditional courtyard-style residences primarily located in the southern part of Nanjing's old city. Typology 3 is the most common among multi-story residential buildings (2-6 floors). For buildings with seven or more stories, Typology 6 is the most numerous, reflecting a shift during the 1990-1999 period towards mid-rise (7-11 stories) and high-rise (12 or more stories) residential construction. After 2000, the volume of residential

construction significantly declined, and the development of multi-story residential buildings gradually ceased.

Based on the Gaussian Mixture Model (GMM), the eight building typologies (excluding Typology 1) were further subdivided into a total of 30 residential building clusters (Figure 4). Each cluster showcased the five most representative building floor plans to illustrate morphological characteristics, with slab-style residential buildings being predominant across all typologies. For multi-story slab-style residences, Typology 2 features buildings approximately 40 meters in length with a depth of 8-10 meters. Typology 3 includes buildings with greater lengths and depths than those in Typology 2, particularly in cluster 3-4, where lengths reach around 60 meters and depths range between 10-15 meters. While these clusters are less common, the main clusters are 3-2 and 3-3, with lengths of 40-50 meters and depths of 9-13 meters, showing a noticeable increase in size compared to Typology 2. Typology 5 is dominated by cluster 5-2, featuring buildings approximately 40 meters in length and 10 meters in depth, which are slightly smaller in scale compared to Typology 3, with more uniform dimensions. Typology 7 shows an overall increase in size compared to cluster 5, with the main cluster being 7-1, featuring lengths of 40-50 meters and depths of 10-13 meters. In summary, multi-story slab-style residential buildings typically had lengths ranging from 40-50 meters and depths of around 10 meters.

Slab-style residential buildings with seven or more stories are primarily distributed across Typology 4, 6, 8, and 9. These buildings are characterized by more flexible length variations, with depths ranging from 11 to 15 meters, consistent with Liu Quan's research on the specific depth values of slab-style residences(Liu and Ding, 2014). Another notable feature is the relatively smaller length of these buildings. Slab-style residences composed of 1 or 2 units typically have larger average depths compared to those composed of multiple units, a distinction particularly evident in cluster 8-2.

For ease of analysis and discussion, this study categorizes all residential buildings arranged around a single core as tower-style residences. Multi-story tower-style buildings first appeared in cluster 3-1, where each floor typically contained 3-4 household units, with floor areas ranging from 200 to 230㎡. Subsequent tower-style buildings primarily featured 7 or more stories. The tower-style residences in cluster 4-1 share similar characteristics with those in cluster 3-1. Typical high-rise tower-style residences were found in clusters 6-1 and 8-3. Both clusters have similar average story counts, however, cluster 6-1 tends to have more square-shaped floor plans, while cluster 8-3 features a greater length-to-width ratio.

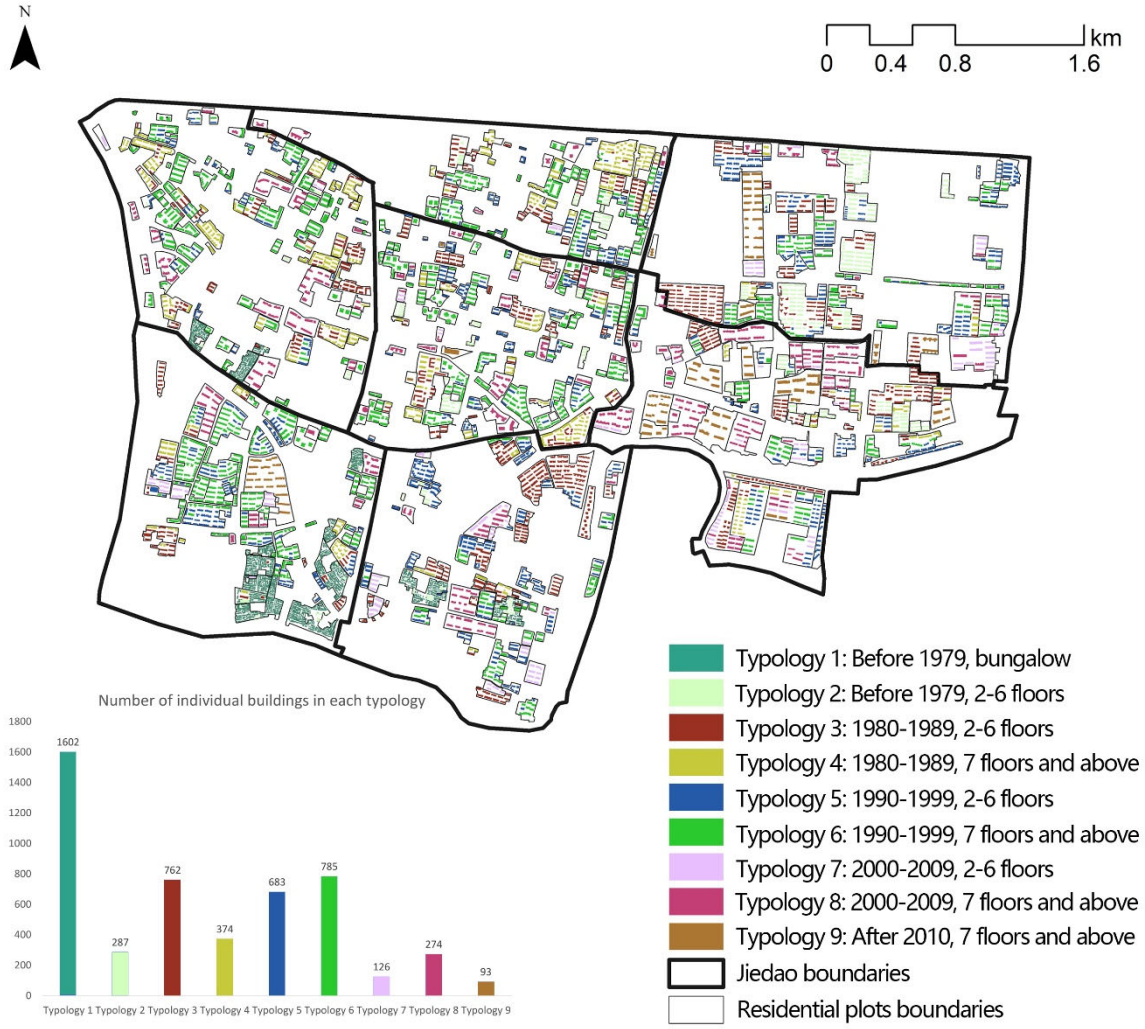

Figure 3. Distribution characteristics and quantities of the nine residential types.

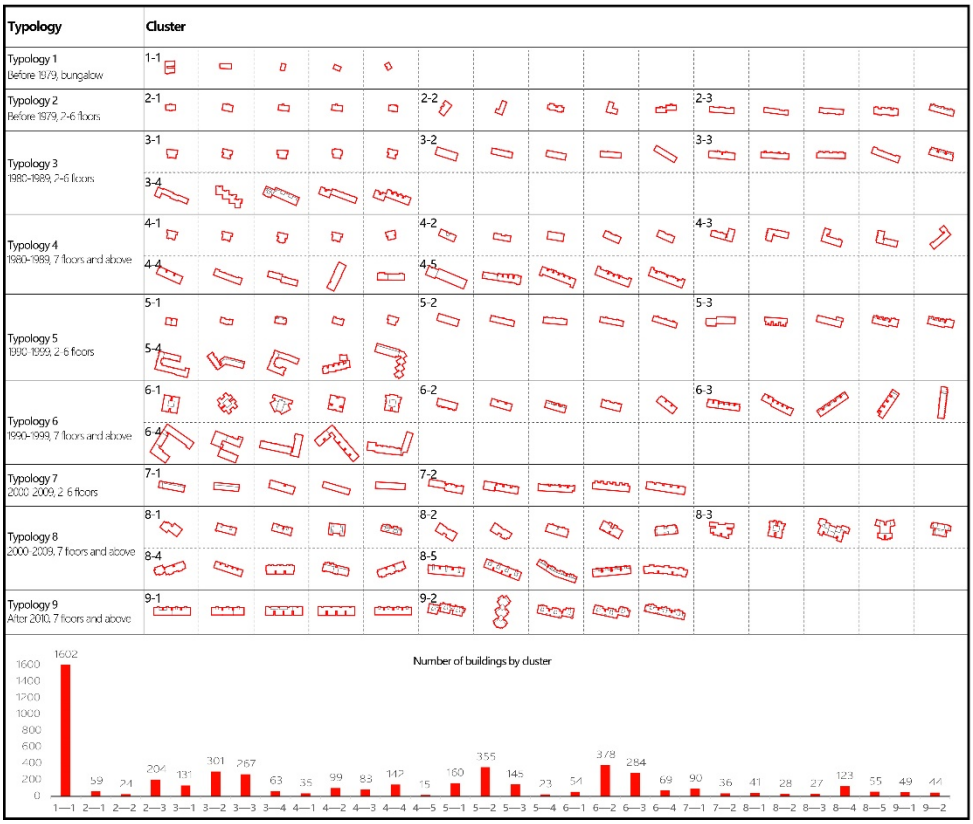

Figure 4. Typical floor plan analysis and quantity characteristics of 30 residential clusters.

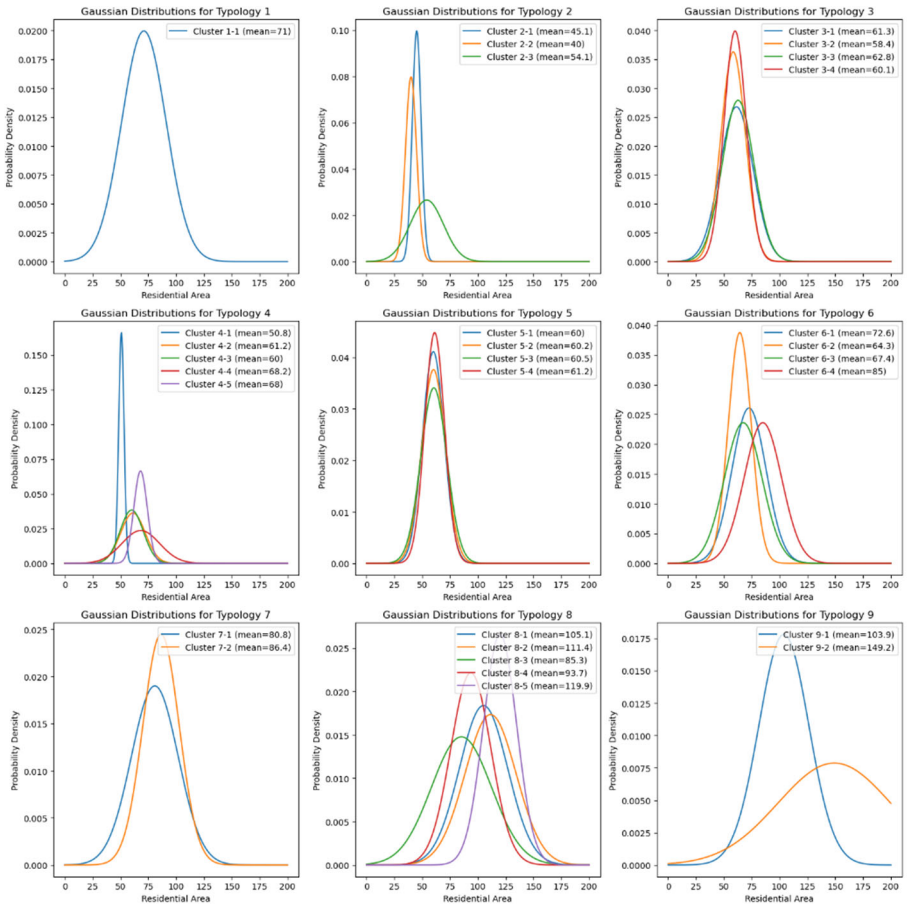

Figure 5. Household unit area distribution characteristics of 30 residential clusters.

The 30 residential building clusters display various trends in household unit area distributions (Figure 5). Overall, the average household unit area increases progressively from Typology 2 to Typology 9. Typology 1, representing historical courtyard-style residences, defaults to single-unit homes, resulting in a larger average residential area compared to Typology 2 from the same period. Among multi-story residences in Typologies 2, 3, 5, and 7, the largest average household unit areas were found in 2-3 (54.1㎡), 5-4 (61.2㎡), 3-3 (62.8㎡), and 7-2 (86.4㎡), respectively. For seven-story and higher buildings in Typologies 4, 6, 8, and 9, the maximum average household unit areas were found in 4-4 (68.2㎡), 6-4 (85㎡), 8-5 (119.9㎡), and 9-2 (149.2㎡), respectively. All of these are slab-style residences. Tower-style residences were primarily found in clusters 3-1, 4-1, 6-1, and 8-3, with average household unit areas of 61.3㎡, 50.8㎡, 72.6㎡, and 85.3㎡. In general, the household unit area of tower-style housing is smaller than that of slab-style residences with similar number of floors.

Synthetic population and building matching

The preliminary matching is based on nine building typologies. The typologies were assigned to residential plots for analysing (Figure 6). Figure 6 shows that Typology 5 has the largest population, with 77,188 people, followed by Typologies 4 and 6, each with populations exceeding 70,000. Typology 1 has the smallest population, with only 3,317 people, followed by Typology 9 with 9,930 people. Using the age structure from the Nanjing Municipal Bureau of Statistics' report from the seventh national population census as a benchmark—with 12.75% for ages 0-14, 73.55% for ages 15-64, and 13.70% for ages 65 and older—only the residential plots in Typologies 7, 8, and 9 meet these criteria. The combined population in these three typologies totals 66,817, which was only 18.10% of

the synthetic population. In all other typologies, the proportion of the working-age population was below the benchmark, while the proportion of the elderly population exceeded the standard.

The population of individual buildings was redistributed according to the population of 30 residential types using formula (5). Figure 7 shows the population of each building and the 30 residential types. At the cluster level, cluster 5-3 had the largest population, with 32,635 people, followed by cluster 6-4, with 28,516 people—both from the 1990-1999 period. At the individual building level, 50 buildings housed populations of 536 or more, primarily located in the Hongwu Jiedao and Chaotiangong Jiedao, with only two being high-rises. Of these, 16 buildings had populations exceeding 879, belonging to clusters 4-5, 5-4, and 6-4. These were slab-style buildings with 6 to 9 stories. Therefore, the relationship between population size and total building area is not simply linear, and a high floor area ratio does not necessarily indicate high residential density.

In this study, population density was categorized as high (10 or more people/100㎡), medium (3-9 people/100㎡), and low (0-2 people/100㎡). Figure 8 reveals that, with Typology 8 as a dividing line, Typologies 1 through 7 show a clear positive correlation between average population density and average total building area. The exception is the high-rise tower in cluster 6-1, which showed a negative correlation, indicating that the actual population might be far below its theoretical capacity. Beyond Typology 8, the correlation shifts to negative, suggesting a change in the housing supply-demand relationship around the year 2000. From a cluster perspective, clusters 2-1, 2-2, 4-1, 4-5, and 5-4 were identified as high-density residential areas, making up 5.89% of the total, with buildings ranging from 2 to 7 stories, only cluster 4-1 was a tower-style residence. Low-density housing was found across single-story, multi-story, and 7-story-and-above buildings, with a concentration primarily in 7-story-and-above buildings within Typologies 6, 8, and 9.

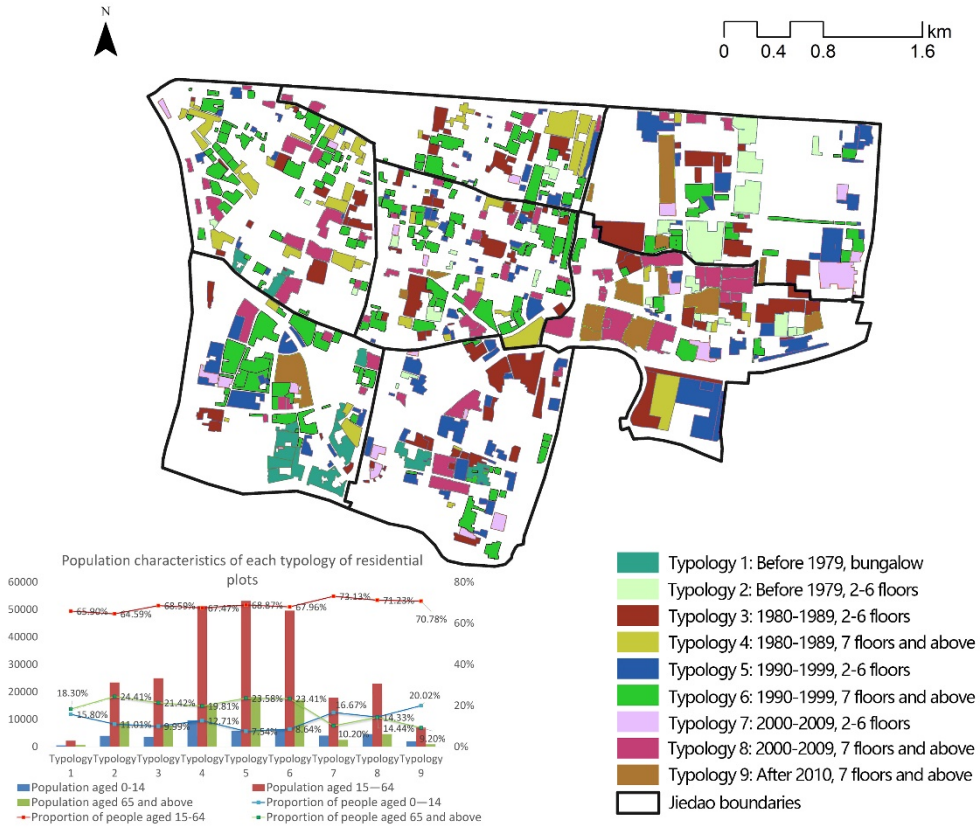

Figure 6. Distribution of nine types of residential plots and characteristics of population size and age structure.

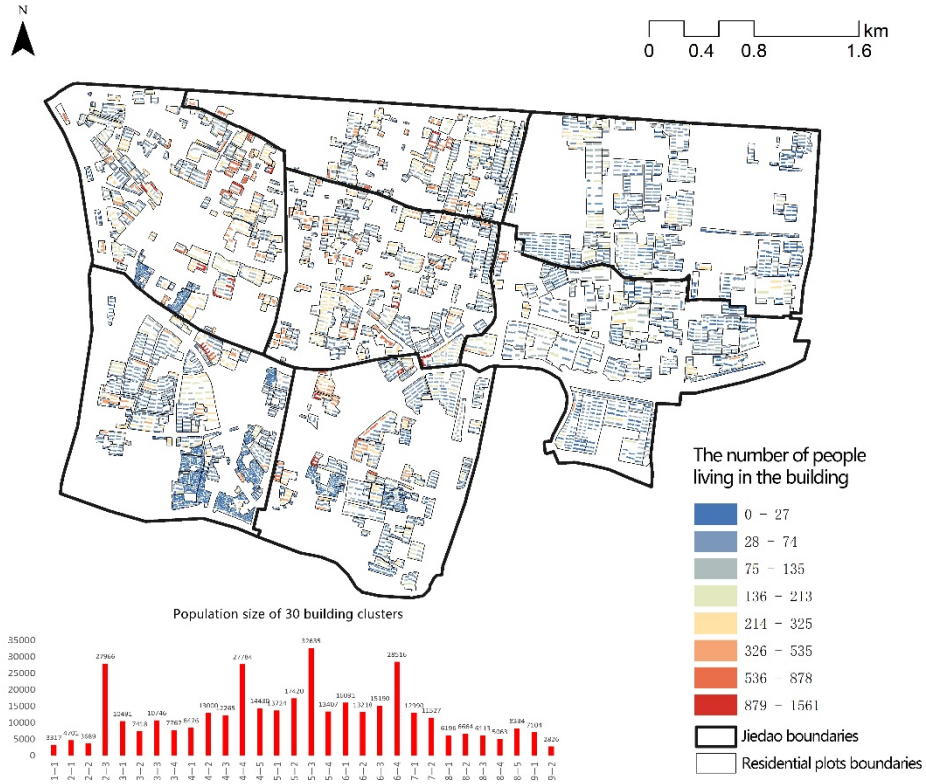

Figure 7. Distribution of individual buildings and population size, and the population size for 30 residential clusters.

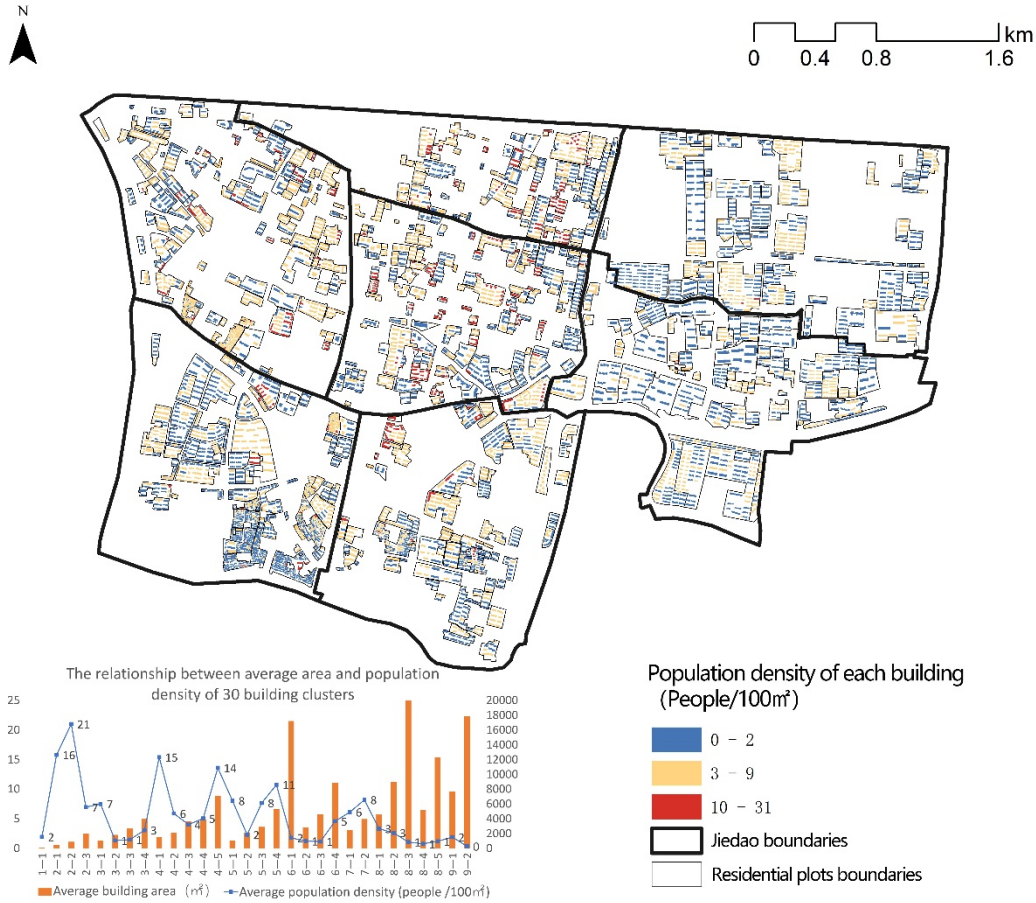

Figure 8. Population density of individual buildings and the average total building area and population density for 30 residential clusters.

Discussion

This study innovatively combined machine learning algorithms with morphological typology knowledge to explore the interdisciplinary challenge of estimating residential building populations. However, several potential limitations exist. First, the synthetic population may overlook rare samples. The sample data used in this study was derived from the national population, but only the subset from Qinhuai District, representing just 0.1% of its population, was extracted. The limited sample size may reduce the accuracy of the synthetic population in reflecting the actual population. Future research should aim to use more granular data to enhance the model's estimation performance. Second, there may be errors in the Gaussian distributions of household unit areas for the 30 clusters. In this study, the estimation method for each cluster primarily relied on street view map observations, supplemented by field surveys. Given the large number of estimates required, only about 40% of the residences in each cluster were sampled to construct the Gaussian distributions which could affect the accuracy of population estimates. To minimize these errors, future research should focus on updating and refining the survey data. Third, the study lacks model validation. At present, this research remains theoretical, and the data presented has not been field-verified. Further investigation is necessary to confirm the accuracy of the findings.

CONCLUSIONS

This study began by generating a synthetic population dataset for the research area using Bayesian networks (BN) and the Iterative Proportional Fitting (IPF) algorithm. Residential buildings were classified into 30 types after two classifications. Gaussian distributions were constructed based on household unit area, and these distributions were employed to calculate the relative probabilities of synthetic populations for each cluster. This process provided estimates of the synthetic population for each cluster. Ultimately, the synthetic population was further detailed and matched to individual buildings. Analysis of the population characteristics revealed that residential building population density varied widely, ranging from as low as 0 people per 100㎡ to as high as 31 people per 100㎡. Notably, the 16 buildings with the highest population counts were all 6-9 story slab buildings, while 72.9% of high-rise buildings had a population density of only 0-2 people per 100㎡. This suggested that a high floor area ratio has not necessarily correlated with high residential density and may have led to excessively low population densities. Therefore, estimating population characteristics based on the classification of residential morphology is beneficial for reestablishing the relationship between building forms and population distribution.

This study demonstrated several advantages by using a synthetic population with residential information, rather than relying solely on basic population statistics, to guide residential building classification and model estimation. First, it enhanced the correlation between population and morphological data, facilitating the classification of residential forms and directly linking them to population numbers. Second, having accurate synthetic populations for classified residential types improved the accuracy of the estimates. Third, it allowed for the analysis of additional population characteristics, such as age structure, beyond mere numbers. However, this approach remained in its preliminary stages. To ensure accuracy, future research should compare various construction methods to determine the most effective model.

From an architectural perspective, this research aimed to uncover the relationship between residential buildings and population by estimating the number of inhabitants. The analysis of residential morphology was primarily focused on overall exterior and planar forms due to the large sample size. As a result, comparisons of residential forms with different population characteristics were largely based on exterior morphology. Future research could delve deeper into specific residential forms and analyze population differences more thoroughly, leading to more detailed and actionable insights.

Acknowledgements

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Segregation and accessibility: process of shaping urban spaces in the medium-sized city of Campos dos Goytacazes, RJ, Brazil

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ABSTRACT

Brazilian medium-sized cities, like Campos dos Goytacazes, have within them peculiarities that enlighten their own process of urban expansion. In this paper, we aim to discuss the articulation between two conditions that broadly guide it. Socio-spatial segregation, a process characterized by the concentration of certain social segments in different regions or neighbourhoods (VILLAÇA, 1998), and accessibility, a crucial dimension of sustainable urban mobility that enables urban activities to be reached by certain individuals or group of individuals from different locations in the city (PEREIRA et al., 2017). Through the analysis of location, shape and frequency of large horizontal housing isolated polygons in the urban fabric of Campos dos Goytacazes, in the state of Rio de Janeiro, Brazil, and the expansion of the road network since 1980, we aim to develop spatial correlations to contribute to a critical review on the conflicting ability to move around the city depending on the social group of origin. Thus, we hope to highlight the radical spatial detachment of segregated social groups from parts of urban space.

Keywords: Accessibility, segregation, medium-sized city, Campos dos Goytacazes.

INTRODUCTION

Brazil's medium-sized cities have gained prominence in terms of production of urban space and urbanization. A comparison between the 2010 and 2022 Censuses shows that of the 12 million increase in the Brazilian population, 8.3 million people are concentrated in medium-sized cities. In addition, 278 Brazilian municipalities have a population between 100 and 500 thousand inhabitants and are classified as medium-sized cities, an increase of 12% compared to the 2010 Census, when there were 245 Brazilian municipalities with a population between 100 and 500 thousand inhabitants (IBGE, 2023).

Although it is still too early to define the data from the 2022 Census as a trend towards the re-spatialization of the population across Brazilian territory, it is undeniable that medium-sized cities play a specific role in the country's urban arrangement. Driven by the migration caused by the global Covid-19 pandemic in 2020, the more widespread possibility of remote working, the constant increase in the

cost of living and the perception of violence in the metropolis, medium-sized cities have been consolidating themselves as a representative space in the process of urban expansion in Brazil. The medium-sized city of Campos dos Goytacazes (Figure 1), in the north of the state of Rio de Janeiro, has a prominent regional political and economic position, given that its territory is home to the second largest oil and natural gas producing basin in the country, the Campos Basin. It is the largest municipality in the state of Rio de Janeiro, with a territorial unit of 4,032.487 km², 13 districts plus the central district and a population, according to the 2022 Census, of 483,540 inhabitants, approximately 90% of whom are urban.

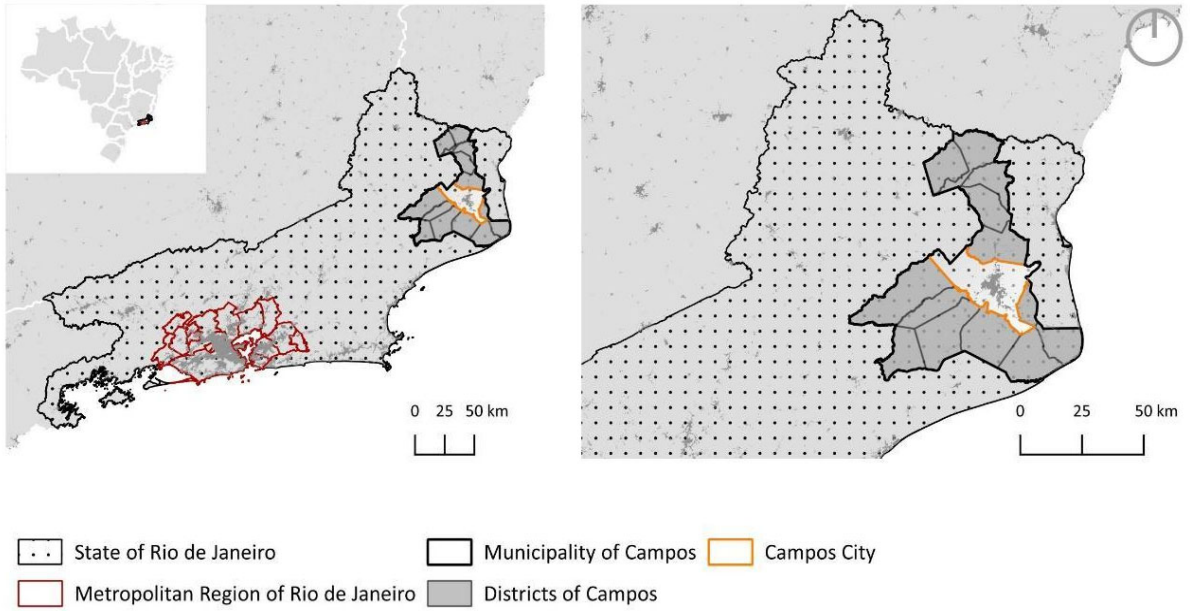

Figure 1 - Location of the Municipality of Campos dos Goytacazes in the State of Rio de Janeiro.Source: Author, 2024.

In the 1980s, the process of shaping the urban space of Brazilian cities was crossed by the proliferation of what we call horizontal housing isolated polygons (Hhip's), a phenomenon in which Campos dos Goytacazes was no exception. This new housing typology is essentially characterised by grouping residential units on a vast portion of land with its perimeter surrounded by ostentatious boundaries separating inside and outside, highlighting the dynamics of the city's spatial control, which segregates and limits the equal use of urban spaces by all city dwellers.

Hhip's reinforce a discontinuous mode of urban growth, disconnected from the city's main historical and consolidated centrality. The demand for large tracts of low-value land as a criterion for this real estate product drives the displacement of the Hhip's to the edge of urbanisation, promoting fragmented urban expansion. What's more, to transfer the housing of high-income social segments from the central area to the edges of the urban perimeter, it was necessary to double down on the expansion of urban mobility based on the private automobile matrix.

This article seeks to analyse the distribution of Hhip's in the territory and their relationship of dependence on road infrastructure and the predominance of individual motorised transport, which reproduce the historical process of segregation in Campos dos Goytacazes, Rio de Janeiro. The first part of the article discusses the emergence and consolidation of closed horizontal residential spaces

in Brazilian cities, urban mobility policy in Brazil and the preponderance of road mobility infrastructure production aimed at individual transportation.

In the second part, we present the methodology that was developed using a multi-scalar and multivariate qualitative and quantitative approach to analyse the phenomenon articulated between the real estate production dimensions of the Hhip's and the structuring road axes of urban mobility. For data and information on the Hhip's in Campos de Goytacazes, primary data was collected in the archives of the Municipal Department of Urban Planning, Mobility and Environment of Campos dos Goytacazes City Hall. Socio-economic data was taken from the IBGE (2010) and vehicle fleet data from DETRAN-RJ (2024).

In the conclusions, we argue about the essential characteristics of this much desired and widespread real estate product, the Hhip's, which demand vast tracts of land on the edges of the consolidated urban fabric. By relying on road accessibility, they promote fragmented urban growth and accentuate the historic process of socio-spatial segregation which characterises the urbanisation of Brazilian cities.

Production of horizontal housing isolated polygons (Hhip's)

The study of horizontal housing isolated polygons as a housing typology (GOMES, 2024) has been recurrent in various scientific fields such as sociology, anthropology, geography and urbanism since its emergence in the mid-twentieth century in the USA. The concern that leads scholars to turn their attention to the phenomenon of the proliferation of Hhip's in the most varied cities around the world is due to one main cause: the suspicion that Hhip's symbolise a much more profound transformation in society than merely a new possibility for urban dwelling (BLAKELY and SNYDER, 1997).

The repeatedly disseminated ideal of living in privatised, homogenised, walled and mainly controlled spaces indicates that there is an articulated global movement that assumes and promotes this type of housing as the contemporary ideal of living. This urbanisation movement is based on the neoliberal logic that the qualities and benefits of the city, such as safety, accessibility, mobility, housing, education, health cannot be delivered and managed by the public authorities and must therefore be produced, offered and managed by the private sector.

Thus, like Sposito (2013), "...we have adopted the generic expression 'closed residential spaces'..." (SPOSITO and GOES, 2013) because we reiterate that more important than their legal status is the reality of their existence in the urban territory. We would like to point out that in the course of this work we will also frequently use the nomenclature 'polygons' followed by the adjectives 'isolated', 'housing' and 'horizontal'. As this work highlights the morphological analysis of the process of urban configuration promoted by the expansion of spaces for private housing use on the edges of the city of Campos dos Goytacazes, we emphasise the power of form in structuring the urban fabric, and for this reason, at certain point we have replaced the name 'space' by 'polygons'.

In Brazil, the most relevant path that studies the phenomenon of closed horizontal residential spaces, connects it with the significant increase in insecurity and the growth of violence in large cities. Caldeira (2011) and Sposito (2013) will focus their research by determining that the main cause of the advance of closed residential spaces as a mode of urban dwelling is urban insecurity.

According to Caldeira (2011), recent transformations in social dynamics, driven by technological revolutions, restructuring of the world of work, exhaustion of a model based on nationalism, and neoliberal postulates such as privatisation, individualism and inefficiency of public power, have reconfigured the way in which the dominant social segments permeate urban space and segregate themselves in closed residential spaces. This allows us to suspect that the self-segregation of the elites in the urban territory operated under the capitalist mode of production is still confirmed as a rule in the process of producing urban space and, therefore, merits analysis that identifies how this contemporary socio-spatial segregation is reflected in the daily lives of different social groups and their accessibility.

Urban mobility

Urban mobility has become a central principle of the urbanisation process, rather than one of its consequences (ASCHER, 2004; URRY, 2007; BERTOLINI, 2017). The sharp growth in the mobility of people and goods has been accompanied by a transformation in the size and shape of cities. Under the influence of new technologies, the dynamics are intensifying, and the processes of urban expansion and fragmentation are shaping urban centres, which are interspersed with both functionally specialised areas and natural areas, connected by transport infrastructure and the continuous flow of people, goods and information (ALVIM; IZAGA et al., 2024).

In Brazil, mobility conditions in cities with more than sixty thousand inhabitants (VASCONCELLOS, 2013) present a picture where journeys by public transport are longer and take longer on average than those made by individual transport, which are 62% shorter and spend 58% less time. Despite the advances represented by the National Urban Mobility Policy (Law No. 12,587/12) and its monitoring (BRASIL, 2018), a policy based on benefits and exemptions given to cars and motorcycles and inadequate public transport policies still prevail, which have increased its cost and decreased its reliability, generating many inequities.

Campos dos Goytacazes Sustainable Mobility Plan (2022), although it aims to "... incorporate the principles of sustainable mobility, with a focus on public transport and non-motorized transport, through the adoption of guidelines and measures oriented towards a safe, efficient and accessible urban transport system" (CAMPOS DOS GOYTACAZES, 2022, p. 4), privileges in its text the treatment of the infrastructure of the road system to the detriment of public transport planning.

In Campos dos Goytacazes, cars and motorcycles have increased by almost 174% in the last 20 years, while the population has grown by 18% (IBGE, 2022; DETRAN RJ, 2024). In other words, we've gone from a ratio of one vehicle for every 6 people in 2000 to almost half that in 2022, one vehicle for every 2.5 people. There was a vertiginous growth rate of 68% between 2000 and 2010 and it remained stable at 63% from 2010 to 2022, above the state average, which varied between 56.5% in 2010 and 51.6% in 2022.

As far as public transport is concerned, the bus system is considered to have a lack of lines to certain regions, non-compliance with timetables and the scrapping of the fleet, providing a poor-quality service (ARAUJO, 2012; CRUZ, 2021; SILVA, 2022). The lack of open data on the structure of journeys highlights the operational and planning difficulties faced by the body responsible, the Municipal Institute of Traffic and Transport (IMTT). The City Council's policy of subsidising fares, with the implementation of the "Citizen Card", has had an impact on the increase in journeys since 2009

(ARAÚJO, 2012; p.52). The city has two terminals, the Roberto Silveira Bus Terminal, the departure point for all inter-district lines, and the Luiz Carlos Prestes Urban Terminal, which serves urban lines. The organisation of the lines is radial, from the centre to the outlying neighbourhoods, promoting little adherence to the territory, resulting in poor accessibility. With a predominantly flat configuration, organised by a central, historically established main district, with other nuclei configured in a dispersed manner, Campos has 55 km of cycling routes in place, with improvements and expansion of the network expected over the next few years. This situation means that the bicycle (MARINO, QUINTANILHA *et al*., 2021) is the only remaining option for the population with lower incomes, who live in the outlying areas.



Figure 02 – Aerial photo of Campos dos Goytacazes. Source: Author, 2022.

METHOD

The approach is based on studies of the urban morphology of the contemporary city (PANERAI, 2006; SOLÀ-MORALES, 1997; COSTA, 2015), where we seek to explore tools that allow us to think of the agglomeration as a whole, to identify its parts and describe its forms.

In line with Lefebvre's interpretation of the city as a projection on the ground of social relations, Panerai (2006) highlights elements that organise the territory. The road, the regular projected grid of extensions, to which are superimposed, with the development of means of transportation and communication, dynamics that produce fragmented and diffuse fabrics in the contemporary city. Based on this, he defines the constituent elements of the urban fabric as threefold: the road network, land parcels and buildings.

Likewise, for Solà-Morales (1997), the layout is the most permanent dimension of urban form, understood as a real and collective synthesis of existing and future built form. Solà-Morales develops an understanding of the temporal process of its constituent elements - subdivision, urbanisation and building - from which he lists six forms of urban growth in cities: i- grid extension, ii- suburban growth based on the logic of the road and in contiguity with the main urban nucleus, iii- peripheral urbanisation, in discontinuity with the main urban nucleus, iv- the garden city, v- informal urbanisation or favela and vi- monofunctional polygons.

We will adopt a multi-scalar and multivariate qualitative-quantitative approach to analyse the phenomenon articulated between the real estate production dimensions of the Hhip's and the structuring road axes of urban mobility in the municipality of Campos de Goytacazes. The analysis is based on the research carried out at the Municipal Department of Urban Planning, Mobility and Environment of Campos dos Goytacazes City Hall, where 42 Hhip's were found with approval licenses (Figure 03) (GOMES, 2023).

To map the urbanization growth, in the time frame between 1984 and 2024, the Google Earth mapping database was used. Socio-economic data was taken from IBGE (2010) and urban mobility data from DETRAN-RJ (2024).

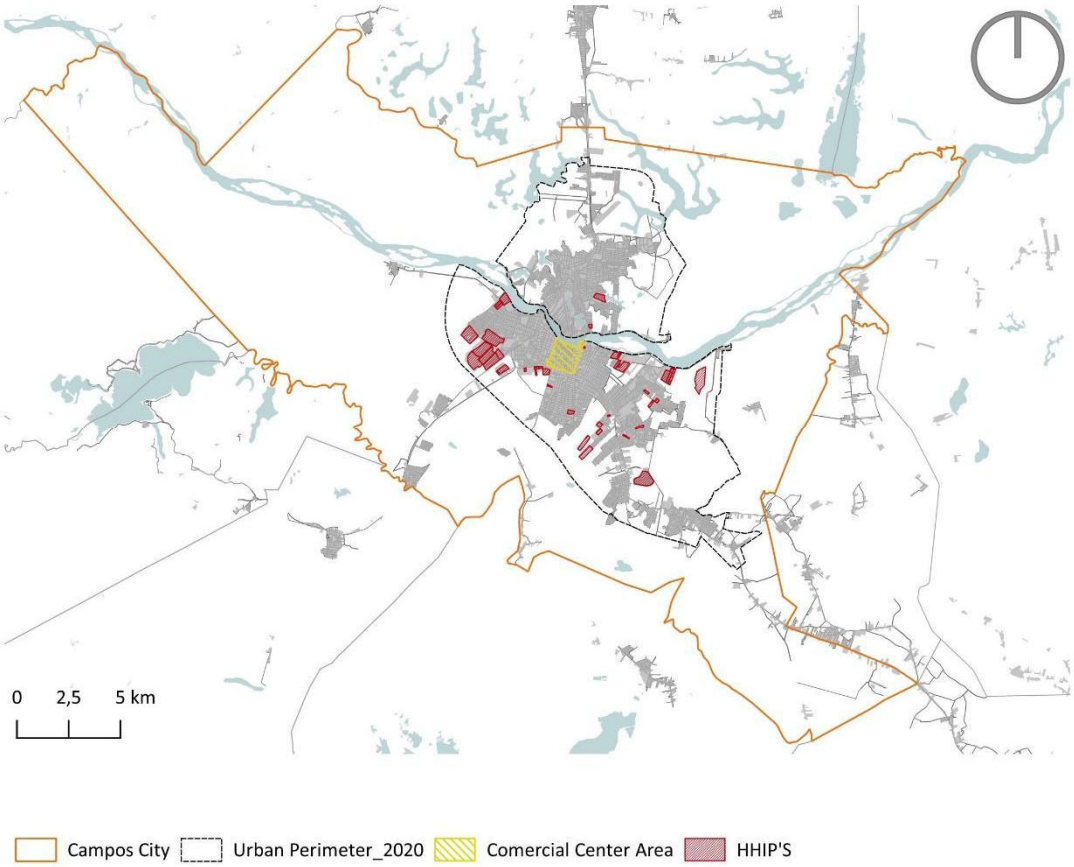

Figure 3 - Urban fabric of Campos dos Goytacazes and location of the 42 Hhip's. Source: Author, 2024.

RESULTS AND DISCUSSIONS

The occupation of the territory of Campos dos Goytacazes began on the right bank of the Paraíba do Sul River, with the urban core being established on the highest part, around the current Praça São Salvador. The direction of occupation is from the coast towards the interior, from Farol de São Tomé towards the Paraíba do Sul River, where sugar cane mills were installed in the 18th century. From 1837 to 1875, the urban area grew very little, but this changed with the arrival of the railroad in 1873. The vectors of the city's expansion until the mid-20th century were influenced by the 1902 Urban Plan, developed by Saturnino de Brito, and the 1944 Urbanization Plan for Campos, developed by Coimbra Bueno e Companhia Ltda.

At that time, three vectors of growth were identified: one in a westerly direction, another in a southerly/easterly direction, towards the coast and the appearance of the urban area of Guarus on the other bank of the river, to the north. In the middle of the 20th century, a quadrilateral is identified with dense occupation, defined by the river and the railroad beds, with some prominent nuclei to the south (Costa, 2005). At the end of the 20th century, there was a vector of growth towards the coast, as well as urban growth along the BR-101 towards Vitória.

Since the appearance of the first closed horizontal residential space, the Residencial do Horto condominium of single-family houses, in 1981, this form of housing has been proliferating assiduously in the urban fabric of Campos dos Goytacazes. The emergence of Hhip’s largely depends on the availability of vast tracts of idle land that can be divided up into smaller plots for the development. Thus, the very nature of the real estate business in terms of launching a larger number of condominiums requires the search for urban land of lower value, in order to maximise business profits. Historically, the urban land least valued by the real estate market has been located on the edges of the urban perimeter, i.e. on the limits of what is urban and what is rural. Generally, the further away from the centrality(ies), where access to urban facilities and infrastructures is greater, the lower the value of the land.

For this reason, the phenomenon of the proliferation of Hhip’s takes place in a very specific part of the city's territory: on the edge of urbanisation, on the margins of the consolidated city, where the land is of low value, but where there is the possibility of access to the main urban centrality quickly and efficiently.

From an analysis of the city's urban growth, highlighted every 10 years since the first Hhip’s appeared, the developments are set up exactly where the consolidated urban fabric meets the non-urbanized one (Figure 4).

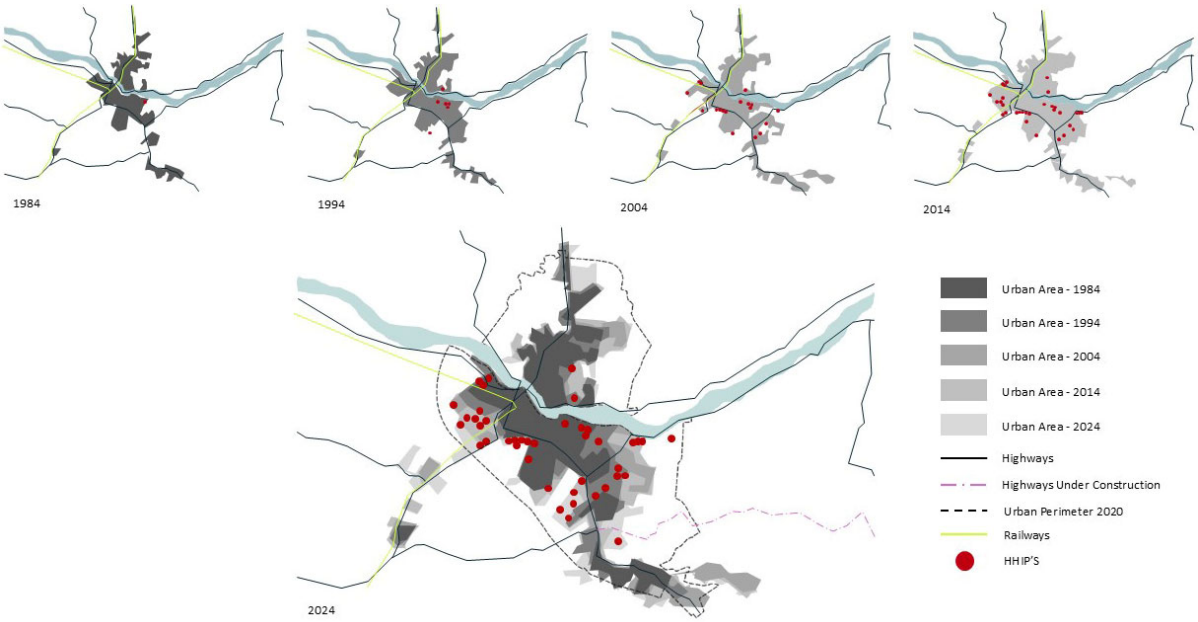

Figure 4 – Urban growth of Campos dos Goytacazes and the proliferation of Hhip's. Source: Author, 2024.

CONCLUSIONS

Freed from dependence on the city, the Hhip's model gains autonomy in relation to urban space, detaches itself from complex urban issues and becomes independent to praise its original qualities. While the narrative of violence and urban insecurity is being inflated by the hegemonic media, the condominium offers control and harmony. While the public space is dirty, gray and chaotic, the condominium is immaculate, green and peaceful. While everyone circulates in the city, only a few circulate in the condominium. While in the city there is encounter, enjoyment and celebration, in the condominium there is isolation, apathy and boredom. In the city there is freedom, in the condominium there is domination.

Despite this, there is only one condition external to the Hhip's that still binds it to the urban space. Even if the horizontal condominium denies the qualities of concentrating the benefits of the city, its inhabitants still depend on the city for their daily living. In fact, it is undeniably included and participates in the urban organisation.

Although the trend towards the evolution of the programmatic content of the design of closed horizontal residential spaces aims for almost absolute independence from the city, including all these functions within its internal perimeter, there is still a dependence on a collective urban element that is essential for the implementation and survival of the condominium: the circulation routes that allow its residents access to the consolidated city. The transfer of housing from the city to the condominium is based on the ability of its future residents to afford the costs and time spent commuting between the city and the condominium.

Villaça's (1998) question as to what comes first - investment in urban infrastructure equipment or the need for infrastructure to meet an urban expansion already underway - is answered in this case. Hhip's operate like plugs, which basically need an efficient road network - a network that doesn't even depend on municipal investment, because they are usually state and federal highways - to connect and suck in the useful effects of agglomeration that have already developed and matured in that city.

This way of fitting Hhip's typomorphology into urban dynamics, developed by urban space developers, alerts us to a mode of urban growth that is opportunistic and disconnected from the commitment to the city's community character.

The constant and frequent coupling of these fragments to the road network that connects them to the open city is structured in a powerful business model that, by maximizing the value of urban land and aligned with public interests, transforms the urban fabric, alters the usual events of urban expansion traditionally driven by more organic processes and disqualifies the open city as a public space and, therefore, to be watched over and cared for by a community.

The construction of Hhip's in areas close to the regional road system establishes itself as a belt around the central urban core. At the same time, detached from this, poorer centers are developing on the more distant outskirts (Figure 5). In other words, if on one hand we have the extensive use of cars by the inhabitants of the Hhip's, which are on average 6km from the central area, on the other hand we observe the fragility of the public transport that serves the more distant districts, which are organised in a discontinuous way in relation to the central urban core. This dynamic exacerbates the historical process of differentiated appropriation of space, with the discontinuous expansion of the urban sprawl resulting from the selective expansion of the city, in which differences in accessibility produce inequality and express the historical process of segregation of its organisation.

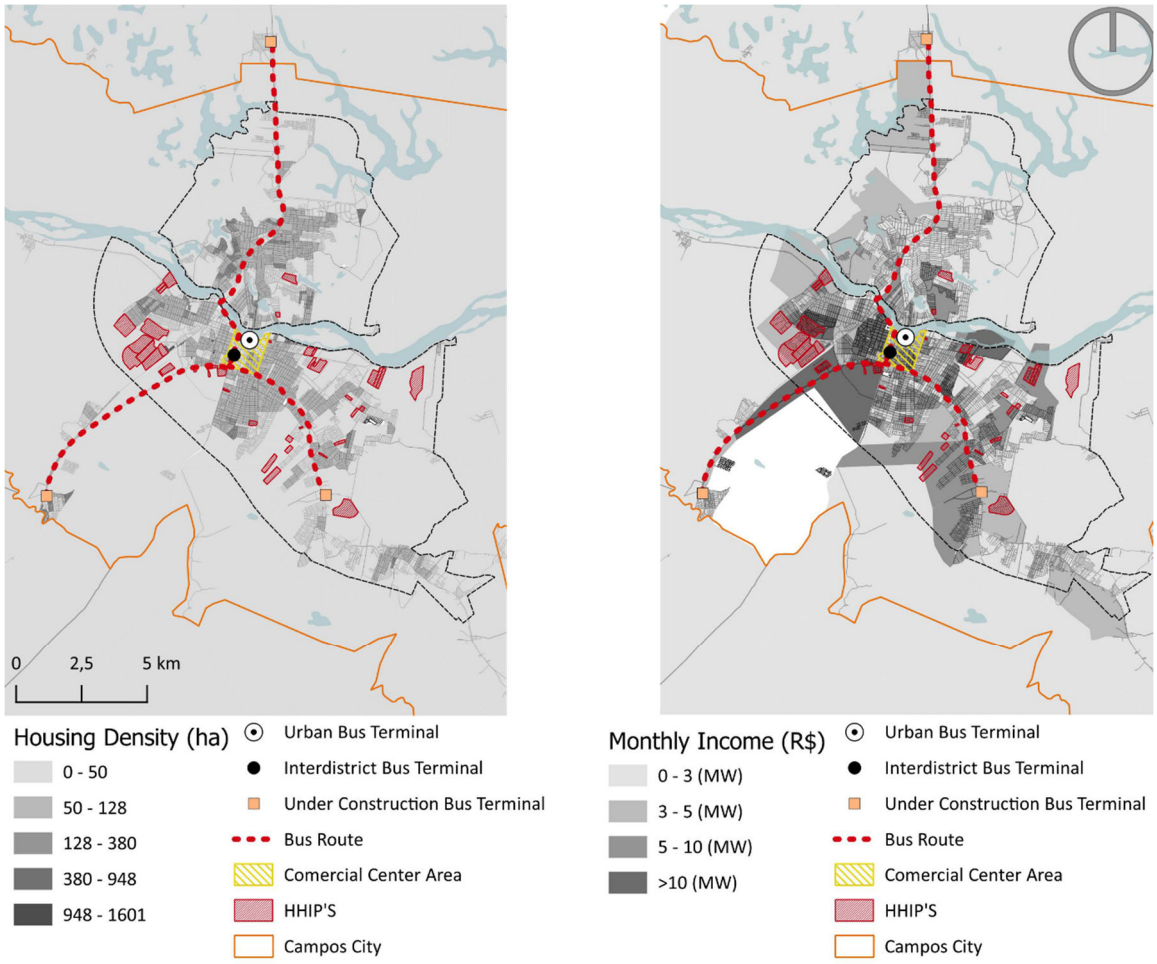

Figure 5 - Housing density and monthly income in the city of Campos dos Goytacazes. Source: Author, 2024.

Thus, the research highlighted three important urban growth trends driven by the close connection between the proliferation of Hhip's on the edges of urbanization and the reinforcement of urban mobility based on the private road matrix.

Hhip's encourage a fragmented urban growth that reinforces the emergence of peripherical areas of concentrated poor population and the emergence of areas contiguous to the traditional center of the city concentrated by higher incomes.

Roads are considered the main element of urbanization, defining a hierarchy between the three fundamental elements of the urban shaping process: streets, urban blocks and buildings.

Upper classes auto-segregation in Hhip's goes hand-by-hand with the urban and mobility planning models, privileging the richest and relegating to the poorest the outlying areas where the transport service is inefficient.

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Study on the "authenticity remodeling" of urban regeneration in residential historical areas: a case study on Xiaoxihu Block, Nanjing, China

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ABSTRACT

With the rapid urbanization in China, the homogenization and gentrification issues in the regeneration of old cities have become prominent, posing negative impacts on the authenticity of residential historical areas. Based on urban sociological and phenomenological theories, combined with field observation records and design practice, this paper takes the "Preservation and Regeneration of Xiaoxihu Block in Old South City Area, Nanjing" as an empirical case to systematically analyze the phenomenon, motivations, practical goals, and design strategies of "authenticity remodeling". By examining the two driving forces behind authenticity remodeling, the paper reveals the demands of residents' rights protection and cultural consumption development underlying authenticity remodeling. Furthermore, from the perspectives of "home" and "consumption", the paper analyzes how the Xiaoxihu regeneration practice maintains the authentic life of the community and effectively stimulates new authenticity experiences. The Xiaoxihu practice provides an autonomous, gradual and open ideal state of "authenticity remodeling", offering an empirical reference for responsible and socially sustainable urban regeneration in residential historical areas.

Keywords: Authenticity, Urban Regeneration, Residential Historical Area, Home, Consumption

INTRODUCTION

Connotation and Significance of Authenticity

"Authenticity", a concept with extensive and profound connotations, occupies an important position in multiple disciplines such as cultural heritage protection and natural ecosystem maintenance. It has also been introduced into the research scope of urban geography and sociology, becoming a theoretical tool for analyzing urban phenomena. In her book "Naked City" (2010), Sharon Zukin employed the perspective of "authenticity" to examine the remodeling of place characteristics and the game among diverse groups during the urban regeneration process in New York, opening up a new theoretical horizon for urban regeneration research (Zukin, 2010). "Authenticity" research focuses on the genuineness and uniqueness of places (including spaces and people's activities), and has significant theoretical and practical value in resisting homogenization and gentrification issues caused by urban regeneration.

"Authenticity" is not merely a static description of physical spaces or cultural symbols but a comprehensive concept that closely connects the temporal and spatial dimensions. Pursuing "authenticity" is essentially an emotional attachment and continuous maintenance of a certain kind of life and the urban spaces that support it, allowing the historical accumulation of living habits and cultural images to be embodied and serving as a yardstick for judging whether the urban living experience is authentic or not. Meanwhile, "authenticity" is dynamic and ever-evolving. Each generation or newcomer constructs a unique sense of belonging to neighborhoods, communities, buildings, public spaces, and resident groups based on their unique historical backgrounds and individual experiences. This process deeply reflects the influence of the era on individual and collective memory, and how these memories shape and remodeling the "authenticity" of the city.

Therefore, deep reflection on "authenticity" highlights the crucial role of the temporal factor, prompting us to confront the challenge of finding an ideal state of "coexistence" between maintaining existing "authentic life" and creating new "authenticity" to address the challenges and opportunities brought by urban regeneration and explore the path of socially sustainable urban development.

Research Object: Overview of Xiaoxihu regeneration Practice

Xiaoxihu Block, located in the Southern Historic District of Nanjing, China, is one of rare historic communities that have maintained the traditional spatial form and social structure. By 2016, 810 households and 25 enterprises were located within the 4.69-hectare block, with the population beyond 3,000 and the per capita living area of only 10m² without complete public services and infrastructure. The Block exhibited a decayed and chaotic living environment. During the summer of 2015, the Nanjing Planning Bureau and the Qinhuai District Government jointly initiated a volunteer action involving graduate students from three universities to explore preservation and regeneration strategies. After expert evaluation, it was determined that the team from Southeast University would undertake the planning and design, while the Nanjing Historic Urban Area Protection and Construction Group would be responsible for project implementation. Through a series of explorations, the Xiaoxihu regeneration practice has formed a small-scale, gradual preservation and regeneration path with the participation of multiple entities (Han, 2022). Based on understanding and respecting the evolution of the historical environment, the Xiaoxihu regeneration design aims to improve residents' living quality, preserve the ambiance of daily life, and integrate cultural creativity, cultural tourism and other new forms of business, has achieved good social, cultural and economic benefits. It is an important practice case of urban regeneration in residential historical areas.

The regeneration practice provides architects and theorists with an important academic perspective, interpreting design issues from a sociological perspective to explore a truly "human-centered" urban regeneration. Li Hua defines "good enough city" as an urban concept opposite to "massive demolition and construction": the city is a process of continuous evolution rather than revolution, with the goal of shaping a "decent" life rather than building a "perfect" city (Li, 2022). Based on observations of the Xiaoxihu practice, Wang Hui raises the question of who benefits from "urban regeneration," inquiring from the perspective of "spatial justice" about whom the regeneration is for (Wang, 2022). Zhang Jingxiang et al. interpret the Xiaoxihu regeneration mechanism from the perspectives of autonomous regeneration collective action and actor-network theory (Gao and Zhang, 2023; Wang and Zhang, 2022).

Research content and Structure of this paper

Based on urban sociological and phenomenological theories, combined with field observation records and design practice, this paper takes the "Preservation and Regeneration of Xiaoxihu Block in Old South City Area, Nanjing" as an empirical case to systematically analyze the phenomenon, motivations, practical goals, and design strategies of "authenticity remodeling".

Starting with an analysis of the phenomenon of "authenticity remodeling" , this research interprets the crises and motivations of "authenticity remodeling" from the two forces of "Origins vs. New Beginnings" (Zukin, 2010), placing urban regeneration in the context of resident rights protection and cultural consumption development to clarify the controversies and challenges in "authenticity remodeling" and find a responsible and sustainable design stance for practice. Furthermore, from the two dimensions of "home" and "consumption", this paper analyzes how the Xiaoxihu Block maintains the authentic life of the community in preservation and regeneration design practice and effectively stimulates new authenticity experiences. The former interprets the human-centered stance and delicate design that maintain authentic life experiences through the practice of "deducing the whole story from small traces"; the latter summarizes the authenticity remodeling strategies of the neighborhood as a cultural consumption destination in plain language. On this basis, this paper analyzes the ideal state of autonomous, gradual, and open "authenticity remodeling" constructed by the Xiaoxihu regeneration project, summarizes its experience, and provides an important perspective and reference for the research and practice of urban regeneration in residential historical areas.

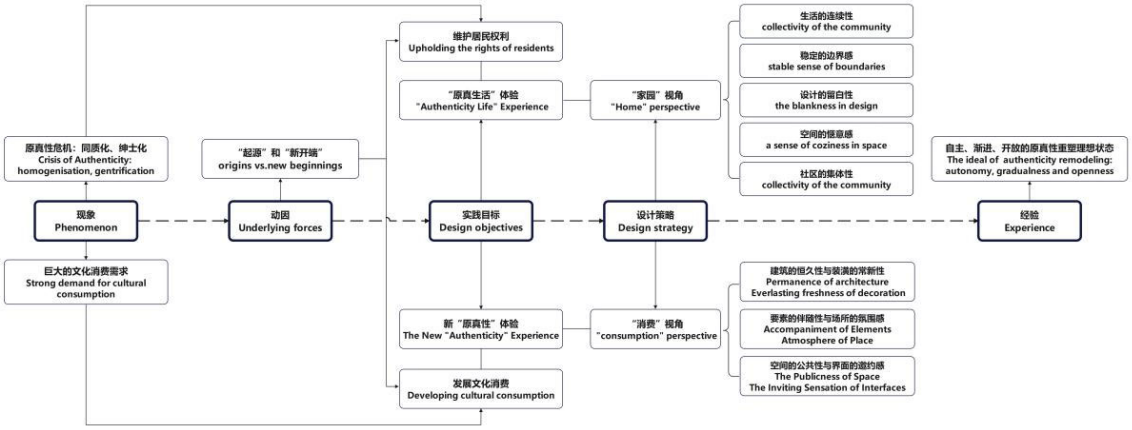

Figure 1. Structure of This Paper, photo credit: Bao and Wang.

Origins vs. New Beginnings": The Two Driving Forces in "authenticity remodeling"

In the process of urban regeneration in residential historic areas, the dynamic process of "authenticity remodeling" profoundly reflects the interweaving and interaction between the two forces of "origins" and "new beginnings": on the one hand, each generation believes that the place where they reside throughout their lives has original characteristics; on the other hand, new generations create their own unique features (Zukin, 2010). In view of the commercialization trend of historical residential areas in China, the current contestation of demands between "indigenous residents" and "consumption" participants (capital, merchants, consumers, etc.) plays a more central role in remodeling the authenticity of residential historic areas.

"Origins": The "Right" of Residents to Live Here

Lefebvre's concept of "the right to the city" focuses on citizens' geographical right to occupy urban centers: the right to stay live in place, to afford one's residence (Lefebvre, 1996). The notion of "origins" encompasses residents' residential rights to a specific area, rooted in their long-term life experiences and emotional attachments. "'Origins' suggests instead a moral right to the city that enables people to put down roots. This is the right to inhabit a space, not just to consume it as an experience. Authenticity in this sense is a continuous process of living and working, a gradual buildup of everyday experience, the expectation that neighbors and buildings that are here today will be here tomorrow." (Zukin, 2010: 5-8)

"Authenticity" is not merely the continuation of streetscapes and architectural styles but also a guarantee of the right to maintain residents' living continuity and collective memory, serving as the cornerstone for the sustained existence and development of residential communities in specific areas. Understanding the "origins" of residential historic areas should avoid a simplistic retrospection to the architectural forms of a particular historical period, which is both impractical and unreasonable given the intricate historical context of cities. Instead, focus should be placed on the continuation of current residents' living experiences and cultural memories, viewed as a dynamic manifestation of historical inheritance.

The Xiaoxihu project in Nanjing, as an exemplary practice in urban regeneration, effectively safeguards residents' continuity of living in the community through prioritizing "retention" and "renovation" over "demolition" and implementing strategies of "self-regeneration, organic regeneration, and continuous regeneration." This process, through close communication between community planners, architects, and residents, ensures the effective communication of residents' opinions and the full satisfaction of their needs, thereby strengthening the narrative power of "origins" authenticity. Amidst the rapid urbanization tide, it upholds respect for life and the continuation of memory, marking an essential shift in the value orientation of urban regeneration.

"New Beginnings": The Irresistible Force of the Consumer Era

Zukin highlights the complexity of authenticity in urban spaces, where it can be both a quality of historical continuity and a product of contemporary cultural innovation and redevelopment (Zukin, 2010). Authenticity remodeling is not just about preserving the past but also about creating new, meaningful experiences and cultural identities in the present.

As modern cities are increasingly characterized by glass and concrete "boxes," the brick buildings, winding lanes, and vibrant scenes of old city life in the Xiaoxihu historic district have emerged as a unique cultural landscape, attracting citizens and tourists with their cultural temperament and aesthetic value. "Origins" evoke people's deep-seated nostalgia, prompting reflections on the complex connections between history, present, and future, generating diverse imaginations and explorations, and driving people's consumption desire for cultural values and fresh experiences.

Here, people experience the thrill of rejecting the standardized urban landscape of modernism and escaping the fast-paced urban life. The pursuit of individual freedom and relaxed living inspires the design and production of consumer goods and spaces, which not only carry new lifestyles but also serve as visual symbols, reinforcing the unique cultural identity of the place—a "new beginnings" authenticity.

This has given birth to new spaces in Xiaoxihu—places with both local cultural products and global marketing features. The Textile Dyeing Museum and Lantern Workshop rejuvenate ancient crafts through modern design and cultural consumption packaging. The emergence of new businesses such as cafes, music bars, craft beer bars, and plant shops integrates into the daily lives of young people, enriching the cultural ecology of the district. The convergence of local, Sichuan, Japanese, and Southeast Asian cuisines not only showcases the diversity of consumer culture in the context of globalization but also highlights the unique charm of Xiaoxihu as a "new beginnings" authenticity location. Urban regeneration creates new consumption spaces and relies on these spaces to respond to contemporary lifestyles, thereby enhancing urban attractiveness and commercial value.

Practical Objective: Coexistence of "Home" and "Consumption"

The "authenticity remodeling" of residential historic areas is a dynamic and interactive process that encompasses the adjustment of spatial forms, the preservation and reproduction of historical memories, the continuation and reconstruction of residents' rights, and the introduction and expansion of consumer culture.

"Is Xiaoxihu a commercial district or a residential area? Is it an attractive tourist spot in the city or a place for daily life? These ambiguities and intermediate states precisely reflect certain normalities and true realities of the city." (Li , 2022: 41-46) The regeneration practice must effectively respond to the dual propositions of "home-consumption" and find the ideal state of "authenticity remodeling."

The Xiaoxihu project reflects that the significance of the existence of this generation of Chinese architects is not only to do architectural design, but also to do social design (Wang, 2022). The design team of Xiaoxihu, serving as the project designers orchestrated by the government, design consultants for public-private partnerships, and quality controllers for residents' self-directed regenerations, becomes a coordinator among multiple stakeholders throughout the entire process from design planning to implementation and even operation and maintenance (Bao and Sun, 2022). They focus on how to maintain residents' "authentic life" experiences while simultaneously crafting new "authenticity" experiences favored by consumers, thereby achieving the coexistence of "home" and "consumption."

Preserving "Authentic Living" from the Perspective of "Home"

In the book "Home," Alison Blunt and Robin Dowling argue that home is not merely a "place" where we reside and live; it transcends this physicality, embodying a concept and imagination that encompasses a sense of belonging, desire, and intimacy (Blunt and Dowling, 2022). Home is both material structure and profound manifestation of human perception, emotion, attitude, and identity.

"Origins" implies the continuity of life, the accumulation of experiences, and the aspiration for the permanence of home. The "origins" authenticity manifests in the "everyday life" developed through residents' long-term habitation, usage, and habits. Designers should pay attention to the existing social structure and real needs of the community, and design around the core content of "daily life" as a "home" perspective, so that residents can continue to live in the familiar environment and participate in open urban activities. The design team of Xiaoxihu, through their sincere and locally-rooted approach, successfully constructed a framework that intertwines human connections and geographical context. As a result, a profound connection between people and land, as well as history, present, and future, is realized and embodied within the residential space (Bao and Sun, 2022).

In "The Geography of the Lifeworld," David Seamon describes "Rootedness, Appropriation, Recovery, At-easeness, and Warmth" as qualities that constitute "at-homeness." From a phenomenological perspective, he notes that both the "body-subject" and the "feeling-subject" require time to familiarize themselves with and attach to new environments, both desiring minimal changes in their lived world (Seamon, 2022). This continuity is intimately linked to "at-homeness." The design practices of Xiaoxihu's residential and public spaces respect and embody Continuity of Living Space, Stable Sense of Boundaries,The Blankness in Design, A Sense of Coziness in Space, and The Collectivity of the Community, fully interpreting these five qualities of "at-homeness" to preserve the authenticity of "home."

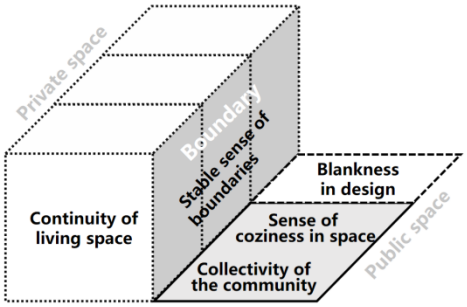

Figure 2. Authenticity Design from the Perspective of "Home", photo credit: Wang.

"Rootedness" · Continuity of Living Space

"Rootedness" is the power of home that organizes the habitual and physical dimensions of personal living spaces (Seamon, 2022). It embodies residents' inner desire to maintain space minimal changes, involving not just cognitive analysis of spatial structures but also facilitating a seamless integration between space and individual behavior patterns, marking a more intrinsic, direct, and vital connection between space and individual existence.

"Rootedness" is a crucial component of authenticity experiences, representing the authentic and genuine aspects of residents' lives. Design should preserve this continuity and habituation in the relationship between people and space. Mr Long's home is a demonstrative courtyard in the Xiaoxihu project. The Mr and Mrs Long have always been accustomed to washing in the courtyard. The architect adjusted the kitchen design according to this living habit of theirs, arranging the operating platform along the south window and locating the sink in the courtyard outside the window (Figure 3), and designing a canopy for this purpose, which preserves the habit of using water and facilitates the interaction between indoors and outdoors. Through a deep understanding of the residents‘ habitual wishes, this kind of "Rootedness" specific and micro-design, which exists widely in the various spatial and temporal corners of the micro-renewal practice in Xiaoxihu, fully respects the residents’ living habits (Bao and Sun, 2022), and also maintains the residents' "authenticity" experience.

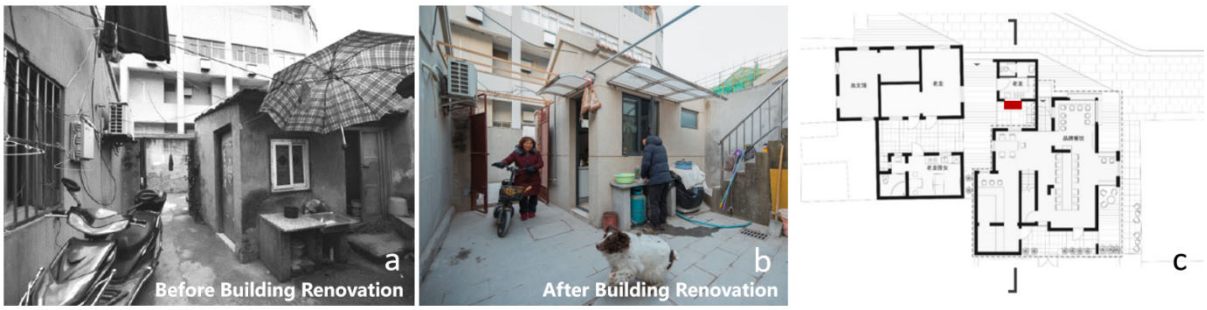

Figure 3. Renovation of Mr Long's home, photo credit: Libao Group(a), Hou Bowen(b), Bao(c).

"Appropriation" · Stable Sense of Boundaries

The concept of home essentially involves the appropriation and domination of space, a sense of control over space as a resource. When space is inappropriately interfered with or violated by external forces, the occupant's right to possession is challenged, leading to a sense of loss of control, which triggers deep emotional and subjective responses from the occupant, which may be manifested as direct feedback at the "feeling-subject" level, such as anger, anxiety, or discomfort (Seamon, 2022).

"Appropriation" provides residents with a spatial order that belongs to and relies on them. A moderate sense of appropriation is a manifestation of place attachment, expressing an authentic human-land relationship that deserves respect and preservation. The regeneration design should fully respect the demands of neighboring residents, maintaining the stability of boundary perceptions through considerate design. In the renovation of No. 5 Madao Street, the street-facing section was transformed into commercial space, while the courtyard within housed the autonomous regeneration of three residential units. The initial design aimed to increase commercial space utilization by designing the commercial section from one level to two levels, raising the roof above its original height. This change evoked a sense of discomfort among courtyard residents who felt their space was being violated. During the design optimization process (Figure 4), the architects lowered the roof ridge height of the new second-story building as much as possible and retreated the "one-span space" adjacent to the courtyard to create an outdoor platform, thus successfully eliminating the sense of "appropriation" brought about by the elevated roof. By giving way to the public interest and forming a stable boundary between public and private spaces, the authenticity experience of "at-homeness" of the residents is maintained.

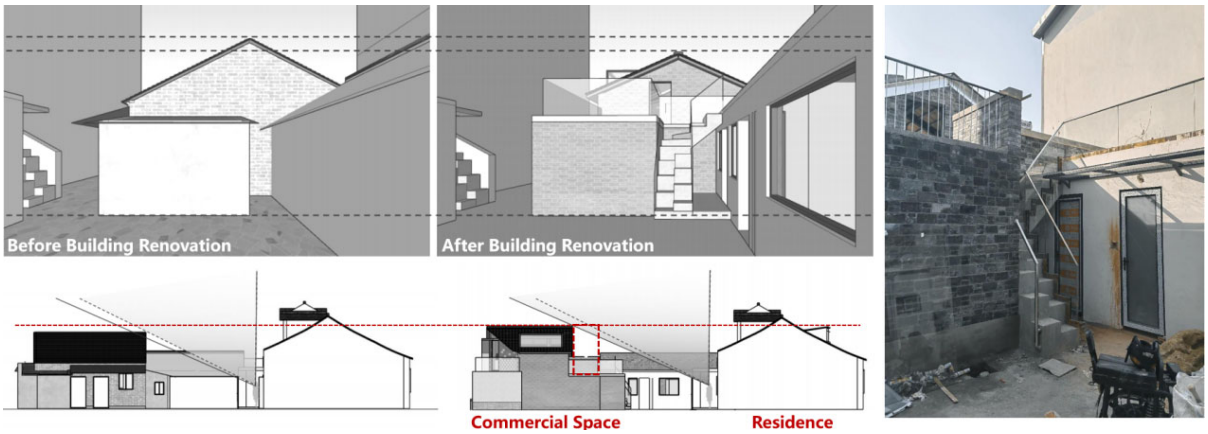

Figure 4. Renovation of No. 5 Madao Street, photo credit: Bao and Wang.

"Recovery" · The Blankness in Design

In exploring the mechanisms of rest and recovery, the individual seeking rest needs to achieve a state of stasis and relaxation. The process of "recovery", in this context, refers to the nourishing and accumulating effect of space on the energy and vitality of the individual (Seamon, 2022).

Returning to an authentic lifestyle, where rest and relaxation are taken for granted, constitutes a vital aspect of the quality of "at-homeness". In the Xiaoxihu Block, there exists a vibrant vegetable garden (Figure 5, bottom) where an elderly resident cultivates various vegetables in foam boxes and plastic buckets, chatting on wooden chairs beside their plots during breaks. This garden narrates the passage of time: in autumn, corn kernels are spread on the ground to dry for storage; in winter, the second-floor balconies are adorned with Nanjing's beloved air-dried bacon. This open space was preserved by the development company, LiBao Group, and the community planner during the regeneration process, and this "authenticity" left behind has brought a sense of rest to the elderly and other community residents, and has become a spiritual garden for the community's recovery and regeneration. The triangular open space behind No. 31 Xiaoxihu was also left "blank" (Figure 5, top), with the design team retaining two gracefully positioned Tanghuai trees along the path, where residents continue to utilize the space beneath them (Bao and Sun, 2022). The "blankness" in design is a crucial strategy to maintain the authenticity of the place, and the "do-nothing" of the design is to better allow the residents to "do-something", so that the residents can define their interaction with space and time.

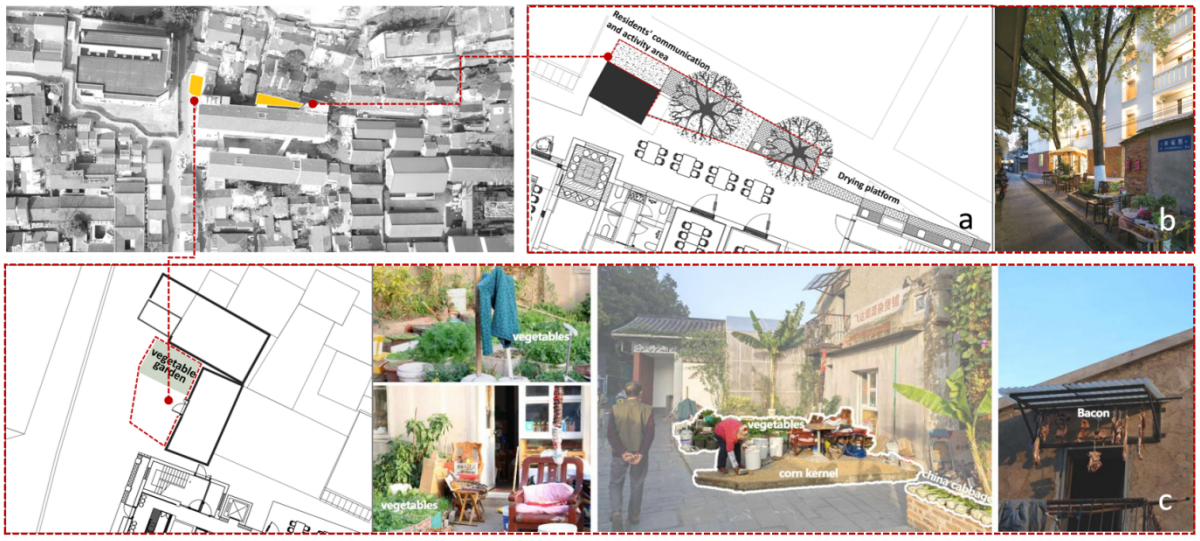

Figure 5. The triangular open space (top) and vegetable garden (bottom) in Xiaoxihu Block, photo credit: Bao(a), Hou Bowen(b), Wang(c).

"At-easeness" · A Sense of Coziness in Space

"At-easeness" signifies a state where individuals can present their most authentic selves in a space, transcending the constraints of social roles (Seamon, 2022). This state embodies one's true, unadorned nature, aligning closely with the philosophical concept of "authenticity." A "cozy" space encourages individuals to experience a pleasant life within their environment.

Seating is a vital prop for creating "at-easeness" places, connecting space and the human body and fostering more lingering and social situations. The diverse seating designs in Xiaoxihu Block inspire a

variety of cozy behaviors (Figure 6): parents waiting for their children to finish school sit or lean on wooden chairs and stone benches along the alleys, construction workers rest on stone benches, and elderly community members chat about life's details on artistic groups of stainless steel stools. These scenes collectively construct a vivid and harmonious "place ballet" (Seamon, 2022), demonstrating the positive role of "cozy" spaces in promoting community belonging and individual happiness.



Figure 6. Seating usage scenarios in Xiaoxihu Block, photo credit: Wang.

"Warmth" · The Collectivity of the Community

"Warmth" embodies an abstract yet profound emotional connection, a vital component of the "authenticity" experience from the "home" perspective, nourished by both space and collective activities. It sustains a joyful and companionable atmosphere (Seamon, 2022), encompassing individuals' sense of belonging and identity to their families and communities.

Shaping spaces and planning activities based on the local context and community needs is crucial for fostering a sense of community collectivity. The houses to the north of Xiangluan Temple burned down, leaving an open space, the design team meticulously restored the Republican-era villas to the north, transforming the enclosed space with Xiangluan Temple into a community square with a traditional stage at the eastern end. This square has become a venue for spontaneous cultural and sports activities and performances organized by surrounding residents (Figure 7), hosting events such as the Qinhuai Lantern Festival lighting ceremony and the Xiaoxihu Theatre Festival (Dong and Han, 2022). The design of public spaces contributes to stimulating community collectivity by shaping memory places where residents can rest daily and perceive history, forming an essential foundation for collective authenticity perception.



Figure 7. Xiangluan Square and residents activities, photo credit: Prof Han Dongqing's team(a), Fang Fei(b), Xue Liang(c), Wang(d).

Design Inspiration for "New Authenticity Experience" from the Perspective of "Consumption"

Consumption culture, as a powerful driving force, is gradually shaping residential historic areas into urban "cultural destinations". This process is a transformation of social space and material entities under the intertwined forces of government policy direction, developer investment, media publicity, and consumer experience preference (Zukin, 2010).

The regeneration practice of Xiaoxihu, with its preserved old alleys and buildings as the foundation, has transformed the space into an artistic and fashionable arena, fostering a series of social and leisure venues for citizens and tourists. It creates a delightful atmosphere that sparks consumers' imagination and offers an enjoyable experience. It embodies Jane Jacobs' essence of building vibrant urban districts, featuring harmonious coexistence of old and new buildings, rich street experiences, continuous attraction of people, and diversity of spatial uses (Jacobs, 1961). The multidimensional aesthetic presentation of alleys, buildings, art, merchandise, and dining experiences aligns with cultural consumers' pursuit of individuality, jointly creating a spatial experience that embodies both cultural heritage and modern life, enriching the "New Beginnings." authenticity of Xiaoxihu.

"Dressed up the Space": The Permanence of Architecture and the Everlasting Freshness of Decoration

On the block scale, Xiaoxihu emphasizes the protection and restoration of the overall structure and morphological characteristics of the historic community. On the architectural scale, it respects the architectural types and styles of different historical periods, selecting materials and craftsmanship that harmonize with the historical environment for renovation or reconstruction, demonstrating "permanence" in architectural form and style. If "architecture" is likened to "people," then "decoration" is akin to attire. Xiaoxihu's commercial atmosphere is akin to a continuous "dressing up," with stylized decorations updated roughly annually to accommodate different business types and brands (Figure 8), continuously creating new visual stimuli and enduring appeal for consumers. The "new beginnings" authenticity experience intensifies within the context of "consumption." The tension in Xiaoxihu Block from the juxtaposition of novelty and difference from "Consumption" perspective and continuity and stability from "Home" perspective.



Figure 8. Everlasting Freshness of Decoration, photo credit: Wang(a), XiaoHongShu(b).

The everlasting freshness of decoration is also evident in Xiaoxihu's diverse urban exhibitions, which enrich visitors' experiences through indoor and outdoor displays related to seasonal changes, city events, and traditional culture. Integrating urban exhibitions with micro-regeneration has become a trend in shaping new urban spaces and promoting traffic growth (Zhang, 2021). Residents, citizens, and tourists can experience and interact firsthand, deeply perceiving the close connection between regeneration activities and personal lives, and appreciating the authenticity rooted in Nanjing's "Old South City Area" history, culture, and residents' lives.

"Accompaniment and Atmosphere": The Accompaniment of Elements and the Atmosphere of Place

Environmental atmosphere needs to be captured and perceived with the help of creating a spatial "continuum" through the establishment of complete paths and flow sequences, and forming a perceivable rhythmic beauty (Li, 2023). The Xiaoxihu district, based on its original winding and freely extending street network, with pocket plazas, creative seats, art installations and colourful shop signboards dotted on both sides, as well as walls made of different materials and climbing greenery, which together construct a spatial environment that always accompanies and attracts the public and tourists (Figure 9), and strengthen the accompaniment of the tour paths - strolling along the lanes, the scenery changes with each step - enriching the authenticity experience intertwined with "origins" and "new beginnings".



Figure 9. strolling along the lanes, the scenery changes with each step, photo credit: Wang.

The regenerated district has been widely disseminated through self-media platforms, using images as a medium to showcase snippets of personal life while also shaping Xiaoxihu's social recognition as a "new beginnings" authenticity experience destination. In this process, the power of "web hotspot" and dissemination has been deeply recognized by planners and designers, with "ambience" becoming an essential consideration in place-making. Taking No. 31 Xiaoxihu as an example, the building, originally a four-story apartment from the 1970s, has been transformed into a boutique hotel integrated with commercial spaces on the ground floor. During the renovation, designers appreciated the intricate and rhythmic design of the original balconies, choosing to preserve them while optimizing the facade rhythm and architectural details. This fusion of the "origins" authenticity of old residential buildings with the low-saturation ins aesthetics preferred by younger generations created a unique atmosphere (Figure 10), attracting citizens and tourists to visit the block, thereby becoming the focal point of "new beginnings" authenticity experiences in Xiaoxihu.



Figure 10. "Internet-celebrity Balcony" at No. 31 Xiaoxihu, photo credit: Bao(a), Wang(b), Hou Bowen(c).

Embrace and Enter": The Publicness of Space and the Inviting Sensation of Interfaces

The Xiaoxihu Integrated Control Center plot gradually evolved into a public space during its regeneration (Figure 11),. The site used to be a parking space for the power supply company, but in the process of renewal, based on the consideration of municipal needs and the value of the site, it was transformed into the main street of the Xiaoxihu block and the commercial spaces on both sides of the street. The transformed plot, now fully public, integrates public facilities and commercial functions, serving as a symbolic southern entrance to the Xiaoxihu block (Dong and Han, 2022). The regeneration enables Xiaoxihu to "embrace" citizens and tourists, inviting them into the block.

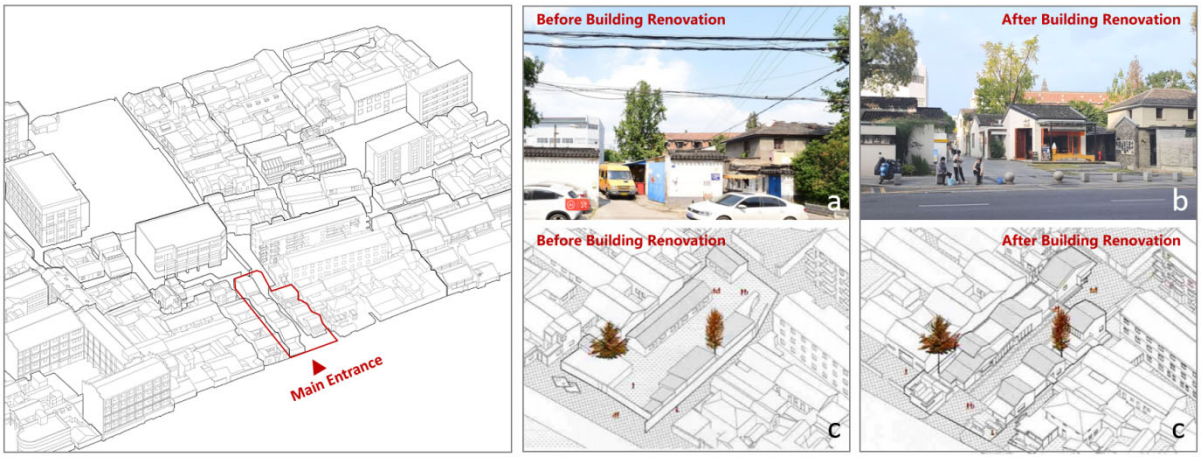

Figure 11. Regeneration of Xiaoxihu Integrated Control Center Plot, photo credit: Baidu Street View(a), Wang(b), Prof Han Dongqing's team(c).

Collaboratively designed by architects, interior designers and merchants, Xiaoxihu's commercial interfaces exude an "inviting sensation." Standing by the roadside, one can glimpse through low walls, stylish courtyards, and transparent glass, and see the textures of interior walls and the ambient lighting cast upon them, almost as if already stepping into the restaurant or café. The large glass with permeability of sight appears flexibly on all facades and walls of the building, inviting people passing by from different angles (Figure 12). Under these "embraces" and "invitations" from the space and interface, people complete the visual experience and consumption of space, well-designed spatial hierarchy, visual elements, colour rendering are fully perceived by consumers, the fashionable and relaxing sense of these commercial spaces bring people "new beginnings" authenticity experiences.



Figure 12. Xiaoxihu Commercial Spaces: The Inviting Sensation of Interfaces, photo credit: Wang.

Conclusion: The Ideal State of Autonomous, Gradual, and Open "authenticity remodeling"

Based on preceding observations, practices, and reflections, we can conclude that the regeneration of Xiaoxihu embodies an ideal state of autonomous, gradual, and open "authenticity remodeling".

"Autonomy" refers to respecting residents and their choices. The regeneration practice of Xiaoxihu safeguards the rights of original residents to "continue living here", which serves as the fundamental premise for preserving the "authenticity lifestyle." The subjectivity and participation of individual residents in urban regeneration are fully prioritized. The practice of community planners in Xiaoxihu "returns to the concern for people," implementing a tailored approach for each household. They listen attentively to residents' aspirations, ranging from ideas for renovating their courtyards, considerations regarding neighborhood relations, to imaginations of community collective memories. In their fragmented daily lives, community residents are able to participate deeply in the process of community planning and design through decision-making (Bao and Sun, 2022). After the regeneration of Xiaoxihu, a large number of original residents still live there, retaining the courtyard form, lifestyle, living tradition, and the "origins" authenticity experience with local characteristics.

"Graduality" is a prudent strategy against drastic remodeling of authenticity and safeguards "origins" authenticity. Xiaoxihu's two-tier control system, comprising 15 "planning management units" and 127"micro-regeneration implementation units" (Dong and Han, 2022), supports the "small-scale, gradual, courtyard-by-courtyard" regeneration model, averting authenticity crises such as fractured community identity and homogenized neighborhoods caused by large-scale, mass-produced regeneration. Ample design cycles and fine services for each household ensure that the design team, grounded in a profound understanding of residents' authentic lives, implements regeneration designs. This strategy avoiding the disintegration of the differentiated authentic experiences of different families and individuals by the "fast-food," standardized designs. "Gradual" regeneration also shapes an intertwined texture and harmonious fusion of new and old, commercial and residential spaces, creating a more vivid "authentic" place.

"Openness" signifies respecting the objective law that authenticity is constantly dynamic, integrating the memories and new vitality of the present era into the existing environment, continually creating and evolving novel authenticity experiences. Xiaoxihu's regeneration design adheres to the principle of "practical utilization", preserving the unique image of historic areas while ingeniously integrating modern elements suitable for new consumption formats. This open and inclusive regeneration design satisfies the diverse needs of the new era. The blend of visitors' experiences and residents' daily lives fosters interactions between fashion and tradition, sophistication and earthly charm. A "truly living" Xiaoxihu exudes a unique charisma that seamlessly blends "new beginnings" and "origins" authenticity experiences, making it a place where "residents feel at ease, neighbors are delighted, and travelers are drawn".

The regeneration of Xiaoxihu, "authenticity remodeling," has achieved an "coexistent and win-win situation" in enhancing living quality, bolstering community vitality, fostering cultural consumption, and promoting cultural tourism development. It provides invaluable insights for responsible and sustainable urban regeneration in residential historical areas today.

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Subtropical parallels: Comparative urban form of Florianópolis and Brisbane.

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ABSTRACT

This study undertakes a comparison of the subtropical cities of Florianópolis and Brisbane that share a common geographical latitude of 27.5° South, with location on the eastern coastline of Brazil and Australia respectively. The juxtaposition aims to explore the distinctive characteristics and socio-cultural dynamics that define these two cities. Through a morphological approach, we assess the natural environment, historical, and cultural facets of Brisbane and Florianópolis, shedding light on the intricate interplay between nature and human societies in the form of these distinct latitudes. A historical analysis unfolds from the urban evolution of each city from the establishment of urban grids in their development as colonised places. Critically, socio-cultural dimensions have been underplayed in the appraisal of the dynamics of urban evolution. By considering the perspectives of indigenous communities, settlers, and migrants, the study seeks to unravel the unique palimpsest of identities that contributes to the socio-cultural fabric of each sub-tropical city. The paper concludes with analysis and synthesis of the intersection of natural environments, settlement histories, and socio-cultural dynamics, providing insights into the commonalities and distinctions between Florianópolis and Brisbane. The conclusions drawn offer a deeper understanding of the complex relationships between nature and human societies, contributing to discussions on sustainable urban development that considers cultural perspectives, and the coexistence of diverse communities in sub-tropical latitudes.

Keywords: Morphology, Subtropical, Florianópolis, Brisbane

INTRODUCTION

Both subtropical cities of Brisbane and Florianópolis share a similar latitude in the southern hemisphere approximately 27.5°S (Figure 1). Brisbane is the capital city of Queensland in Australia and is situated on latitude 27° 28’ South, approximately 750 km due north of Sydney. Florianópolis is also a capital, but of southern Brazil’s Santa Catarina state and is situated 27° 48’ South.

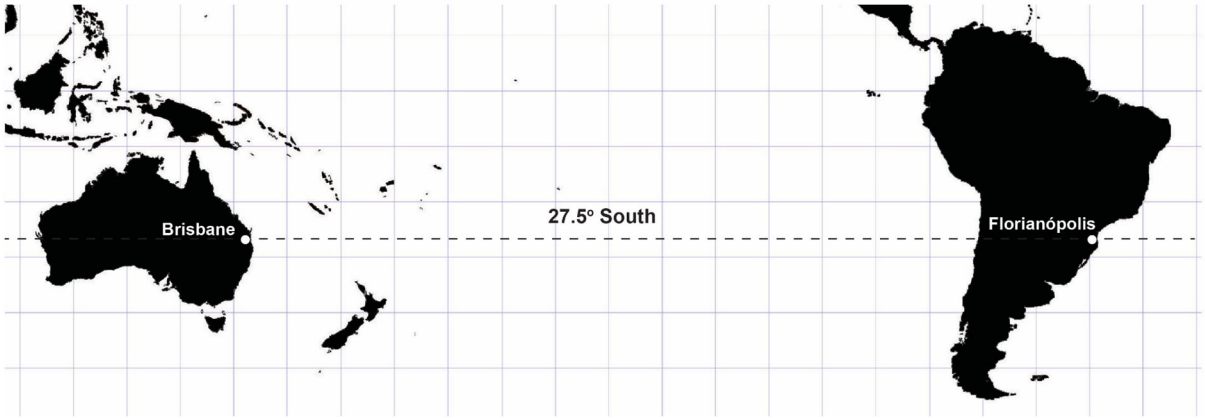

Figure 1. Map showing the 27.5° latitude line passing through Florianópolis and Brisbane. Source: Authors

The cities share an almost identical sub-tropical climate with Florianópolis, which is slightly wetter and more humid than Brisbane. Looking at the comparative regional maps of Brisbane and Florianópolis (figure 2), we see a similar coastal topography in the presence of large island formations. The most striking comparative feature being the urban footprint of Brisbane is almost entirely located on the mainland, whereas Florianópolis is dispersed with the city centre orientated on the Island. A small town called Dunwich, located on the west coast of the neighbouring Stradbroke Island (Minjerribah) has a very similar appearance to that seen from the island of Florianópolis, however it did not develop significantly in urban scale, partly due to the resistance to build a physical transport link to the island. Both urban centres share a strong relationship and conflict with their waterways. Brisbane's central business district (CBD) is almost entirely surrounded by the Brisbane River with Spring Hill forming its northern boundary. Floripa likewise has a CBD that is almost surrounded by its north and south bays with its large hill to the east hemming in the CBD. Both cities are located on the east coast of their respective continents sharing similar access to islands, lake systems, sand dunes and amazing beaches. Both cities have the backdrop of large mountain ranges to the west.

The locations of both cities were inhabited originally by first nations people who enjoyed the bounty of resources from the land and sea. Brisbane (Meaanjin) was inhabited by the Turrabul and Yaggera peoples and Florianópolis by the Carijo Indians, ancestors of the Guaranis. Both groups of indigenous peoples were either driven away, murdered or in Brazil's case enslaved or relocated in missions as is the colonial way of doing business. Traces of first nations people's activities are found in the form of bora rings (ceremonial spaces) and middens along the neighbouring coasts of Brisbane and in cave art on the Isle of Santa Catarina. Brisbane and its surrounds still have communities of first nations people with a deep connection to their land.

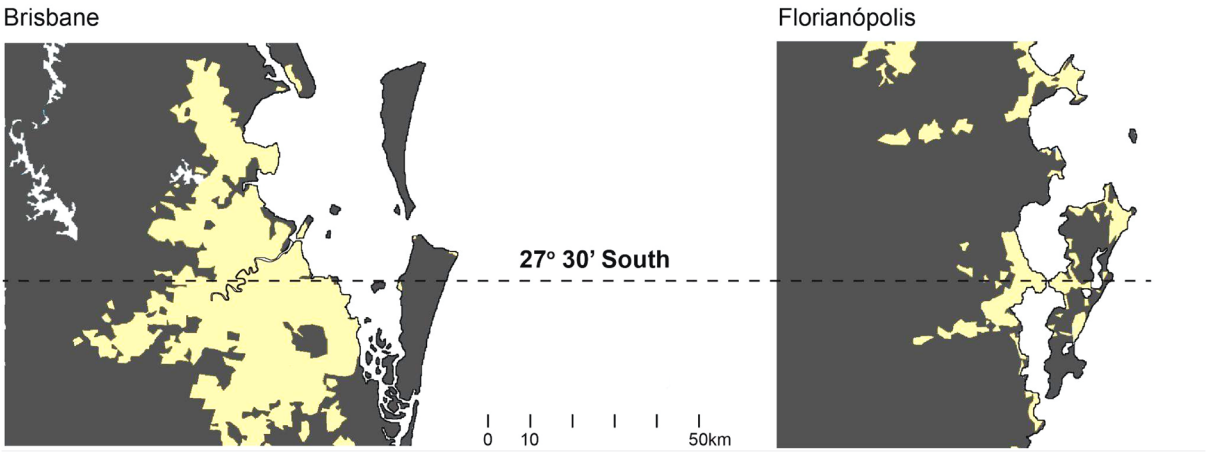

Figure2. Regional maps of Brisbane and Florianópolis showing urban footprint (yellow). Source: Authors

In front of the Florianópolis Parish Church, there is a square, Praça XV de Novembro, with its paving reproducing a design with folklore motifs. According to data from the library of the Brazilian Institute of Geography and Statistics, it was from there that the city began to expand and this area is home to a large number of historic buildings, which display the original architectural features preserved by law. During the 19th century, the square was planted with trees of great size, such as the Centennial Fig Tree (Figure 3). Interestingly, this type of tree planting is also found in the Brisbane CBD (Figure 4).



Figure 3. Florianópolis fig tree. Source: https://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view=detalhesandid=441402.

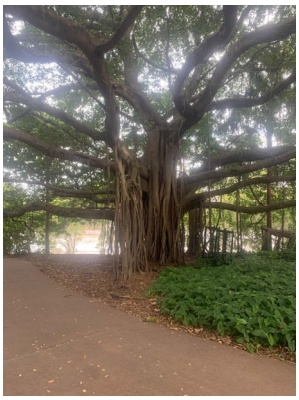

Figure 4. Brisbane fig tree. Source: Photo by Anna Pimenta.

According to Conceição (2011), artisanal mullet fishing is a resource that is as highly valued today as it was by the Azoreans when they first arrived on the island. The importance of this tradition is

economic, cultural and social, and the fishing method is carried out by artisanal fishermen using traditional techniques, such as the use of trawl nets on the beach. This practice is often carried out in a community manner, involving entire families and preserving cultural practices passed down from parents to children over successive generations. From there, we see another cultural similarity between the two cities addressed here, since according to Barker and Ross (2003), Brisbane also has a fishing activity aimed at sea mullet, which is important for commercial, recreational and indigenous fishermen.

Due to the different colonising histories of the Portuguese (in Brazil) and British (in Australia) the original settlement timings vary significantly, with Florianópolis being settled some 350 years ago, and Brisbane settled approximately 200 years ago. Both started as ports in their early years with the first historical buildings of each settlement located on the southside and adjoining their respective waterways. Their cities' colonial grids were defined by this relationship to the water. In Florianópolis' case, the main historical town stretches roughly east - west parallel to the coast with the main church and square dominating the harbour side, along with the main market and commerce areas.

Therefore, we have chosen in this article to begin by addressing the cities separately, starting with Florianópolis in Brazil. Both cities will be given a historical contextualization, followed by a section on physical and spatial issues, and then on to the socioeconomic aspects, always focusing on the influence of all this on urban morphology. Only after this individual approach to each city, the article presents the comparisons in the discussion and conclusion.

FLORIANÓPOLIS

Historical Context Of The Urban Network's Structure - Florianópolis

For a general overview regarding Brazil, Garcia (2015) points out that archaeological research estimates that the Brazilian territory was already occupied more than 12,000 years ago by different ethnic groups. The presence of at least 1,400 different peoples who would have inhabited Brazil before the arrival of Europeans was recognized, and those adopted different reactions when in contact with the colonisers, including large displacements with the intention of escaping slavery or conflicts. At the time of the maritime "discoveries" Pedro Alvares Cabral, Portuguese navigator and explorer, arrived in Brazil on April 22, 1500, a date considered to be the beginning of Portuguese colonisation. Kern (2000) speaks of the intention of conquest of gold, silver, or the souls of the Indians through missions to evangelise them.

This settlement of Brazil by the Portuguese began on the coast, with the intention of establishing sugar cane plantations, mills, and ports. Parallel to this, the colonists organised expeditions in search of labour, metals and precious stones. The brazilian city we are approaching in this article, Florianópolis, is an island of the coast of the southern region of Brazil, and upon the arrival of the colonisers, the Europeans saw these territories occupied by indigenous groups called Kaingang, Xokleng, Xetá and Guarani, and the domination of these territories involved a series of violent and systematic actions that ended up decimating and impacting the local population in a permanent and lasting way (Garcia, 2015, 92).

At this time, of the beginning of the 16th century, ships travelling to the River Plate Basin stopped on the island to pick up supplies such as water and food, which later led to the the recognition of the

settlement with the name of “Nossa Senhora do Desterro” (currently Florianópolis) around 1675, with the arrival of a coloniser from the São Paulo region, Francisco Dias Velho, with his family. According to Vaz (1991) the part of the island chosen to establish this settlement remains until today as the city's central business district (CBD).

During his time there, Dias Velho arrested a crew of a pirate ship carrying silver, confiscating its assets to the Royal Treasury. A year later, the pirates who had escaped returned, caused destruction, and killed him. After that the place was abandoned until twenty-three years later when French navigator Amadèe Frèzier arrived on the island and found around 150 people, led to the place by Lisbon native Manoel Manso de Avelar. Thus began a new phase in the occupation of the site (IPHAN - The National Historic and Artistic Heritage Institute in Brazil). The settlement of Desterro was elevated to the category of village in 1726. Around ten years later, due to its strategic position for the Portuguese crown in Brazil, it began to be occupied militarily. At that time, fortresses began to be built. Portugal recognized the convenience of fortifying the island and taking care of its settlement and commissioned Brigadier José da Silva Paes, appointed governor of the local prison, to carry out this mission.

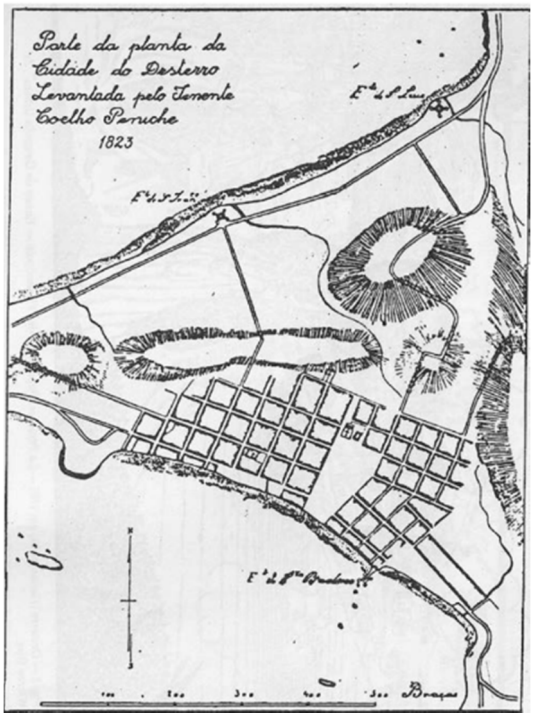

Figure 5. Floor plan of Florianópolis from 1823. Source: Peluso Júnior, 1991

Silva Paes began the construction of the Government House, the four fortresses and the project of the main Church. Saboya, Reis, and Bueno (2016) point out that until the 18th century, the occupation of the Island was practically restricted to the immediate vicinity of the initially founded village and other specific occupations scattered throughout the interior of the Island and adjacent continental coasts. Measures were taken to help occupy the Island, highlighting the Azorean settlement, which began in 1748. Between that year and 1756, around six thousand immigrants disembarked, populating the Island and the nearby continent. The same authors also note that as a consequence of this immigration there was an occupation focused on agriculture, forming a territorial structure that persists, in part, being drastically modified only with the development of urban occupation focused on tourism present today.

The city plan was subordinate to the sea, promoting a densification of housing in the western part of the city. The house groups that at the time marked the directions of the streets that were being formed. After a certain point the guiding element was no longer the beach, but the base of the hill on which the houses were built. In 1819, the city's densification progressed to the east of the square, on the plain that facilitates the street layout (figure 5)parallel to the beach (Peluso Júnior, 1991).

After Brazil adopted a republican form of government in 1889, according to Castelhano et al. (2023), until 1950 there was a strengthening of the State's capital status, a period with administrative and industrial activities, and improvements in commerce and services activities. The construction of the Hercílio Luz bridge, in 1926, marked a moment of political, economic and social transformations, being the first road connection between the Island and the mainland. The arrival of the bridge on the island was in a not so noble region, alongside the cemetery, the waste incineration, factories and the city's workers' village. Little by little and with subsequent plans for the city (Ferraro and Yunes, 2016). From the 1940s onwards, this portion and the entire central area of the city began to change its configuration.

Physical And Spatial Aspects - Florianópolis.

Florianópolis has most of its territory on the island of Santa Catarina and a small portion on the mainland. The island part of the municipality was strategically positioned as a refuelling point for ships heading to the Prata River Basin and military intending a defensive occupation (Conceição, 2014). Although its relief was very rugged, with hills ranging from 400 to 532 m, and with its east coast facing the open sea, which difficult for ships to dock, on its west coast, its proximity to the continent formed an area protected from the bad weather and a natural harbour that, according to Conceição (2014), was the driver of the city's development for almost 2 centuries. The proximity to the continent in the narrowing of the channel offered ships two bays, the north bay and the south bay, with calm waters where access to land was facilitated by the existence of plains with a greater aptitude for occupation, as can be seen on the map produced in 1710 by French navigators (Figure 6). It was in this region where the channel narrowed that the first settlement on the island was formed, today the central region of Florianópolis. The island's mountainous topography is depicted at the bottom of the 1716 French map (Figure 7).

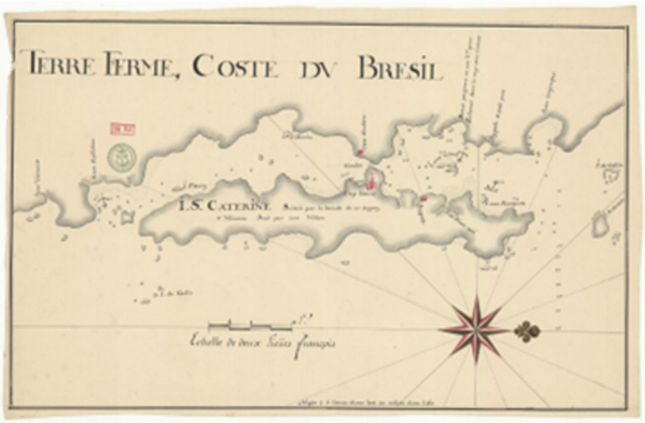

Figure 6. French map of Santa Catarina Island (1710). Source: National Library of France (gallica.bnf.fr)



Figure 7. Island of Santa Catarina map. Located on the coast of Brazil (Carte Particuliere de l'Isle de Ste. Catherine. Située à la Côte du Bresil). Source: National Library of France (gallica.bnf.fr)

With a mountainous massif that cuts the island from south to north, in the portion facing to mainland there are plains that favour the formation of mangroves, while on the island Atlantic side the slope is steeper with dune formations and extensive beaches (Figure 8). This island geomorphological conformation favoured an initial occupation in the plains on the west coast and in small areas along the entire coast. Another important aspect that guided the occupation of the island was the water network, formed by small river basins with their rivers, lakes and lagoons, the main water formations being Lagoa da Conceição and Lagoa do Peri. This initial occupation sought proximity to water sources, both at the sea and at the mouths of rivers (Figures 9 and 10). Thus, parishes were born that were, in large part, the basis of the current consolidated neighbourhoods, configuring a polynuclear occupation on the island, the basis of the urban structure that currently exists in Florianópolis.

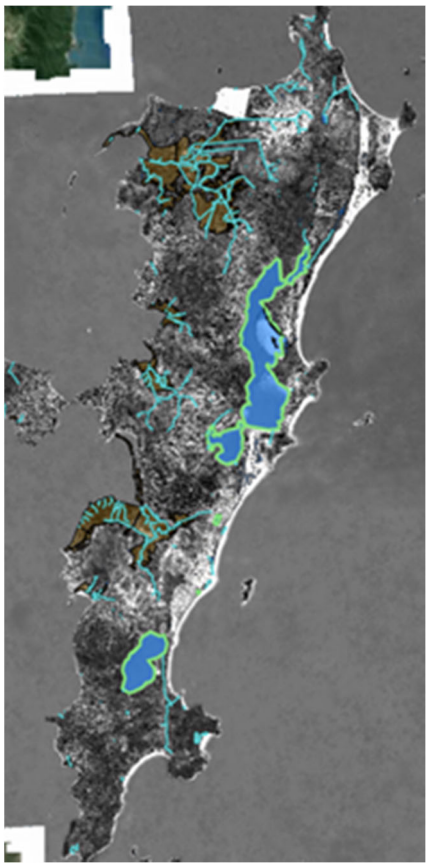

Figure 8. Main elements of the geomorphology of Santa Catarina Island. Source: Elaboration from Florianópolis City Hall (geofloripa.pmf.sc.gov.br)



Figure 9. Occupation plan of Santa Catarina Island at the beginning of its occupation, uncertain date of the 1700s (Map prepared by French navigators). Source: Florianópolis City Hall



Figure 10. Spanish map by Tomas Lopez from 1777 with the first occupations on the island of Santa Catarina, highlighting the location of the fortresses. Source: Florianópolis City Hall

In 1673, Francisco Dias Velho officially occupied the island territory, following the principle common to the Portuguese island layout at the time: a chapel facing the coast, with a square between it and the sea, flanked by the colonists' houses. Added to this form of occupation, the port dynamics established there led to the first urban structure in Florianópolis maintained to this day. In Figure 11, the map from the first decade of the 19th century shows this configuration.



Figure 11. Urban structure around the port in the first decade from the 19th century. Source: Florianópolis municipal archive collection.



Figure 12. Hercílio Luz Bridge – 1935. Source: Floripa.travel (https://www.Florianópolis.travel/historia-pt.html)



Figure 13. Florianópolis Center - Public Market by the sea - early 1990s. Source: http://fotosantigasFlorianópolis.blogspot.com

The construction of the Hercílio Luz Bridge will reinforce this process of centrality of the port area with a slow occupation process and which will maintain the initial foundations of the land structure until the beginning of the 19th century (Figures 12 and 13), still with a strong relationship with the sea. The characteristics of the Island's relief created difficulties in displacements and the old trails, normally at the bottom of the valleys, are becoming the main paths and routes that today structure the island's mobility system.

Focused on increasing mobility, given this road structure that is difficult to expand, there has been, since 1970, a large investment in expanding connecting roads and implementing extensive embankments, aiming to make areas available for the road system (Sugai, 2015). Florianópolis' urban expansion and development initiatives have included, among other measures, the execution of landfills along the city's coast. Lisboa (2004) notes that until 1990, four landfills were built in the city, three on its island portion and one on its continental portion (Figure 14).

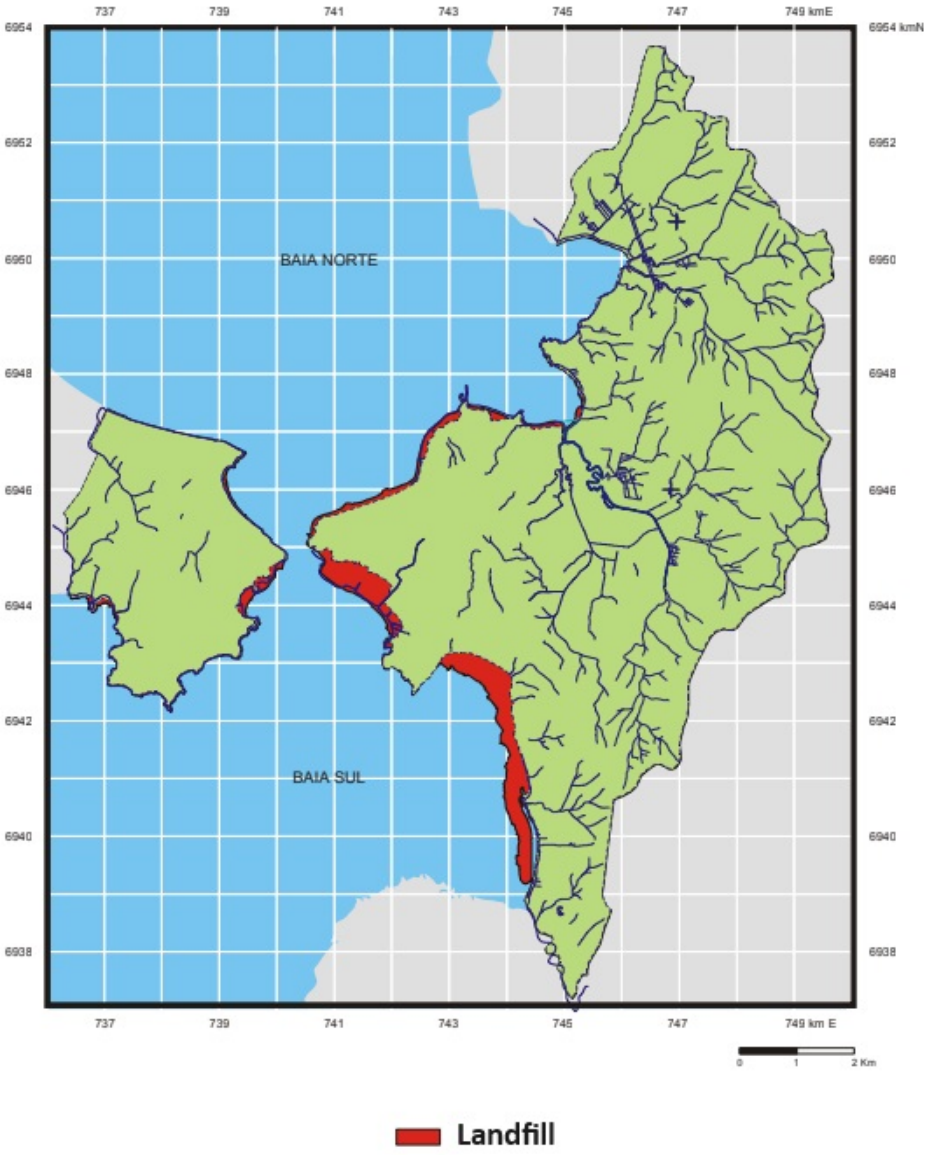

Figure 14. Morphological change of the coastline between 1966 and 2002. Source: LISBÔA, 2004. pg.62.

Of the 433 km² of Florianópolis' territory, 9 km² were created by landfilling (Prochnow, Dal Santo and Amey, 2009). In addition to the need for larger spaces, there are also difficulties in island urban development in Florianópolis due to its geographical barriers. The rugged terrain not only slows down the city's growth, but also hinders the flow of goods and people. The landfills would come from the need to increase road connections, between the island and the mainland and several more central locations on the Island of Santa Catarina itself, being the main reason for their construction and installation.

The first landfill, called Baía Sul, was built in the early 1970s, starting from the Hercílio Luz bridge to the southern coastal region of the island. The intervention aimed to induce growth in the southern region of the city, which is less valued compared to the north. The development of the south of the island was stimulated by a local road expansion and restructuring plan, essentially prioritising travel by private cars (LISBOA, 2004). The second landfill, called Baía Norte, expanded, also in the 1970s, in the opposite direction to the first, from the Hercílio Luz bridge to the northern coastal region of the

island, directing the city's growth towards the local hydrographic network and of the recently installed campus of the Federal University of Santa Catarina (LISBOA, 2004).

Two other landfills in Florianópolis were carried out in the following decades, according to the same logic as the first two, but differing in their processes due to the environmental protection laws consolidated by the Federal Constitution of 1988, which restrict the uses and changes that the intervention could be carried out, based on environmental impact studies (LISBOA, 2004). The third landfill, called Saco da Lama, was the first one to be located on the mainland of the city, on the other side of the Hercílio Luz bridge. The landfills moved the sea away from its central area and radically changed the character of the city.

According to Andriani, 2017, the most recent landfill to date was built with the aim of creating an avenue on the Sea side of the Continental part of Florianópolis, to ease traffic in that area (Figure 15). The work on this landfill began in 2004, amidst great controversy regarding environmental issues, and was completed in 2012, transforming this part of the coast into a three-lane avenue with one-way traffic heading north, which is the same direction as the two streets, mainly to alleviate traffic congestion (Andriani, 2017).



Figure 15. Location of the last landfill made on the mainland. Source: Google Earth, adapted by Anna Pimenta according to Andriani, 2017.

The expansion of occupation of the old peripheral centres occurred slowly until the mid-1970s, but these investments in landfills, road infrastructure and the beginning of tourism on the island began to attract interest from the real estate sector. In 1976, a new Master Plan was approved that focused on improving road access to beach neighbourhoods with a view to their development. During this period, the expansion of urban growth began towards the north of the Island. Although there was an incentive

in the legislation for occupation towards the east, this only intensified at the end of the 90s. Figure 16 with orthophotos of Florianópolis in the years 1938, 1957, 1977, 1994, 2002, 2007, 2016 and satellite image from 2024, allows us to visualise the evolution of the city's occupation.

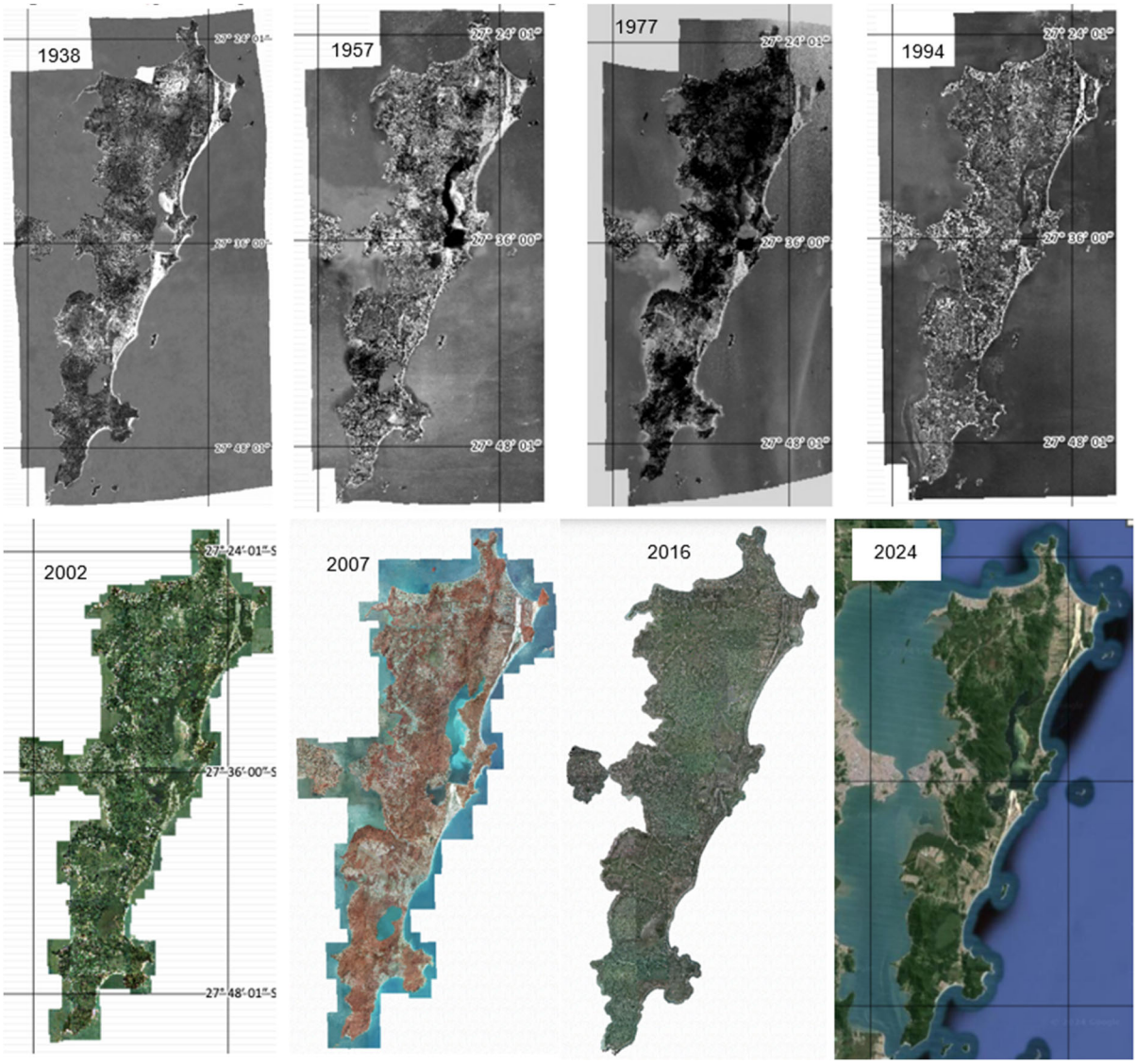

Figure 16. Florianópolis Orthophotos from 1938 to 2016 and satellite image from 2024. Source: Elaboration from Florianópolis City Hall (geofloripa.pmf.sc.gov.br)

Figure 17 shows the evolution of the urban area during periods of greatest growth (between 1977 and 2012). It is observed that the central-western zone of the island and the continent were almost completely consolidated until 1977, with few changes in subsequent periods. There was an increase in occupation between 1977 and 1994, most significantly in the North region, in the Canasvieiras and Jurerê neighbourhoods, and to the south in the Campeche plain. In the second period of great growth, there is again an intensification of occupation in the North region, but at this time in the Ingleses and Rio Vermelho neighbourhoods, which today is one of the main growth vectors on the Island along with the consolidation and expansion of the Planície do Campeche. The 2019 map of the urban area and the current satellite image do not show a major expansion in occupation, however there was a significant increase in population in the period, highlighting an ongoing verticalization process. In all periods, alignment with the structuring road axes is identified.

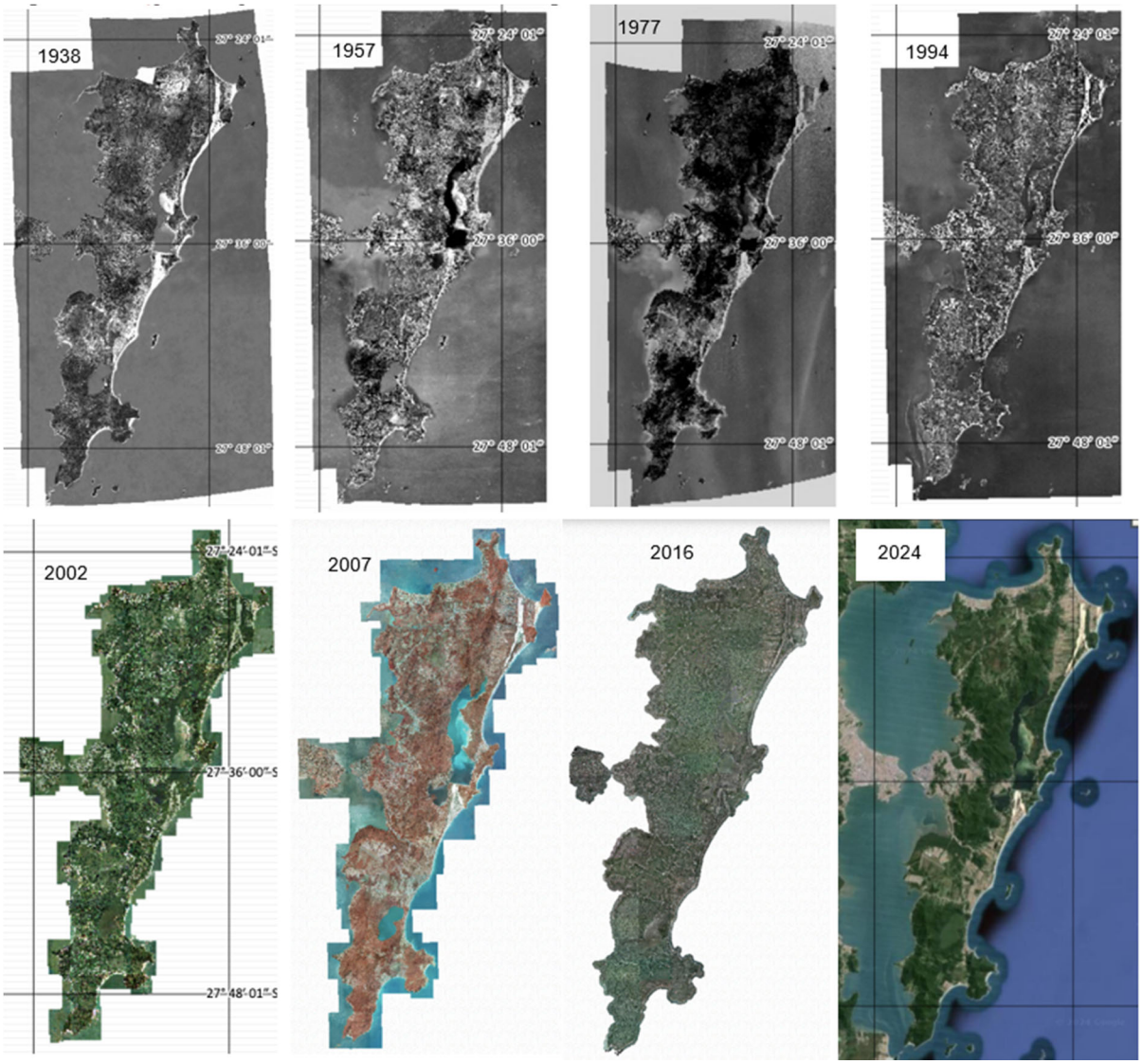

Figure 17. Urban area of Florianópolis evolution. Source: Elaboration from Florianópolis City Hall (geofloripa.pmf.sc.gov.br)

These were considered the main physical and spatial aspects that influenced the changes in the urban morphology of the city of Florianópolis over the years. However, we cannot fail to consider the influence of socioeconomic aspects on urban morphology by shaping income distribution, housing quality and infrastructure. Income affects the location and quality of residences and services, while urban planning policies and regulations reflect economic interests and determine land use. Therefore, these aspects will be addressed in the next section of this article.

Socio-Economic Aspects (Consolidation And Configuration Of Housing Neighbourhoods) - Florianópolis

Florianópolis' residential neighbourhoods may be roughly classified into two main types, according to their origin and resulting street layout: the first comprises planned portions which, for the most part, have more regular grids and are located in lower and flatter terrains. The second includes neighbourhoods that developed largely spontaneously and have a street system based on one or very few main roads organising fragmented and disconnected streets.

Another important distinction is between the central areas and those located at the beaches around the main Island. While the first has a more uniform and regular street layout, the others are much more heterogeneous and have both types of layouts. In these latter areas, two traditions coexist: on the one side, traditional settlements that transformed from rural areas into incipient urban areas, and later received a lot of interest from the real estate market because of their position near the beaches. On the other, tourism-led developments carried out by large profit-seeking firms and land owners.

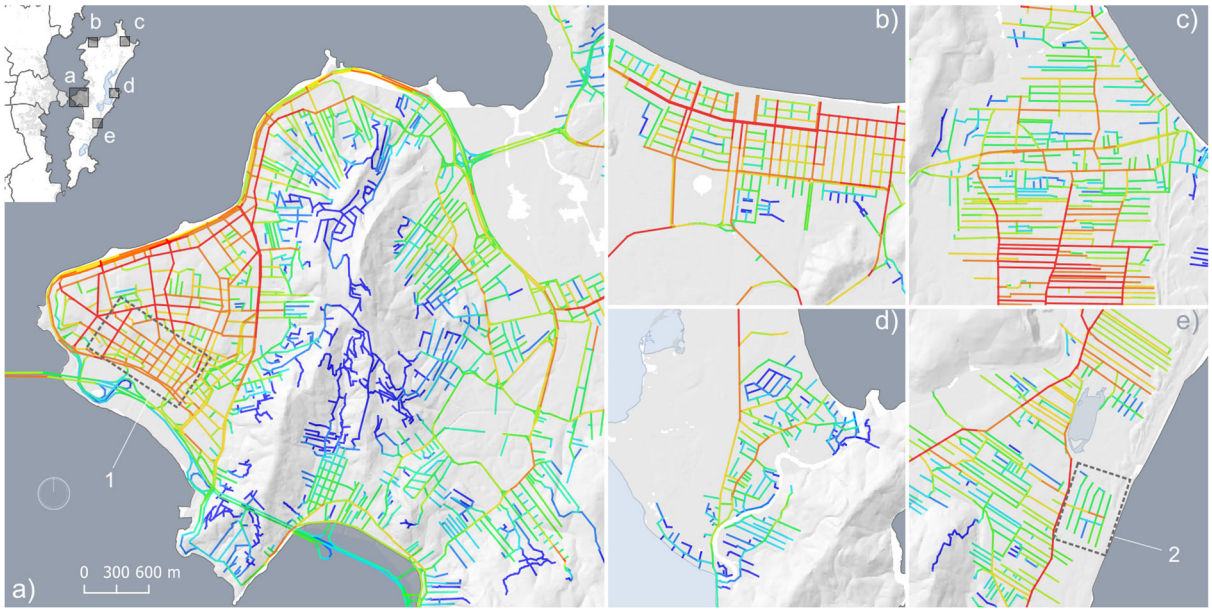

Figure 18. Street layouts of Florianópolis' historic centre and of four of its beachside neighbourhoods. Source: edited by the authors with original data by IBGE (2010) and Municipality of Florianópolis.

Figure 18 shows the street layouts of Florianópolis' historic centre and of four of its beachside neighbourhoods. They are represented by their level of Local Integration at the 1200m radius, meaning that street segments in more vivid colours (red and orange) are, on average, closer to other streets within the radius. Blue hues represent the opposite: street segments that are, on average, distant from the immediate (1200m) vicinity. Figure 18a shows that the historic centre has a regular grid on the South that corresponds to the foundational nuclei (marked "1"), and that the layout of the surrounding streets are more fragmented. The central hill is an extreme case of such fragmentation, being linked to socioeconomic processes of spontaneous occupation by low-income populations in search of well located places near jobs and other amenities. Figure 18b shows a modern and planned seaside neighbourhood (Jurerê) with its regular grid, while Figures 18c and 18d show more traditional neighbourhoods that developed around unplanned street layouts. These areas are heavily dependent on just a few streets. Finally, Figure 18e shows an hybrid neighbourhood with mostly irregular and fragmented street grid, developed spontaneously, and a small and more recent planned neighbourhood (marked as "2"). Both of the planned and regular seaside neighbourhoods cater to high income groups and tourists, while the spontaneous areas are more socially mixed.

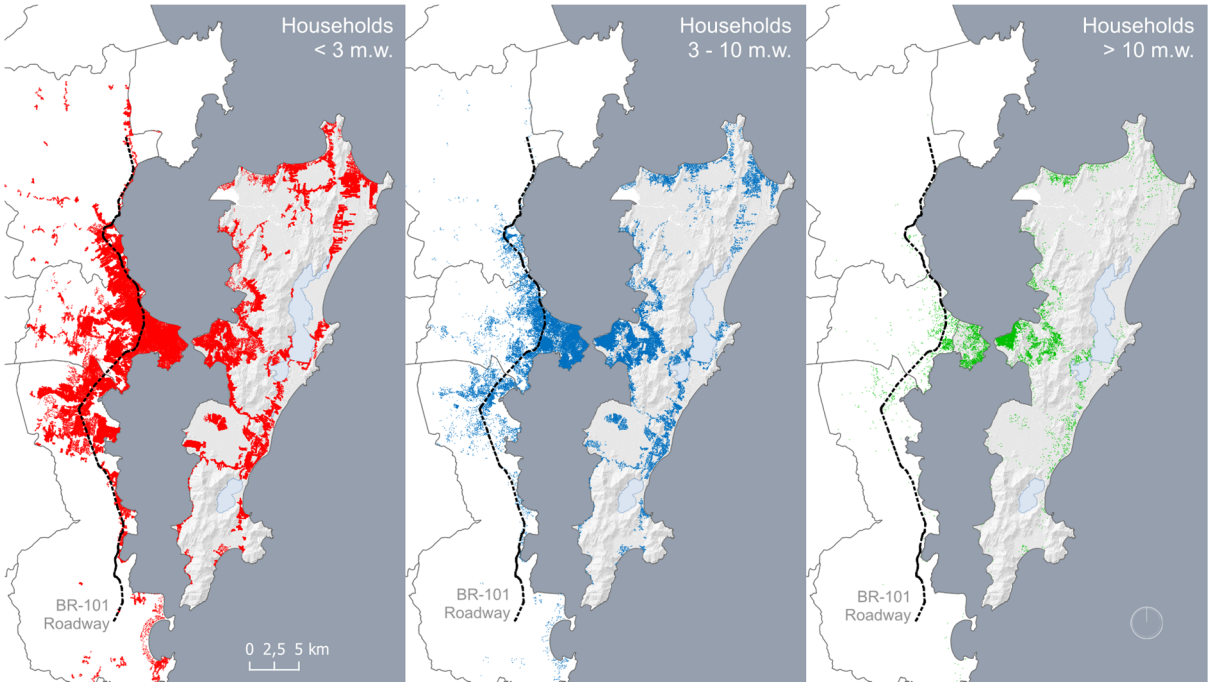

Figure 19. Distribution of residences by income classes (per capita). Note: m.w. = minimum wage. Source: edited by the authors with original data by IBGE (2010).

Another important characteristic of Florianópolis' residential neighbourhood is the distribution of income groups between the Island and the mainland. Figure 19 shows that there were still numerous households of the low-income group in the Island in 2010 (last available data) but, as Sugai (2015) has shown, the pattern of change in the last decades has been their displacement and relocation on the fringes of adjacent cities. Little by little, traditional neighbourhoods are being occupied by upper class residents coming from other Brazilian cities - and even from abroad - in search of natural coastal landscapes, services and other amenities, raising land and values and housing costs in the process.

BRISBANE

Historical Context Of The Urban Network's Structure - Brisbane

Aboriginal civilisation is considered one of the longest surviving cultures in human history, with evidence tracing their ancestry back over 50,000 years to arrivals from the Indonesian archipelago. Originally forming semi-nomadic hunter-gatherer tribes, they lived within well-defined geographical boundaries (Schub and Smith 2024). The first inhabitants and traditional owners of the Brisbane River area are the Aboriginal groups of the Turrbal, and Jagara people (Greenop and Memmott, 2007, 216). Their place values and place-making activities, being points of orientation for spiritual, social and cultural reference and including sites of large gatherings (Greenop and Memmott, 2007, 214), were numerous and widespread throughout the region. Kerkhove (2018) confirms the pre-colonial existence of a number of meeting and camping grounds to the south of the river which featured swamps, woodlands, and rainforests. Traditionally called Kurilpa ('place of bush rats'), this area, now known as West End and South Brisbane, was rich in resources and a popular hunting location for game (Figure 20).

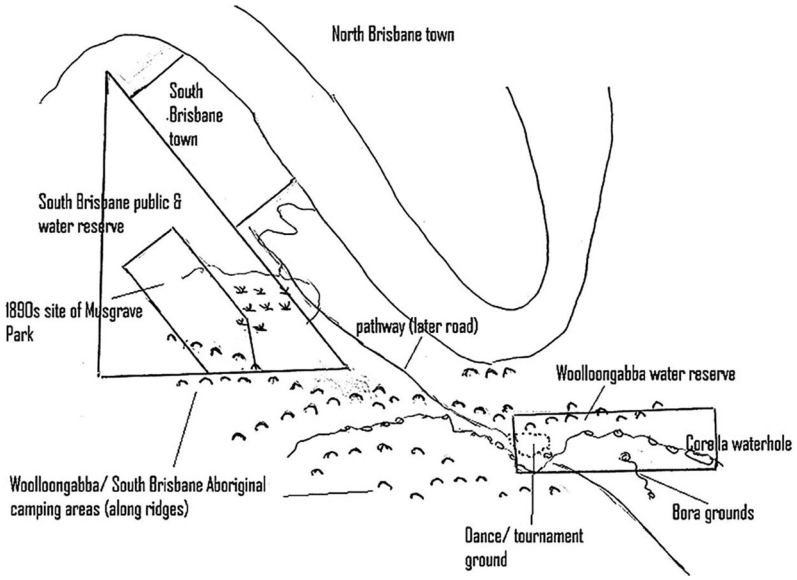

Figure 20. Location of Water/Recreation Reserves and Aboriginal camps (Kerkhove 2018).

Moreton Bay is a wedge-shaped embayment situated between the mainland and the offshore barrier islands. Coastal headlands are most notable on the dune islands, which are formed from tertiary basalts. Moreton and North Stradbroke Islands (Minjerribah) are characterised by high rocky headlands in their north-east corners, specifically Cape Moreton and Point Lookout, respectively (McPhee, 2017).

British occupation followed John Oxley's discovery and survey in 1823 of a large tidal river suitable for settlement (Johnson, 1988, 12; Johnson and Gregory, 1989b, p.238). A convict colony, initially known as Moreton Bay Settlement (Johnson and Gregory, 1989b, 242) was soon established on the banks of the river some 16 km upstream from the sheltered Moreton Bay and housed only the hardiest of criminals from the penal colony in Sydney. The settlement was short-lived and was closed in 1839, and the transportation of convicts officially ceased in 1841, with the official proclamation that ended the penal colony declared shortly after in 1842 (Gough and Ogilvie, 1985, 8; Johnson, 1988).

Even during the period when the convict settlement was being dis-established, preparations for free-settlement were already well underway. Starting in 1839, three surveyors had been sent to Moreton Bay to conduct trigonometrical surveys (Figure 21) in order to determine topography as well as to report on the condition of soils, water and timber supply, with a view to recommending sites for towns, villages and other purposes (Johnson, 1988).



Figure 21. Dixon, R (1839) Plan of Brisbane River and Moreton Bay. Source: State Library of Queensland.



Figure 22.. Dixon's map of Brisbane Town 1840. Source: State National Library of Australia.

The following year, Dixon drew up a plan (Figure 22) proposing the layout for the new town, incorporating a system of large square grids, each ten chains long, and streets one chain wide or 66 feet/ 19.8 metres (Johnson and Gregory, 1989a, 260), with the original prisoners' barracks building providing the reference for the main alignment (Johnson, 1988, 34). Dixon's plan was subsequently modified by Henry Wade with the principal revision being the modification of the square blocks into rectangular grids (Figure 23).

There was considerable debate regarding the suitable width of streets, partly due to Governor George Gipps' view that Brisbane would not develop into a very significant town; the only concession to the original plan of relatively narrow streets, was the provision for a main central street (Queen Street) to be wider than the others with a width dimension of 1.21 chains or 80 feet/ 24.4metres (Johnson and Gregory, 1989a; Johnson, 1988; Mellor, 1960). Siksna identified that the settlement pattern of Brisbane was based on 200x90m 'medium rectangular blocks' with a street spacing mesh of 221x111m; internally divided with 20 equal back-to-back lots (Siksna, 1997, 30).

Australia shares many characteristics with America in terms of city block settlement patterns (Siksna 1997) and the frequent, significant changes in urban form driven by successive economic cycles. Both countries have relatively young towns and cities, with the earliest settlements being spatially minimal compared to their later expansions. Rapid change is a constant, making the study of urban morphology less organised and structured than in Europe (Conzen, M.P., 2001).

In Europe, historic centres allow for the assessment of morphological patterns through the interpretation of existing forms. In contrast, Australia's urban fabric has fewer historic buildings, necessitating a greater reliance on archives and records for morphological analysis. However, the relative youth of Australian cities, combined with a tradition of meticulous British surveying, recording, and archiving practices, provides a wealth of secondary data suitable for morphological research.



Figure 23. Ham, T. and Co. (1863). Ham's Map of the City of Brisbane, Queensland, 1863. [Cartographical material].

Physical And Spatial Aspects – Brisbane

The Greater Brisbane area has most of its urban territory on the mainland, with only the small-town settlements of Dunwich, point Amity, and Point lookout on North Stradbroke Island (See Figure 24), this being the converse situation with the case of Florianópolis. The city area mainly consists of undulating to low hilly lands, generally below 80 metres in elevation, but rising to around 120 metres, with a few isolated higher hills to the West of the city centre, which reaches 255 metres. This region also includes very low-level plateaus to the South, which are small remnants of an ancient surface that sloped gently toward the coast. The low hilly areas typically have gentle to moderate slopes, while the middle to upper slopes of higher ridges, particularly in the western suburbs and on isolated prominent hills, are moderately to steeply sloped. This region features a variety of rock types, including carbonaceous shales and lithic sandstones. Additionally, a narrow, north-south band of rhyolitic tuff (ignimbrite) is found east of the city (Beckmann et al. 1987).

The climate is subtropical and maritime, featuring hot, humid, and rainy summers, and short, mild, relatively dry winters, with minor rain peaks around June-July. About two-thirds of the annual rain falls between November and April. Brisbane's climate data shows an average annual rainfall of 1146 mm, maximum and minimum temperatures of 25°C and 19°C, and an annual evaporation of 1630 mm. Frosts may occur from June to August, mainly in low-lying inland areas (Beckmann et al. 1987).

Most of the native vegetation has been destroyed due to urban and rural development, with the remaining areas significantly altered. The least disturbed remnants are found on steep lands (mainly west of the city), poorer soils, and wet or saline lands on the lower plains and coast. Several major vegetation formations are closely linked to soil differences influenced by parent rocks, nutrient content, water regimes, and salinity. The main vegetation types include: (a) Eucalyptus open forests and woodlands; (b) Paper Bark tea-tree open forests and woodlands in poorly drained coastal plains and valley bottoms; (c) Closed forests with emergent hoop pine, found along streams, in sheltered valleys, and on southern slopes (Beckmann et al. 1987).



Figure 24. Depicts the extent of urban sprawl of South East Queensland 2024 – adapted from Queensland Globe online resource. The approximate extent of the city in 1895 (from McKellars Map) is highlighted in yellow. Dunwich, the small-town settlement on North Stradbroke Island is indicated with a purple dot. The extent of land subdivision to create the container terminal for the Port of Brisbane is indicated with a red outline. Source: Earthstar Geographics. Includes material © State of Queensland (Department of Resources); Commonwealth of Australia (Geoscience Australia); 2024.

During the twentieth century, Brisbane's expansion was fuelled by the electrification of tramways and the development of a suburban rail network. By 1901, Brisbane had a population of 120,000, representing just a quarter of the population of Sydney or Melbourne. Despite this, the city continued to extend its reach, with railway lines constructed to Moreton Bay for recreational purposes, as well

as to Southport, Coolangatta, and Tweed Heads. In 1915, the first subdivision in Surfers Paradise was established (Spearritt, 2009). The power of Brisbane as a main urban centre stemmed from the amalgamation of numerous small towns and shires into an expanded Brisbane City Council that controlled an area of nearly one thousand square kilometres, and governance over metropolitan services and finances (Minnery and Chow, 2010). At the end of World War II, the car became a symbol of independence, prosperity, and luxury worldwide, with the USA leading the charge during its post-war boom. This period saw the rise of suburban living, with privately owned suburban shopping centres replacing traditional high streets. Drive-in cinemas, fast food joints, bottle shops, and dry cleaners became hallmarks of this new suburban culture, epitomising convenience and modern living. International delegations, including the Lord Mayor of Brisbane visited the USA to witness the promise of this new world firsthand.

In Brisbane, American traffic engineers were enlisted to solve traffic congestion problems in the narrow CBD streets. By the late 1960s, the tram system was dismantled, and the CBD street network was converted into a one-way system. This transformation included constructing the Riverside Expressway, Captain Cook Bridge, and the Southeast Freeway connecting the city to the coast. The new elevated Riverside Expressway severed Brisbane's connection to the river, leaving the riverbanks in shaded, dark under crofts. A similar disconnection was anticipated with a proposed road along the northeast side of the CBD and the river shore, which would further disconnect the city from its river.

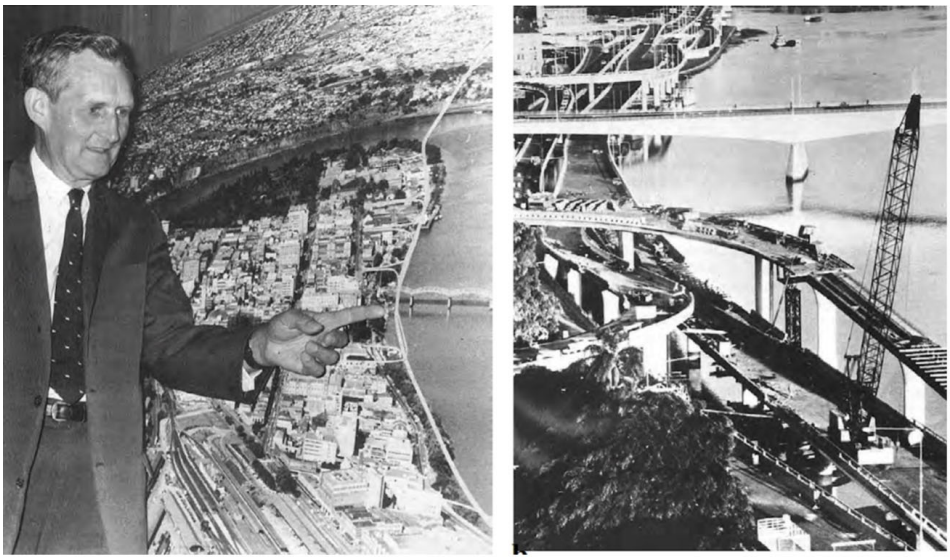

Figure 25. Riverside Expressway traversing the edge of the Brisbane River. a: Wilbur Smith, in 1968 demonstrating the line of the proposed Riverside Expressway, a main feature of the Brisbane Transportation Study. b: Construction of the Riverside Expressway nearing completion in 1974. Source: (Cole, 1984).

Since the 1970s, three rapidly expanding urban areas in Southeast Queensland have united to form a continuous 200 km coastal city. Brisbane, which lacks surf beaches, saw its residents travelling two hours to smaller, developing towns with stunning beaches for over a century. Starting in the late 1950s, the ‘Gold Coast’ to the south and the ‘Sunshine Coast’ to the north were marketed as prime holiday destinations. As small coastal towns merged with each other and with Brisbane, they created one of the longest urban coastal strips in the world, with a population nearing three million. Brisbane, a state capital with a modest industrial base, has been connected to these two holiday coasts through freeway-driven suburban expansion. Consequently, these coastal areas have experienced such rapid

population growth that their economies now depend not only on vacationers and retirees but have integrated into the broader metropolitan economy that now dominates the coastline (Spearritt, 2009).

As part of its corporate visioning process in 2002, the Brisbane City Council created an aspirational city's identity through the concept of a "city designed for subtropical living" (Kennedy, 2018). Despite these goals the Central Business District (CBD) of Brisbane has undergone significant intensification in development resulting in numerous skyscrapers. Greater Brisbane, typical of other Australian large cities like Sydney and Melbourne, is a sprawling car-reliant city, that has nonetheless concentrated construction investment at their CBDs, that has manifested an urban form compression and exaggerated vertical city skyline.



Figure 26. Nighttime view of Brisbane CBD. In the foreground is 'One William Street', 'Brisbane Skytower' dominating the right skyline, and in the left distance is 'The One' Building. Source: Paul Trotter

The tallest towers are predominantly residential, with the 90 storey (270 metres) 'Brisbane Skytower', followed closely by the 82 storey (264 metre) 'The One' building. Government also contributes to the proliferation of high-rise towers, with the Brisbane City Council occupying the 38 storey (151 metre) tall 'Brisbane Square', while also on the river edge the Queensland Government Executive is located in the 46 storey (260 metre) 'One William Street' building. The goal of subtropical living is significantly challenged in developer driven super high residential towers due to the height related climatic variables of skyscrapers (Jory, 2018), internalised air-conditioned living is the consequence.

Socio-Economic Aspects (Consolidation and Configuration of Housing Neighbourhoods) - Brisbane

The period of economic development in the new free settlement was initiated in 1841 by free traders and tradesmen who had established shops through leasing space in the former convict premises; this was soon followed by the first sale of land in 1842, by auction in Sydney for £100 per acre (Gough and Ogilvie, 1985; Johnson and Gregory, 1989a, 261; Johnson, 1988). The new town experienced a steady

growth during its formative decades, with commercial and trading businesses emerging concurrently as the migrant population increased. The first census in 1846 showed that there were 960 people living in Brisbane, and 2258 people spread across the region; by the 1851 census Brisbane's population had increased to 8375 (Gough and Ogilvie, 1985,.8; Johnson and Gregory, 1989a, 106).

It was not until 1867 that the settlement underwent its first economic boom following the discovery of gold by James Nash at Gympie, some 170 km north of Brisbane. The huge influx of people that followed triggered an unprecedented growth in primary industries, and a period of prosperity and building activity that would last 15 years and would not be equalled for a century. It was eventually ended by the cutting out of the gold and the world financial crisis of the early 1890s (Holthouse, 1982, p.41). Brisbane had become a significant shipping port with minerals, rural products and sugar as its primary exports. It was the capital of the annexed state of Queensland and was to be proclaimed a city in 1902. The population of greater Brisbane at the time of the 1901 census was 119,428 people. The period of economic growth continued up to the advent of World War I (Australian Bureau of Statistics, 2009). From 1918, Queensland's economic base continued to be mainly foreign trade to the UK (73% of total exports); primary goods being wool (41%), butter (19.5%) and meat products (24.5%).

In 1925, the City of Brisbane Act (1924) came into effect, rationalising civic government by amalgamating 18 former local government areas under a single administration, the Brisbane City Council (Holthouse, 1982, p.55). Despite strengthening Brisbane as an economically powerful civic entity, the impact of the Wall Street Crash of 1929 brought about the Great Depression in Australia during the early 1930s. Nevertheless by 1935 Queensland emerged with employment levels restored, stimulated from public works expenditure and the recovery of wool, wheat and metal prices to pre-depression levels (Australian Bureau of Statistics, 2009). Optimism was short-lived however, due to the onset of World War II which once again stifled economic growth and development in the city. The post-war decades from 1944 found Brisbane dilapidated and neglected, and it was to recover much more slowly than either Sydney or Melbourne. However, in the 1960s, with new mineral discoveries in Queensland, the city finally entered an enduring phase of prosperity from which Brisbane emerged as a modern city through a program of large-scale urban and civil construction, which has been sustained until the present day.

In summary, there have been two significant economic periods in Brisbane's history that have generated two distinct morphological periods of urban development in shaping the form of the city. These are approximately its initial growth from 1840s up to 1914; and then, following fifty years of relative fallow activity, a rapid growth from the 1960s to the present day, a period where the metropolitan population has increased from approximately 600,000 to 2.5 million.

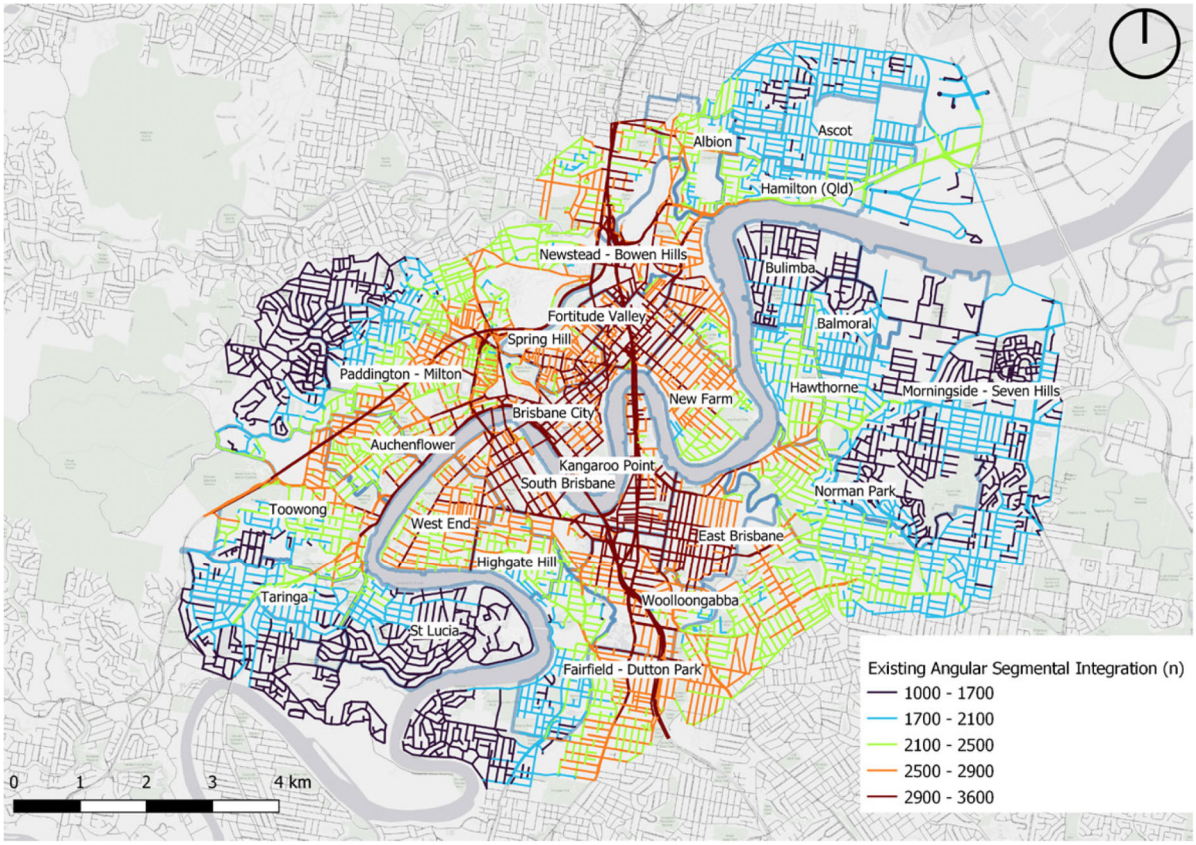

Figure 27. Space Syntax modelling of Inner Brisbane road network (Firat and Ozgun, 2023).

Connectivity refers to how well a street is linked with neighbouring streets. A hierarchy of connectivity can be established from streets with numerous connections (deemed highly connected), whereas those with fewer connections are considered to have low connectivity (Firat and Ozgun, 2023). Figure 27 maps the main arterial routes (Red) in the central area. The Riverside Expressway (Figure 20) is the principal spine, being the Pacific Highway from the Gold Coast is the south, extending across the Brisbane River to the West edge of the CBD and continuing towards Toowong as Coronation Drive. The other significant trunk road runs north from the Woolloongabba across the Story Bridge towards Newstead and beyond.

Adjacent streets to these main roads present as the next highest category of street connectivity, reducing in intensity particularly into the remote neighbourhood areas created by the winding river bends. These more secluded residential ‘pockets’ tend to have higher land values, and therefore higher household incomes, as can be deduced from Figure 28.

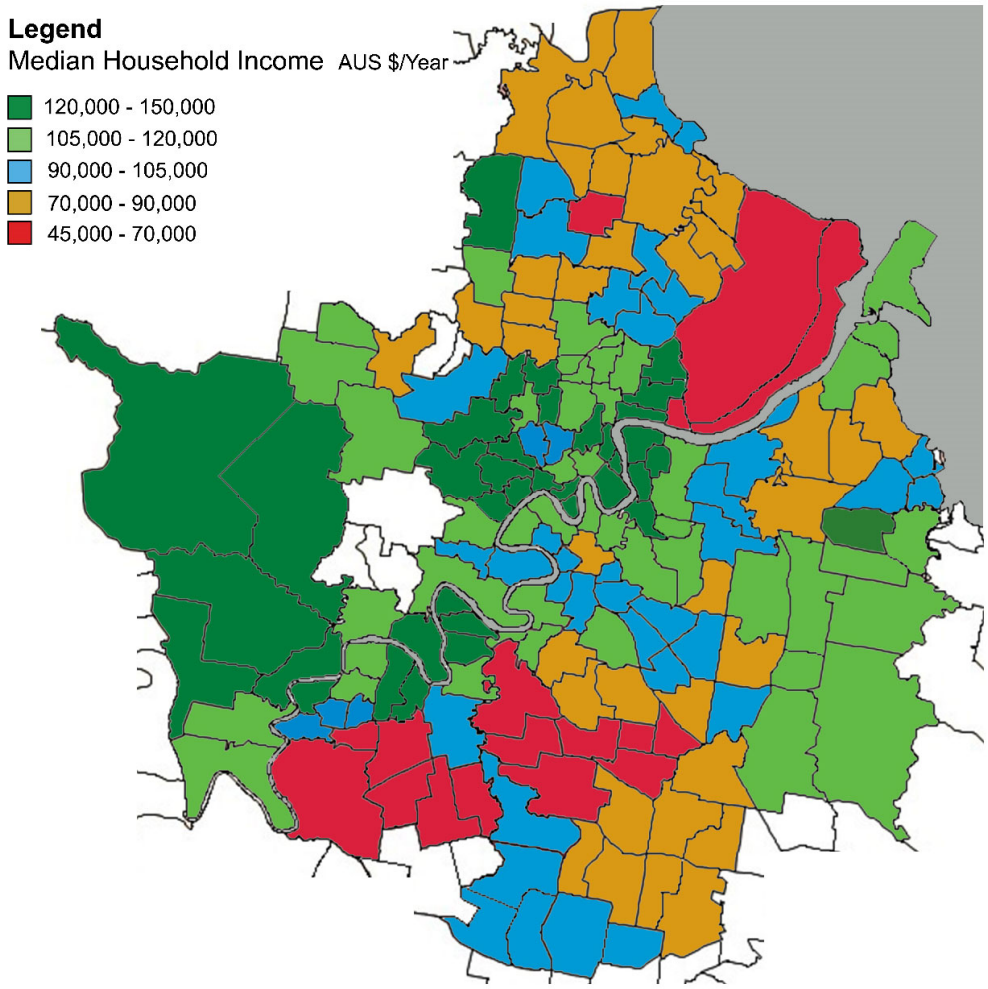

Figure 28. Distribution of residences by household income. Adapted from Willing and Pojani (2017).

The distribution of income groups across suburbs in Brisbane is mapped in Figure 28 ranging from the lowest socio- economic status (Dark Green) to the wealthiest neighbourhoods. In both Brisbane's inner city (85%) and its surrounding metropolitan area (79%), the majority of housing consists of single-family homes. High-rise apartment buildings are primarily located in the city centre, where employment and office buildings are also concentrated. Residential areas tend to be low-density and spread out extensively. Compared to global standards, Brisbane is a safe, clean, and well-kept city, abundant in parks and greenery. Schools are funded at a central level, leading to relatively uniform quality across different suburbs. The city centre benefits from an extensive public transport system, including trains, buses, river ferries, and bike-sharing options. However, while this network reaches most suburbs, service frequency drops notably outside the inner city. Car ownership is prevalent, with more than 80% of households in Brisbane owning a vehicle (Willing and Pojani 2017). Inner-city housing affordability continues to be an issue.

DISCUSSION

Throughout the histories of both cities, there have been notable shifts in cultural perceptions that have significantly influenced their urban development patterns and transportation networks. Initially established as colonial towns, their primary roles were centred around functioning as ports and fortifications, safeguarding the exploitative economic practices of the era. The surrounding waterways

and oceans were perceived not only as crucial conduits for merchant trade and vital sources for fisheries but also as potential security threats from foreign powers.

The 1960s and 1970s marked a period of rapid urban expansion in both cities, characterised by a vision aligned with the "American Dream" of connectivity and individual mobility through widespread car ownership. This phase of development was notably marked by unchanged perceptions of their waterways as obsolete or abandoned ports. Rivers and bays were seen as obstacles to the necessary connectivity required by automobiles, leading to the construction of large freeways, accompanied by land reclamation, bridges, and tunnels to mitigate the physical disruptions caused by these natural features.

In Brisbane, the pursuit of this automobile-centric vision led to the abandonment of its electric tram network and the neglect of train corridors. Simultaneously, the construction of the Riverside Expressway, a massive infrastructure project overshadowing the city's riverbanks, dramatically altered Brisbane's relationship with its river, disconnecting the city from this vital natural element. Similarly, Florianópolis undertook large-scale infrastructure projects, including the construction of freeway bridges and land reclamation efforts that distanced the city from its northern and southern bays. Additionally, Florianópolis introduced active transport corridors along the reclaimed edges of its bay and proposed speculative plans for marina developments along its shoreline.

During this period, both cities also developed a strong attachment to their coastal beaches, which became a focal point of real estate speculation and rising property values, spurring rapid development in these coastal areas. While Brisbane's distance from its beaches was not mitigated by the construction of a bridge to nearby islands, as was the case in Florianópolis, the city instead addressed beach access by continuously expanding its freeway networks. This resulted in the duplication and triplication of routes to both the northern and southern coastal areas, namely the Sunshine Coast and the Gold Coast. In Florianópolis, a similar strategy was employed, with the development of freeways to facilitate beach access by circumnavigating the western side of Santa Catarina Island.

Despite the enduring emphasis on car-centric development in both cities, significant changes in the perception of waterways have emerged since the late 1980s. In Brisbane, the community's relationship with the river was notably reshaped by two key projects. The first was the extensive land acquisition in South Brisbane for the development of the World Expo 88, which prominently featured the river along the event's southern bank opposite the central business district. This area was later transformed into a cultural and tourist precinct known as South Bank, featuring an artificial beach. The second major project was the development of the Riverside Centre on Eagle Street, which, rather than turning away from the river, embraced its waterfront location by creating publicly accessible spaces and ensuring that two-thirds of the tower's tenancies faced the river. These initiatives have continued to drive river-focused urban development in Brisbane, symbolising a broader shift in urban planning that reconnects the city with its waterways.

A principal point of difference is the scale of the cities, while Brisbane is currently at a population of approximately 2.5 million people over an area of 6000km2 and density of 3.46 persons/hectare (World Population Review, 2024). Florianópolis is just over 0.5 million across 674.8 km2 with an urban density of 7.96 persons/hectare (IBGE Cities, 2023). The corresponding and contrasting urban footprints are clearly differentiated in Figure 2. While Brisbane is a relatively low density city, its CBD has a highly

concentrated urban development with a few tower buildings exceeding 80 storeys in height, whereas Florianópolis has a more even density distribution with buildings of lower height. Brisbane developed almost entirely on the mainland centred on the river, while leaving the islands to the sand mining industry, low density tourism, and local indigenous inhabitants. In Florianopolis, the historical urban centre was on its principal island with expansion onto the mainland facilitated by the bridge connections.

CONCLUSION

In both Brisbane and Florianópolis, shifts in cultural perceptions have profoundly shaped their urban development and transport networks. Initially viewed as essential for trade and defence, waterways were later seen as obstacles to car-centric growth during the mid-20th century, resulting in large-scale infrastructure projects that distanced both cities from their rivers and bays. However, since the late 1980s, there has been a renewed appreciation for these natural elements, particularly in Brisbane, where river-focused development projects have reestablished connections between the city and its waterways. This evolving relationship highlights the dynamic interplay between urban planning and cultural values.

This paper has been a broad assessment of parallels between two cities of the sub-tropics on opposite sides of the globe, separated by 201 degrees of longitude. Not only do the cities reside on almost the same degree of latitude at 27.5 degrees south each metropolis finds itself expanding around similar climatic, topographic, oceanic opportunities and constraints. It is hoped that further detailed analytical research will build upon the inertia of this initial study.

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The integration of geotechnologies in landscape analysis and the execution of public administration

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ABSTRACT

Geotechnologies have played a significant role in landscape analysis and the enhancement of public administration, providing an innovative and efficient approach to understanding and planning urban development. The application of geospatial tools enables a more precise analysis of the elements comprising the landscape, from topographical aspects to the distribution of public services. In Sobral, detailed mapping aids in identifying flood-prone areas, contributing to the development of strategies for the prevention and mitigation of natural disasters. Furthermore, geotechnology has been crucial in optimizing urban infrastructure, including the planning of new developments, roads, and green spaces. This results in more effective management of municipal resources, fostering a more sustainable and resilient urban environment. This study aims to demonstrate how the use of these technologies has impacted the municipal administration of Sobral, Ceará, through data collection, interviews, and other methods. It is important to recognize that the potential of these tools extends beyond disaster analysis and prevention, infrastructure optimization, and transparency promotion. Municipal management could further benefit by strategically using these resources to guide public investments. With accurate technical readings and georeferenced data, resource allocation could be more efficient, addressing the specific demands of each region and ensuring a more equitable development.

Keywords: geotechnologies, landscape analysis, public administration

INTRODUCTION

Geoprocessing is a field of geographic science that has gained prominence in recent decades in urban planning and management, as it has emerged as a tool capable of modernizing the process of collecting, processing, manipulating, and analyzing spatial data. Data collection and organization procedures were for a long time carried out in the public sphere through handwritten records organized in physical files. With the advancement of Information and Communication Technologies (ICTs), these procedures began to be conducted through operating systems that allowed for the manipulation, generation, and plotting of data via spreadsheets, graphs, tables, and text documents.

However, despite these advances, limitations still existed regarding the location and spatial analysis of data.

Geoprocessing emerged in the mid-1960s in Canada as part of a government program to create a natural resource inventory. In Brazil, the use of Geoprocessing tools began in the 1980s in Higher Education Institutions (Bolfe, Matias, and Ferreira, 2008). Over the years, Geoprocessing tools gained greater prominence with the popularization of geoinformation through spatial query software and GPS-based location applications, such as Google Earth and Google Maps, SIGWebs, and free GIS software for creating thematic maps and manipulating vector and raster data, such as Quantum GIS.

Despite increased access to Geoprocessing tools and developers' efforts to create more intuitive interfaces to facilitate user handling, there remains a gap in the use of spatial data by public administration. Issues include: low familiarity with Geoprocessing and its contributions to planning and management; lack of resources for investing in technological infrastructure and trained personnel; and more archaic issues such as resistance from some public managers (Lopes and Silva, 2013; Câmara et al., 2005).

Thus, this paper aims to present the contributions of Geoprocessing to urban space planning and management, using the city of Sobral - CE, as an example. This topic is chosen because, despite the contributions of Geoprocessing tools for a more in-depth understanding of the territory and better spatial analysis of the aspects and dynamics that constitute urban space, it is still neglected or even unknown in municipal public administrations. The underutilization or deprivation of Geoprocessing tools in city halls represents a loss for urban space planning and management, as the preparation of diagnostics, decision-making processes, and the development of interventions and public policies require precise and geolocated data about the various aspects constituting territorial dynamics (Campos, 2022; Bitti et al., 2021; Silva and Lopes, 2013).

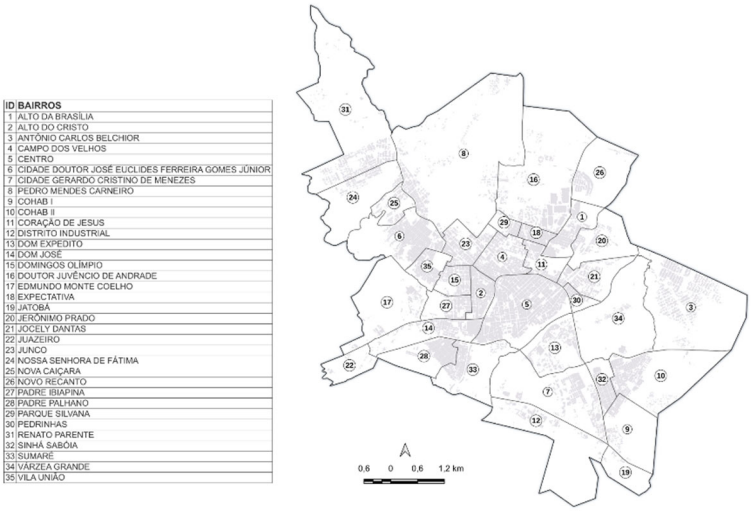
THE CITY OF SOBRAL

The municipality of Sobral - CE has an estimated population of around 212,437 inhabitants (IBGE, 2010) and is located in the northwestern portion of the State of Ceará. It is composed of 17 districts, including the main district. Sobral stands out due to its role as a regional hub for commerce and services, as well as its significant prominence in industrial production compared to neighboring municipalities, a fact that contributed to the creation of the Sobral Metropolitan Region in 2016 (Rodrigues; Teles; Holanda, 2020). The map below illustrates the location of the municipality of Sobral within the State of Ceará, as well as its territorial boundaries and district divisions.



Map 02 - Location, Territorial Boundaries, and District Division of the Municipality of Sobral – CE. Source: IPECE (2019); Created by the author using data from the Municipality of Sobral (2023).

Among the districts that make up the territory of Sobral, we highlight the main district, where the economic activities that give the municipality prominence in the northern region are concentrated and where most of the movement flows converge. The main district currently consists of 35 neighborhoods, as shown in the map below:



ID	BAIRROS
1	ALTO DA BRASÍLIA
2	ALTO DO CRISTO
3	ANTÔNIO CARLOS BELCHIOR
4	CAMPO DOS VELHOS
5	CENTRO
6	CIDADE DOUTOR JOSÉ EUCLIDES FERREIRA GOMES JÚNIOR
7	CIDADE GERARDO CRISTINO DE MENEZES
8	PEDRO MENDES CARNEIRO
9	COHAB I
10	COHAB II
11	CORAÇÃO DE JESUS
12	DISTRITO INDUSTRIAL
13	DOM EXPEDITO
14	DOM JOSÉ
15	DOMINGOS OLÍMPIO
16	DOUTOR JUVÊNCIO DE ANDRADE
17	EDMUNDO MONTE COELHO
18	EXPECTATIVA
19	JATOBÁ
20	JERÔNIMO PRADO
21	JOCELY DANTAS
22	JUAZEIRO
23	JUNCO
24	NOSSA SENHORA DE FÁTIMA
25	NOVA CAIÇARA
26	NOVO RECANTO
27	PADRE IBIAPINA
28	PADRE PALHANO
29	PARQUE SILVANA
30	PEDRINHAS
31	RENATO PARENTE
32	SINHÁ SABÓIA
33	SUMARÉ
34	VÁRZEA GRANDE
35	VILA UNIÃO

Map 03 - Official Neighborhood Division of the Main District of Sobral. Source: Created by the author using data from the Municipality of Sobral (2023).

The urban space of Sobral presents complex issues that impact the city's growth and development, requiring constant monitoring by the public authorities. Among these issues are real estate speculation, particularly in the opening of subdivisions; processes of irregular occupation in high-risk areas; disputes involving environmental issues; crime monitoring and social vulnerability; mobility and accessibility problems, among others.

Given this complexity, the importance of mapping and monitoring socio-spatial aspects is emphasized, as their spatial location allows for a more precise and integrated analysis of urban phenomena, which is essential for the decision-making process in the public sphere (MOURA, 2005). Currently, the mapping and monitoring of these aspects contribute to Sobral's urban planning by generating important information through georeferenced data regarding land use and occupation as well as urban territorial dynamics.

The use of Geoprocessing applied to the planning and management of Sobral's urban space began in 2006 with the National Program for Administrative and Fiscal Management Support for Brazilian Municipalities - PNAFM, which aimed to modernize the administrative and fiscal management of municipalities, including the creation of a Multipurpose Technical Register and the development of a Generic Value Plan.

Within the PNAFM, the Situar Project was created, aiming to promote the development and implementation of a Territorial Information System for the Municipality of Sobral. The project's activities were carried out by the Planning Secretariat - SPLAN. At the time, in addition to the implementation of the Territorial Information System, an aerial photogrammetric survey was also conducted, enabling a deeper understanding of the city's socio-spatial aspects

Later, in 2013, the Secretariat of Urbanism, Historical Heritage, and Environment of Sobral (SEURB) was established. In this context, Geoprocessing became consolidated in Sobral's urban planning, becoming part of SEURB's organizational structure with the creation of the Mapping and Geoprocessing Cell, which was managed by Geographers and Civil Construction Technologists. Currently, the Mapping and Geoprocessing Cell is part of the organizational structure of the Secretariat of Urbanism, Housing, and Environment - SEUMA, where it has been renamed the Geoprocessing and Monitoring Cell. The inclusion of "monitoring" is justified by the fact that, in addition to developing activities using Geoprocessing techniques and technologies (including mapping), it is also considered important to monitor the progress, setbacks, and interactions of different aspects of the city.

Regarding the organizational structure, it is important to highlight that the Geoprocessing and Monitoring Cell is directly connected to the Urban Planning Coordination - COURB. In this department, Geoprocessing operates on two fronts: through the Geoprocessing and Monitoring Cell and through the Urban Cadastre Cell.

Concerning the techniques and technologies used, both the Geoprocessing and Monitoring Cell and the Urban Cadastre Cell use a Geographic Information System (GIS) for their procedures, which allows for the processing and manipulation of spatial data as well as the creation of maps. The system used is part of the open-source software Quantum GIS (QGIS), which has gained popularity in recent years due to its free access and user-friendly interface. Among the various functionalities of QGIS used by these cells, the use of the PostgreSQL Spatial Database Management System and its geographic extension PostGIS stands out, enabling data to be worked on in a shared and real-time GIS environment, optimizing the data update process and preventing the risk of data loss since the information is stored in the cloud.

In addition to QGIS, other sources of geographic data are also used, such as Web Mapping Google Earth and shapefile (.shp) files from official government websites, for example, data provided by the

Brazilian Institute of Geography and Statistics (IBGE) and the Institute of Research and Economic Strategy of Ceará (IPECE).

Regarding specific spatial data for the municipality of Sobral, it is important to mention that in 2017, the municipality was included in the Urban Development Program for Regional Hubs of Ceará - Vales do Jaguaribe and Acaraú, which aimed to strengthen fiscal and tax management in regional hub cities located in the Jaguaribe Valley and Acaraú Valley regions. The program aimed to promote tax re-registration, strengthen the multipurpose technical property register, develop/update the generic value plan, among other objectives. To achieve this, it was necessary to construct a robust set of updated and accurate spatial data from which the proposed actions could be carried out.

In March 2017, a service contract was signed between the Secretariat of Cities and the company Topocart Topografia Engenharia e Aerolevantamento S/S LTDA, through which the city of Sobral was provided with Tax Re-registration (through Aerial Photogrammetry for Digital Planialtimetric Mapping, Multipurpose Technical Real Estate Registration, Furniture and Streets); Updating of Municipal Tax Codes; and Development/Updating of the Generic Value Plan.

The products resulting from the contracted service were crucial in supporting Sobral's urban planning. Among the main ones, we can mention: georeferenced aerial photogrammetry images of the main district and the districts of Aracatiaçu, Taperuaba, and Jaibaras; Digital Terrain Model - DTM; 1-meter contour lines; road polygons (street boundaries), road axis, buildings, lots, blocks, among others.

Finally, through this contract, the Municipality of Sobral also gained access to the WebGIS Topovision, which serves as an online platform where some spatialized data is available for consultation, used by the departments and coordinations that constitute the public administration, especially those dealing with urban land issues, such as land subdivision; land regularization; licensing; urban cadastre; urban planning, among others.

All the cartographic material resulting from the aforementioned contract is currently used as a basis for socio-spatial analyses of the municipality. It is important to note that the Geoprocessing and Monitoring Cell is responsible for updating this data and conducting surveys of socio-spatial data not covered by the aforementioned contract. Currently, efforts are being made to compile spatial data related to the main district centers and rural areas to enhance planning focused on these areas.

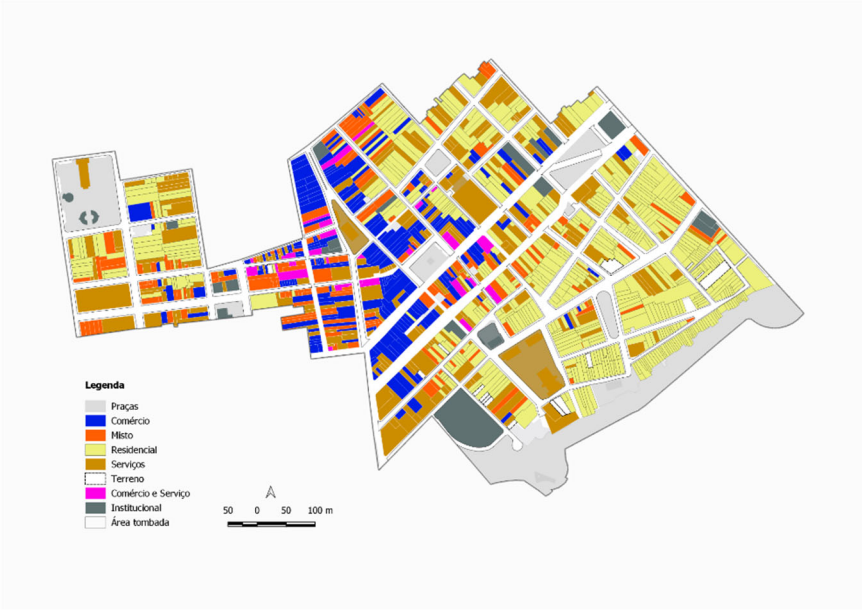
To demonstrate the contributions of Geoprocessing to public planning and management, we will present below some analyses of the urban dynamics and socio-spatial aspects of the city of Sobral, based on cartographic mapping.

GEOPROCESSING AND URBAN SOCIO-SPATIAL DYNAMICS IN SOBRAL

The understanding of the structure and materialities that constitute urban space presupposes an understanding of socio-spatial dynamics, socio-spatial aspects, and the political, economic, and socio-cultural transformations that occur in space over time. The analysis of urban space must consider the historical context, transformative agents, and socio-spatial aspects in the process of urban evolution (Corrêa, 1989); (Souza, 2013); (Santos, 1985). However, it is important to emphasize that an effective socio-spatial analysis requires knowledge of the location and interaction of urban socio-spatial phenomena in space and time (Xavier, 2017).

Among the most important aspects for understanding urban socio-spatial dynamics are land use and occupation. Understanding the city through the spatialization of land use and occupation allows us to identify space-time transformations influenced by the capitalist system that have impacted and continue to impact the redefinition of types of use and the establishment of urban functions (Santos, 1985). Thus, the spatialization of land use and occupation enables the identification of important issues related to socio-spatial dynamics, such as identifying expansion vectors; locating areas with urban voids; densely populated areas; points of conflict and increased movement flows; areas served and underserved by public services, among others.

The process of land use and occupation in Sobral is strongly linked to its historical context, in an urban structuring influenced by economic cycles such as livestock farming, which began in the 18th century, and cotton cultivation, which became established in the 19th century. Besides the economic aspect, land use and occupation were also influenced by social actors connected to the Church and the State in the 19th and 20th centuries, with the implementation of infrastructure and urban interventions that remain to this day as references in the urban space and have transformed the socio-spatial dynamics of Sobral (Rocha, 2017; Aragão, 2014).The following map illustrates the updated classification of land use and occupation typologies in the area listed by the National Institute of Historical and Artistic Heritage - IPHAN, located in the city center:



Map 04 - Land Use and Occupation Typology in the Listed Area of the Centro Neighborhood. Source: Created by the author using data from the Municipality of Sobral (2023).

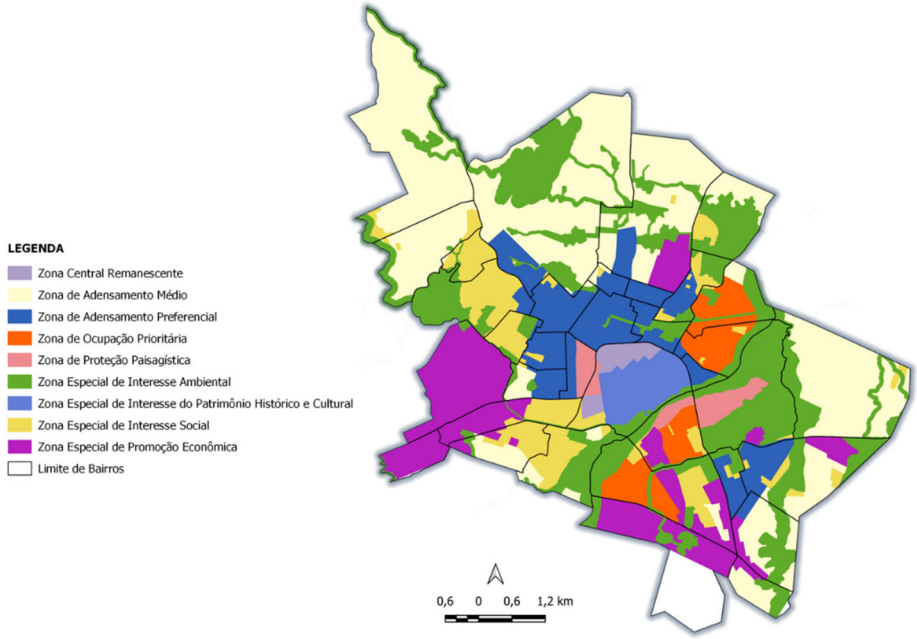
The reading of the above map allows us to visualize some manifestations of urban dynamics over time. In summary, the blue-colored lots represent part of the consolidated commercial area. The commercial concentration results in a higher flow of movement in this area, leading to mobility and accessibility issues, as well as strong real estate speculation due to the higher cost per square meter in the generic value plan. A significant point to note on the map is the concentration of residential lots to the east, northeast, and northwest, reflecting the establishment of residential buildings and urban facilities in the 19th century (Aragão, 2014).

Another important issue shown on the map is the more balanced distribution of service lots, which is present not only in the listed area but throughout the Centro neighborhood. This more harmonious distribution reveals a trend towards the consolidation of new centralities. Identifying urban voids in land use and occupation spatialization is also of great value to public administration, as it serves as a warning for inspection needs in these areas to ensure compliance with urban legislation and the social function of property.

Further addressing the contributions of Geoprocessing to urban planning and management and considering the importance of mapping and monitoring land use and occupation, we also highlight the significance of urban zoning spatialization as a means of ensuring territorial organization and guiding land use and occupation. Zoning is an urban planning and management tool through which the city is divided into areas subject to different guidelines for land use and occupation (Souza, 2002).

In a GIS environment, it is possible to delineate the areas that make up the urban zoning by assigning information to them. The spatialization of zones allows for the identification of: areas to receive large-scale developments; neighborhoods that may or may not experience vertical expansion; neighborhoods where density needs to be more restricted; locations where occupation should be prioritized; sections where the priority is to protect the landscape and environmental resources; and areas where the priority is to meet social housing demands

In addition to defining zoning areas and overlaying them with other layers, it is also possible to categorize zones according to their specific characteristics and assign colors or styles to make them visually more identifiable. In the map below, you can see the urban zoning of the main district of Sobral, categorized by colors:



Map 05 - Urban Zoning of Sobral – CE. Source: Created by the author using data from the Municipality of Sobral (2023).

In urban planning responsibilities, it is important to emphasize that beyond issues related to land use and occupation, attention must also be given to the importance of the circulation of people and goods

for the production and reproduction of urban space (Gottdiener, 1993); (Villaça, 1998); (Santos, 2004). Mobility and accessibility are socio-spatial aspects that require special attention from public authorities since the entire socio-spatial dynamic depends on a fluid urban network as well as on infrastructure for mobility and accessibility that can meet the demands of the population and different sectors of the economy.

Mapping and monitoring socio-spatial aspects related to mobility and accessibility allow for the identification and tracking of obstacles that may compromise socio-spatial fluidity, such as: identifying areas underserved by transportation services; points of convergence or intense flow; conflict points; slow traffic; demands for accessibility, among others. Additionally, it is also important to highlight that the pursuit of sustainability through encouraging the use of public transportation or walking also depends on a more detailed understanding of the territory, which allows for the assessment of the feasibility of proposed interventions in infrastructure for mobility and accessibility.

The following map illustrates part of the infrastructure for mobility and accessibility in the city of Sobral through the spatialization of bus routes; bus stops; bike lanes; green corridor lanes; and the civic axis, which aims to encourage walking over the use of motorized transportation in this part of the city center.



Map 06 - Infrastructure for Mobility and Accessibility in the Centro Neighborhood. Source: Created by the author using data from the Municipality of Sobral (2023).

Regarding the implementation of green corridors along stretches of the road network, it is important to highlight that in recent years, the public administration of Sobral has sought to strengthen local sustainability through sectoral plans such as the Arborization Plan and the Urban Mobility Plan, as well as by ensuring the protection and preservation of natural resources through the establishment of the Special Environmental Interest Zone (ZEIA) and the designation of Permanent Preservation Areas (APPs).

Ensuring the protection and conservation of natural resources in urban areas is currently a true challenge for municipal public managers, given the various interests of social actors who have the

power to make decisions that can directly or indirectly affect environmental quality in cities (Quintas, 2006).

It is in the face of the complex web involving the production of space and different land uses (SANTOS, 2004), as well as the social relations established within it, that environmental issues become a focal point, necessitating measures to ensure preservation or conservation. The delimitation and mapping of green areas and preservation areas contribute to this task.

The urban planning sector in the city of Sobral has in its geographic database the mapping of these areas, which is frequently used for consultations in land subdivision processes and licensing, as well as for the inspection of construction works. In urban zoning, green areas and environmental preservation areas constitute the so-called Special Environmental Interest Zone (ZEIA), which can be seen in the following map:



Map 07 - Delimitation of the Special Environmental Interest Zone and Location of Squares, Parks, and Green Areas. Source: Created by the author using data from the Municipality of Sobral (2023).

Regarding areas within the urban perimeter, it is important to emphasize that the city of Sobral has grown amidst water resources that connect throughout the territory, extending from the more densely populated areas to areas with less intense occupation but currently facing strong real estate speculation, mainly through the opening of new subdivisions.

In this way, mapping the ZEIA allows for the visualization of sections where the likelihood of environmental impacts or damage would be greater, providing a basis for the actions of the urban inspection sector, and also indicating areas where the environment is more susceptible to human interference.

CONCLUSIONS

In recent years, geoprocessing tools have transcended the academic realm, gaining prominence among society and public authorities due to technological advancements that popularized the use of

spatial data (Bolfe; Matias; Ferreira, 2008). However, despite the progress in information technologies; the development of intuitive geoprocessing software and SIGWEBs; access to internet networks and georeferenced data from reliable sources; and the variety of contributions geoprocessing offers, it is still a fact that many public administrations plan and manage cities without the support of mapping and monitoring territorial data. Thus, this article aimed to analyze and demonstrate the contributions of geoprocessing to urban planning and management using the city of Sobral - CE as a case study.

The research methodology involved an initial bibliographic survey on the contributions of geoprocessing to public planning and management to demonstrate its benefits and the challenges faced by municipalities regarding its adoption. Additionally, analyses of the city of Sobral were conducted based on thematic maps to understand how the use of Geographic Information Systems (GIS) and Remote Sensing can enhance the knowledge of elements that make up the urban space and the understanding of socio-spatial dynamics. Finally, the role of geoprocessing in the Municipality of Sobral was discussed as support to the Urban Planning Coordination, through the Geoprocessing and Monitoring Cell and the Urban Cadastre Cell.

Data collection instruments for the research included: testimonies from professionals responsible for the Geoprocessing and Monitoring Cell and the Urban Cadastre Cell; information gathered from the Municipality of Sobral; and consultations of municipal data available in the PostGIS database and SIGWeb Topovision. For the preparation of city maps, the Quantum GIS (QGIS) software version 3.22.10 Biatowiesa and shapefile (.shp) files provided by the Municipality of Sobral were used.

Regarding the structure of this article, we began with an introduction to the research, followed by Section 02, which provided a brief analysis of urban planning and management in its historical process and its relevance to the consolidation of cities. Then, in Section 03, we addressed geoprocessing and its evolution with technological modernization. In item 3.1, we analyzed in-depth the applications and contributions of geoprocessing in public management, followed by item 3.2, where we examined the role of geoprocessing tools in the planning and management of the city of Sobral - CE.

Thus, throughout this study, we sought to present the contributions of geoprocessing to urban planning and management, using the city of Sobral - CE as a positive example. The choice of this topic is justified by the fact that, despite significantly contributing to a deeper understanding of the territory and a better spatial analysis of the aspects and dynamics that constitute urban space, geoprocessing is still underutilized or even unknown in municipal public administrations (Campos, 2022; Bitti et al., 2021). This fact raised concerns as we recognized the relevance of geoprocessing as a supportive tool for planning and managing the city of Sobral, particularly in supporting the development of Public Policies, Sectoral Plans, Master Plans, and decision-making processes.

It is hoped that the reflections presented here will lead to a better understanding by municipal public administrations, the academic community, and civil society of the contributions of geoprocessing to urban planning and management.

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The investigation of gradient inversions in the use of public spaces in the Santa Marta (Rio de Janeiro) and Paraisópolis (São Paulo) favelas, based on an urban morphology methodology

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ABSTRACT

Favelas are established informal settlements in South American metropolises, and although they are an integral part of the city, they are extensively studied due to their formation processes and urban morphological aspects. The forms, uses, and functions of these informal areas are a consequence of land use and various modes of utilization, making them complex, fluid, and dynamic, defined by the residents' practices. These spaces exhibit different gradients of privacy, ranging from open areas (such as pathways, stairs, ramps, or crossings), semi-open areas (such as galleries, balconies, private stairs, and terraces), to enclosed areas, which infiltrate private and semi-private contexts, disrupting the traditional hierarchy. To understand these spaces, the research juxtaposes the studies of the Italian School of Urban Morphology by Muratori, Caniggia and Canella. The goal is to reconstruct and narrate the aspects and complexity of human relationships with the urban form in the slums of Santa Marta (Rio de Janeiro) and Paraisópolis (São Paulo), and to demonstrate that the informal city is perfectly coherent with the sociocultural dynamics of the favelas. The research involves a comparative analysis of the two public spaces within each favela, examining dimensions, morphology, color, modes of space appropriation, and particularly, the process of local rooting. The various narratives have contributed significantly to the understanding of informal public spaces.

Keywords: Morphology, Territory, Urban, Informal, Space.

INTRODUCTION

The topic of precarious settlements as spatial, economic, and socio-cultural systems has become a focal point of critical attention in contemporary studies of cities and metropolises over recent decades. Informal settlements have long been regarded and treated as fragile phenomena destined to evolve, more or less forcibly, into formal configurations. After the era of "tabula rasa" practices, which persisted until the 1970s and aimed at destroying settlements under the economic pressures of planned cities, contemporary reality shows—contrary to this vision a shift in the dynamics of urban development, marked by the emergence of informal entrenchment processes. These unstable and precarious settlements, even after partial and forced removals or reductions, calcify in space, solidifying and embedding themselves into the collective imagination, leading to an unprecedented physical and cultural transformation of cities. This paradigm shift gives rise to widespread phenomena

of non-replacement: the population of informal settlements—constantly and steadily growing—becomes consolidated. The process of entrenchment manifests through a growing sense of social belonging among the inhabitants and, above all, through the physical embodiment of this city, which transforms, adopting logics of stabilization and reorganization.

This theme has been the subject of a broad field of research, encompassing various disciplines, including the social sciences, which have sought to examine the development and transformation of informal settlements, the community practices that emerge within them, and the dynamics of identity and cultural rooting. However, few studies focus on the urban and spatial forms produced in these spaces, considering morphological analysis as a strategic tool to interrogate, understand, and interpret the phenomenon. Informality cannot be reduced to a mere illegal urban practice, a planning issue, or an economic model; it is primarily a mindset, a strategy. If a planned city is, by definition, ordered by a specific set of norms designed to regulate social life and anticipate its development, informality is a leveling system that introduces chaos into order, an adaptive attitude that embraces the lack of a comprehensive strategy and accepts surprise and chance as inevitable elements of life. To fully understand their structural logic, a general comparative observation is insufficient; it is essential to comprehend the local specificities of each territory.

In order to obtain a precise and accurate reading of informal morphological structures, the research focuses on a specific typology of informal settlement with its own distinct characteristics: the favela. The favela is an urban phenomenon that integrates into the territory as part of the city's morphology, shaping its design without adhering to urban planning principles: street layouts are not pre-determined, and infrastructure systems are implemented after spatial occupation, defined by the availability of space. Furthermore, it is a territory that does not follow the guidelines and norms dictated by land use and zoning laws: land appropriation, typically public, occurs without the owner's consent.

The research systematically and rigorously analyzes the morphological structure of the urban fabric of Santa Marta favela in Rio de Janeiro and Paraisópolis in São Paulo. Through close and detailed observation, it explores the mechanisms by which these inherently ephemeral urban bodies develop self-regulation codes that allow them to become stable phenomena over time and space.

The case studies were carefully chosen to maximize spatial diversification and cover the widest possible spectrum of the phenomenon. There are several reasons for this operational strategy: first, the case studies allow for an "inside" analysis of the favela, establishing a direct relationship with residents. This context-dependent approach enables the intersection of practical and theoretical knowledge, subjective and objective viewpoints on the same level. Second, the methodology allows for the development of specific expertise on the subject, a strategic condition for understanding the urban and social dynamics of informal settlements. Third, the case studies can be employed in all stages of the research for different purposes, whether exploratory, descriptive, or explanatory. Face-to-face interviews were a crucial and incisive investigative tool, bringing the voices of informal actors to the forefront of the analyzed themes.

The analyzed case studies consist of a system that emerges from spatial limitations and, over time, triggers processes of intense functional interaction with public space to compensate for the limitations of internal spaces. In this sense, the research aims to understand the various processes and dynamics,

meticulously investigating them and using complementary methodologies to analyze the formation processes of two significant favelas in Brazil: Santa Marta in Rio de Janeiro and Paraisópolis in São Paulo.

Through the construction of a “morphological atlas,” the work documents the phenomenon of actions, forms, and urban spaces analyzed from within the urban body. In this regard, it draws on strategies for reading the urban fabric derived from morphological analysis of the city, with particular reference to authors from the "Italian School," such as Saverio Muratori (1959, 1960, 1963), Guido Canella (1960), and Gianfranco Caniggia (1971, 1977), used by Alessandro Tessari (2020, 2024) in Informal Rooting: An Open Atlas and Paraisopolis: Um Atlas Morfologico.

The research is conducted in two phases: at the territorial scale, where the growth and transformation processes of the two favelas in relation to the metropolis are observed, and at the local scale, where the micro-spatial transformations and the syntax of the urban fabric’s evolution are identified and understood, with particular focus on public spaces.

ANALYSIS OF INFORMAL PUBLIC SPACE

To understand informal urban spaces, their capacity for regeneration, and their consolidation in the face of various challenges, this research investigates the morphological process of forming public spaces. The transformation of informal space occurs through various modes, forms, and processes. Although a comprehensive observation of the territory may not represent a complete picture of reality, it is useful for defining some recurring patterns and behaviors. The capacity of a space to aggregate in constant dynamism reflects a network of social relations created by individuals, which Lefebvre considers essential for maintaining, stimulating, and experiencing the space. In this sense, Harvey argues that enjoyment has a dialectical relationship with the capacity for space production, as open, public spaces are generated by the individual's ability to use them. They are the form and response of the process, rather than its product, incorporating social, economic, ideological, and technological aspects into the physical construction process. That is, the physicality is intertwined with the relationships that the previous authors include in the process. Since, as previously mentioned, the process is dynamic, there is a constant reconstruction, reinvention, and interpretation of daily needs.

The authors, therefore, share and reaffirm the changing nature of favela space, recognizing the complexity of the informal phenomenon through its capacity for aggregation, enjoyment, constructive process, space-time, and form. These aspects are unlikely to be perceived unless observed with a rigorous method, which, though not necessarily complex, must be capable of interpreting and redesigning these relationships. Public space within the informal city is a direct consequence of the daily movements and relationships constructed by its residents. It results from a gradual construction that is difficult to perceive from beginning to end, not composed of a single idea, and cannot be strictly defined as a classified element. Its dynamism and variation often blur the boundaries between the public and private sectors, particularly at the scale of the home, where the family living space extends to the enjoyment of other residents due to its position within the hierarchies built into the favela’s fabric. For example, a narrow street may serve as a passageway but also as a space for enjoyment among nearby residents; a veranda may become a public element and a collective meeting place; intimate space may become a social area. The same can be said of rooftops, which on weekends may

accommodate as many people as a planned public square. Therefore, its dynamism should be studied with equal rigor. Mehrotra asserts that the kinetic city is incomprehensible if viewed as a two-dimensional entity; it must be perceived as a city in motion, in a constant state of reinvention and self-transformation (Tessari, 2020).

A deeper investigation reveals that this is not the logic of informal spaces primarily because they present constant shifts in organization, and secondly, because they exhibit overlapping relationships with varying degrees of intimacy, never entirely public or private. Faced with this complexity, the study of public spaces combines elements of territorial morphological analysis, including those related to historical development processes, topography, vegetation, land subdivision, building density, facade relationships, development direction, and interventions, with the urban analysis framework introduced by Lynch, which considers paths, access, nodes, and boundaries, to understand the composition of public spaces. By combining these elements at the block scale with selected public spaces, various relationships and outcomes were revealed, providing substantial insight into the nature of public spaces.

The informal settlements studied demonstrate several recurring dynamics from their inception, allowing for a necessary final summary to generalize the specific conclusions drawn. In almost all cases, their origin traces back to rapid and unexpected occupation; the chosen location for invasion is always residual territory, whether a natural area with rugged topography, land subject to hydrogeological risks, or an abandoned and unused part of the formal city situated among formal infrastructure networks.

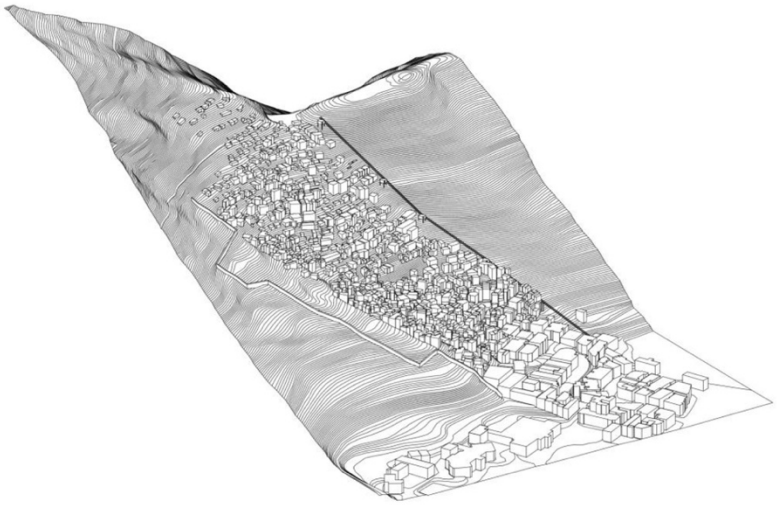

Figure 1. Volumetric axonometry Community of Santa Marta. Rio de Janeiro.



Figure 2. Volumetric axonometry Community of Paraisopolis. São Paulo.

ANALYSIS OF INFORMAL PUBLIC SPACE

METHOD

METHOD 1 – SANTA MARTA (RIO DE JANEIRO)

The choice of Santa Marta as a study area is based on several theoretical and practical reasons. Firstly, it represents a typical informal community in Rio de Janeiro. As one of the oldest favelas in the city's center, it has been the site of struggles to defend the right to exist. Clinging to the steepest and most rugged of the many 'morros' that shape the Rio landscape, Santa Marta holds iconic status in the collective imagination. Its geographical location and stark contrast with nearby formal neighborhoods are recurring elements in many of Rio's favelas. Santa Marta gained fame far beyond national borders due to media events that brought it into the global spotlight, making it a symbol of Rio's popular culture and, more broadly, Brazilian culture. Studying this favela, therefore, means investigating the 'universal' characteristics of this type of settlement.

The accessibility and safety of Santa Marta were decisive factors in ensuring continuity and consistency in the analysis. Located in the southern zone of the metropolis—the richest and most developed area—it is well-connected to public transportation, making it easily accessible at all hours of the day and throughout the year.

The analysis of Santa Marta takes place on two levels: an urban-territorial scale reading and an examination of the urban space generated within it.

The first analysis studies the recurring dynamics that help understand the origin and formation of the favela, starting from the most complex aspects of the context, such as the organization and structure

of the internal circulation system, the expansion and occupation of the territory, the creation of new geographies, and the favela's ability to absorb changes in its surroundings and flexibly respond to environmental traumas. This organizational syntax does not refer to repeated material models in space, following a predetermined scheme, but rather to "spatial action models"—processes that generate spaces, rather than fixed forms. These models involve the documentation of residents' daily practices, such as the construction, use, and transformation of the urban fabric, which then leads to the creation of material forms.

Closer observation allows for the analysis of a specific public space within the favela, where the majority of community actions and interactions are concentrated.

The public space analyzed is located in the southern part of Santa Marta, along a staircase that accommodates the steep slope of the area and facilitates the passage of many residents in and out of the favela. The strategic location of this space, connected to the Rua Francisco de Moura road, near the starting station of the inclined plane and the city's main public transportation routes, makes it the official gateway to the community—a place not only for transit but also for socialization and gathering. The key element that transforms this mobility infrastructure into a collective and economic hub is its role as a transitional space: the boundary between the formal and informal city. The proximity of the two urban fabrics triggers processes of mutual influence, which impact the quality of construction and public space, creating an openness unusually extended toward the formal neighborhood of Botafogo.



Figure 3. Photography of the public space. Santa Marta, Rio de Janeiro

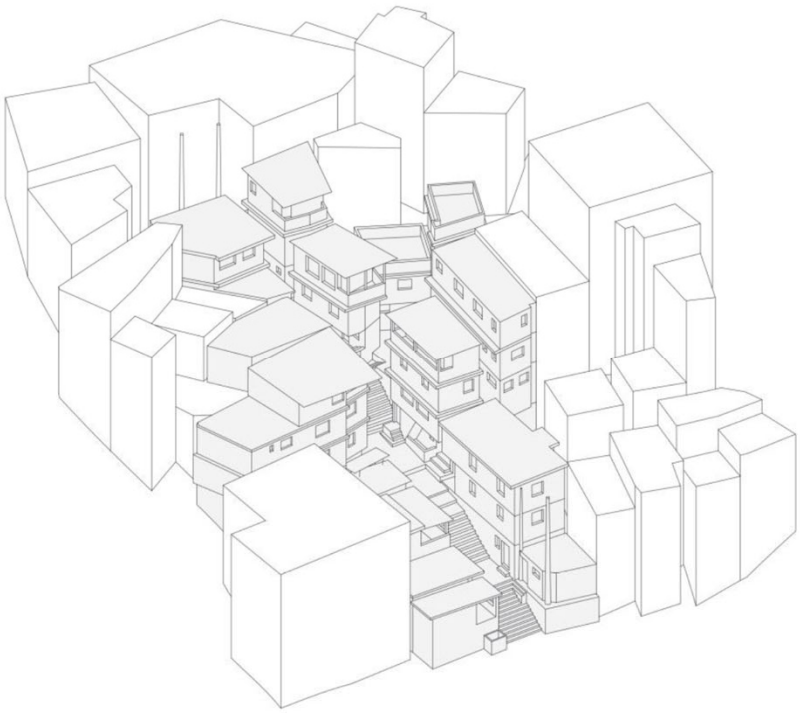

Figure 4. Volumetric of the public space. Santa Marta, Rio de Janeiro.

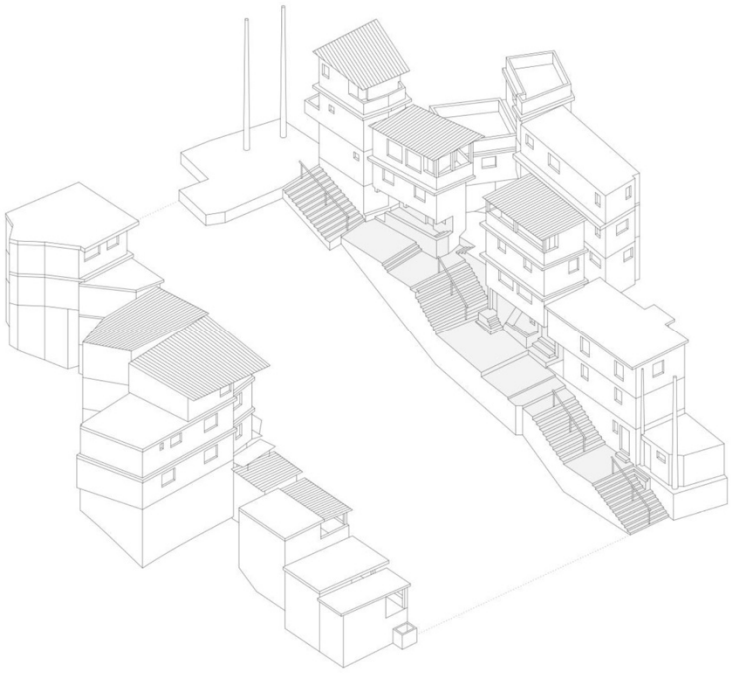

Figure 5. Volumetric section of the public space. Santa Marta, Rio de Janeiro.

Spatial Morphology. The infrastructure on which Public Space 1 is situated is a large staircase, constructed as part of the Favela Bairro project to replace and consolidate the pre-existing inclined dirt path that once served as access to the community. The staircase comprises four flights of steps,

interspersed with wide platforms, covering a total elevation of approximately eighteen meters. This structure provides access to the central-southern sector, the most populous and densely built area of Santa Marta. The construction of this staircase initiated two significant urban transformation processes: the densification of the surrounding residential buildings, which saw property values quickly rise to levels approaching those of formal neighborhoods, and the internal transformation of housing systems, particularly the ground floors, which were converted into public spaces or artisanal workshops. These small commercial activities, numbering around ten along the entire staircase, contributed to the creation of a flourishing local micro-economy, establishing Public Space 1 as a social catalyst within the community.

Urban Elements and Colors. The primary urban materials that shape the public space include the concrete staircase, featuring a central metal handrail, and a series of semi-private platforms in front of commercial establishments, distributed along the double frontage of the buildings. The staircase serves as the dominant urban element, guiding, through its sequence of ramps and landings, the points of higher and lower activity within the system. While dependent on the staircase, the platforms play an equally strategic role by helping to transform a mobility infrastructure into a distinctive urban space with its own identity. These micro-spatial areas are often equipped with canopies for protection from the sun and rain and furnished with fixed seating made of concrete or wood. The vibrant colors of the space aim to create a domestic and familiar atmosphere for customers. Together, the staircase and platforms—anchored into the steep topography—form a cohesive spatial entity with significant urban presence, further reinforced and amplified by the colorful buildings that surround them.

Social Appropriation. The flow of passersby using the staircase to enter and exit the community generates a dynamic and chaotic scene, animating the public space, particularly on weekdays when the favela is more reliant on the formal city. This social energy has led to another mode of appropriation by residents, who use the staircase as a popular place for resting, meeting, and socializing. The transformation of infrastructure into public space is a common phenomenon in favelas, where the drive for private occupation of free areas often halts in the face of the essential need for internal movement. The intense flow of people up and down the staircase blends with those who use it as an open-air amphitheater, a natural extension of the private environment. Public Space 1, extending towards the Botafogo neighborhood, presents an atypical dimension of theatricality for the favela, where community spaces are generally fragmented and shielded from the outside.

Rooting. The staircase infrastructure, established as a strategic axis of mobility, plays a pivotal role in stabilizing the urban fabric of the southern sector, shaping its spatial hierarchies and social dynamics. This rooting process results in the appropriation of the infrastructure by residents, transforming it into a collective platform. Several factors contributed to this transformation. First, the preservation of the staircase's open space, which has resisted occupation despite building pressures from the southern sector of Santa Marta. Second, the transformation of housing systems, which have adapted to the new public platform by developing micro-spatial solutions that enhance its collective usability and expand its public dimension. Finally, the staircase has been redefined as a multi-level plaza, functioning not just as a transit space but as a place where the complex web of social relationships—crucial to the construction of identity and a sense of belonging in the informal city—are woven together.

METHOD 2 – PARAISÓPOLIS (SÃO PAULO)

The research initially aimed to analyze various blocks within Paraisópolis and, from this analysis, develop a comparative framework of the different urban fabrics found in each block. The method involved field research, conversations with residents, photographs, graphic surveys, on-site drawings, and other necessary studies. Paraisópolis comprises a total of 33 blocks, each with configurations that vary based on several morphological factors, shaped by their position within the territory and the relationships built between different influencing elements. The most notable diversifications occur where there are significant elevation changes, requiring the adaptation of the built environment to the natural terrain, with linear lots gradually adjusted to accommodate orographic conditions. This has led to a substantial population increase, reflected today in the dense construction of buildings without setbacks or clear urban limits. To conduct a more detailed analysis of public spaces, the research focused on six main blocks.

For each of these blocks, a thorough field analysis was conducted, supported by existing cartography, historical photographic archives, maps, and bibliographies that introduced and detailed certain historical and structural aspects of the area. The most critical part of the research was done on-site, with visits and the simultaneous development of a critical perspective necessary for understanding the morphological transformations at the block level. This process resulted in analytical diagrams of the selected spaces, followed by data elaboration for presentation. The analysis was carried out across three levels of observation:

This first level involved a broad examination, starting with the historical development of the area to understand polarizations, development trends, and the phases of growth, densification, and verticalization across the different built sectors within the pre-selected blocks. Additional observations focused on topography, hydrography, vegetation, original land subdivisions, and boundaries.

The second level of analysis focused on interpreting the built environment, shaped by how the factors observed in the first level have been adapted. This included assessing each building's height, its orientation and development, facades, and the relationships between the buildings and their immediate context. Also observed were the conditions of each building in terms of upkeep and deterioration, their functions, and any public interventions either within or surrounding the block.

The third level zoomed in on the details, examining the dimensions of built and unbuilt spaces within or along the edges of the blocks, access points, pathways, nodes, and the ground layout, which is defined by the distribution of pedestrian and vehicle routes within the blocks. Lastly, the analysis considered the public spaces within the blocks, their location and distribution, and how residents interacted with these areas.

As mentioned, these analyses are presented in greater detail in this study. However, it is important to note that the goal of this methodology is to create an intersection of overlapping factors that shape the blocks. It is not solely a thematic observation of structure and functionality, but rather an understanding of the transformations generated by the interaction of the three levels of analysis in each context. This approach aims to produce data about the various territories of the favela, which is often limited in other studies to socio-economic data and generally lacks spatial analysis. It's worth

noting that not all observations were made on-site; in some cases, pre-existing maps were used in combination with collected data and the author's own knowledge.

The public space analyzed is located in Block 66, at the edge of the Grotão sector, and is connected to one of the residential complexes built by the state of São Paulo 15 years ago for the social relocation of residents from high-risk areas. The "Campo de Futebol Palmeirinha" (Palmeirinha Football Field), situated within this urban fabric, is the largest and only sports complex in the entire favela. More than just an open space in the urban agglomeration, it serves as a significant social hub. It is a key symbol of the favela’s struggle and resilience, having remained intact and preserved from the beginning of the occupation of the entire complex. The field has never been overtaken by activities other than football and the most important community events in the favela’s history.



Figure 6. Photography of the public space. Paraisopolis, São Paulo.

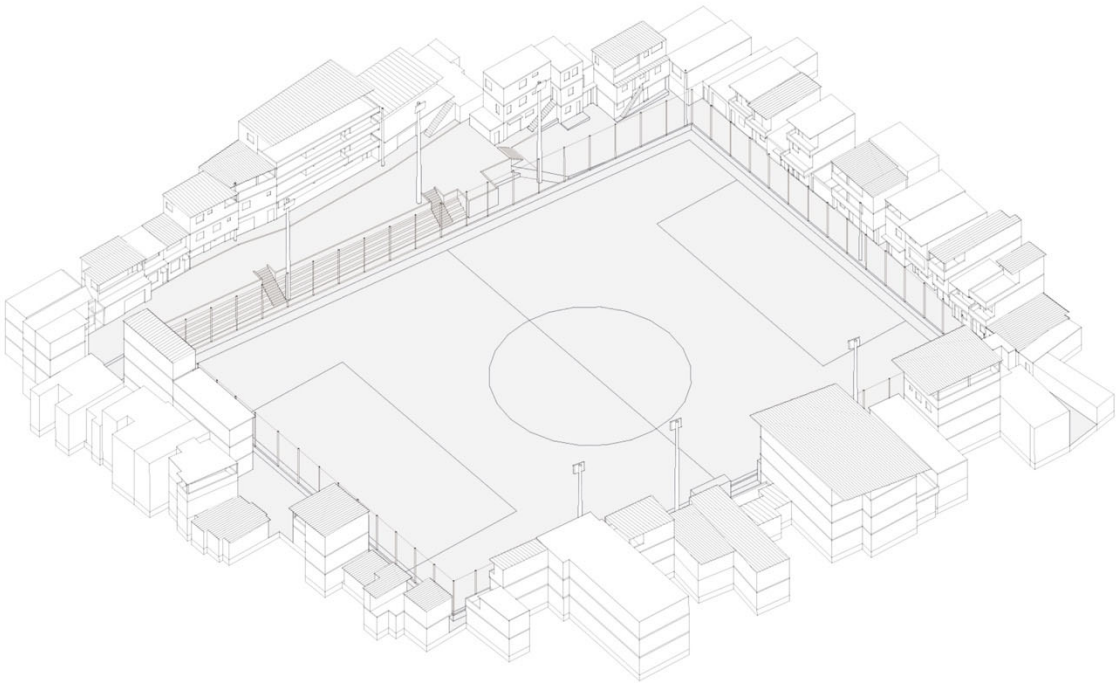

Figure 7. Volumetric axonometry of the public space. Paraisopolis, São Paulo.

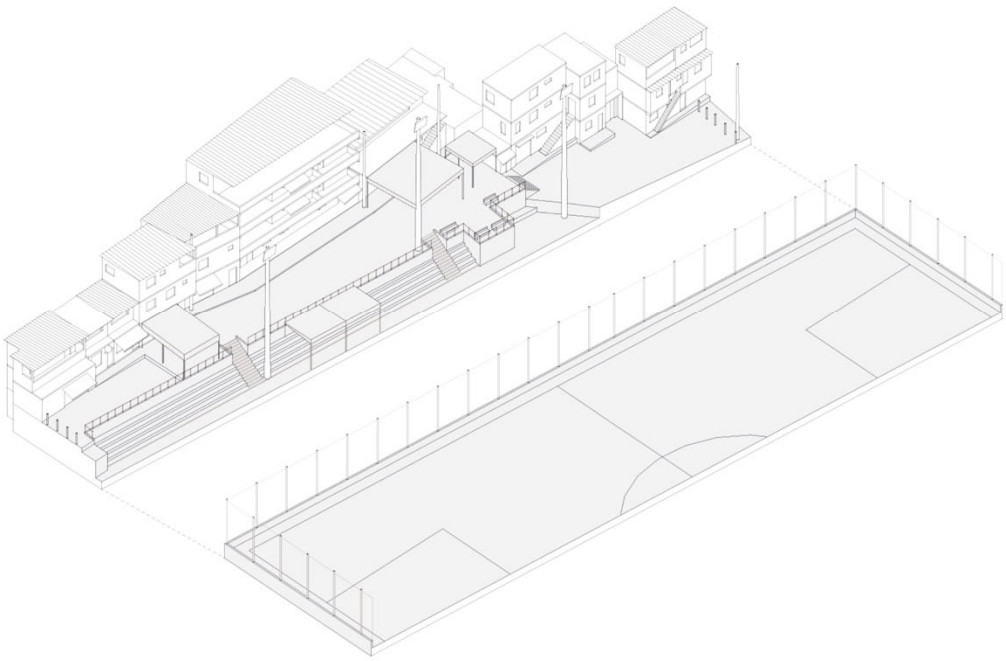

Figure 8. Volumetric section axonometry of the public space. Paraisopolis, São Paulo.

Spatial Morphology

The spatial configuration of Space 66_01 presents a variety of solutions that arise from the relationship between the football field and the surrounding built environment. To the east, access to the center of the block is provided by a pedestrian and motorcycle alley, nearly linear, about 2 meters wide, and paved with concrete. This path is often obstructed by parked motorcycles and trash. The southern sector, in contrast, has a completely different character. At a higher elevation, accessed via platforms and ramps, this area features broad unoccupied spaces, which have been adapted for various uses such as restaurants, bars, and a community center connected to sports activities. Additionally, the stands offer spectators a complete view of the field.

Urban Elements and Colors. The football field is the central urban element defining this space. It is grass-covered, surrounded by fences, and equipped with lighting for nighttime use, as well as spectator stands. Like many informal settings, the field serves multiple purposes beyond its primary function. The platforms, originally built to navigate elevation differences, are repurposed during events, functioning as stages, play areas, and, with the help of tents and tarps, educational and theatrical spaces. The platforms take on the role of an inclined square, becoming a significant space for social and community interaction. Another key element in shaping the social space is the presence of trees and plants that provide shade, which are also used to support tents and stalls during events. A final important urban feature is the micro-transformation of ground-floor facades in the southern sector and along the western route. Temporary additions such as benches and nylon coverings create informal seating and shaded areas, allowing for external tables and providing spaces for spectators during events. Colors play a crucial role in characterizing the space. Buildings surrounding the football field, particularly the taller ones, often adopt vibrant colors that make them highly visible, especially through the open fencing. The colors frequently reflect the teams participating in tournaments, and

the buildings also serve as platforms for communication and advertising banners, further enhancing the identity of the space.

Social Appropriation. Two main forms of social appropriation occur in this space. The first happens in the western sector, where commercial activity thrives along a busy corridor, with vendors, restaurants, and bar tables creating a dynamic environment. The second form of appropriation takes place in the southern sector, where the higher elevation limits pedestrian access, offering a more secluded area for social gatherings. This space hosts community events, parties, meetings among favela groups, and cheering moments during football matches, making it one of the most vital daytime gathering spots in the favela. This vibrancy has been captured in numerous reports, photographs, and videos shared online.

Rooting. Rooting provides a fascinating lens through which to observe the impact of this public space. The football field, a public infrastructure project, has been carefully maintained by the local community and represents a pivotal moment for the favela. Its construction was initially seen as a disruption, but the community has responded with several strategies, most notably the verticalization and formalization of the facades of buildings facing the field. Another strategy is visible at ground level, where every available space between the block and surrounding buildings has been transformed for public use. These areas include the lower sections of platforms near the fences, pathways, and informal meeting points, all of which revolve around the football field as a central gathering space.

CONCLUSIONS

Contrary to the widespread belief that favelas lack public spaces, the conducted analysis demonstrates not only their existence but also their essential structural role in defining the hierarchies and urban morphology of Santa Marta and Paraisópolis. In both favelas, public spaces play a fundamental role in psychological, social, and physical dynamics. These spaces are where a complex network of values and images is constructed, forming the community's identity. They represent an element of balance, providing a territory of resistance between the pressures of informal construction and the need for interaction and sharing. Within the hierarchy of "continuous informal space," public areas serve as support structures that unite the various levels of usage within the favela, adapting to transformations.

The study of public spaces proves to be complex, given their independence from formal structures. In formal public spaces, there exists a clear correspondence between urban form and social use; conversely, in informal contexts, this connection becomes tenuous, complicating interpretation. Fragmented and unfinished areas can transform into socially significant places, while formalized spaces, endowed with attractiveness, may be invaded by new constructions or turned into open dumps. This contradiction between spatial availability and the generation of public spaces is intricate, and the analyzed cases attempt to navigate it, offering interpretations linked to their geographical and urban contexts.

Morphological analysis has revealed the processes through which these spaces have developed and their rapid evolution over time. Observing social practices of meeting and celebration has supported

the interpretation of spatial appropriation phenomena. Finally, the analysis has focused on the signals of the public spaces' rooting within the community.

The public spaces examined do not easily fit into typical categories; they manifest as dynamic systems in which actions and uses are more significant than morphological structure. This variety renders each space both ordinary and unique, utilized daily without restrictions imposed by built forms, where new meanings emerge through individual or group appropriation. In this freedom of use, these spaces become special and irreplaceable.

The analysis of public spaces in Santa Marta and Paraisópolis reveals elements of interest for understanding the phenomenon of informal urbanism. While the construction of housing spaces is often the result of individual initiatives, public spaces originate from collective needs. These spaces may appear as areas left undeveloped, yet every construction implies the necessity for an external public space with a defined hierarchy. Each new construction considers the existing context; the order of this process is determined by public space, which plays a crucial role in the physical organization of the informal fabric.

Public spaces are characterized by their accessibility to residents, intimacy, and strong symbolic and identity connotations, where norms and values of a social group are recognized. These meeting places facilitate a complex framework of actions driven by affections and interpersonal bonds. Their structure is continuously adapted and modified through a lengthy and unstoppable urban composition process. This ongoing transformation is largely managed by the residents themselves, individually or through participatory groups.

New streets are created, existing pathways are closed or diverted, and areas of collective use are encroached upon by new constructions. In this dynamic scenario, public spaces assume a fundamental role in organizing pathways and social dynamics within the community, becoming true "condensers of social life," where cultural and identity values are formed and exchanged.

Public spaces frequently serve as extensions of the domestic realm. Doors and windows, as connection points between these two dimensions, remain open, facilitating fluid interaction between public and private spaces. The internal environment is infused with the external space, both functionally and aesthetically, highlighting the residents' personalization through transformations of use and aesthetic controls.

The connection between public spaces and daily social dynamics is evident, with each space successfully constructing a consolidated image within the community through urban and architectural strategies implemented by local residents. The alterations made to ground floors originally designated for residential use, now creatively converted into commercial spaces, along with aesthetic transformations of facades and the use of greenery, illustrate the cooperation between residents and the physical materialization of public spaces.

Public space in the favelas is characterized by a close connection to social dynamics and everyday life; all spaces manage to construct a consolidated image within the community through temporal urban and architectural strategies enacted by local residents. These actions include radical transformations of ground floors of buildings originally intended for residential use, creatively converted into commercial areas, aesthetic alterations of facades toward the street, featuring unusual color

modulations or high-quality finishes, and generous use of greenery, such as domestic plants or small to medium-sized trees. These dynamics clearly frame the indispensable and synergistic cooperation between residents and the physical manifestation of public spaces.

Public spaces in Santa Marta and Paraisópolis are shaped by often unpredictable social appropriation dynamics connected to levels of social use; their reversible nature frequently allows for fluctuations between public, semi-public, and private domains. Primarily developed and managed by residents, these spaces reflect their needs and aspirations. Their development process is not coordinated by a fixed plan but consists of a day-to-day program shaped by the changing perceptions and visions of the inhabitants.

In both favelas, informal public spaces adapt to various geometric, dimensional, and formal conditions, taking on a wide variety of morphological configurations. As spaces generated from pre-existing conditions, they are not characterized by rigid, preconceived elements but rather exhibit an adaptive quality that allows them to embed into different scenarios and transform them progressively. Space is shaped, articulated, and invented according to specific functional needs, levels of usage, and the unpredictable circumstances of local social life.

Public spaces in Santa Marta and particularly in Paraisópolis frequently arise at intersections of streets and pedestrian movement, depending on higher foot traffic and, consequently, greater social safety. One triggering factor in this dynamic is the establishment of commercial, recreational, or cultural activities that ignite the transformation of areas not originally configured as public spaces. Even architectural elements or urban furniture of private premises, such as awnings, sidewalks, or tables, often remain available for collective use, even outside operational hours, contradicting the widespread notion of favelas as sites of hyper-privatization.

The public spaces of both favelas are available for transformation, mutation, and evolution into other conditions. They are not codified by elements that rigidify them within space; rather, they are open systems that can progressively expand into adjacent areas through expansion, infiltration, or budding, creating additional public uses without altering their functionality and reversibility.

In light of the reflections presented, three significant aspects emerge. First, public spaces in both favelas are produced, managed, and controlled by the local population. Second, informal public spaces follow models of collective production and development; their growth is guided by a “shared vision” that evolves over time and is influenced by economic, political, cultural, and social factors. The development process aligns with the fluctuating and mutable expectations of residents. This notion of gradual development and constant evolution allows for the understanding of public space as an urban material that is "unfinished." The production and utilization of informal public space are integral parts of the same process; they are continually created, used, and transformed. The third and perhaps most significant aspect concerns the attribution of meanings and collective values to public spaces, representing the clearest signal of the ongoing social and cultural rooting within the favela.

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Urban megaprojects around the Cais[47] do Valongo – Rio de Janeiro: impacts on cultural memory and Afro-Brazilian resistance

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ABSTRACT

This article presents a critical analysis of the impacts of Urban Megaprojects (UMPs) on cultural memory and heritage, using the Cais do Valongo in Rio de Janeiro as a case study. Grounded in theories of urbanism, heritage, and memory, we investigate how UMPs trigger cultural and infrastructural transformations, often marginalizing social practices and expropriating collective memories. The Cais do Valongo, recognized as a space of Afro-Brazilian memory, is analyzed as a territory of resistance and resilience amidst processes of erasure and invisibilization caused by political and urban decisions. The patrimonialization of the Cais signals the re-signification of urban spaces politically contested. Methodologically, the research selected three UMPs that significantly transformed the urban form and spatial dynamics of Rio de Janeiro's port zone in the 20th and 21st centuries, using official documents, interviews, and scientific texts. The results focus on identifying cultural and infrastructural transformations and their impacts on heritage preservation and Afro-Brazilian cultural memory. The article concludes with reflections on the relationship between UMPs and cultural memory, emphasizing the importance of sensitive and inclusive urban planning for the preservation of local histories and identities.

Keywords: Urban revitalization; Gentrification; Afro-Brazilian memory; Porto Maravilha; Cultural heritage preservation.

[47] "Cais" is the Brazilian Portuguese term for "wharf." We do not translate the name "Cais do Valongo"; however, in some contexts, references to the location may use the word "wharf."

URBAN MEGA PROJECTS AND THEIR IMPACTS ON AFRO-BRAZILIAN CULTURAL MEMORY: A CRITICAL STUDY

To understand the impacts of Urban Megaprojects (UMPs) on cultural memory, we propose a brief review of the narratives that define UMPs within urbanism, drawing on the studies of Lungo (2007), Lungo and Smolka (2007), Moura (2011), and Vainer, Oliveira, and Lima (2012). These authors perceive UMPs as instruments for restructuring urban space in favor of capital, often funded by public resources and promoted by multilateral agencies, which replace traditional urban planning and result in socio-spatial segregation and territorial fragmentation (Moura, 2011).

We assume that the socio-spatial segregation caused by UMPs uproots local populations and fragments territories. In the case of Rio de Janeiro's Port Zone, gentrification has impacted Afro-Brazilian memory, threatening its rich cultural heritage. We reflect on how urban design and land-use management affect territorial practices, breaking the ties that sustain cultural memory. For Lungo and Smolka (2007), UMPs transform land value and use, affecting land structures and introducing new urban functions.

These dynamics also involve private economic agents, with the public sector as a partner, promoting land speculation. Moura (2011) notes that UMPs intricately link the public and private sectors, justifying themselves by the need for connection with the global scale and triggering economic development and urban restructuring. These projects generate impacts on land structures, real estate appreciation, and changes in the social division of space, with little significant socio-environmental consideration (Moura, 2011).

The academic literature is divided on UMPs: some view them as appropriate practices for the contemporary world, while others highlight their harmful exclusionary effects, rooted in neoliberal principles that connect local spaces to global wealth flows, often through public-private partnerships and marketing strategies (Moura, 2011). Under the discourse of requalification, UMPs restructure spaces for capital flows, resulting in architectural and urban icons, but also in socio-spatial segregation (Moura, 2011).

Considering the impact of UMPs, we must question whether they create conditions for the establishment of modernity clusters amidst socio-economic exclusion zones, thereby intensifying urban segregation (Lungo, 2007). In Rio de Janeiro's Port Zone, especially at Cais do Valongo, UMPs threaten the Afro-Brazilian cultural memory embedded in the area. Moura (2011) argues that these projects often cause ruptures in socio-economic and cultural structures, accelerating gentrification processes and environmental impacts by altering the urban form.

Vainer, Oliveira, and Lima (2012) emphasize that the ruptures caused by UMPs can be institutional, urbanistic, legal, real estate, political, symbolic, and scalar. These changes significantly impact the daily dynamics of the local population, crossing cultures and their tangible and intangible heritage, triggering the expropriation of knowledge and practices, and contributing to the erasure and invisibilization of black memory in Brazil, particularly in Rio de Janeiro's Port Zone (Bandeira, 1990).

The relationship between large urban projects, erasure, and the invisibility of afro-brazilian memory

Urban Megaprojects (UMPs) are large-scale urban interventions often promoted with the goal of restructuring and modernizing urban space. Funded by both public and private resources, they seek to meet the demands of capital, triggering a series of territorial disruptions that profoundly affect the socioeconomic, cultural, and environmental dynamics of the areas where they are implemented. Harvey (2008) argues that these projects operate within the logic of capitalist accumulation, transforming cities into commodities at the service of global capital. In this process, collective memories, especially of historically marginalized groups such as the Afro-Brazilian population, are often erased or rendered invisible.

The impact of UMPs on the Port Zone of Rio de Janeiro, particularly at the Cais do Valongo, is a paradigmatic example of how these interventions affect Afro-Brazilian memory. Bandeira (1990) alerts us to the attempts to erase Black identities in Brazil, emphasizing the importance of preserving the territories where the knowledge and practices of these cultures were carried out. The Cais do Valongo, as a disembarkation site for enslaved Africans, is a central space in the history of the African diaspora in Brazil. As Lima (2018) explains, Cais do Valongo symbolizes the legacy of slavery and Afro-Brazilian resistance, being a place of memory of a traumatic past where, "The exceptional universal value attributed to it was centrally justified by its character as a site of memory of the Atlantic slave trade and cultural and political resistance of the Black population to a long history of violence and exclusion" (Lima, 2018, p. 99).

The discovery of the Cais do Valongo in 2011, during the Porto Maravilha construction works, and its recognition as a World Heritage Site by UNESCO in 2017, highlighted the importance of preserving this place. Suiama (2023) points out that Cais do Valongo was the largest slave port in the Americas, where approximately 800,000 Africans were disembarked. However, the wharf was progressively erased from urban history with the construction of the Empress Wharf in 1843, and later buried as part of the new port works in Rio de Janeiro in 1906 under the Pereira Passos Urban Improvement Plan.

This process of erasure, according to Bandeira (1990), is part of a historical strategy of making Black cultures invisible in Brazil. The ethnic diversity among enslaved people was used as a mechanism to fragment their identities, weakening social cohesion among them. Bandeira describes how the imposition of the Portuguese language was one of the main forms of “cultural domestication” used by colonizers to silence African voices, rendering the “[...] ethnic diversity manipulated as a fragmenting mechanism of social origin identity, making African languages inoperative as an instrument of interaction and cohesion” (Bandeira, 1990, p. 9-10).

This cultural erasure is part of a broader exclusion process that Nascimento (1978) describes as forced “assimilation,” masked under the discourse of national unity. Nascimento denounces how this assimilation serves to suppress Afro-Brazilian memory, perpetuating a structure of domination that marginalizes Black contributions to the formation of Brazilian society.

In the context of UMPs, Missiatto (2021) discusses the “polysomic nature of whiteness,” which permeates various spheres of society, including architecture and urbanism. She argues that the production of urban space is shaped by a white perspective that marginalizes other forms of territorial

appropriation, contributing to the invisibility of non-white cultural identities, as "the polysomic nature of whiteness operates through a multiplicity of meanings, values, and norms associated with whiteness that permeate various spheres of society" (Missiatto, 2021, p. 256).

Thus, the UMPs that have traversed the Port Zone from the Pereira Passos Improvement Plan to the Porto Maravilha project contribute to the deterritorialization of Afro-Brazilian communities, driving processes of gentrification that result in the physical and symbolic extinction of their spaces of memory and resistance. The modernizing logic that guides these projects, with its hygienist bias, ignores or minimizes the histories and experiences of these communities, erasing their territories and their contributions to the city's formation.

It is important to highlight that the control of urban territories, as identity-laden cultural spaces, is also constantly under dispute. Haesbaert (1997) reminds us that the concept of territory can be understood as "an appropriated space, in which appropriation takes place on various scales, involving political, economic, and above all, identity control" (pp. 36-37). In other words, we are dealing with human practices on territory that constitute territorialities, described as "[...] a set of relationships developed by a collective with the space they inhabit, mediated by instruments of control and appropriation, both concrete and symbolic" (pp. 36-37). Applying these concepts to the context of urban transformations materialized by Urban Megaprojects (UMPs) that impacted the port area of Rio de Janeiro, we observe that such urban interventions on this historical territory of Afro-Brazilian practices result in the continuous deterritorialization of the identity ties of the Black population. As Haesbaert (1997) points out, deterritorialization48 is the process of "disassociation of a community or individual from their original territory," often associated with globalization processes and capitalist transformations that "uproot" the identities and cultural practices once embedded in that space (pp. 258-259).

Therefore, when discussing Urban Megaprojects (UMPs) in the context of Rio de Janeiro's Port Zone, it is essential to consider not only the physical impacts of these interventions but also the profound effects they have on the preservation of Afro-Brazilian memory and identity. Missiatto (2021) points out that Black deterritorialization is a process rooted in the African diaspora and perpetuated by urban marginalization policies that reinforce the coloniality of thought and power in Brazilian cities. In this way, UMPs not only restructure the physical space but also contribute to the erasure and invisibility of Afro-descendant memories and identities within urban contexts.

Memory and gentrification: the Cais do Valongo and conflicts in the Port Zone

The concept of memory is closely linked to territory, as it is revealed in the cultural and identity practices anchored in urban spaces, the territorialities exercised through that territory. In the context of Urban Megaprojects (UMPs), such as the Porto Maravilha project, these memories are often erased or marginalized, especially when the focus is on reconfiguration and gentrification of space, as discussed by Lungo and Smolka (2007). The Port Zone of Rio de Janeiro, particularly the Cais do

[48] Associated with the concept of deterritorialization, the discussion also extends to that of reterritorialization. Haesbaert (1997) clarifies that reterritorialization is described as the subsequent movement to deterritorialization, in which a new territory is constructed or appropriated, usually involving "[...] new arrangements of control and appropriation, which can be both physical and symbolic" (p. 154-155).

Valongo, emerges as an emblematic example of this process of erasure and cultural resistance (Vassallo & Cicalo, 2015).

We cannot discuss UMPs in the port zone of Rio de Janeiro without addressing how gentrification processes act to erase and render Afro-Brazilian memories invisible. As Ribeiro (2018) clarifies, the concept of gentrification revolves around two key elements: (i) physical interventions in the territory and (ii) population replacement, that is, the removal of poorer residents by wealthier groups. This process, as noted, is not limited to the physical transformation of space but also involves a profound social and cultural reconfiguration of the affected areas. Anchored in Zukin (1995), Ribeiro (2018) highlights that one of the "new forms of gentrification" is related to the transformation of public space, which, after being restructured architecturally and urbanistically, becomes regulated by new norms of use that end up excluding its usual visitors and replacing them with groups of greater economic power (Ribeiro, 2018, p. 1342).

The author also reminds us of that other dynamics of exclusion manifest themselves in different ways, such as commercial gentrification, which, according to Van Criekingen and Fleury (2006), occurs when pioneering merchants in certain areas remodel their establishments to attract a new, wealthier clientele, transforming the region's socioeconomic profile (Ribeiro, 2018, p. 1342). There is also the gentrification of new constructions, described by Davidson and Lees (2005), which involves the construction of high-end housing in central or industrial areas, drastically altering the local social fabric without necessarily displacing previously established low-income residents but creating a hostile environment for their permanence (Ribeiro, 2018, p. 1342). These contemporary forms of gentrification reinforce the exclusionary logic of UMPs, which not only transform the urban landscape but also erase cultural identities, particularly in areas with a strong Afro-Brazilian presence, such as Rio de Janeiro's port zone.

Grounded in this perspective, we understand that UMPs, driven by the discourse of modernization and progress, tend to transform the territory to serve the interests of capital, often resulting in population displacement and the erasure of memories associated with these places (Moura, 2011). In the case of the Port Zone, the revitalization led by the Porto Maravilha project, covering five million square meters and aimed at requalifying the region for mega-events like the 2014 World Cup and the 2016 Olympics, and currently, in 2024, undergoing intense real estate speculation, neglected the preservation of Afro-Brazilian cultural practices and memory long rooted in the area (Lima, 2018).

The Cais do Valongo, rediscovered in 2011 during Porto Maravilha's works, symbolizes the African diaspora and the legacy of slavery in Brazil. Its *patrimonialization* by UNESCO in 2017 was a significant milestone in recognizing the traumatic past of the Atlantic slave trade. However, as Pollak (1989) points out, memory and identity are constantly contested, and in the case of Valongo, the transformation of the area into a tourist product sparked tensions between urban development policies and Afro-Brazilian communities' demands for preservation and respect for this sacred space (Pollak, 1992).

The urban transformations driven by UMPs carry an exclusionary dimension. As Vassallo and Cicalo (2015) argue, the Porto Maravilha project was developed to attract real estate and tourism investments, without considering the needs and identities of local communities. This process resulted

in the gentrification of the region and the expulsion of low-income populations that had traditionally occupied the area, reproducing dynamics of racial and socioeconomic exclusion (Vassallo & Cicalo, 2015). This reality echoes Moura's (2011) analyses, which highlight that UMPs tend to transform the social division of urban space, creating enclaves of modernity and wealth at the expense of destroying culturally significant territories.

In the specific case of the Cais do Valongo, the attempt to silence Afro-Brazilian history becomes clear in how the space was rediscovered and incorporated into the tourist circuit. Cultural erasure, as described by Missiatto (2021), manifests not only in the physical destruction of territories but also in the symbolic and identity-based *invisibilization* of Black communities, whose memories are instrumentalized for market purposes. The Cais do Valongo, a place of Black memory and cultural resistance, was transformed, under the discourse of revitalization, into a tourist attraction, disregarding the deep meaning the site holds for Afro-descendant communities (Lungo & Smolka, 2007).

“The extermination of a people's memories can itself be the erasure of that people, as the removal of certain minority groups from the annals of history imposes on their ancestry and descendants the weakening of their identities and social consciousness, furthering the symbolic, psychological, and cosmological disappearance of their otherness.” (Missiatto, 2021, p. 258).

The *patrimonialization* of the Cais do Valongo further reflects the complexity of memory disputes in the urban context. For Black movement leaders, Valongo is a symbol of resistance and ancestry, and its preservation must be guided by reflections on the enslaved past and the fight against racial discrimination. However, for municipal managers and investors, the archaeological site is primarily seen as a tourism development opportunity, aimed at attracting a higher-income audience (Vassallo & Cicalo, 2015). This tension between memory and modernization highlights the exclusionary nature of UMPs, which often prioritize profit and real estate speculation over the preservation of local history and identities.

As Pollak (1992) asserts, political memory is a field of dispute, and in the case of the Cais do Valongo, this dispute translates into a divergence between demands for memory tourism and economic development aimed at reconfiguring the area. For these memory spaces to truly contribute to reconstructing Afro-Brazilian history, it is essential that local communities' voices are heard, and their narratives respected. Institutionalizing places like the Cais do Valongo is an important step, but without an inclusive management and preservation process, there is a risk of turning these resistance spaces into tourist products devoid of deep cultural significance.

METHODOLOGY

This study adopts a qualitative approach, focusing on document analysis and the review of scientific literature to understand the impacts of Urban Megaprojects (UMPs) on the Cais do Valongo and Afro-Brazilian cultural memory. The research is based on a rigorous review of academic and historiographical sources that discuss processes of urbanization, the preservation of cultural heritage, and the social effects of large-scale urban interventions. The theoretical review included texts addressing the concepts of collective memory, urbanism, and gentrification, such as the works of

Lungo and Smolka (2007), which explore socio-spatial dynamics and the exclusionary effects of UMPs in Latin America.

In addition to consulting academic articles, books, and documents that detail the Pereira Passos Urban Reform Plan and its relationship to Afro-Brazilian memory, the research draws on primary and secondary sources to establish a historical connection between the port area's enslaved past and the present context, evidenced in the Porto Maravilha project. The investigation also considers reports from cultural organizations, such as UNESCO, and journalistic materials, providing a current perspective on the debates surrounding the *patrimonialization* of the Cais do Valongo and the broader implications of urban revitalization in the area.

The selected UMPs, which have transformed the urban form and spatial dynamics of the Rio de Janeiro port area during the 20th and 21st centuries, are analyzed through the lens of two complementary perspectives proposed by Lungo and Smolka (2007). The first focuses on the transformative action on the form of urban space, particularly on how urban planning prioritizes physical, aesthetic, and symbolic dimensions. The second examines the economic valuation of land resulting from these large projects and their impact on socio-spatial distribution.

PRESENTATION OF RESULTS

Based on the discussions developed thus far, this section presents an analysis of the results obtained, organized into three main topics: *The Pereira Passos Plan: modernization, sanitation, and the erasure of Afro-Brazilian memories in Rio de Janeiro*; *Impacts of Urban Modernization: the construction and demolition of the Perimetral Overpass*; and *Porto Maravilha: impacts of UMPs (Urban Megaprojects) and the preservation of Afro-Brazilian memory*. These topics highlight the relationship between large-scale urban reforms and the erasure of Afro-Brazilian cultural memory, showing how urban transformations throughout history, culminating in recent UMPs, have led to social, symbolic, and spatial ruptures in Rio de Janeiro's port area. Throughout the analysis, the impact of these interventions on the preservation of Afro-Brazilian memory, particularly in historically significant locations like Cais do Valongo, is examined, raising critical questions about the role of urban policies in perpetuating the invisibility of Afro-descendant communities.

The Pereira Passos Plan: modernization, sanitation, and the erasure of afro-brazilian memories in Rio de Janeiro

The Pereira Passos Urban Reform Plan, implemented between 1903 and 1906, marked a significant milestone in the history of Brazilian urbanism, aiming to modernize Rio de Janeiro and align it with European standards. Mayor Pereira Passos drew inspiration from two major urban movements: the Paris Urban Renewal Program (1853-1870), led by Haussmann, and the City Beautiful Movement, which began in the United States in the 1890s. This study, as outlined in the methodology, follows the analysis proposed by Lungo and Smolka (2007), where the first perspective addresses the physical and symbolic transformation of space, and the second, land value appreciation and socio-spatial changes.

The hygienist urbanism promoted by Haussmann, mirrored in Passos' actions, reorganized the urban landscape through the demolition of areas deemed unhealthy and the creation of new avenues and squares. However, as the analysis of sources suggests, these physical interventions also contributed

to cultural erasure, especially of the Black population that occupied the Valongo area, as noted by Azevedo (2016). The territory, which once housed a dense network of meanings related to Afro-Brazilian memory, underwent a process of cultural deterritorialization, being transformed in favor of a Europeanized vision of the city. The layers of territorial reconfiguration demonstrate the transformative power of Urban Megaprojects (UMPs).

The Cais do Valongo, a memory site linked to the transatlantic slave trade, was overlaid by the Cais da Imperatriz (Figures 1, 2, and 3) in a clear attempt to silence and make invisible Afro-Brazilian memories (Azevedo, 2016). This erasure process directly relates to the second perspective of Lungo and Smolka (2007), which discusses how land value can be elevated and how new uses of space are created, often at the expense of the original populations.

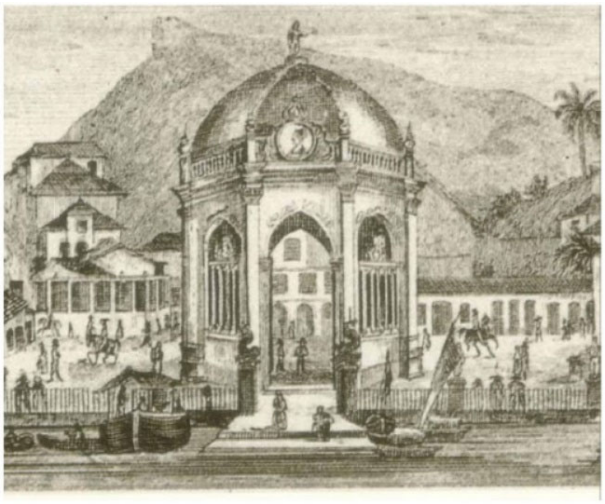

Figure 1: Cais do Valongo beautified for the disembarkation of the Empress, lithograph by Friedrich Pustkow, circa 1844. State Library of Rio de Janeiro. Source: Lima, Sene, & Souza (2016).

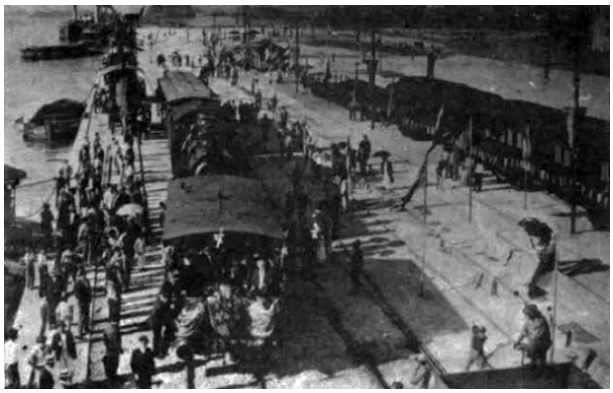

Figure 2: Inauguration of the first 500 meters of the wharf in 1906. Most of the landfill in the port area was created by leveling the Morro do Senado, demolished to create the circulation axis between Lapa and Estácio (Credit: Augusto Malta/General Archive of the City of Rio de Janeiro). Source: MultiRio. (n.d.).

The historical context, therefore, reveals a series of interventions that not only modified the urban form but also reshaped how Afro-Brazilian cultural memory was experienced in the city. The exclusion of Black populations, promoted through forced displacements and the criminalization of their cultural practices, exemplifies how large-scale urban decisions, typical of UMPs (Urban Megaprojects), reconfigured local sociability. As pointed out by Arantes (2005), the socio-spatial segregation caused

by the Pereira Passos reforms cannot be separated from the attempt to control the identity expressions of marginalized populations, reinforcing racial control and cultural erasure.

In conclusion, the Pereira Passos Plan exemplifies how UMPs, by transforming the territory, directly affect the preservation of memory and cultural practices. Although the reforms brought infrastructural advancements, the displacement of vulnerable populations and the erasure of Afro-Brazilian memory represent symbolic and urban ruptures that persist to this day.



Figure 3: Superimposition of the Pereira Passos Urban Improvement Plan over an aerial image from 2024, identifying the Cais do Valongo and other landmarks significant to Afro-Brazilian culture. Source: Viver Cidades+, 2024.

Impacts of urban modernization: the construction and demolition of the Perimetral Elevated Highway

The construction of the Perimetral Elevated Highway, between 1957 and 1978, was part of Rio de Janeiro's modernization efforts aimed at improving traffic flow in the port area and connecting strategic parts of the city. Although the project fulfilled its function of facilitating mobility, the cultural and historical impacts were significant, including the destruction of landmarks such as the Central Market and the Pharoux Hotel (Figures 4 and 5). In addition to disrupting the visual and physical integration between the port area and the historical downtown, the elevated highway symbolized the disconnection between new infrastructure and local urban life, neglecting the cultural memories and identities of communities in favor of economic restructuring.

As Fridman (2013) argues, the urban planning initiatives of the Vargas Era, which influenced projects like the Perimetral, proposed the creation of proletarian housing and the eradication of slums and tenements, transferring families to healthier housing units. However, these hygienist interventions

led to the formation of impoverished peripheries, displacing working-class populations to distant neighborhoods, often lacking adequate transportation and services infrastructure (Fridman, 2013, p. 215). This model of urban intervention created a disconnect between infrastructure policies and the needs of local communities, exemplifying how economic modernization can overshadow the preservation of urban memories.

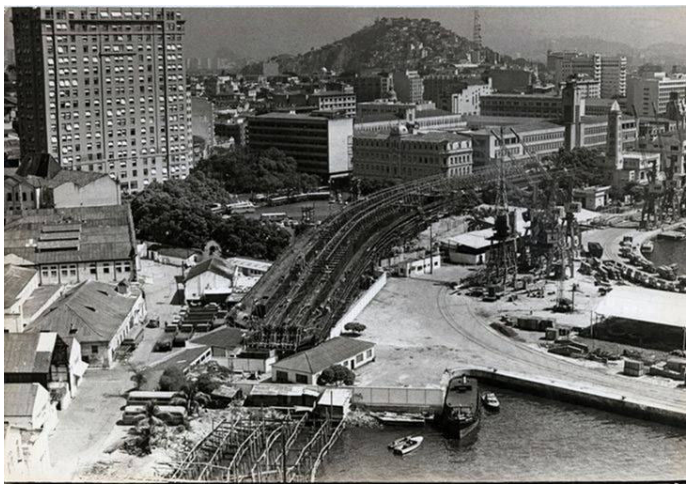

Figure 4: Construction of the Perimetral Viaduct over Praça Mauá, where the Museu de Arte do Rio (MAR) is now located. On the right, the pier where the Museu do Amanhã stands today, and on the left, the A Noite Building. Source: Diário do Rio. (n.d.).



Figure 5: Misericórdia Region, 1900. To the southwest, one of the towers and part of the Municipal Market. In the center, aligned with several buildings, the farthest to the left is the Hotel Pharoux. Behind it are the Escola da Magistratura do Estado do Rio de Janeiro, the Naval Museum, and the Ministry of Transportation (H-shaped building). Behind it, the Casa de Câmara e Cadeia, and to its right, part of the Imperial Palace. Source: Histórias e Monumentos. (n.d.).

The demolition of the Perimetral Elevated Highway, between 2013 and 2014, marked the beginning of the Porto Maravilha project, one of the Urban Megaprojects (UMPs) in the port zone (Figure 6). Although the stated intention was to revitalize the region and recover its historical heritage, it can be conjectured that this type of intervention primarily serves the interests of global capital, functioning as a form of real estate speculation. The relationship between modernization and urban memory,

particularly Afro-Brazilian memory, is characterized by a persistent tension, where cultural preservation does not always align with economic development.



Figure 6: Implosion of the Perimetral Viaduct on November 24, 2013, to replace the Avenida Rodrigues Alves / Perimetral with the Binário do Porto and Express / Túnel Marcello Alencar roads. In the background to the right, the Cidade do Samba. Source: Engenhareia. (2017, May 11).

We must not lose sight, as Lungo and Smolka (2007) remind us, that UMPs (Urban Megaprojects) often operate under the logic of economic restructuring, frequently resulting in socio-spatial segregation and cultural exclusion. In the case of the Perimetral Viaduct, the project helped shape Rio de Janeiro to align with global capital flows, but at the cost of key historical layers that shaped the local identity.

The demolition of the viaduct and the revitalization of the area around Cais do Valongo illustrate the complexities of reclaiming Afro-Brazilian memory in the city. Declared a World Heritage Site by UNESCO on July 9, 2017, Cais do Valongo stands as a symbol of resistance and memory of the African diaspora. The study of the construction and demolition of the Perimetral Viaduct demonstrates how UMPs deeply impact a city's cultural memory. While the demolition was justified as part of a revitalization process, it highlights the challenge of balancing modernization with historical preservation, especially in areas like the port zone that hold profound cultural significance. The Porto Maravilha project emerges as one of the primary UMPs, aiming to revitalize the port region, redefining the territory and its heritage. However, as with the Perimetral, the project also raises questions about the impacts of modernization on local cultural memory and identity, sparking debates about real estate speculation and social exclusion.

Porto Maravilha sought not only to restructure the physical infrastructure but also to integrate economic development with cultural heritage. The Cais do Valongo, valued as a World Heritage Site, represents this tension between cultural revival and erasure. Nevertheless, the critique remains: is the project perpetuating a model of modernization geared toward global capital interests, as the Perimetral once did? The challenge is to strike a balance between promoting new urban uses and respecting historical memory, ensuring that the region's cultural legacy is not lost in the process of urban transformation.

Porto Maravilha: impacts of UMPs and the preservation of afro-brazilian memory

The Porto Maravilha Project, initiated in 2009, is one of the largest urban revitalization efforts in Rio de Janeiro, aiming to requalify the port area to meet the demands of major international events, such

as the 2014 World Cup and the 2016 Olympic Games. Managed by the Urban Development Company of the Port Region (CDURP), the project follows a model commonly used in Urban Megaprojects (UMPs), aiming to transform urban space to serve the needs of capital, as previously noted by Lungo and Smolka (2007). Like other UMPs across Latin America, Porto Maravilha is funded by public resources and involves international consultants and agencies (Moura, 2011), promoting a "modernizing discourse" that often conceals processes of exclusion and gentrification, which result in socio-spatial segregation (Vainer, Oliveira & Lima, 2012).

Following the elitist urbanization pattern observed in similar projects, Porto Maravilha prioritized the creation of tourist and cultural spaces, such as the Museum of Tomorrow and AquaRio, over preserving the Afro-Brazilian history and traditions rooted in the area (Pinheiro & Carneiro, 2016). This phenomenon aligns with Lungo's (2007) critique of UMPs, which often generate “ruptures in socio-spatial dynamics,” driven by increased real estate speculation and the devaluation of local cultural practices. Paula and Herédia (2018) emphasize that the project encompassed five million square meters, focusing on infrastructure and tourism, while placing Afro-Brazilian cultural memory in the background.

The discovery of the Cais do Valongo (Figure 7) during the Porto Maravilha construction in 2011 underscored the importance of preserving Afro-Brazilian heritage. Recognized as a UNESCO World Heritage site in 2017, the wharf represents the memory of the African slave trade, serving as a space of resistance and anti-racist struggle. However, as Vainer, Oliveira, and Lima (2012) observe, the touristification of the port area has commodified this memory, distancing it from the local identities and narratives. This reflects the effects of UMPs, which, according to Moura (2011), are driven by public-private partnerships under a neoliberal framework, prioritizing economic development at the expense of social exclusion and the destruction of historical and cultural ties.



Figure 7: Reurbanized Valongo Wharf. Source: Lima, Sene, & Souza (2016).

This dynamic is reflected in what Ribeiro (2018) describes as “new forms of gentrification,” where the transformation of public space, alongside real estate speculation, results in the exclusion of former users and residents, who are replaced by wealthier groups. This phenomenon is evident in Porto Maravilha, where real estate speculation significantly increased land prices, leading to housing displacements as many poorer residents could no longer afford to stay in the area (Nascimento, 2019).

This process reinforces the cycle of commercial and residential gentrification, where culturally significant areas are restructured to serve tourism and real estate interests, while Afro-Brazilian traditions and memories are marginalized.

Lungo and Smolka (2007) suggest two perspectives for understanding UMPs. The first relates to the physical transformation of space and the increase in real estate value, aspects clearly visible in Porto Maravilha, where urban reforms raised land prices but also fragmented the relationship between residents and their territory. The second perspective refers to the creation of new functions for specific areas, such as the port zone, which was redefined to attract investments and tourists, often at the expense of traditional populations.

Porto Maravilha thus demonstrates how UMPs can act as mechanisms of urban reconfiguration, not only altering the form and function of space but also deeply affecting local cultural and identity narratives. While interventions in the port zone brought economic and tourism benefits, they also generated tensions between urban development and the preservation of Afro-Brazilian memory. As Bandeira (1990) discusses, cultural erasure is a consequence of colonial practices and capitalist logic that subjugate and marginalize historically oppressed cultures, such as the Afro-Brazilian population.

Therefore, in analyzing the impact of Porto Maravilha, it is essential to consider the social and cultural implications of urban interventions to avoid the erasure of histories and identities fundamental to the cohesion of local communities. The pressures created by real estate speculation and gentrification, as described by Nascimento (2019), reveal that, although the project was presented as revitalization, it also perpetuates inequalities and contributes to the erasure of Afro-Brazilian traditions that form the cultural foundation of the port zone.

CONCLUSIONS

This article analyzes the impacts of Urban Megaprojects (UMPs) on Afro-Brazilian cultural memory, using the Porto Maravilha and the Port Zone of Rio de Janeiro as case studies. Urban modernization, initiated with the Pereira Passos Reform Plan, has historically reconfigured urban space, leading to cultural erasure and social exclusion, particularly of Afro-Brazilian populations. Examples of this process include the overlaying of the Cais da Imperatriz on the Cais do Valongo and the construction of the Perimetral Overpass, both projects that neglected the preservation of local memories and identities in favor of elitist economic and aesthetic interests. Porto Maravilha exemplifies how urban redevelopment can perpetuate gentrification and real estate speculation, marginalizing traditional communities. This article argues that future urban projects should prioritize the preservation of Afro-Brazilian memory and identity, which is essential for urban planning that promotes inclusion and cultural resilience.

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A morphological study of the transformations of civic district, Singapore by the historico-geographical approach

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ABSTRACT

Singapore's Civic District, once the heart of colonial city, has experienced significant transformation due to rapid urban development. This area reflects the broader issues of Singapore's heritage conservation policies, the dilemma between economic development and the historical integrity of urban landscapes. Despite its rich colonial heritage significance, the district's historical character has been greatly damaged by the modern development. By conducting a diachronic study by the historico-morphological approach, this paper traces the Civic District's morphological transformation through four morphological periods: the early colonial period (1819-1867), the later colonial period (1867-1950), the transitional period (1950-1990), and the cosmopolitan period (1990-present). The morphological analysis underscores how the district's original street patterns, building layouts, and land use have evolved under the social, economic and cultural influences. This study aims to provide evidence for urban planners on how to integrate isolated heritage sites into a cohesive conservation framework. It can serve as a more analytical approach to cope with the current challenges in Singapore's heritage conservation which always prioritise economic value over historic integrity of urban landscape.

Keywords: Urban morphology, urban transformation, historico-geographical approach (Conzenian approach), Singapore, Civic district

INTRODUCTION

Since the independence in 1965 from colonization of United Kingdom, Singapore has undergone extensive urban redevelopment which demolished historic districts to accommodate new constructions. Most old settlements of high population density and poor housing were replaced by modern infrastructure, particularly in the city center, which evolved from a densely populated colonial area into a commercial hub. As a former important colonial port city, Singapore has many colonial historic districts with significant heritage value, which have been impacted by urban renewal.

While the government started conserving some national monuments in the 1970s, comprehensive heritage area-based conservation policies only emerged in 1986 (Teo & Huang, 1995), when the Urban Redevelopment Authority (URA) announced a plan to conserve six historical areas. By that time, much of the building heritages had already been altered or demolished. After institutionalizing heritage

conservation, Singapore still faces challenges. One key issue is that conservation efforts often prioritize the commercial value of areas over historical integrity, leading to a fragmentation of original historic urban landscape. Due to the lack comprehensive approach to take the integrity of urban heritages in consideration, there is a disconnect between conservation objects of different scales and levels. The heritage conservation needs measures that are more sensitive to historical contexts.

This paper focuses on the Civic District of Singapore, a prime example of these challenges. Civic district was nominated as the born place of modern Singapore which was the typical British colonial urban core evolved under colonial planning and new post-independence policies. Historically, this area was the starting point for the establishment of colony and was the administrative centre of the city, and today, this area is close to the central business district of Singapore. Hence, the conflict between economic development and heritage conservation and the fragmentation of conservation sites are also reflected here.

This paper aims to trace the history of the Civic District, analysing its morphological transformations by the historico-geographical approach. Since its introduction by Conzen (Conzen, 1960), this approach has been widely used not only in Western historic towns (Conzen, 1962; 2004), but also in Eastern urban studies with well-established examples (Karimi, 2000; Gu, 2001). It has also been applied by scholars in other historic areas of Singapore (Li & Zhang, 2021). The historico-geographical approach can identify a hierarchy of plan units that reflected the historical development of the urban area. It delineates the morphological regions and examines the consistency and change of these morphological regions through different periods to understand the interplay between morphological change, urban planning, and socio-economic contexts. It is proved that morphological study can provide guidance for townscape management, particularly contributing to urban heritage conservation (Larkham, 2002). The goal of this paper is to offer a framework for assessing how historical planning and socio-economic factors, particularly in scale of historic grain, has influenced the built environment. Additionally, the analysis can establish a theoretical foundation as a historic layering to enhance the current top-down planning strategies.

METHOD

Conzenian approach, known as historic-geographical urban morphology method (Kropf, 2009), was named after urban geographer Conzen (1960). Morphological period refers to distinct phases in the development of a town's physical structure over time, shaped by the socio-economic and cultural circumstances of each era (Conzen, 1960).

Morphological region refers to the area that exhibits a distinct physical or structural form, which reflects its historical development and functional characteristics. These regions are defined based on different form complexes, such as s ground plan, building fabric and land use (Table 1) (Conzen, 1960; Whitehand, 2010). The first-order morphological regions defined by different primary functional areas with distinguishable morphological characteristics shaped by social-economic factors of each special periods. The second-order morphological regions correspond to variations in the plan unit. The three elements including land plots, building block, and street systems—are considered to have high

persistence, as they are less vulnerable to change over time and can therefore carry more historical information. The third-order morphological regions focus on differences in building types and land use, which are more prone to change. Based on this, in each period, the morphological regions of different levels within the Civic District are identified.

Cadastral maps, archives literatures are the data source. Data are collected and overlaid in QGIS, such as cartographic maps of Singapore in 1846, 1893, satellite map in 1950, buildings and roads map in 1988, current open street map data, and planning documents from National Archives of Singapore and National Library of Singapore.

Table 1. . The contribution of different morphological attributes to morphological regions delimitation. Source: Conzen, 2004; Whitehand, 2009

Attribute	Persistence	Contribution to hierarchy
Ground plan (including street, building block, land plot)	High	Mainly high and intermediate rank
Building fabric	Variable but often considerable	Mainly intermediate and low rank
Land use	Low	Mainly low and intermediate rank

ANALYSIS

Origin of the civil district as the British colonial urban centre

During the 1670s, Lord Shaftesbury proposed the Grand Modell (Home, 2013), a colonial urban planning guideline for Britain's global colonies, featuring open squares and square grid plot divisions. As British colonialism evolved, this model was refined, particularly in Asia, where it developed into a hierarchical plan with racial-segregated zoning (Kosambi & Brush, 1988). This stable spatial framework, characterized by governmental areas, open squares (Widodo, 2004), defensive forts, and government buildings, became common in British Southeast Asian colonies. Singapore's first urban plan Jackson Town Plan reflected this model. Implemented by Sir Raffles, it included open spaces, military installations, and government buildings. In the Jackson Town Plan, the area on the north bank of the Singapore River was planned as the Government Area, the center of the colony, and this area was the basis for our study area, the Civic District.

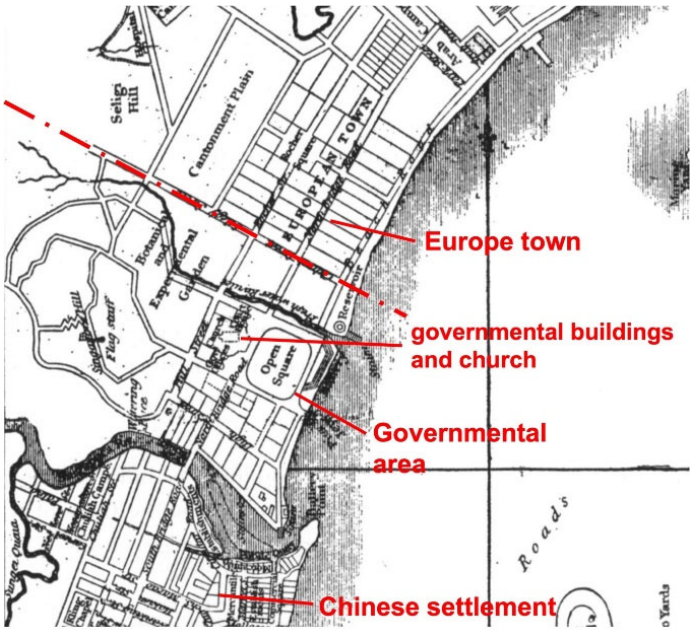

Figure 1. Government area in Jackson Plan. Source: National Archive of Singapore

Morphological Periodization

Based on the periodization in the study of Singapore's history and planning history, four morphological periods were recognised: first period: the early colonial period (1819-1867), second period: the later colonial period (1867-1950), third period: transitional period (1950-1990), and fourth period: cosmopolitan period (1990- now).

The First Period spans from the establishment of the colony in 1819 to 1867. This era represents the early phase of colonial development. In 1867, the authority over the Straits Settlements was transferred from the Calcutta administration of British India to the Colonial Office in London, thus Singapore became Crown Colony. The opening of the Suez Canal in 1869 increased the importance of Malacca Straits, making Singapore an increasingly significant port (Turnbull, 2009; Yeoh, 2003; Abshire, 2011). This led to a population boost and new urban development in the late 19th century. It marked the second period, the later colonial period (1967-1950).

The transitional period spans from 1950 to 1990. Urban renewal became the focus of urban development activities in Singapore after the establishment of colonial autonomous government and subsequent independence since the 1950s. In this period, Singapore turned to an independent state city from a colony, establishing a new stable urban planning framework by around 1990. Subsequently, the fourth morphological period is cosmopolitan period, from 1990s to the present day. Singapore became the fourth-largest foreign exchange market in the world by the 1990s, after only New York, London, and Tokyo (Lee, 2012). Outstanding economic status made Singapore a cosmopolitan city.

Morphological Region Delimitation

First Period: Early colonial period (1819-1867):

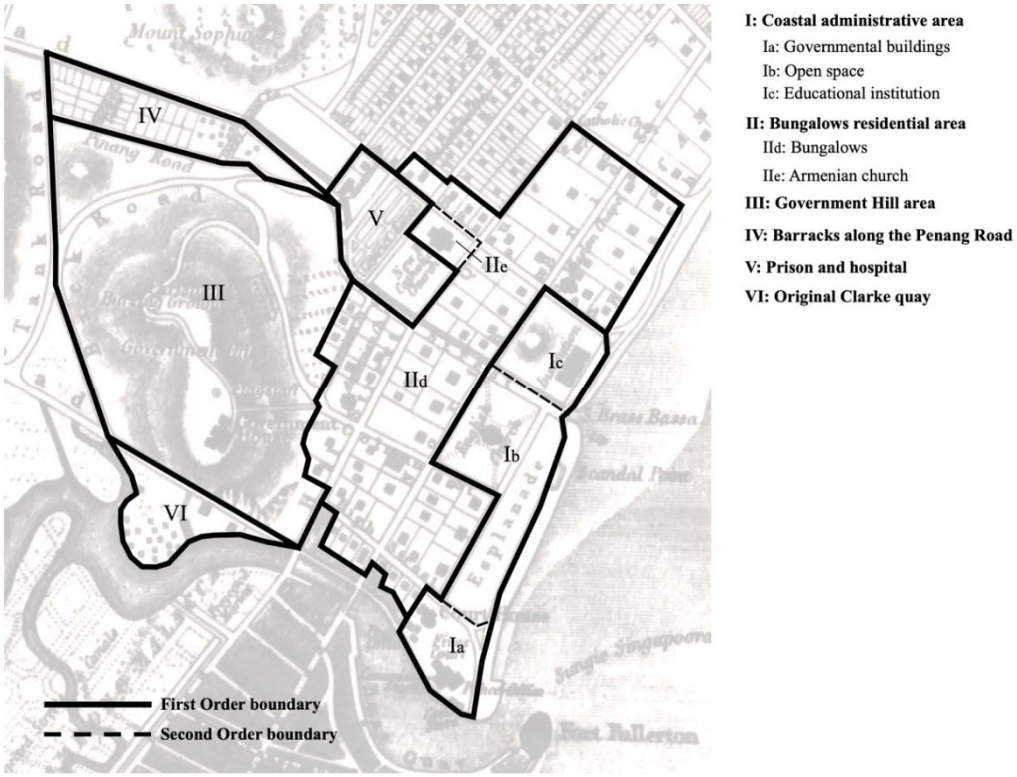

Figure. 2 Morphological Region of the Early Colonial Period (based on 1846 cadastral map)

Singapore's first urban plan, the Jackson Town Plan gazetted in 1822, designated the area north of the Singapore River as the Government Area, which was the predecessor of Civic District. As a public area owned by the colonial government, this region laid the foundation for its role: governmental and public services. Following the British colonial planning framework, the Jackson Town Plan introduced a rectangular grid for the main street networks and land division around the public square in this area, which largely established the road structure. The key elements of a typical colonial city centre—government buildings, churches, and open squares—were constructed during this period. The city's population had not yet experienced significant growth, and high-density residential areas to accommodate a large population had not been built yet (Yeoh, 2003).

Region I is designated as the coastal administrative area (Figure. 2). In the Jackson Town Plan, the main buildings in the Government Area included the English Church, Government Office, Court House, and an open square on the coastline. In the plan, the Court House and government office were symmetrically placed on either side of a church, with all three buildings planned on the western side of the open square (Figure 1). In the planned layout, this group of buildings was aligned along an axis from Government Hill to the coast. However, in the actual built environment, their locations differ from the plan, with this area distributed along the coastline. The public office and courthouse (Ia) were constructed on plots south of the Esplanade (Figure. 2). St. Andrew's Cathedral, the earliest Anglican church in Singapore, which corresponds to the church in the Jackson Plan, was completed in 1836 on the western side of the esplanade. The ground of church formed an open space together with the esplanade (Ib in Figure 4). Raffles Institution, the first school of Singapore colony, provided education for the children of local leaders. Although not included in the Jackson Plan, the school was built the year after the plan's release on a plot north of the Esplanade (Pearson, 1969).

Bungalow residential area (II) is divided into rectangular plots following an orthogonal grid, consistent with aforementioned British colonial planning tradition. Before the Jackson Plan was gazetted, some bungalows[1] had already been built in the Government Area. According to Raffles' orders and correspondence from the 1820s and Jackson's manuscripts, while the Government Area was reserved for governmental buildings in the Jackson Plan, some houses were not removed to make way for public buildings in this period (Pearson, 1953; Cangi, 1993; Eng & Savage, 1985). the Government Area at that time included private residences situated between the esplanade and Government Hill. For instance, the residence of the prominent Chinese merchant Tan Tock Seng (NHB, 2020), the home of Singapore's famous colonial architect Coleman (Cornelius, 2016), and the Caldwell House designed by Coleman, were all built in the bungalow residential area (II) during this period.

Government Hill area (III) is on Bukit Larangan (means Forbidden Hill in Malay), now known as Fort Canning Hill. Raffles established the Government House on Forbidden Hill, and since then, the hill had also been called Government Hill. To the north of Government Hill lies barracks along the Penang road (IV), which was used as barracks to canton sepoys, Indian soldiers in British army (NHB, 2023). Region V was where Singapore's first hospital and first prison were located (Thulaja, 2016).

South of Government Hill is the Clarke Quay area (VI), where the street network had not yet formed. Before the Jackson Plan was introduced, this area was an original kampong. Afterward, it developed into a quay with merchants building business houses, workshops, and residences there. It is recording that notable Chinese merchants of the time, such as Tan Kim Seng and Tan Tock Seng (Cornelius, 2019), built shops in this area.

Second Period: Later colonial period (1867-1950):

During this period, the main change in the study area was a rapid increase in building density, further subdivision of land, and the construction of more public buildings. The Government Area (I) transformed from the colonial administrative core into a multifunctional, high-density urban centre. During this period, more public buildings of various functions were built including community buildings, commercial buildings, museum, and library. It further clarified the role of the Civic District during this period as a civic center, rather than just an area of governmental buildings, as it was in the First Period. Due to the growth of the population, both the number and density of residential buildings significantly increased in the Civic District. The basic structure of the road network in the urban layout remained unchanged, new branch roads were developed. The morphological region delimitation is showed in Figure.3.

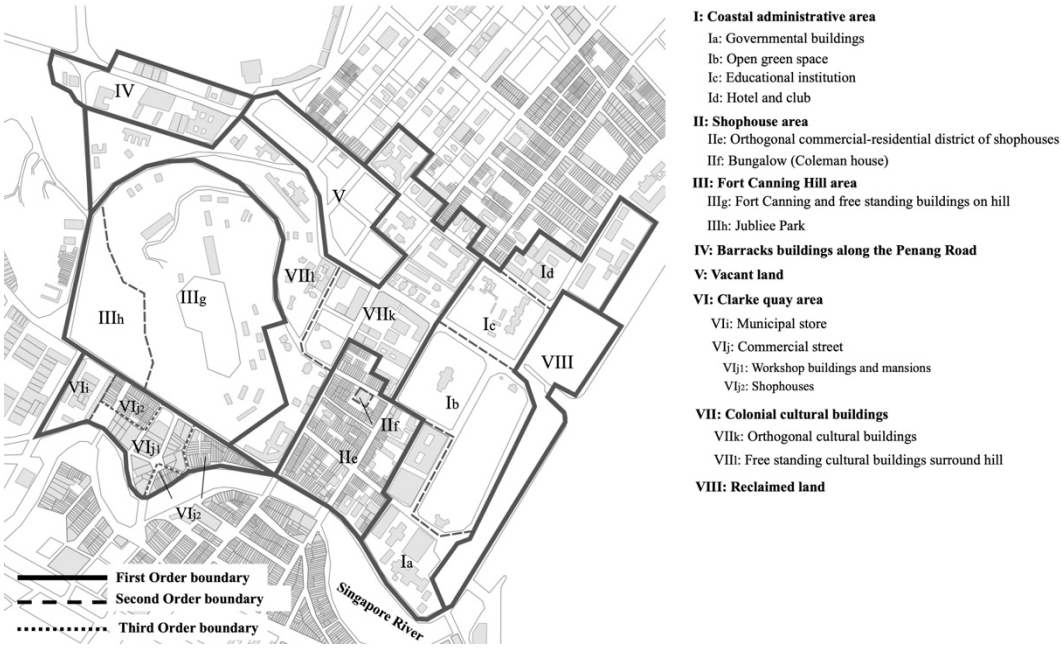

Figure. 3 Morphological Region of the Later Colonial Period (based on 1950 aerial photo)

Costal administrative area (I) expanded northward along the coastline. The Raffles Hotel and several clubs (Id) were established along the coast on the north of Raffles Institution (Figure.3). The open square Esplanade expanded to its current size during this period. It was called "the Padang," in Malay, meaning "field," which later became its official name. With the City Hall and the Supreme Court built in 1929 and 1939, the colonial government building groups surrounding The Padang took the shape as we see today. In the tentative UNESCO World Cultural Heritage description, The Padang and the surrounding colonial civic buildings are referred to as “The Padang Civic Ensemble” to present the heritage value of typical British colonial civic square. It includes the Parliament House buildings to the south of The Padang, St. Andrew's Cathedral to the west which were already built in the first period, and the City Hall and Supreme Court (Ia and Ib).

During the second period, the bungalow residential areas evolved into two distinct zones, shown as Shophouse area (II) and Colonial cultural buildings area (VII). Shophouse area became a district composed of shophouses streets. This newly emerging type of building and plan during the period was a commercial-residential district characterized by an orthogonal street pattern, with shophouses aligned along the streets, forming dense, continuous rows. Shophouse is a king of mixed-use building commonly found in Southeast Asia and southern China. It typically features a narrow and long shape, with the ground floor used as shop and the upper floors as residential areas (Han & Beisi, 2015). As the population grew, the racially segregated planning zones of the colonial era could no longer accommodate the original population. During this time, the Chinese population overflowed from their original settlement on the southern bank of the Singapore River into the northern bank areas, which were previously designated as the government area and European Town in colonial plan. Due to population growth, the low-density bungalow residential areas, with larger plots, were partially replaced by shophouses which had smaller, more tightly subdivided plots, creating high-density commercial-residential districts.

In colonial cultural buildings area (VII), colonial-style cultural buildings replaced the original bungalows. Part of cultural buildings orthogonally laid out within the orthogonal street grid that was

established in the earlier periods (VIIk). This area includes Singapore's most exclusive theater at the time, the Capitol Theatre (Tan, 2015), the first telephone company, Oriental Telephone Company (Chua, 2011), and the department store Whiteaway Laidlaw (Jia, 2020). Another part (VIIl) consists of free-standing public service buildings arranged along the contours of the hill. This area includes public cultural buildings like the Raffles Library and Museum, as well as community buildings such as the Young Men's Christian Association (Y.M.C.A) and the Young Women's Christian Association (Y.W.C.A).

The Fort Canning Hill area (III) is where Government Hill was located during the first period. In 1859, the government house on the hill was relocated, and construction of military fort Fort Canning began at the original site, which was completed in 1861. From then on, the hill became known as Fort Canning Hill. In the previous period, Clarke Quay area (VI) already served as a commercial hub with trading activities and shop buildings, but no road system had yet been established. During this period, roads was developed in Clarke Quay, connecting it with other areas and forming a distinct street grid. It consisted of the Municipal Store area (VIi) and the commercial street area (VIj). The commercial street area was characterized by a central cross street (VIIj1) flanked by shophouses on either side (VIIj2). The central cross street included wealthy merchants' mansions, such as River House (Yeo, 2018), and various workshops, including a rice mill.

Third Period: Transitional Period (1950-1990):

The main morphological changes of transitional period were due to slum clearance and population decentralization carried out in the 1960s-1970s. As the city centre, the Civic District saw its previously crowded neighbourhoods demolished and the population relocated to suburbs. The land emptied by the slum clearance was restructured and redivided, with high-value commercial properties introduced (Wong, 2001). In 1962, in urban planning consultation from United Nations, UN advisor Eric Lorange recommended redevelopment precincts that included parts of the Civic District (Red highlight of Eric Lorange Plan in Figure.5). These areas encompassed the banks of the Singapore River and the southern section of the central blocks within the Civic District, which were exactly the high-density shophouse streets. In subsequent urban plans, the central blocks of the Civic District were consistently designated as part of a planned commercial corridor (Red highlight of 1963, 1985, and 1988 Plan in Figure.5). This led to the continuous expansion of the commercial buildings area. Large-scale new modern public buildings were constructed, such as major multistorey shopping complexes and luxury hotels. New national landmark buildings were also erected in this area, including the National Library and the National Theatre.

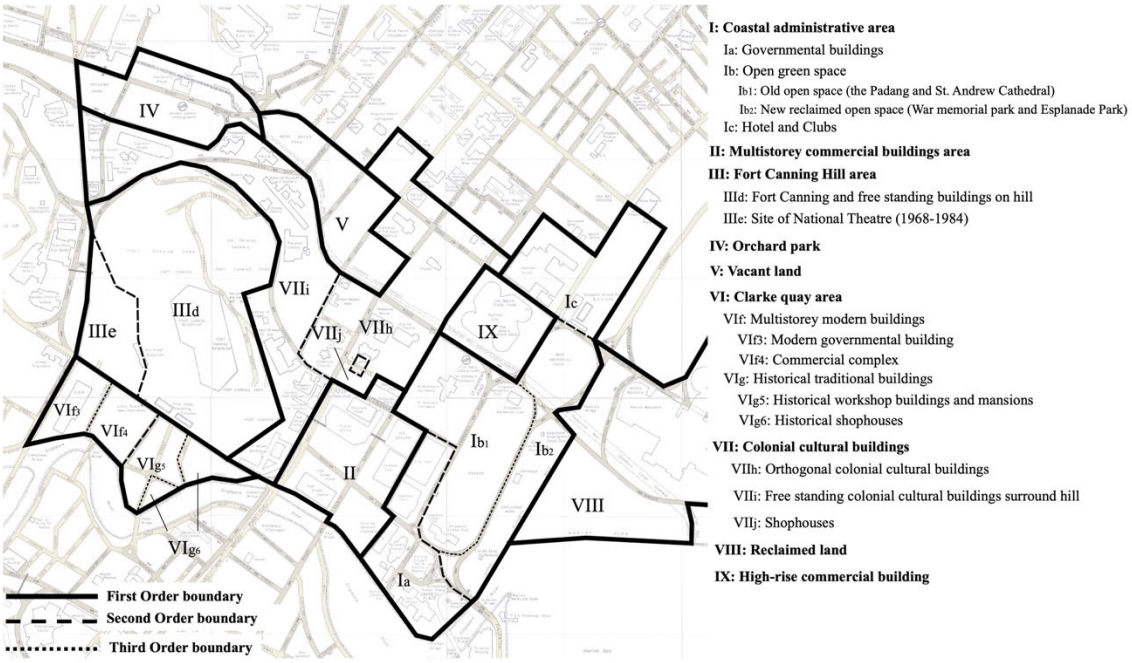

Figure.4: Morphological Regions of the Transitional Period (based on 1988 Aerial Photograph)

Persistent land reclamation altered the coastline of Civic District. For example, costal administrative buildings area (I) expanded during this period. War Memorial Park and Esplanade Park (Ib2) were established as extensions of open space on the newly reclaimed land from last period (Figure.4). Additionally, reclamation of Marina Bay was completed during this time (VIII), which was planned as new commercial and tourism hub. The former costal administrative buildings and The Padang no longer bordered the sea.

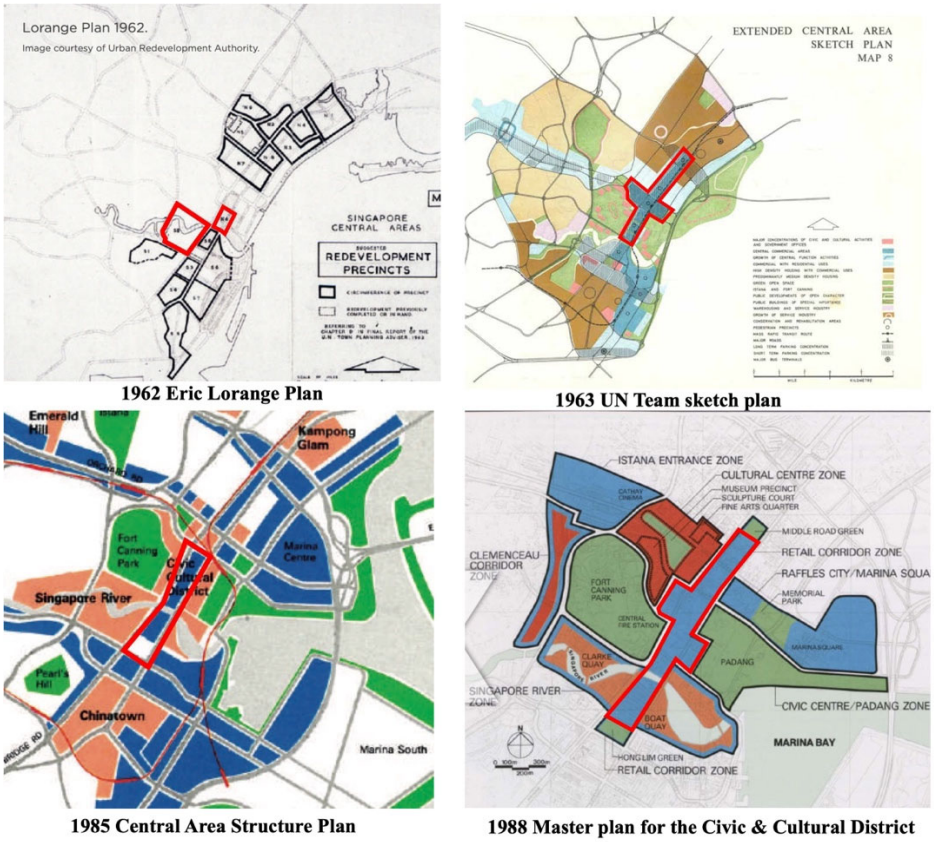

Figure.5 Master plan of the Civic District since 1962 to 1988 (Guo, 2016; URA, 2019)

Shophouses as a high-density residential model from the colonial era were largely demolished in city center during this period due to population decentralization. Previous shophouse area (II) and Clark Quay area (VI) were the most affected by this change. Multistorey commercial buildings area (II), which was shophouse area in last period, saw most of original shophouse districts removed during urban renewal. New buildings were modern multistorey commercial complexes, such as Funan Digital Mall and High Street Centre. Similarly, in Clarke Quay area, some of shophouses (VIf4) were demolished to make way for high-rise hotel, apartment, and commercial complexes (NHB, 2023c).

Site of high-rise commercial building (IX) was original site of Raffle Institution before it was relocated. In this period, the old building of institution was demolished to make way for Raffle City. Raffles City is a 150-meter-tall high-rise complex with four towers, designed by famous modernism architect I.M. Pei. The complex consists of the one-time world's tallest hotel and currently the world's fourteenth tallest hotel. This modernist skyscraper is a new building type in the Civic District, occupying the entire block. Its huge volume and modernist style contrast to the surrounding colonial buildings.

Fourth period): Cosmopolitan period (1990s- now):

In the 1990s, some of the national landmark buildings from the early independent period outdated and no longer met the needs. Some remained and were conserved at their original locations, such as the Supreme Court and Parliament House, while others were demolished and relocated to different areas, such as the National Library. Master plan for the Civic & Culture District was issued in 1988, which is the first special plan for Civic District. Subsequently, first conservation plan of Singapore was

issued in 1989, and a new master plan was issued in 1991. Urban heritage conservation began to gain attention, with the Civic District's role shifting to a cultural tourism destination and a colonial heritage area. As a global city, Singapore required new national landmarks. Marina Bay (VIII), the most significant urban project at the turn of the century, was reclaimed in the early 1990s and completed during this period, becoming a new national landmark (Figure.6). Marina Bay extended the physical area of the Civic District, as indicated in the 1988 master plan of Civic & Culture District. The newly built theatre named The Esplanade, functionally replaced the demolished National Theatre, becoming part of the Civic District.

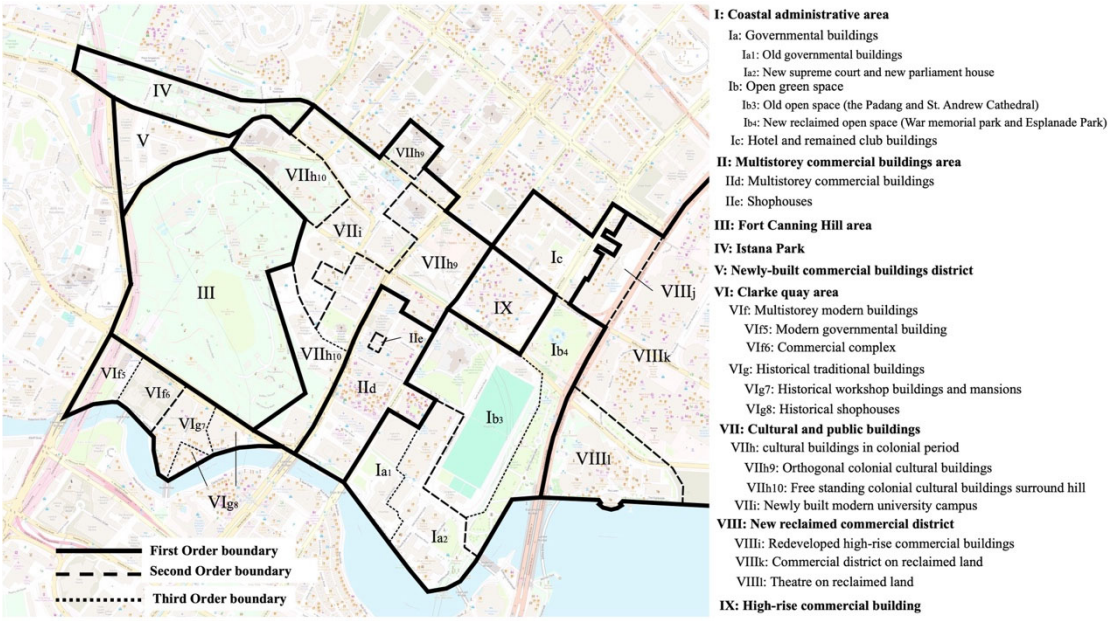

Figure.6 Morphological Regions of the Cosmopolitan Period (based on current Open Street Map)

During this period, indicating the development of a modern commercial building area (II), the boundary between it and Cultural and public buildings area (VII) shifted further north. A new building type emerged in former colonial cultural buildings area (VII): the modern university building. During this period, Singapore Management University established its campus in the Civic District (VIIi), and the former colonial culture area was fragmented by the modern campus buildings.

RESULTS AND DISCUSSIONS

Through diachronic analysis of the four periods the transformation of the different hierarchies of morphological regions of the Civic District are examined. From the first-order morphological regions over four periods, it shows that the origin of the civic district as a colonial center has gradually transformed from a governmental district to a cultural and tourism hub. Costal administrative area (I) and Fort Canning Hill area (II), serving as the eastern and western boundary of the area, has remained stable throughout its development. These two were also the earliest functional area of a colonial administrative center as military and governmental area. The coastal administrative buildings area expanded northward along the coastline during the colonial period. After independence, due to land reclamation, this area no longer relied on the coastline as a boundary, but its morphology has largely remained stable. Similarly, Fort Canning Hill served as the governor's residence in the early colonial period, became a military fortress and was later transformed into a public park after independence. While despite the functional changes, the morphology of this area has remained largely stable with

no significant change. These two areas define the boundaries of the Civic District. Meanwhile, these two areas are where the public functions and heritage of the Civic District are best conserved. Within the constraints of these two zones, development in the Civic District has tended to be more connected to the north and south, rather than west or east oriented.

Compared to the relatively stable morphology of Fort Canning Hill and the coastal administrative buildings, Multistorey commercial buildings area (II) and Cultural and public buildings area (VII) between the hill and the coastal buildings have undergone more frequent changes in form, influenced by the socio-economic context and planning of different periods. These two areas which used to have same pattern in the early colonial period, became differentiated in the later colonial period. The southern area (II) near Chinese immigrant settlements, turned to a high-density commercial-residential area due to population overflow in Chinese settlement (Figure.7). The area developed smaller blocks and more brunch roads based on the rectangular street networks from the previous period. Within the blocks, the land plots are subdivided in a terraced layout along street. The shophouses built on this were narrow and terraced, corresponding to the shape of land parcel. In contrast, the northern blocks (VII), close to the European Town designated in the colonial plan for European residents, evolved into a lower-density area primarily characterized by colonial cultural buildings in the later colonial period with lower land plot density. Correspondingly, the buildings are mainly colonial-style cultural buildings with larger scale than shophouse (Figure.7, Figure. 8)

The differentiation was continued in the transitional period. Due to the extensive urban renewal, the southern area contained shophouses area undergone the plot amalgamation in the transitional period. Land plots and blocks were amalgamated. Shophouses were replaced by modern multistorey commercial buildings. Streets lined with shophouses turned to commercial district dominated by shopping malls. The northern area, however, was less affected by urban renewal. The form of land plots remained stable during this period, with most buildings being preserved due to their value as public and cultural buildings from the colonial era. In the subsequent cosmopolitan period, the boundary between the two areas continued to shift northward due to the ongoing commercial development in the south.

In the morphological regions delimitation, second-order and third-order regions were delimitated based on building types and land use. Their transformation reflects the increasing variety of building types within the macro morphological framework of the Civic District. For example, during the colonial period, the types of secondary morphological regions were still limited, and the building types and land use within each first-order region were relatively uniform. However, after independence, urban renewal disrupted the original layout, especially after the 1990s, when more modern buildings replaced older ones on the original plot. For instance, in the Cultural and public buildings area (VII), the secondary regions were relatively uniform during the colonial period. In the cosmopolitan period, the emergence of modern campus buildings led to significant changes in the secondary regions of this area. Similarly, during this period, the secondary regions of the coastal administrative buildings area underwent substantial changes due to the construction of new government buildings.



Figure.7 Changes of morphological regions in centre of Civic District in four different morphological periods

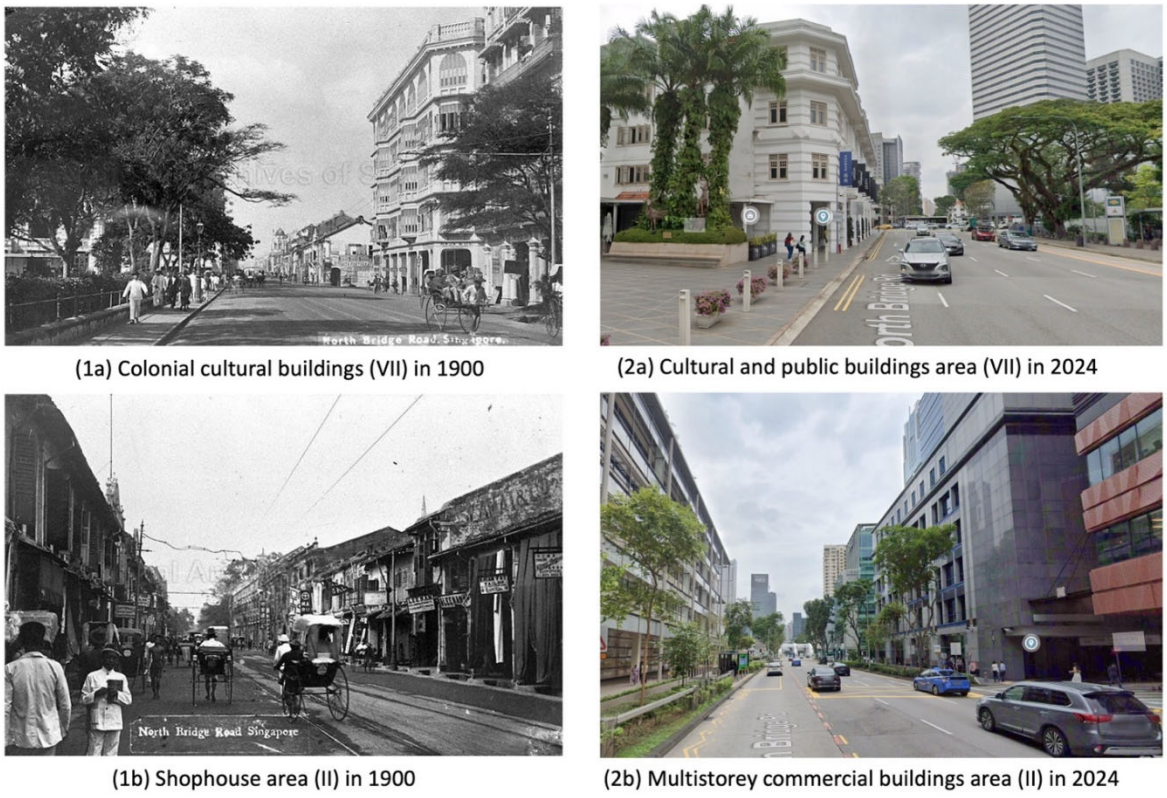

Figure.8 different street views of a same street, North Bridge Road, in Multistorey commercial buildings area (II) and Cultural and public buildings area (VII) in 1900 (1a, 1b) and 2024 (2a, 2b). (1a) Colonial cultural buildings (II) in 1900, (1b) Shophouse area (II) in 1900 (source: National Archives of Singapore); (2a) Cultural and public buildings area (VII) in 2024, (2b) Multistorey commercial buildings area (II) in 2024 (source: Google Street View)

CONCLUSIONS

The historic-geographical analysis of the Civic District provides insight into the evolution of Singapore's historical area, tracing its transformation from a colonial administrative center to a cosmopolitan city center. This analysis reveals that the history of the Civic District extends beyond the governmental area planned in the Jackson Plan, highlighting its development into a multifunctional urban area over the colonial period. The existing built heritage in the district encompasses legacies from multiple periods, reflecting the influence of various socio-economic backgrounds on the built environment. The results of the morphological analysis can serve as a reference for conservation planning. Diachronic morphological analysis reveals the development process of the existing isolated heritage site within boarder historic landscape. Meanwhile, the delimitation of morphological regions provides a broader boundary reference for the currently fragmented conservation sites. It complements the traditional top-down planning process and presents an analytical methodology to the current challenges in Singapore's heritage conservation efforts.



Figure.9 Current conserved heritage of Civic District (Based on current Conservation Guideline, Urban Redevelopment Authority, Singapore. Data source: data.gov.sg

There are two kinds of conserved heritage sites in Singapore: Conservation Areas designated by the Urban Redevelopment Authority and National Monument and National Monuments designated by the National Heritage Board (Figure.9). Unfortunately, some urban heritage sites have already been demolished by urban redevelopment, resulting in fragmentation of surviving historical areas. This has resulted in the current designation of conserved sites being further fragmented the historical connections among them. Additionally, the boundaries of some conserved areas only consider isolated historical buildings, without considering the broader urban landscape they were located in.

Morphological analysis showed that individual site belongs to the same morphological region, suggesting a lager urban landscape of historic value. Identifying these regions can help expand the conservation scope and reconnect fragmented heritage sites through historical analysis. Taking the open square (The Padang) as an example, the Padang and the surrounding government buildings were submitted in 2022 as the Padang Civic Ensemble, a typical civic square of British colonial rule, for tentative UNESCO World Cultural Heritage status. In the domestic heritage conservation policy, The Padang was designated as a National Monument in the same year. Thus, The Padang and its

surrounding colonial-era government buildings are now recognized as a conserved heritage site. However, in the conservation policies, these were not included within a conservation area as part of a historic urban landscape with integrated heritage value. Based on the above delimitation of the morphological region, it can be observed that the heritage of The Padang and the surrounding government buildings belongs to the Coastal administrative area (I) in morphological regionalization. This region stems from the tradition of British colonial urban design, characterized by an urban core composed of open squares and the administrative buildings arranged around them. This pattern was established early in the colonial period and expanded along the coastline, stabilizing in function and form during the later colonial period (Figure.10).

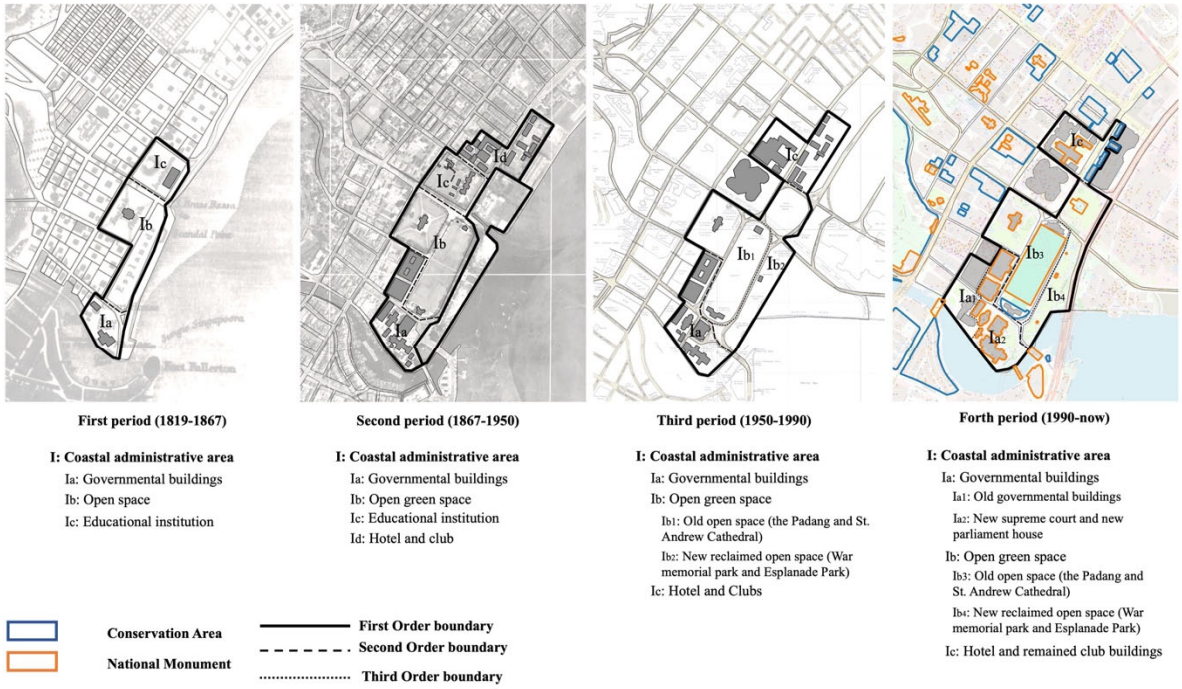

Figure.10 Transformation of Costal administrative area (based on cadastral map of 1846, aerial photo of1950, buildings map of 1988 and current Open Street Map)

The boundary of the first-order morphological region identified in this study can serve as a reference for a broader conservation boundary. The open space and government building complex that once stood along the coastline were no longer located by the coast within the city after independence due to land reclamation. As a result, the connections between these isolated heritage buildings have been overlooked. Managing this series of heritage buildings within a broader area would reflect the historic functional zone these heritage sites once served in the city and highlight their historical connections. Meanwhile, having a larger buffer reduces the potential hazard of new constructions that might greatly differ from their surroundings, disrupting the overall integrity of the historic district. Moreover, the second-order and third-order of morphological regions reflect the building types within the area, which can serve more detailed historical area management. Modern government building areas and historical government buildings belong to different third-level regions. This zoning provides an area-based reference on control coding for ensuring style unity in potential adaptive renovations within historical areas.

This study provides a feasible example of examining the pre-colonial city center of a Southeast Asian city and its evolution from a morphological perspective, but there are still some shortcomings and

areas for improvement. For instance, future research could expand the scope to include all historic districts from the colonial period and their evolution, not just Civic District, to explore the overall development process of historical urban areas. Additionally, a comparative research method based on the same morphological perspective could be applied, focusing on other Southeast Asian cities with historical backgrounds like Singapore, such as Penang and Malacca in the Malay Peninsula, to explore the broader application of morphological methods in the study of Southeast Asian colonial heritage.

Endnote

1. The bungalow originated from the early vernacular houses of South Asia and the Malay Peninsula (King, 1974). During the British colonial period, the British adapted these indigenous houses to create single- or double-story villas with sloped roofs. The wooden structures in vernacular houses were often be replaced with brick walls or brick columns when the British built it.

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Transitional morphological scales. the impact of gigamorphologies on the unitary expression within the urban morphology sciences

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ABSTRACT

In 2002 De Jong & Rosenmann postulated scalar variations within the scientific framework aimed at research and analysis of the urban, architectural, and technical disciplines. Under the heading of ‘unravelling scales’ twenty-two scale variations are associated to the analytical spectrum of the build landscape. Commencing at the submaterial scale (units with nominal radius smaller than a millimetre) and ending with the global scale (units with nominal radius of 10 000 kilometres), the scale variations cross the scale orders of ‘building segment’, ‘buildings’, ‘building complexes’, ‘ensemble’ and ‘neighbourhoods’ amongst others, claiming morphological positions nine to thirteen within their twenty-two-scale protocol. When compared to the morphological sciences, the aforementioned scale entanglements have produced dependencies within the expression of measurable and quantifiable morphological units valid for medium dense cities, but ineffective as a scientific instrument in the contemporary atmosphere of giga scale undertakings.

The purpose of this paper is to critically reflect on De Jong and Rosenmann's suggested scale order, criticising its validity and contemporary morphological valance. Furthermore, the article will advocate for the revision and probable implementation of new morphological scale orders that incorporate other scale variations that reflect current urbanisation developments. Using case studies from across the world, with a focus on megablocks and compact-city-territories scales, the study will align and introduce the new orders inside De Jong and Rosenmann's scale protocols particularly relevant to the morphological sciences. Conclusions are formed on the transition from traditional scale orders to what could be referred to as 'mega-morphological scales' and new urbanisation units based on compact-city-territory phenomena, emphasising the need for scalar revisions as part of the evolutionary development of urban morphology as a science.

Keywords: Megamorphologies, Scale orders, Compact-city-territory, Morphological units

INTRODUCTION

The concepts of scale have a significant influence on urban form and its broader discourse. (Oliveria, 2016; Kropf, 2018). When examining the city from a variety of perspectives, whether it is comprehending the city as a walkable context (Van Nes, 2021), the morphology of a post pandemic city (Batty, 2021), recognising the urban landscape as intricate systems (Nel, 2022; Salat and Boudric, 2012), or perceiving the individual elements of the city (Fleischmann, et al., 2020), the concept of scale continues to be an essential component in all urban discourses.

Expanding the scope, the relevance of scale continues to be very relevant to all elements of the morphological sciences, as evidenced by the 1.6 million results on Google Scholar that belong to subjects of scale and urban morphology. The scalar evolution within urban morphology has developed significantly over the last decades. Commencing with the three schools of thought (Italian, French and British), the noteworthy differences in analytic perspectives that we observe today, have provided unique analytic nuances in the use and application of scale. The application of scale in the assessment of urban transformations, the typological variations of unitary urban elements to the comparison of villages and cities, has now developed analytical expertise across new scales on either side of the low scale orders, as for example, interiors (Monteiro, 2022), toys (Zhang, 2013) and on the opposite scale, high scale order for example region, urbanised complexes (Krenz, et al., 2017) scale spectrums.

However, the validity and applicability of this framework have been called into question, particularly in the context of contemporary megascale urban developments. Moreover, the rapid pace of urbanization, coupled with the ambitions of larger projects, has led to the emergence of giga-scale projects, which encompass vast areas and complex infrastructures. Projects as Neom (Saudi Arabia), Amaravati (Egypt), and Chengdu Future City (China), as either conceptual or realised projects have begun to challenge the traditional morphological scales, necessitating the development of new frameworks that can accommodate the scale and complexity of contemporary urbanization.

Regional concepts as the Greater Bay Area GBA, drawing together 11 cities, or the concepts of urban and mega regional compaction (Endemann, 2024), have destabilised the interconnections between scale and morphology. Such scalar shifts have highlighted a new focus on the meaning and importance of scale, not as a mere analytical variable, but as an equally critical conceptual tool challenging hierarchical levels of large-scale urban trends.

In this framework, and given the notable trends in developmental scales, we view this as an opportune time to reconsider and reinterpret scale as a crucial determinant, questioning scale’s significance for the field of morphological sciences. This paper seeks to analyse and evaluate the scale orders proposed by De Jong and Rosenmann (2002), assessing what they propose, and its applicability in the present context of new giga projects through case study.

The paper is organised in the following manner. Section one constructs the foundation and premise within and De Jong and Rosenmann's scale proposals. Section two outlines the methodology and case selection, Section three presets four mega block cases in the Greater Bay Area. Section four and five, the discussion and conclusion clarify the transition from traditional scale orders to what could be referred to as 'mega-morphological scales' and new urbanisation units based on compact-city-territory phenomena, emphasising the need for scalar revisions as part of the evolutionary development of urban morphology as a science.

MORPHOLOGICAL SCIENCES AND SCALE ENTANGLEMENTS

In 2002, as part of a publication on Ways to Study and Research Urban, Architectural and Technical Design, De Jong & Rosenmann presented a chapter entitled "Naming Components and Concepts". In this chapter they discussed the dual nature of a problem that connects physical objects to specific names or terms through a scale hierarchy. Their chapter, which is part of a compendium on research methods, highlights the significance of naming that establishes the methodological consequences of measures and comparison. The text not only revolutionised the comprehension of scale in design, but also establishes a simultaneous connection between material nomenclatures and methods of measurement across urban, architectural and technical fields.

In addition to their discussion about research nomenclatures, their chapter devotes a section to the issue of scale. Under heading of "Unravelling Scales", a subsection in the chapter, De Jong and Rosenmann presented twenty-two different scale variations that range from the sub-material level (units smaller than a millimetre in size) to the global scale (units with a size order of 10,000 kilometres) (Table 1). The twenty-two scales traverse various orders, including 'building segment,' 'buildings,' 'building complexes,' 'ensemble,' and 'neighbourhoods,' occupying morphological positions nine to thirteen within their scale protocol, each with measurable metrics, expressed as millimetre (mm), meter (m) or kilometre (km).

De Jong & Rosenmann's definition shifts the focus from understanding scale to the crucial issue of the interdependence between metrics and objects. Object-metrics assess the extent to which disciplinary boundaries and analytical methods restrict or facilitate the exchange of analytical capabilities. 'Light' scale orders are interconnected properties that exist within and across spatial conditions of objects related to architecture, whether it be virtual, real, or perceptual.

At greater depth, De Jong & Rosenmann's low-range scales dependencies are specific to the submaterial scales (scales 2 – 7; submaterial, material, supermaterial, subelement, element, superelement, building component), relevant to materials sciences, and less useful to morphological analysis of the built landscape. Mid-range scale links with urban morphology, making the crossover between the architectural artefact and the neighbourhood (scales 8 – 12: Building part, building segment, building, building complex, ensemble). Upper and midrange orders are specific larger portions of cities, covering neighbourhoods and villages (scales 13 – 15; Neighbourhood/Hamlet, Area/Village, Local District, Borough). Scale emphasis shifts radically at scale orders 16 – 19, covering the orders of sub-regional, regional, sub-national and national hierarchies (Table 1).

Such scale entanglements proposed by De Jong and Rosenmann have established interdependencies in the representation of measurable and quantifiable morphological components. Although these scales are suitable for cities with a moderate level of density, they are not adequate as scientific instruments when it comes to large-scale projects commonly witnessed today.

De Jong and Rosenmann's entire scale spectrum, has to date received limited assessment from within the possibilities they hold for new directions in Morphological sciences and in particular, the scales of giga development. Our hypothesis posits the inclusion of a new scale level called 'subnational' within the existing variations of giga or mega scale morphological frameworks. This would involve

reconfiguring the metrics and indices associated with giga scale and morphological measurements, moving away from the scale ranges of 'building segment,' 'buildings,' and 'building complexes.'

METHOD

This research aims to demonstrate the capabilities of De Jong and Rosenmann's scalar ladder by conducting a comparative analysis between their scalar orders and those used in previous large-scale studies. The emphasis of this analysis is on megablocks as constitutive part to giga-city-territories. Moreover, the presence of giga size projects exposes the material evidence validating the need for further comparison of scale possibilities.

Presented here is a comparative methodology, mirroring De Jong and Rosenmann's scale order with new as well as existing morphological scales to test the fit between current urbanisation patterns with scales hierarchies. The integration of De Jong & Rosenmann's Protocols with 'mega-morphological scales,' has the potential to provide a more precise framework for analysing the intricacies of contemporary giga formations, and moreover, possibly highlight the scale challenges associate with giga projects. Specifically, De Jong & Rosenmann's scale protocols, and its relevance to morphology pertains to scale orders 10 (Building) through 15 (Sub-regional). Outlier examples relate to the examination of typological analysis, specifically focussing on scale order 9 (building segment) and 10 (buildings), evident from ongoing morphological research.

As context for enquiry, the Greater Bay Are (GBA), previously referred to as the Pearl River Delta, is situated in the southern tip of China. The GBA metropolitan entity comprises of 11 cities: Guangzhou, Foshan, Zhaoqing, Huizhou, Dongguan, Zhongshan, Shenzhen, Jiangmen, Zhuhai, Macao and Hong Kong (Bayarea.gove.hk, 2024), with an official population exceeding 86 million (Ibid). The GBA consists of two Special Administrative Regions (S.A.R.) - Hong Kong and Macau, renowned as global hubs for finance and gambling, respectively. Additionally, there are two Special Economic Zones (S.E.Z.) - Shenzhen and Zhuhai, with Shenzhen being renowned as one of the most populous migrant cities. In addition, GBA is equipped with three prominent logistics centres, three international airports, and various ex-urban or previously rural regions such as Longgang, Shunde, and Nansha. The region displays a wide range of spatial conditions and varying degrees of uneven spatial development, all encompassed within an area of 56,000 km^2.

The incorporation of GBA as unitary urbanised entity involves intricate geographical and structural intricacies. For instance, the integration of infrastructure, logistics, and replication at a geographic scale, such as the duplication of cargo handling facilities, or competition between GBA cities, could restrict future growth in terms of available space. The analytical metrics of five cases presented here make use of a five-factor analytical technique to accurately quantify a collection of morphological characteristics expressed through analysis of (a) Block sizes, (b) Block shapes, (c) Road Density, (d) Connectivity and, (e) Proximity.

Each of the five cases consists of case information, an aerial photo, analytical maps for five parameters, calculation results, and analysis. The case information includes the case number, case name, the urbanism type it originated from, and location specifics within China. The aerial snapshot acquired from Google Satellite offers a contextual viewpoints. The morphological study itself, focusses

on five key factors: factor 1 Area (the area of blocks), factor 2 Shape Index (the complexity of block forms), Factor 3 Density (the density of cases and roads), Factor 4 Connectivity (the betweenness of road networks in cases), and Factor 5 Proximity (the closeness of road networks in cases). The determination of factors 1-2 is based on block morphology, whereas factors 3-5 are obtained from the analysis of the road network. The computation results exhibit the values of the subsequent variables for each case, namely: (1) Mean block area in square meters, (2) mean form index value, (3) road density per square km, (4) The outcome of the connection test, (5) Proximity, which is assessed at a local level and cannot be compared between other situations.

The five-factor assessment framework utilises block-level metrics such as size and shape, along with case-level road network analysis including density, connectivity, and proximity. This framework is used to analyse and describe the fundamental elements of the morphological DNA found within the case compendium. The standardised analysis layout allows for quick and easy comparison of cases in the compendium. The aerial views provide a comprehensive understanding of the urban layout, while the mapped factors uncover more specific information. Subsequent analysis will clarify how cases cluster and distribute within the factor space, revealing discernible patterns. However, one's admiration also grows for the distinctiveness that each artefact acquires from its cultural environment, geographical circumstances, and architectural principles. The maps reveal an intricate interaction of forces. Architectural texture provides a privileged understanding of the exposition.

More importantly, factor 1 and 2 - block size (area test by block), examines the scale and dimensions of urban blocks within each case. It is quantified by calculating the mean block area in square meters for each case study. Larger mean block sizes indicate larger urban blocks and scales. Block size metrics can be analysed at the case-level or individual block-level.

The five-factor assessment framework considers block-level metrics like size and shape, as well as case-level road network data like density, connection, and closeness. This framework is used to analyse and describe the fundamental elements of the morphological DNA. The analysis-layout enables rapid and easy comparison of examples across five cases. The aerial views give a complete picture of the metropolitan layout, whereas the plotted factors reveal more particular case information. Subsequent analysis explains how examples cluster and spread within the territory, exposing identifiable patterns. Other attributes as cultural milieu, geographical circumstances, and architectural principles are used as additional variables to highlight case characteristics.

Using plug-ins like sDNA on a GIS platform can automate the process of developing morphological algorithms. However, it is worth noting that human judgement remains an essential part, vital to the morphological analytic process. The rigorous process of clearing, creating, editing, analysing, and formatting each case study reveals information that automated extraction overlooks.

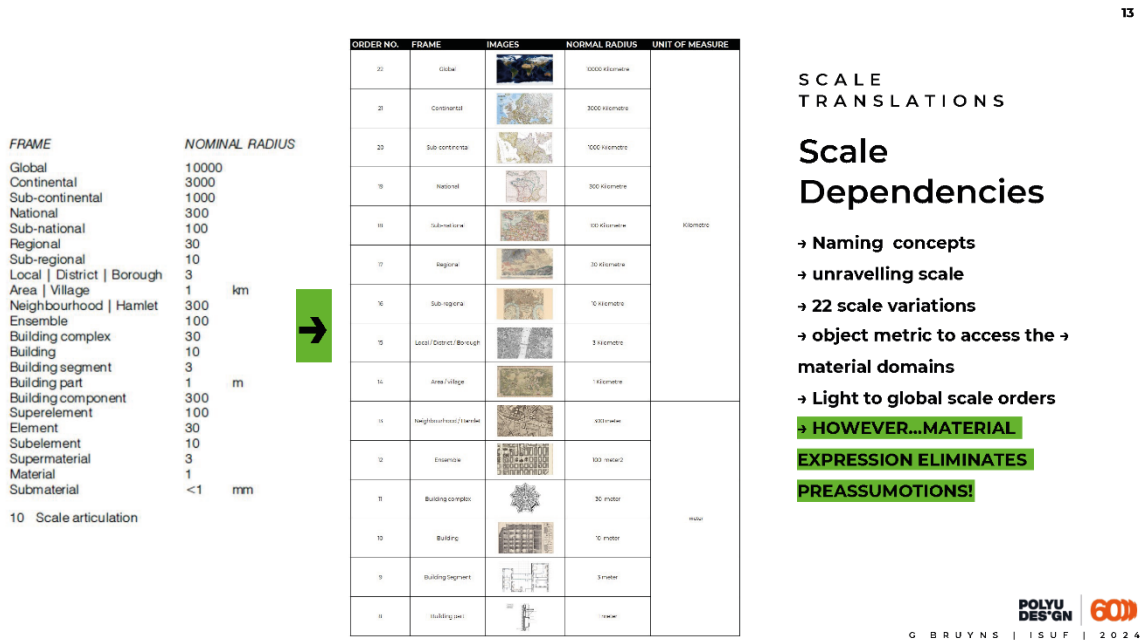

Table 1. Left, De Jong and Rosenmann's (2002) scale table, indicative of the 22 scale orders. Right, the translation of De Jong and Rosenmann's table into spatial evidence in a material build form. Credit: authors, 2024.

CASES

Transitional Morphological Scales presents four cases specific to the Greater Bay Area and its morphological expression. The cases pertain to: Macau SAR, Guangzhou, Shenzhen and Zhuhai.

Case 1: Macau. Macau, a Special Administrative Region (SAR) in the Greater Bay Area, operates as a major gambling hub. Covering an area of 8,573 square meters. The city blends historic expansions with newly reclaimed swamp land, resulting in compact and small blocks. The road network is characterized by frequent angle changes, which reduce its proximity and connectivity indices. The closeness index is moderate to high at 1.547, while the betweenness index is in the higher percentile, reflecting its historical development. Macau has a shape index of 1.334. In morphological terms, Macau's block size index is the lowest among the four cases examined, typically falling within the 0 to 2,000 block size range. Although there are exceptions with some blocks reaching the 126,000 to 164,000 block range, most of Macau's blocks align with the 6,000 to 7,000 block index. This reflects a generally compact urban form, distinct from the larger block patterns observed in other cities. However, this is an exception within the block pattern, as most of Macau's blocks typically fall within the 6,000 to 7,000 block range.

Case 2: Guangzhou. Located in the northeastern part of the Greater Bay Area, Guangzhou spans 40,101.4 square meters. The city has evolved from an old town district into a modernized urban area. It boasts high overall connectivity and fair road density. The closeness indicator is in the higher percentile, while the betweenness index varies from middle to high. Guangzhou has a shape index of 1.314. Proximity tests suggest that the 15-minute walk concept is more feasible in the historic district than in modern developments. Guangzhou's block sizes are extremely large, ranking at the highest level on the matrix scale, with a dominant block size range of 126,000 to 164,000, setting the metrics for extensive sizes and variations to formal block dimensions specific to giga scale development.

Case 3: Shenzhen. Shenzhen, in the southeastern part of the Greater Bay Area, exemplifies hyper-industrialization and urban development over the past 50 years. Covering 29,337.33 square kilometres, it has a shape block size index of 1.278 and a road density of 11.796. The city features distorted rectangular megablocks influenced by the coastline and grid structures. Some megablocks are open on one side, with sub-roads providing connectivity. Proximity performance is medium-low, and block sizes are extremely large, though slightly smaller than Guangzhou's but larger than those in comparable Western cities.

Case 4: Zhuhai. Zhuhai, situated above Macau, covers 60,754.67 square meters and has experienced significant industrial growth over the past 20 years. The city features medium-sized rectangular blocks with insufficient road density, though connectivity and proximity in major areas are acceptable. The road density index is 7.771, and the connectivity index is 1.555. Morphologically, Zhuhai's block sizes align with Guangzhou's, falling within the block size range of 126,000 to 164,000. The betweenness index is middle-high, and the closeness index is in the higher percentile compared to other cases.

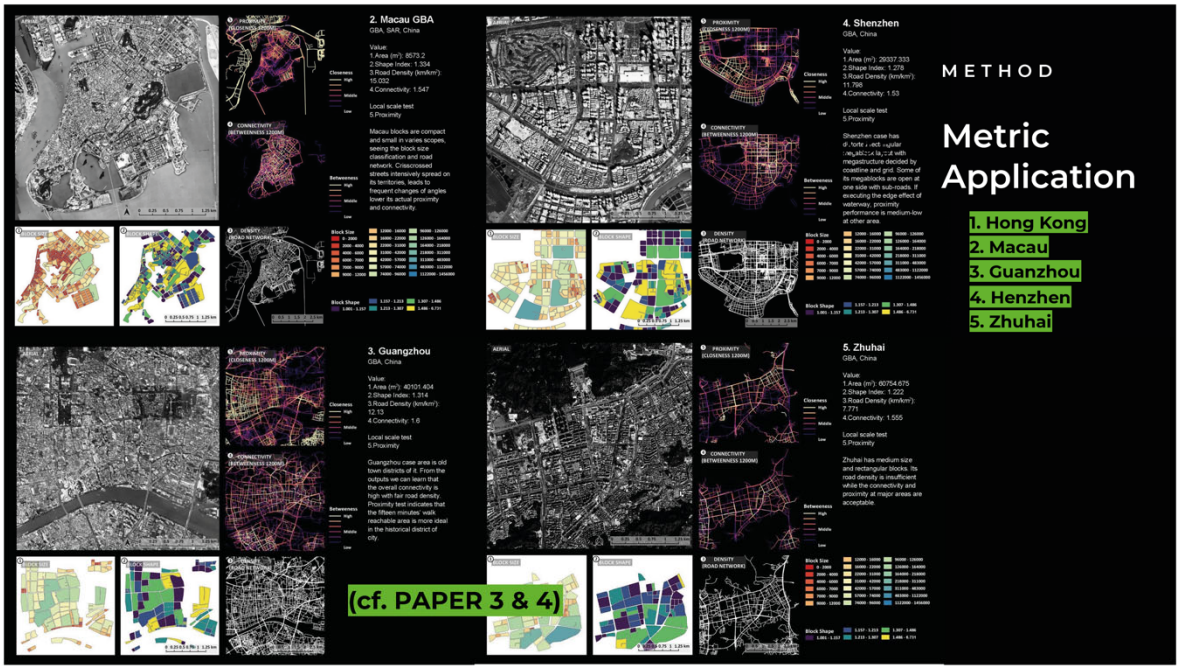

Figure 1. The collection of presented cases, capturing Macau, Shenzhen, Guangzhou, and Zhuhai, Mega City development part of the GBA. Credit: authors, 2024.

RESULTS AND DISCUSSIONS

Comparatively, the four cases shown highlights the diverse urban morphologies within the Greater Bay Area, each city reflecting unique developmental trajectories and planning strategies. From Macau's compact blocks to Shenzhen's megastructures, these cases provide insights into the region's dynamic urban landscape, and the upward shift in the morphological block formation scales.

Each case is exhibited utilising a consistent visual and data protocol as illustrated in image 1. The compilation of aerial photography, case particulars, and factor analysis collectively enhances the case overview. The physical attributes of each case, both collectively and individually, form the basis for subsequent morphological comparative analyses. The GIS plugin tool, Polygon Shape Indices (PSI),

automates the quantitative assessment of morphological properties, thereby streamlining the evaluation of polygon geometry and complexity. Polygon Shape Indices calculates over twenty distinct variables to characterise the dimensions, configuration, and complexity of spatial entities, including urban blocks and structures. These variables are employed to delineate the broader geographical entities.

Furthermore, the body of work builds upon the principles of Spatial Design Network Analysis (sDNA). This approach employs mathematical graph representations to model urban street networks, facilitating the assessment of their structure and connectivity (Barthelemy, 2011). In the sDNA framework, street segments are represented as graph edges, and intersections are illustrated as nodes. This facilitates the quantification of critical metrics, including the distribution of node degrees and the density of intersections (Porta et al., 2006).

Furthermore, advanced sDNA methodologies can assess integration, intelligibility, and synergy to evaluate the efficacy of spatial networks. sDNA employs graph theory to provide planners with vital mathematical metrics for analysing network structure and connectivity, essential for promoting dynamic and sustainable urban morphology.Moreover, the body of work enhances Spatial Design Network Analysis (sDNA). sDNA utilises mathematical graph representations to model urban street networks, facilitating the quantification of spatial structures and their interconnections (Barthelemy, 2011). In the sDNA architecture, street segments are regarded as graph edges, whereas junctions are depicted as nodes. This facilitates the assessment of critical metrics, including the distribution of node degrees and the density of intersections (Porta et al., 2006). Moreover, sophisticated sDNA methodologies can evaluate integration, intelligibility, and synergy to measure the efficacy of spatial networks. sDNA utilises graph theory to furnish planners with essential mathematical metrics for evaluating network structure and connectivity, which are critical for fostering dynamic and sustainable urban morphology.

Taking into account the 100 other cases examined by Peng (2024)—including Brasília, Manhattan in New York City, Old Irving Park in Chicago, and Melbourne—the cases demonstrate a shift in block scale order by an entire category. Evidence indicates that regular block sizes fall within the block size scale orders of 12,000 to 96,000, marking no fewer than eight scale categories (12,000–16,000, 16,000–22,000, 22,000–31,000, 31,000–42,000, 42,000–57,000, 57,000–74,000, 74,000–96,000 ranges). Transitional morphological scales indicate the consolidation of these categories into one full scale order up, (96,000–126,000, 126,000–164,000, 164,000–218,000, 218,000–311,000, 311,000–483,000, 483,000–1,122,000 and 1,122,000–1,456,000 block scale ranges).

Using this as evidence and, reflecting on De Jong and Rosenmann's 22 scale order, the argument for scale shifts is validated, where lower scale orders are subsumed by higher morphological scale orders, such as the sub-regional (scale order 16) and regional orders (scale order 17).

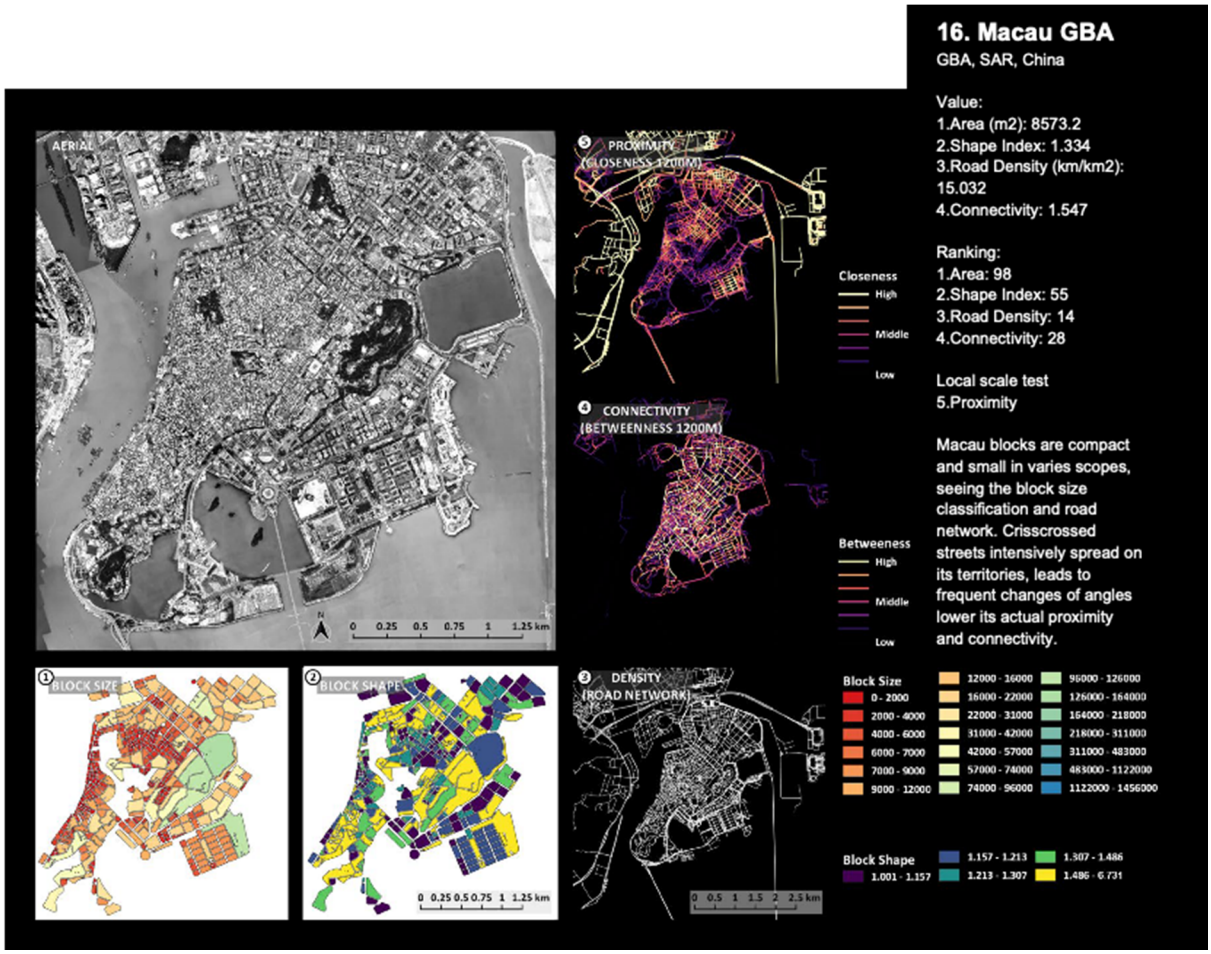

Figure 2. Case 16 of Peng's (2024) 100 massive case study detailing the spatial and morphological properties of Macau. Credit: Peng, 2024.

CONCLUSIONS

This paper has critically reflected on De Jong and Rosenmann's suggested scale order, examining its validity and contemporary relevance. The paper has also examined the empirical reality of urban blocks across four cases of the GBA, as evidence for the revision and implementation of new morphological scales that better reflect the GBA's current urbanization trends.

The findings of this paper underscore the need for both an awareness of scalar shifts as well as scalar revisions as part of the evolutionary development of urban morphology. The work conducted by geospatial sciences and the increasing influence of big city data is already showing evidence of assumed scalar shifts of morphological processing (Boeing, 2021).

Contextual and planning context in the GBA has greatly influenced the development scale and its literal choice of scale or morphological components. Still, the need to further advance the domain of urban morphology will facilitate future research in refining the possible scalar variations and scalar overlaps in the implications of introducing new scales to urban morphology as design instruments beyond mere analytic tools.

Figure 3. Case 55 and 56 of Peng's (2024) 100 massive case study detailing the spatial and morphological properties of Guangzhou and Shenzhen. Credit: Peng, 2024.

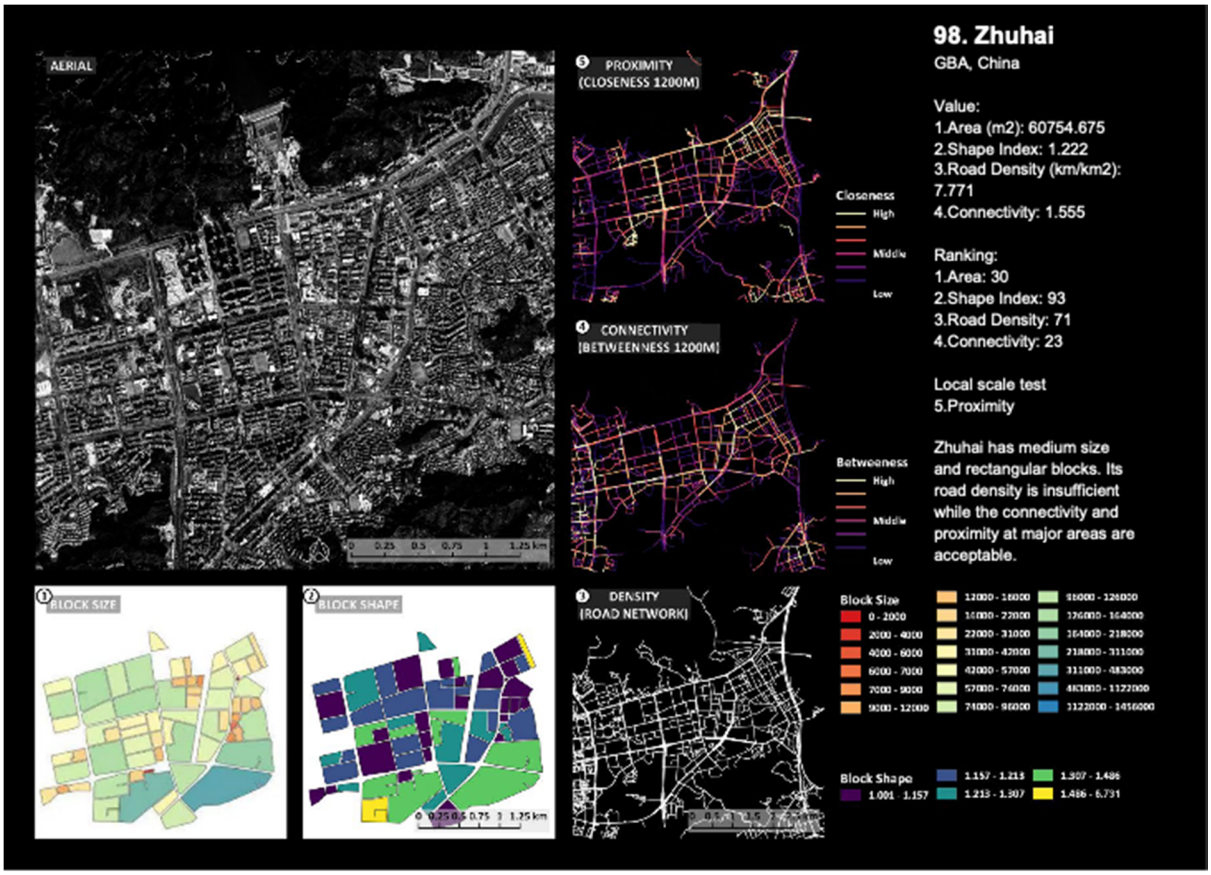

Figure 4. Case 98, taken from Peng's (2024) 100 massive case study detailing the spatial and morphological properties of Zhuhai. Credit: Peng, 2024.

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Understanding urban greenspace morphology: concepts, spatial attributes and application frameworks

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ABSTRACT

Urban greenspaces are an indispensable component of the urban fabric. Although the research on urban greenspace is a much more unnoticed part in urban morphology, it is very necessary to pay attention to the urban greenspace morphology (UGM) because of its enormous potential application in both scientific research and planning practice. In this article, we intend to discuss the relationship between urban greenspace form (UGF) and urban form, the concept and definition of urban greenspace form, as well as the preliminary application and research framework, which mainly includes the following three parts. 1) The concept and definition of UGM were defined from the perspective of urban form, and then the temporal and synchronic characteristics of UGM as well as the relationship between urban greenspace form and artificial built form were explored. 2) The basic types and spatial attributes of UGM is the second part. The focus was on differentiating and describing the two major attribute forms of urban greenspace, namely the noumenon form and performance form. The noumenal form refers to the spatial attributes and characteristics of urban greenspaces. The performance form reflects the spatial utility characteristics of urban greenspaces, including recreational supply, environmental and ecological improvement. 3) The framework of synchronic approach for the planning application and research of UGF was based on the noumenal and performance forms in which a UGF analysis system was setup through form identification, classification, statistics, and indicator quantification. On this basis the planning application scope and related research fields of UGM were proposed.

Keywords: Urban morphology, Greenspaces, Framework, Noumenon form, Performance form

INTRODUCTION [Heading 1]

City is a spatial-explicit physical environment interweaving with man-made and natural elements, Urban greenspaces are an indispensable component of the urban fabric. A large number of studies have confirmed that urban greenspaces have many functions such as ecology, recreation, environment, aesthetics and so on(Kuo, 2015, Bastian et al., 2012, Lo and Jim, 2010, Markevych et al., 2017, Taylor and Hochuli, 2017). Urban ecological and environmental problems have attracted the attention of researchers in geography, ecology, environment science and other disciplines(Grimm et al., 2008, Wolch et al., 2014, Rupprecht and Byrne, 2014). As urban form is the most basic spatial attribute of urban physical environment, these studies consciously or unconsciously involve the relationship between urban form and ecological environment on various scales, in which greenspace

form is an important aspect. However, the research on urban greenspaces is a much more unnoticed part in urban morphology. Some studies have been published in Urban Morphology, but they are only carried out in limited fields such as urban fringe green belt, mostly in a historical and geographical perspective (Whitehand, 2019). There were also several papers on the ecological aspect (Marcus et al., 2019; Pont,2023), but there is still a lot of work to do in this direction. These studies have not paid attention to the urban greenspace form of different types, scales and spatial distribution, and the Urban Greenspaces Morphology (UGM) has not yet formed systematically. In this regard, J. W. R. Whitehand, former editor in chief of the journal, said that the elements of greenspace and open space are missing in the study of urban morphology (Whitehand, 2019). Peter Larkham proposed to conduct in-depth research on greenspace morphology (Larkham, 2022, 2024). So, how do we consider urban greenspace in the study of urban morphology? Are there morphological problems in urban greenspace? It is necessary to pay attention to the UGM due to its enormous potential application in both scientific researches and planning practice.

We pay attention to and think about the UGM because of the great changes brought about by the development of urban greenspace in China in the past 40 years. The status of China's urban greenspace development is very obvious and fast: the proportion of China's urban greenspace (greenspace area rate) has increased from less than 10% in the 1980s to 38.7% in 2023, and the park greenspace area per capita has increased from 1.5m2 to 15.29m2 (National Forestry and Grassland Administration, 2024). For most Chinese cities, the development of urban greenspaces during this period is also huge, for example, the urban greenspace area of Beijing city has increased from 27.5km2 to 835 km2 (Beijing Municipal Forestry and Parks Bureau, 2024), an increase of 30 times. The scale and volume of urban greenspace has become an indispensable part of urban development in China. There are two important driving factors for the development of urban greenspaces in China. First, Urban Greenspace System Planning in China is an important legal strategy document for the development and construction of urban greenspaces. It is not only a part of the legal content of the overall urban planning, but also a more in-depth special planning, including the detailed regulatory planning of the urban green line and biodiversity special planning. Another important driving force is the Garden City campaign, which is based on the selection of “Garden City” and “National Garden County” at national and provincial level by the Chinese Ministry of Construction in 1992 ((Ministry of Housing and Urban-Rural Development of the People's Republic of China, 2022), and “Ecological Garden City” by the Chinese Ministry of Housing and Urban Rural Development in 2004(Ministry of Housing and Urban-Rural Development of the People's Republic of China, 2004), which had been upgraded in 2016. The evaluation index system involved in the selection work has a large number of greenspace form requirements. Greenspaces form has become an increasingly important evaluation and analysis tool, for example, about two thirds of the evaluation indexes in the evaluation system of Ecological Garden City newly issued by the Chinese Ministry of Housing and Urban Rural Development in 2022 have different levels of greenspace form significance (Table 1), in the table, items 1-10 and 13 are indicators related to UGM.

Table 1. The evaluation index system of “Ecological Garden City” in China.

Goal	No.	Index	Details
Eco-friendly	1	Urban Greenspace Ratio（%）	①≥40%； ②≥ 28% for each urban district.

and Livable	2	Urban Green Coverage Rate（%）	①≥43%； ②the proportion of trees and shrubs should be≥70%.
	3	Per Capita Park Greenspace (m²/person)	①≥14.8m2/person； ②≥5.5 m²/person for each urban district.
	4	Coverage Rate of Park Activity Space Service Radius （%）	≥90%
	5	Coverage Rate of Urban Greenway Service Radius（%）	①the length of greenways per 10,000 people should be ≥1.2 km； ②the coverage rate of service radius should be≥70%
	6	Number of Comprehensive Parks per 100,000 People	≥1.5 parks/ per 100,000 people
	7	Compliance Rate of Urban Ecological Corridors（%）	100%
	8	Compliance Rate of Urban Biodiversity Conservation（%）	100%
Healthy and Comfortable	9	Urban tree-covered road Coverage Rate（%）	≥85%
	10	Compliance Rate of Urban Road Greening（%）	≥85%
	11	Implementation Rate of Vertical Greening（%）	≥15%
	12	Compliance Rate of Garden-style Residential Areas (units)（%）	≥60%
Safe and Resilient	13	Blue-Greenspace Ratio in Built-up Areas（%）	≥45%
	14	Compliance Rate of Disaster Prevention and Risk Avoidance Greenspace Facilities （%）	100%
	15	Implementation Rate of Urban Wetland Protection（%）	100%
Unique Features	16	Protection Rate of Parks with Historical Value （%）	100%
	17	Protection Rate of Ancient and Famous Trees and Reserve Resources（%）	100%
	18	Rate of Certified Landscaping Workers（%）	100%； Level 3 workers and above should be ≥20%.

THE RELATIONSHIP BETWEEN CITY FORM AND URBAN GREENSPACE FORM

What role does urban greenspace form play in urban morphology research? As an element of a complex urban system, can urban greenspace form be studied in morphology? Before discussing the concept of urban greenspace form, we first need to consider the relationship between artificial space and natural space in urban form.

City is a coupling system of artificial factors and natural factors, but it has two different driving mechanism logics. Urban artificial construction is the leader of urban spatial form. Its formation is driven by political, economic and social development (Turner, 2005). We can also call it " form-shaper". In the process of urban overall development and evolution, natural space is weakened in function, which is often occupied, blocked, cut and porous in space by artificial development and construction, showing the fragmentation of the overall pattern. These urban constructions are usually anti-natural processes (Forman and Godron, 1986). As the main carrier of urban natural space, the formation mechanism of urban greenspace is mostly the artificial restoration and reconstruction after

the destruction of its natural structure. The urban greenspace form has been restricted by the urban artificial construction, and the vast majority of urban greenspace form is " form-shaped" (Table 2). As a subsystem of the urban system, urban greenspace form is an integral part of the urban form, which is not only restricted by it, but also has its own distinctive characteristics (Neglia, 2024). First of all, because the natural attributes of urban greenspace determine the ecological and environmental function in urban spaces, it carries most of the natural processes and biological habitat functions in urban areas. The study of urban greenspace morphology should pay attention to its ecological and environmental mechanism and recreational function. Second, an important feature of the urban system is the deep and complex mosaic of fine-grained greenspace and artificial space (Forman, 2008). As a part of urban physical space, greenspaces are not completely independent, so it is necessary to consider urban greenspace form under the background of urban form. Third, the natural processes such as air circulation, water balance, heat balance and wildlife food chain occurred throughout the entire urban areas. In this sense, urban greenspace forms have more integrated characteristics and requirements.

Table 2. Comparison of urban natural space and artificial space

Factors	Artificial Space	Natural Space
Driving Factors	Human socio-economic development	Natural process; Human influence, interference or maintenance
Elements	Buildings, roads infrastructure, pavement	Forest, farmland, wetland, river, lake, park
Functions	Land use	Ecosystem services
Forming	Form-giving	Form-given and nature shaped
Feature	Hard	Soft
Shape	Geometrically regular	Naturally winding and humanly constrained

Morphological characteristics are one of the basic representations of urban spatial development, and also a means to reveal its spatial distribution law. The spatial distribution of urban greenspace itself can be explained in form. The various ecological, environmental and recreational functions of urban greenspaces also have clear spatial characteristics, which can be described and analysed in form. Therefore, morphological significance of urban greenspaces is clearly defined and worth studied.

THE CONCEPT AND DEFINITION OF UGM

Urban greenspace morphology (UGM) is a specialized discipline that studies the urban greenspaces form (UGF). In the absence of clear research in this area, how do we understand the form of urban greenspaces? We try to define it and divide all the contents related to UGF into two basic types: the Noumenon form and the Performance form. The basic types and spatial attributes of UGF is in depth discussion below.

The Noumenon form

The noumenon form refers to the spatial attributes and characteristics of urban greenspaces, including the overall descriptive or spatial characteristics of greenspaces such as classification of form types, statistics of quantity composition, and spatial distribution. Statistics can be made separately in terms of the General greenspace and the Special greenspace (Table 3).

1)The General Greenspace mainly reflects the overall level of a city on greenspaces development. 2)The Special Greenspace is a more specific refinement of various types of urban greenspaces, reflecting the quality of a city's greenspaces in recreational, ecological and environmental functions, and partly reflecting the level of greenspace service supply.

We can use a variety of measurement methods to carry out numerical statistics and spatial statistics in the noumenon form descriptions about the number and spatial distribution of greenspaces, which can be expressed in the overall or partial urban land use (Figure 1), and can also be expressed in different land use with the proportion of greenspace (Figure 2).

Table3. Quantity and spatial indices of the Noumenon form

<table>
<tr><th colspan="2" rowspan="2">Classification</th><th colspan="4">Quantity and Spatial Statistics</th></tr>
<tr><th colspan="3">Number and Statistical Indicators of Greenspace</th><th>Spatial Distribution</th></tr>
<tr><td colspan="2" rowspan="5">Overall Greenspace</td><td rowspan="4">Area (hm^2)</td><td>Overall</td><td rowspan="3">Total Area at Corresponding Level (hm^2)
Greenspace Ratio (%)
Green Coverage Ratio (%)</td><td rowspan="12">The distribution of overall or special content of urban greenspaces in the entire or partial urban areas, including shape, area, type and quantity, with optional attributes.

The methods of spatial statistics include:
1) Directional quadrants, buffer zones, and grid systems;
2) Districts or zones;
3) Patches and corridors;</td></tr>
<tr><td>Administrative Division</td></tr>
<tr><td>Functional Division</td></tr>
<tr><td>Individual</td><td>Area of Individual Greenspace
Statistics of Areas of Different Greenspace Level (hm^2)
Ratio of Areas of Different Greenspace Level (%)</td></tr>
<tr><td rowspan="3">Number</td><td>Overall</td><td colspan="2">Patch Number</td></tr>
<tr><td>Administrative Division</td><td colspan="2">Number of Patches</td></tr>
<tr><td>Individual</td><td colspan="2">Number of Greenspace
Statistics of Different Greenspace Level
Ratio of Different Greenspace Level (%)</td></tr>
<tr><td rowspan="12">Special Greenspace</td><td rowspan="4">Park Greenspace</td><td rowspan="2">Area (hm^2)</td><td rowspan="2">Per Capita</td><td>Area of Park per Capita of the City (m^2 per capita)</td></tr>
<tr><td>Area of Park per Capita of the Division (m^2 per capita)</td></tr>
<tr><td>Number</td><td colspan="2">Number of Parks per 10,000 People</td></tr>
<tr><td>Service Radius</td><td colspan="2">Service Radius Ratio of Different Park Level</td></tr>
<tr><td rowspan="2">Greenway</td><td>Length (km)</td><td colspan="2">Total Length of Greenway of the City (km)
Length of Greenway per 10,000 People (km)</td></tr>
<tr><td>Service Radius</td><td colspan="2">Coverage Rate of Residential Areas within a 1 km Radius of Greenways</td></tr>
<tr><td rowspan="2">Residential Greenspace</td><td rowspan="2">Area</td><td colspan="2">Greenspace Ratio in Residential Area (%)</td></tr>
<tr><td colspan="2">Area of Greenspace per Capita (m^2 per capita)</td></tr>
<tr><td rowspan="2">Road Greenspace</td><td>Area</td><td colspan="2">Greenspace Ratio of the Road (%)
Green Coverage Ratio of the Road (%)</td></tr>
<tr><td>Length</td><td colspan="2">Tree Canopy Coverage Ratio (%)
Length of Tree Canopy Coverage per Capita (km)</td></tr>
<tr><td>Ecological Protective Greenspace</td><td></td><td colspan="2">Implementation Ratio of Protective Greenspace Along Railways, Highways, and Major Rivers (%)
Greenspace Ratio of Ecological Buffer Zones between Urban Clusters (%)</td></tr>
</table>

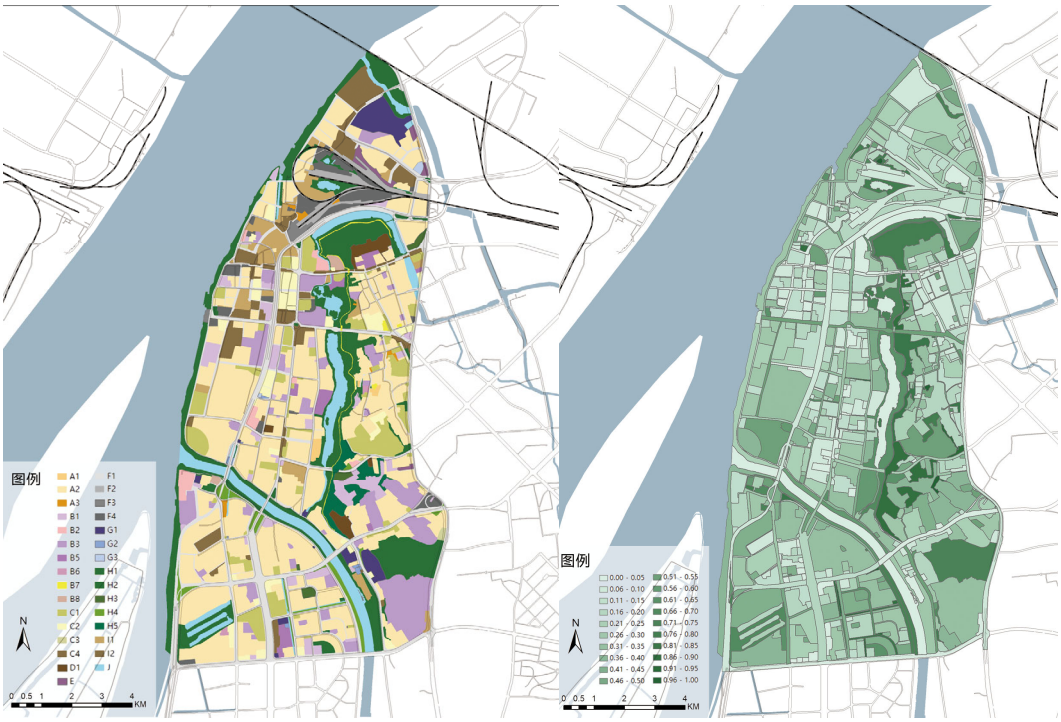

Figure 1. The spatial distribution of urban greenspaces

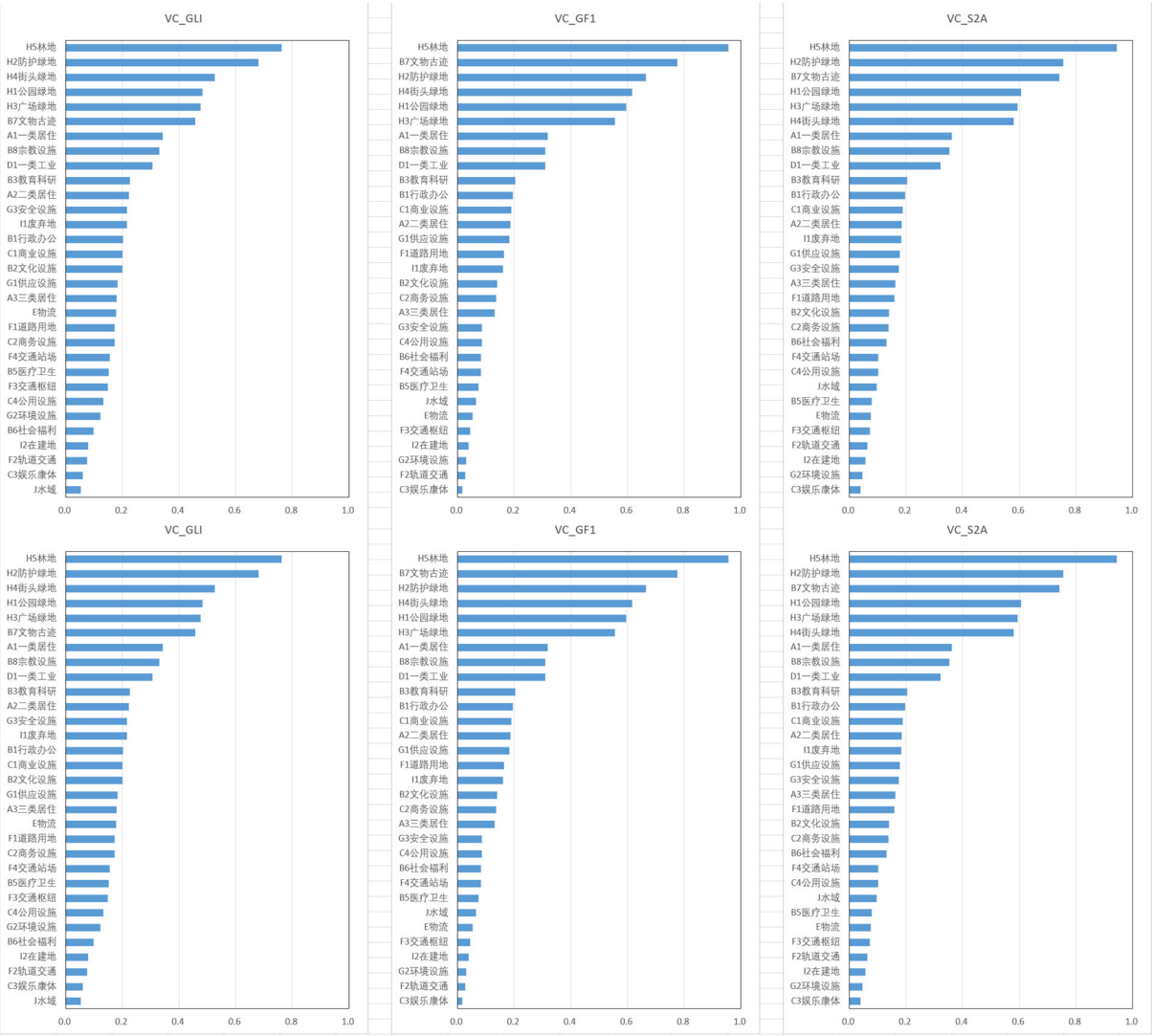

Figure 2. Quantity statistics of greenspace ratios in different land use

The Performance form

The Performance form reflects the spatial utility characteristics of urban greenspaces, including recreational service, quality of public space, ecological security, environment improvement, urban public safety and so on. Among them, recreational supply is dominant in traditional Urban Greenspace System Planning practice and involves the completeness of park recreational functions, the hierarchy of park system, and the accessibility of parks and greenways. Performance form and urban greenspace are related, but not a strict correspondence, and are affected by the urban environment as a whole. Performance form analysis should not be limited to the study of urban greenspace form. For example, the heat-island effect is a response to the overall heat state of the urban environment, but the “cold-lake effect”, which is opposite to the heat-island effect, is strongly related to the spatial distribution of urban greenspaces (Wang et al, 2015; Qian and Wang, 2016). Similarly, the accessibility of park greenspaces is also a type of performance form, which can comprehensively display the distribution of the service level of urban parks.

The relationship between the Noumenon form and the Performance form

Noumenon form is the foundation and the description of the basic state of urban greenspaces, however, the performance form is the application and the expression of urban greenspaces functional

performance (Figure 2). Noumenon form is the direct expression of urban greenspaces form, but the performance form is the extension of various functions of noumenon form and the indirect expression of urban greenspaces form. Noumenon form partly reflects the service level of urban greenspaces, but it cannot intimately reflect the ecological and environmental functions and service level of recreation and public space. Performance form can further supplement, describe and analyse the specific functions of Noumenon form from many aspects.

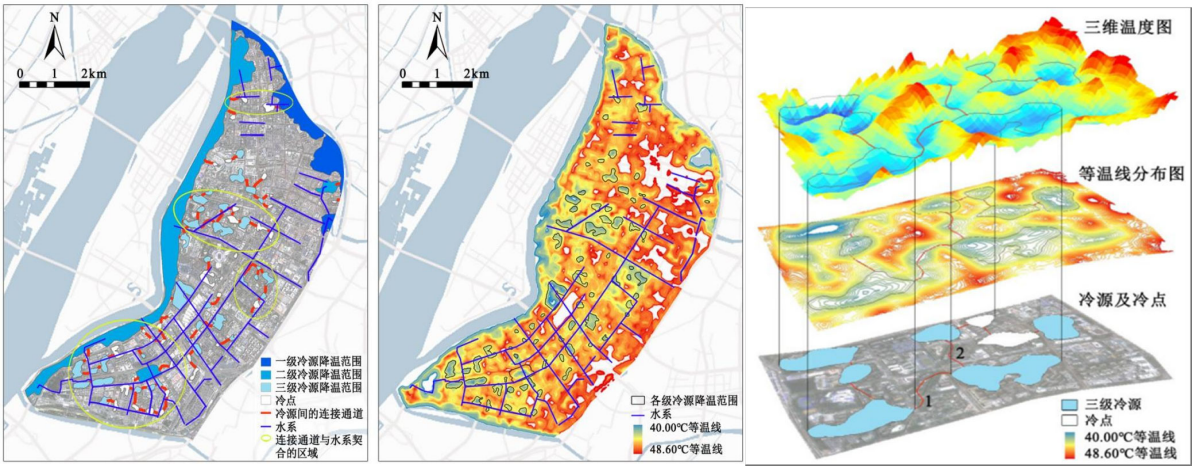

Figure 3. The relationship between the Noumenon form and the Performance form. Illustration of the relationship between the spatial distribution of urban greenspaces and the thermal pattern ofurban heat island the Noumenon form（本体形态） the Performance form（绩效形态）

A FRAMEWORK FOR PLANNING APPLICATION AND RESEARCH OF UGM

There are two basic approaches to the study of urban greenspace morphology, one is diachronic and the other is synchronic. The two approaches are different in terms of methodological framework.

Diachronic approaches to UGM

Diachronic approaches need to be studied from the perspective of greenspace evolution. In the diachronic approach, we usually do not care about the individual urban greenspace, which is usually the research object of history in landscape architecture. We are concerned about the overall development of urban greenspaces in a certain period of time at the city scale, which can be considered from three aspects as follows.

First, the construction of urban greenspace in different times should be adapted to the regional natural conditions and the level of social and economic development, showing the characteristics of the times. Second, the form of urban greenspace is generated in the timeline and is the result of the superposition of multiple times. Third, the policies and regulations, planning ideas and more detailed professional norms in different times have the greatest impact. These are usually from a historical and geographical perspective.

Synchronic approaches to UGM

The synchronic approach studies the current urban greenspace form. Based on the study of noumenon form and performance form, it solves various recreational, ecological, environmental and other problems closely related to urban greenspaces. The main goal of this approach is to achieve liveable

and sustainable environment. A basic research framework and its application strategy is as shown in the following figure (Figure 4), in which a UGF analysis system was setup through form identification, classification, statistics, and indicator quantification. On this basis the planning application scope and related research fields of UGM were proposed. UGM is one of the more scientific and rational foundations for various urban planning and design, and as a subsystem, it can also be effectively used to support the achievement of social development goals.

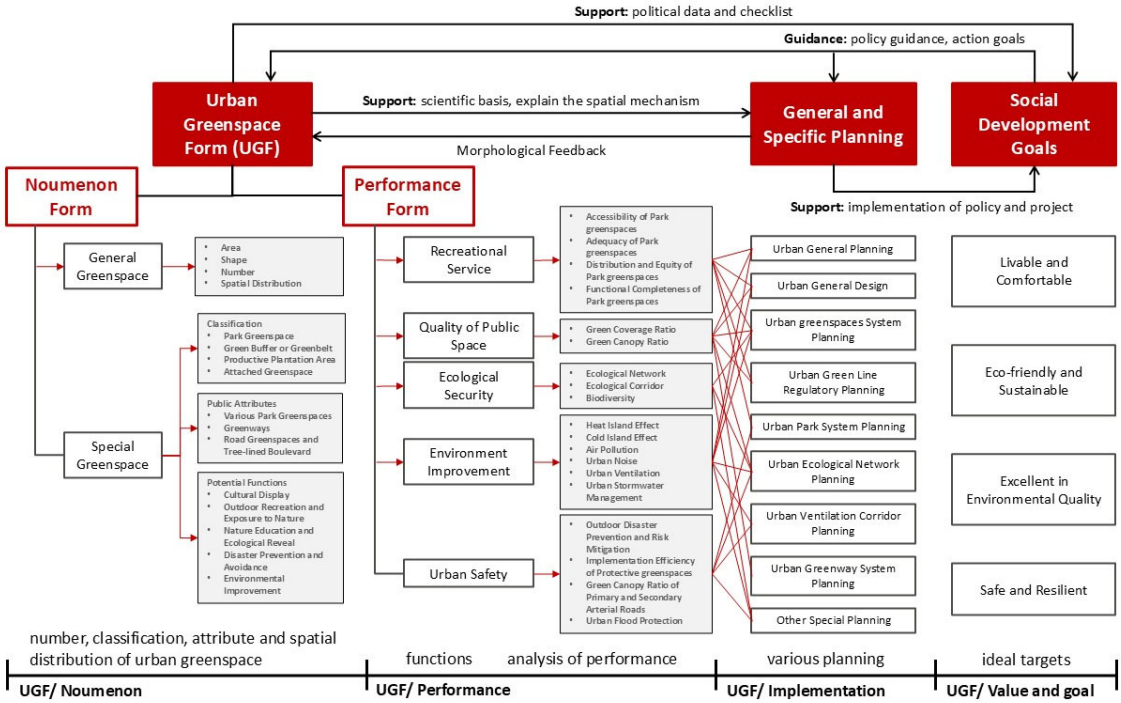

Figure 4. A preliminary research framework of synchronic approaches to UGM

SOME THOUGHTS AND PROSPECTS OF UGM

The purpose of understanding the urban greenspace form is to better understand the roles and functions of greenspace in the urban man-made environment. Although we have put forward the basic concept, definition and a preliminary work framework of UGM, there are still many problems worthy of further discussion.

How were urban greenspace forms shaped? What are the characteristics of them?

What kind of urban development mechanism leads to the formation of urban greenspace forms?

How effective are the urban greenspace forms of different cities in terms of recreational and ecological environment? Are there any advantages and disadvantages? How to evaluate?

How to operate and adjust urban greenspace forms in urban planning and greenspace system planning?

The answers to these questions are the knowledge basis for understanding urban greenspace morphology and further scientific research. Because when our research working group reviewed the progress of the field related to urban greenspace morphology, it found that the lack of this knowledge

basis was one of the main problems in the current related research (Wang et al,2020; Zou and Wang, 2021). Also, the answers to these questions are the basis for our application in planning and construction. Through policy planning, operation and construction, we can adjust and optimize the urban greenspace form to achieve the goal of sustainable development and liveable human environment reconstruction. It is especially beneficial for developing countries with more high-density urban environments all over the world.

Acknowledgements

I would like to thank my doctor and master students for their contributions in the production of charts and references, especially the doctor students, Mengjun HU, Xuntong ZHUANG and Xiao WE.

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Urban form and adaptive rules

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ABSTRACT

Local identity adds value for urban development, attracting people and business, and, therefore, supporting cities both in engineering social and economic transformation. In the dynamic urban landscape, however, there is a tendency for standardised urban regulations, encompassing identical maximum and minimum heights, setbacks, floor area ratio, and other parameters. This homogenization represents a risk for the unique identity inherent in each neighbourhood over the course of time. This research endeavours to identify the distinctive spatial qualities in different neighbourhoods of Porto Alegre, Brazil. The main objective is to support urban regulations that better suit the specific characteristics of each scenario for the city, integrating local identity into the city´s forthcoming masterplan. Berghausen Pont and Haupt (2009) in Spacemate present a method to correlate density and form in order to identify different typologies through four parameters: GSI, FSI, OSR, and Height. This research applies GIS technology in order to use Spacemate to examine Porto Alegre´s block DNA, guiding alternative rules for urban design that can more efficiently recognize local identity and, therefore, design better cities. Through this exploration, we aim not only to recognize the inherent spatial patterns that contribute to defining local identity, but also to provide valuable insights for more adaptive and contextually relevant urban rules in the evolving urban fabric of the cities.

Keywords: urban center; masterplan; urban plan.

INTRODUCTION

From the dawn of human settlements to the rise of contemporary megacities, the preservation of local identity has been a central theme in debates on urban development. On the one hand, it is necessary to ensure urban development by adding new structures to the pre-existing fabric that keep pace with the dynamics of social transformations. On the other hand, there is a need to ensure that certain environmental qualities are preserved in this process of transformation. In the 1960s, Kevin Lynch, in his seminal work *The Image of the City* (1960), laid the foundation for discussions on how the perception of cities by their inhabitants is shaped by physical and symbolic elements that confer identity to these spaces. Lynch introduced concepts that would become fundamental in the following decades, such as "urban image" and "legibility," which are essential to understanding how citizens perceive and connect with the urban environment.

Building on Lynch's pioneering work, other authors such as Jane Jacobs (1961), Aldo Rossi (1966), Edward Relph (1976), Manuel Castells (1997), and David Harvey (2012) continued to emphasize the importance of considering the existing context when planning urban growth. Currently, there seems to be a certain consensus among scholars on the subject that local identity should not only be preserved but also serve as a guide for formulating rules and parameters that direct the development of urban areas. From this reality emerges the challenge of reconciling the need to recognize the constitutive patterns of what is called local identity with specific regulations so that new constructions fit into the existing fabric.

In 2009, Berghausen Pont and Haupt proposed a series of metrics in their book Space, Density and Urban Form that seek to describe, through urban planning parameters commonly applied in urban planning—indices, quotas, zones, and other prescriptions—the morphological type occupation of consolidated urban fabrics. In 2019, Henrique and Turkienicz explored the application of this methodology in the Brazilian context as a way of predicting strategies for ensuring that the parameters for constructing new structures within the existing fabric can draw from existing patterns in their design.

The present work, which uses the method proposed by Henrique and Turkienicz as a basis for proposing alternative urban planning parameters for the new Master Plan of Porto Alegre, is structured into three (3) parts: (i) method, which describes the input data as well as the procedures for identifying the morphological type patterns found in the territory of Porto Alegre; (ii) results and discussions, presenting the results obtained in identifying the city's morphological type patterns and the possible interpretation of results in a comparative analysis with other studies; and (iii) conclusion, presenting the main conclusions on the subject as well as directions and recommendations for future work.

METHOD

Case Study: Porto Alegre, RS, Brazil

The municipality of Porto Alegre is located in the southern part of Brazil, serving as the capital of the state of Rio Grande do Sul. With approximately 1.5 million inhabitants and over 250 years of history, the city is recognized for its tradition in urban planning, a title it earned due to its practice and innovation in the field, being the first capital in the country to have a Master Plan (PORTO ALEGRE, 1999). Despite this position at the forefront of Brazilian planning, what is noticeable today in the capital is a clear homogeneity in the new constructions that emerge in the city. The identity of neighbourhoods is suppressed by buildings that do not recognize the local characteristics, a direct result of the application of the current Master Plan's regulations.



Figure 1. Location of Porto Alegre in Brazil.

Currently, Porto Alegre is in the process of revising its Master Plan, which is why it was deemed appropriate to develop a specific study aimed at addressing the problems identified in the application of the current Master Plan. Since the Master Plan is a law that organizes the development of the entire municipal territory, the area selected for the application of the methodology involved the assessment of parameters across the entire territorial extent of the municipality, covering its 94 (ninety-four) neighborhoods.

To systematize the data from the different components of the urban space, the model proposed by Berghausen Pont and Haupt (2009) was applied, as presented below.

Space, density and urban form

Berghauser Pont and Haupt (2010) present a model capable of associating densities with built forms, allowing the identification of typological patterns associated with different building densities through the Spacemate graph.

The various variables for measuring urban density proposed in the study are derived from the combination of four (4) BASIC MEASURES: Base Land Area (A); Network Length (l); Gross Floor Area (F); and Built-up area, or footprint (B). These basic parameters are correlated to generate three (3) BASIC INDICATORS: Network Density (N); Building Intensity (FSI); and Coverage (GSI). The Basic Indicators, in turn, are correlated to generate what the authors call DERIVED INDICATORS: Building Height (L); Spaciousness (OSR); Tare (T); and Mesh and Profile Width (w and b).

Among these indicators, four (4) are correlated to create the basis of the Spacemate graph: FSI, GSI, OSR, and L. Based on the graph generated, the authors identify zones within the graph that can be used as a basis for identifying specific morphological type patterns, as shown in the figure below.

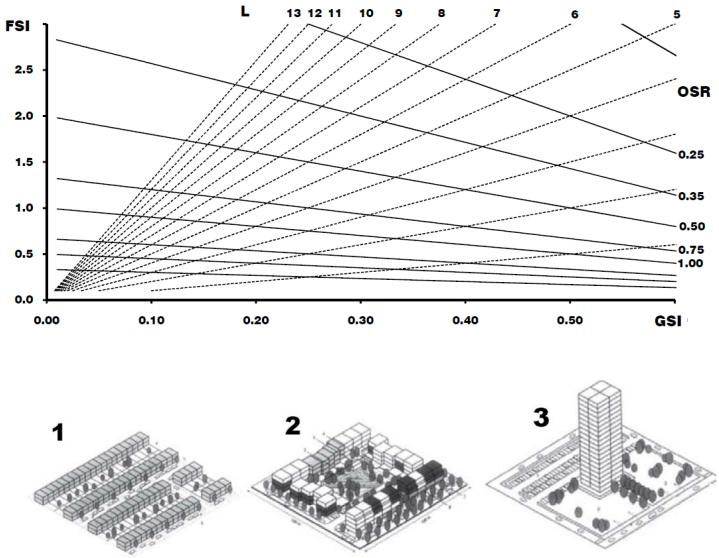
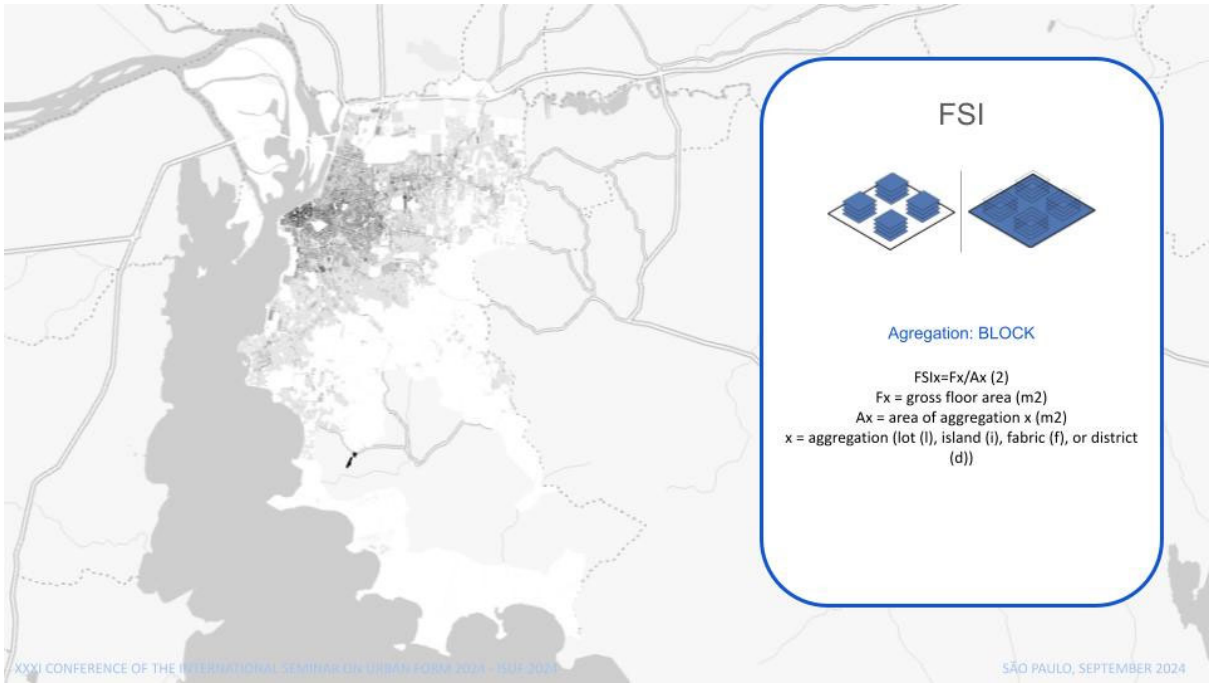
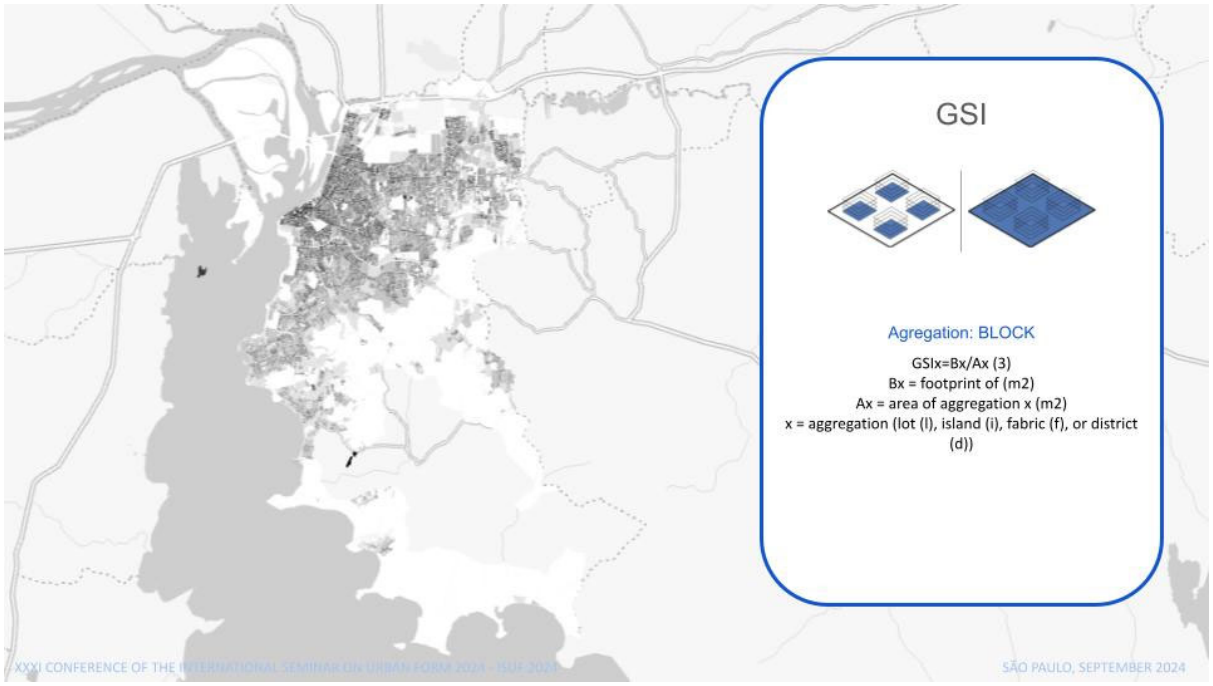


Figure 2. Spacemate. BERGHAUSER PONT e HAUPT, 2009.

Application of the model to the case of Porto Alegre

The description of morphological type patterns in the urban fabric of Porto Alegre initially involved the construction of the four selected indicators from the Spacemate for the territory. For this construction, the aggregation scale chosen was the neighborhood boundaries as the general scale and the urban blocks as the detailed scale.




GSI
Agregation: BLOCK
GSIx=Bx/Ax (3)
Bx = footprint of (m2)
Ax = area of aggregation x (m2)
x = aggregation (lot (l), island (i), fabric (f), or district (d))
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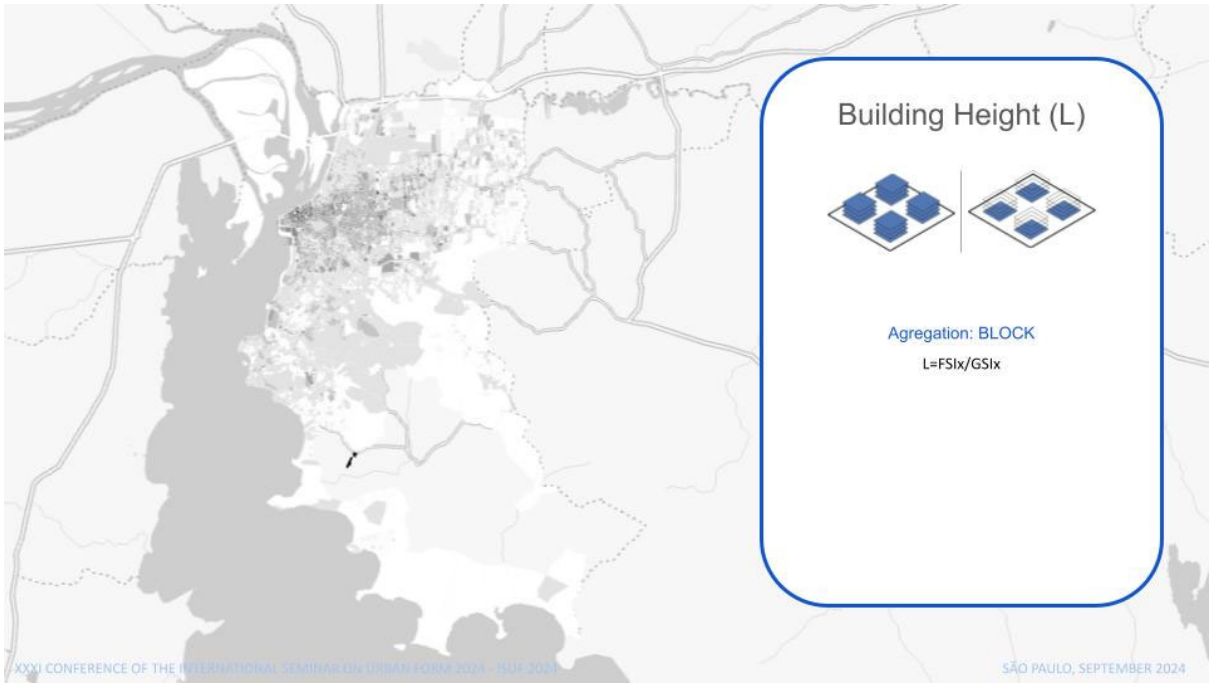
Building Height (L)
Agregation: BLOCK
L=FSIx/GSIx
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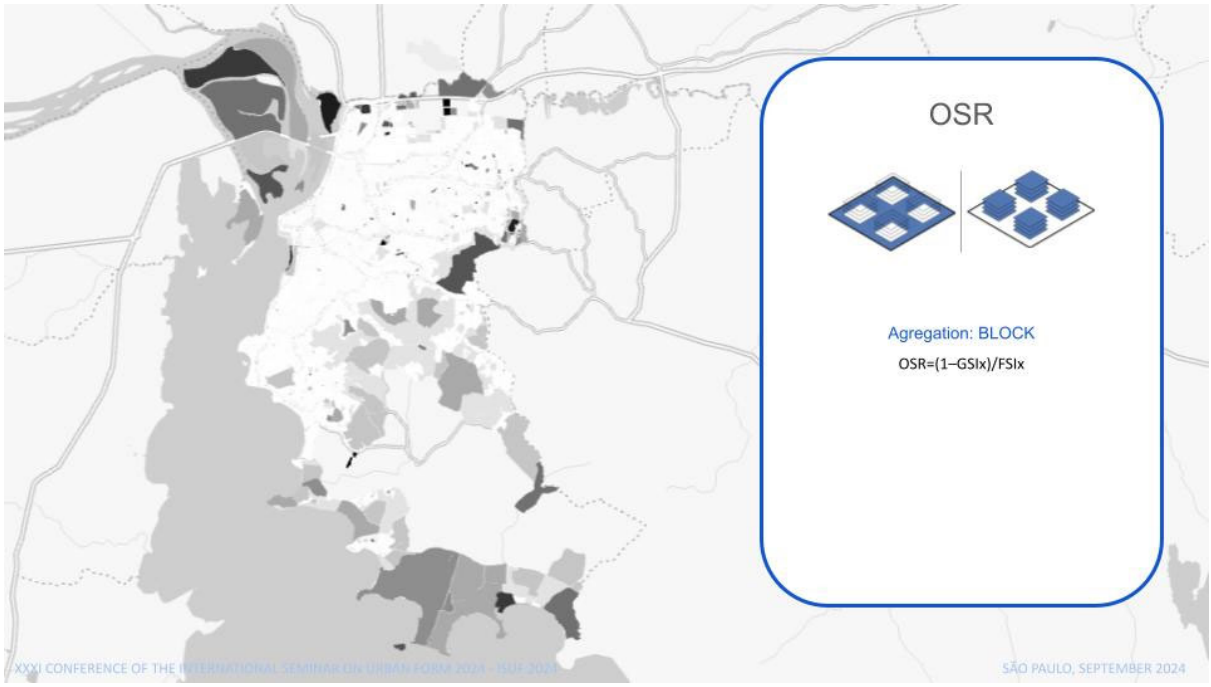
SÃO PAULO, SEPTEMBER 2024



From the results, the aim was to identify clusters based on calibration performed using the Spacemate graph interface to indicate morphological type trends of the blocks in different neighborhoods of the city.

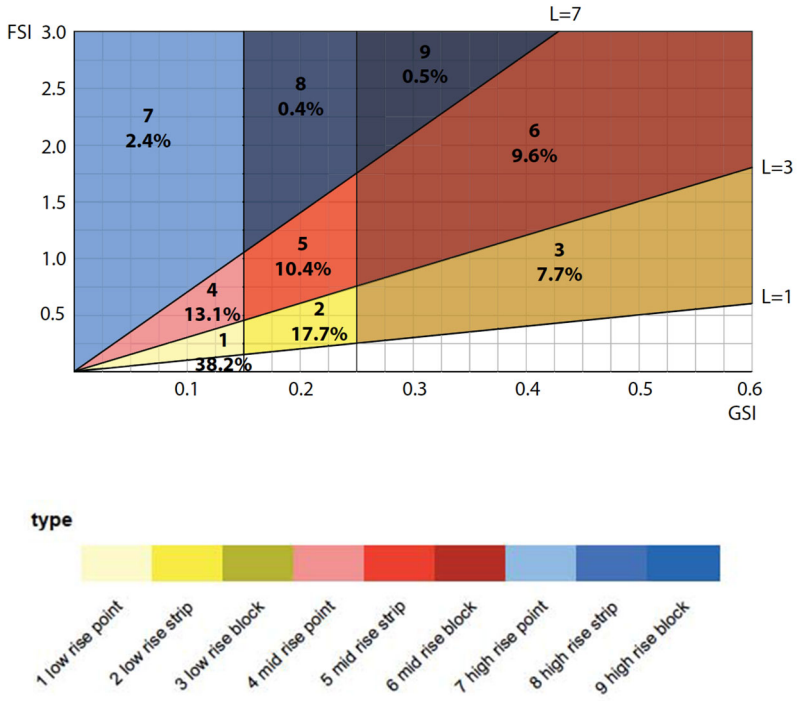
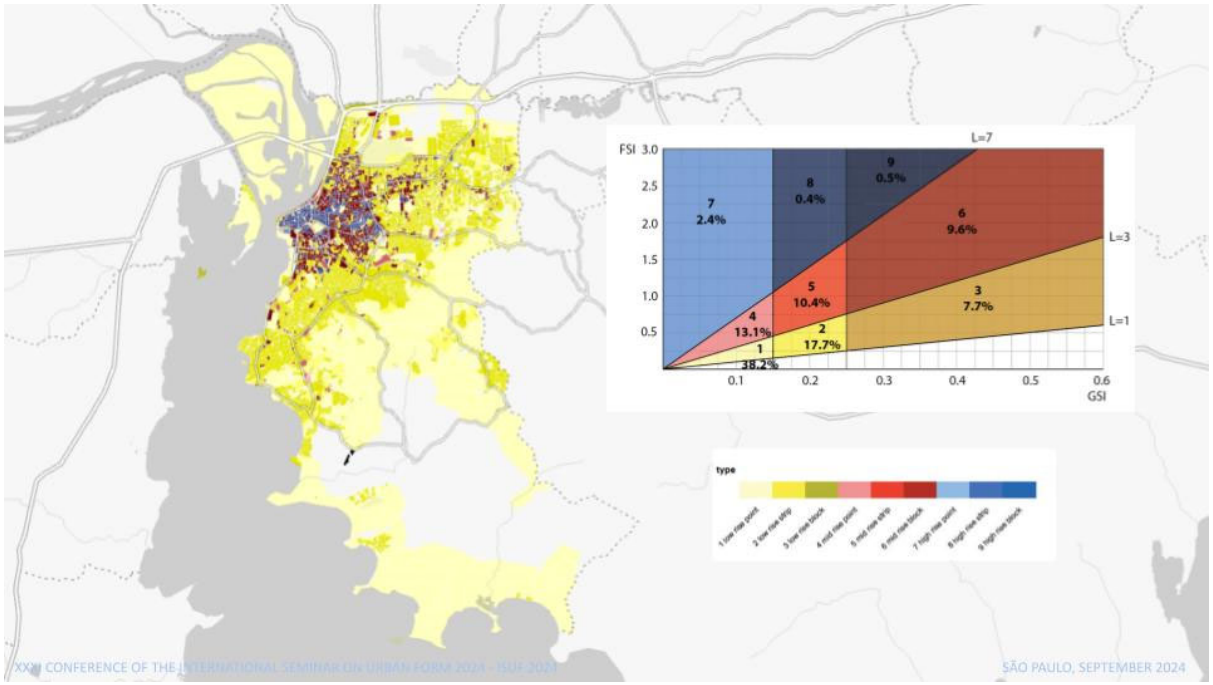
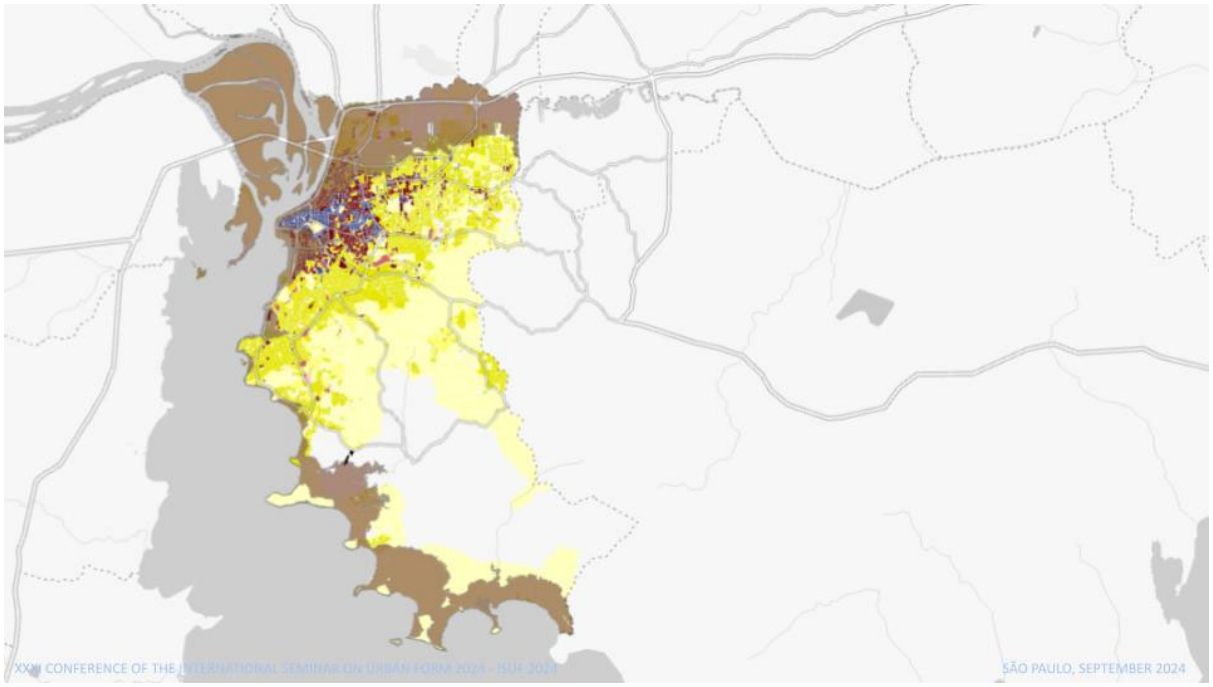


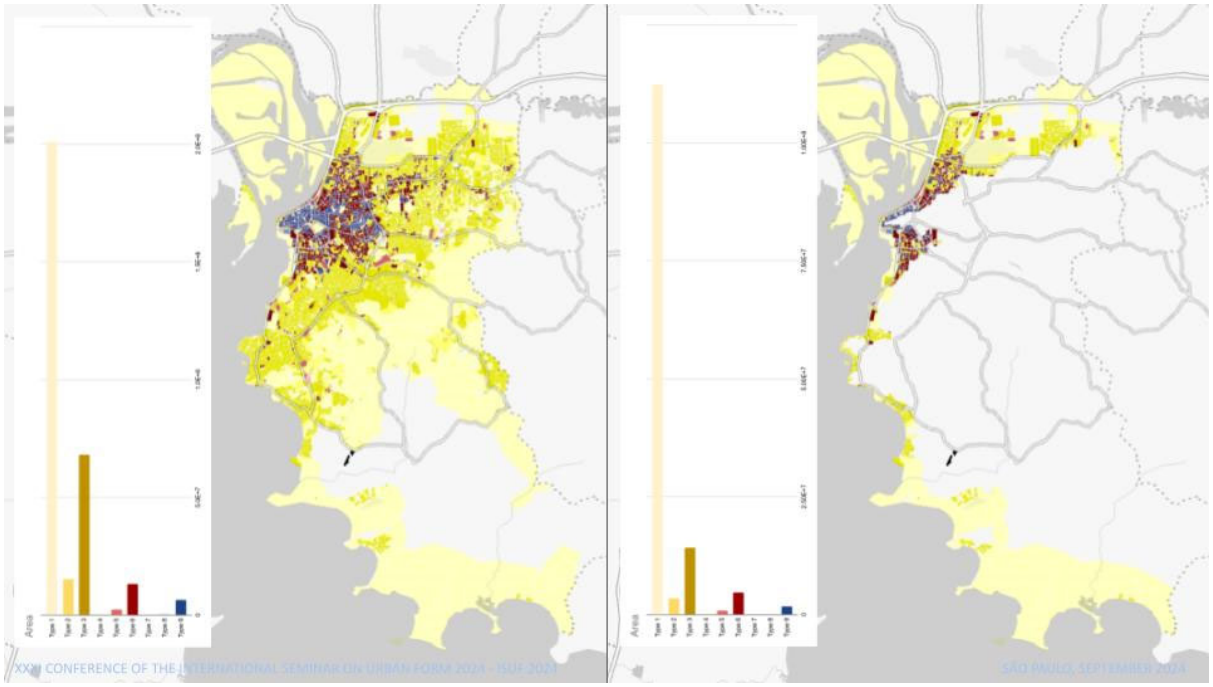
Figure 1. Spacemate. BERGHAUSER PONT e HAUPT, 2009.



RESULTS AND DISCUSSIONS

The morphological type segmentation of the neighborhoods enabled the identification of distinct urban typologies across the city. In May 2024, Porto Alegre experienced its worst climate-related disaster, with 30% of the territory impacted by severe flooding. As the city continues to recover, it becomes evident that any future urban planning efforts must fully integrate flood risk into land occupation regulations. To address this, we conducted a preliminary selection of affected areas from our previous analysis, establishing a baseline for comparison with earlier models. This comparison aims to better understand the existing typologies and define appropriate planning parameters for various regions. Even though this is an initial mapping, the results show that the flooding impacted different typomorphological configurations within the territory, underscoring the need for tailored resilience strategies that respond to the specific characteristics of each urban area.





CONCLUSIONS

The proposed modeling for identifying morphological type characteristics at the neighborhood and block levels in Porto Alegre, although still in the testing phase, has demonstrated its effectiveness for data processing. This approach shows great promise for informing the development of urban parameters that are better aligned with the current conditions of the city. In particular, it offers valuable insights for addressing the specific challenges posed by areas affected by the 2024 floods. By integrating these findings into urban planning, it will be possible to establish more resilient, context-sensitive regulations that account for both the existing typologies and the vulnerabilities exposed by the recent disaster.

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Urban form maintenance in the discontinuity of the routes' history in Itapina, Colatina, Espírito Santo, Brazil

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ABSTRACT

Like other urban nuclei, the Itapina district in Espírito Santo, a Brazilian southeast state, is experiencing exogenous actions impacts from economic processes and, since 2015, contamination consequences from Doce River waters that border it. However, the local economic decline was already manifesting itself in contrast to the first 20th century decades golden times, when Itapina promoted the coffee production flow via railways and the river. On the one hand, the road network logic contributed to changing its central position, leading the town to an economic and populational decline. However, on the other hand, economic dynamics reduction discouraged changes. It allowed the maintenance of the urban form, the prominence of its unique landscape, the permanence of a significant architectural complex; an imposing unfinished bridge, reflecting this transition moment. Such a condition reinforces a dichotomy: Itapina stands out as one of the seven historical sites listed by the state, maintaining its access via the river and the operating railway; however, many buildings are closed. So, this article aims to analyze the historical routes reorganization process associated with economic processes that generated erasures and permanence in Itapina urban form. The methodology involves bibliographical research, cartography survey and examination, and photographs and graphic production that allows the interpretation of the data. The study verified the relationship between the genesis of the urban form in Itapina and the flows that gave it centrality, as well as its economic decline following the rise of new road connections. Therefore, the article unveils the relationship between routes, economic dynamics, and urban form throughout Itapina's history, aiming to highlight possibilities for maintaining its heritage and reversing the current decline.

Keywords: historical routes, economic processes, permanence, Itapina

INTRODUCTION [Heading 1]

Economic dynamics shape the history of occupation and social formation in various brazilian cities. The colonization process, characterized by extractivism and the exploitation of indigenous people and nature, is followed by other economic and social cycles, such as agriculture, initially associated with slavery and immigration, as well as mining and industrial activities, which spurred internal migration processes, promoting the rural-to-urban movement and the formulation of new labor relations.

These processes were accompanied by the expansion of territorial occupation, particularly along routes connecting areas of economic exploitation and ports (interior-coast), resulting in a new organization of roads and transportation, along with changes in preexisting activities and routes. The evolution of these routes, which initially utilized natural waterways and paths that transformed into roads and highways, impacted various settlements, villages, and cities formed along rivers, trails, and pathways, harking back to an earlier period (Tesch, 2018). Primitive road routes were replaced by faster systems with greater load capacity, consolidating new forms of occupation around productive chains and nodes of road networks, resulting in the re-signification of pathways, as well as fluvial and terrestrial routes, alongside human settlements.

Another characteristic of these functional arrangements is the exclusion of previously occupied and prosperous territories from the new routes, which, on one hand, it lead to depopulation and economic decline and, on the other, to the preservation of a significant urban ensemble— a condition evident in the historic sites of São Mateus, Santa Leopoldina, Muqui, São Pedro do Itabapoana, and Itapina, which are protected in the state of Espírito Santo (Lordello, 2018).

In this context, the district of Itapina, which is part of the municipality of Colatina, Espírito Santo, Brazil (Figure 1), underwent a reconfiguration of its access routes and its role as a connector of the coffee territory, due to the impacts of national and regional economic restructuring projects. An important cargo hub in the first half of the 20th century, its occupation intensified with the establishment of the Vitória-Minas Railway (EFVM) in 1907, reaching its peak between 1920 and 1960 (Bona and Almeida, 2019). Starting in 1920, there was a significant movement of coffee production inland to the north of the Doce River, accompanied by the expansion of the road network at the regional and state levels.

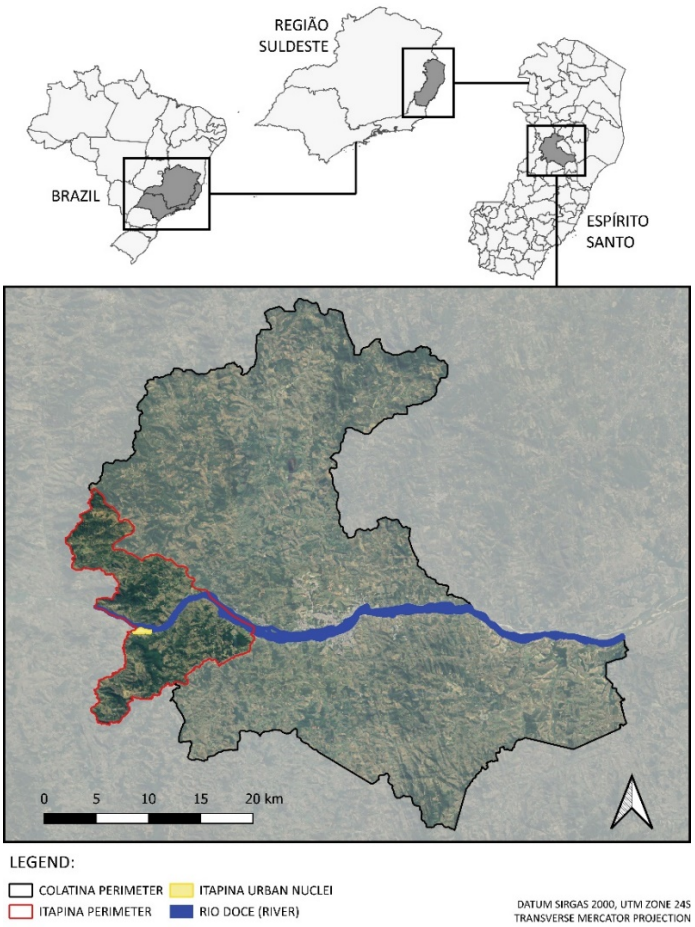

Figure 1. Location of Itapina in Colatina. Fonte: Produced from the Qgis base

Starting in 1950, the national road system was added to this rearrangement, which reconfigured connections and promoted new links through more attractive bridges and highways along new routes, fostering fronts of urban growth. Understanding the morphological processes and the driving forces that operate on the origin and abandonment of agglomerations becomes essential for obtaining an overview of their dynamic character, while also serving as a generic analytical tool that can be applied in other urban contexts (Panerai, 2014).

In the case studied, both state and federal works aimed for greater economic efficiency and the expansion of productive areas. In other words, the primary objective was not to integrate villages and settlements along their routes, which led to a marked decline with the eradication of coffee in Brazil between 1962 and 1967, strongly impacting Espírito Santo after 1967 (Daré, 2010).

Conditions like these, mediated by decisions and actions of the State, are also influenced by the market and affect urban form (Lamas, 2011). Furthermore, evolutionary periods are based on the innovations introduced in the urban landscape, which reflect economic, social, political, and cultural aspects, revealing the rise and fall of certain formal characteristics (Gimmler Netto, Pereira Costa, and Lima, 2014). By analyzing the relationship between form and time, associated with the actions of agents in each period, it is possible to understand urban processes, identifying the reasons for transformations, continuities, and the resulting form (Pereira Costa and Gimmler Netto, 2015).

Thus, this article aims to analyze the process of reorganization of routes associated with economic processes that generated erasures of flows and continuities in the urban form of Itapina, seeking to unveil the historical contexts in which these processes are embedded. It is understood that by examining the impacts of economic cycles and the routes linked to them in Itapina and its surroundings, it is possible to identify processes common to other cities and towns that also experienced decline and economic stagnation but had their urban forms preserved. This procedure also allows for the identification that the erasure of flows resulted in the persistence of elements of historical and landscape value, a condition that can serve as a starting point for the preservation and cultural appreciation in public policies and projects. Thus, over time, in the face of transformations, the persistence can be identified, analyzed, and selected, with the aim of preserving its cultural and environmental value (Pereira Costa and Gimmler Netto, 2015).

Seeking to understand the economic processes that associate access, road configurations, and transportation with the occupation and subsequent depopulation of the region, the article is structured along a timeline marked by three main periods that overlap at certain moments and delineate morphological processes in the Doce River and its surroundings. The first period is characterized by military and tax barriers, along with the exploration expeditions of nature and Indigenous people by the bandeirantes, approximately from 1574 to 1889. The second period encompasses the settlement and clearing of forests for the establishment of coffee agriculture, the improvement of navigation, the arrival of immigrants, the introduction of the railway, and the formation of villages and urban nucleai, covering the interval from 1879 to 1950. The third period is marked by the increasing process of mineral extraction in Minas Gerais, the eradication of coffee plantations, industrialization in Espírito Santo, and emigration, including the opening and infrastructure of land routes and highways starting in 1934.

METHOD

The methodology involves bibliographic research, cartographic surveys and analysis, as well as photographs and graphic production that allow for the interpretation of data. The maps, photographs, and historical data were obtained from institutional collections, while historical information was investigated in books and specialized websites. Theses, dissertations, and articles related to the history of the occupation of the Doce River region were also consulted, seeking the spatiality of the information. The theoretical foundation is based on authors in the field of urban morphology, considering perspectives from different periods, such as Lamas (2011), Lynch (2011), Panerai (2014), and Pereira Costa and Gimmler Netto (2015), the latter being grounded in the English school of morphology. The overlap of the times and elements investigated is synthesized in maps, aiming to understand the relationships between historical routes, road and transport infrastructure, economic processes, erasures, and continuities. In the process, drawings on images and figures were created in Photoshop, in addition to map production using the Qgis program.

RESULTS AND DISCUSSIONS

Origen: security barrier and settlement

During the colonial period, the river routes and precarious roads served the purpose of delineating borders and controlling smuggling. According to the earliest records, access to the Doce River, from its mouth to the region of Baixo Guandu, near the Escadinha Waterfall (now the Mascarenhas

hydroelectric plant), was achieved in 1572 by invading bandeirantes, who reported the presence of stones and precious metals, resulting in the capture of Indigenous people (Teixeira, 1974). Starting in 1786, the occupation of areas around the river was authorized with the granting of sesmarias. However, the growing exploitation in the mining region intensified colonial control over the Doce River beginning in 1798, when the exploration of mines and the establishment of settlement nuclei along its banks were prohibited. This restriction was maintained through the installation of barracks, military posts, and fiscal stations, which later gave rise to villages and, eventually, cities, such as Porto de Souza, in the present-day municipality of Baixo Guandu (Teixeira, 1974).

During the imperial period, the river and the precarious roads took on the role of territorial integration, tax collection, production control, and the flow of goods (Albergaria, 2023). In this context, navigation on the Doce River was reestablished, accompanied by the granting of lands to navigation companies (Teixeira, 1974). In 1835, a decree granted the exclusive right to explore navigation on the Doce River and in the capitals of the empire to the Companhia de Navegação, Comércio e Colonização do Rio Doce. One of the objectives of the decree was to populate and occupy the region. Among the rights granted to the navigation operator were the donation of public lands for the construction of roads, ports, and docks, as well as the freedom to set freight and toll rates. Among the obligations, the granted lands had to be occupied by at least 60 couples of settlers within a seven-year period (Teixeira, 1974).

Within these terms, the Companhia operated steam navigation between 1836 and 1841, revealing the intention to populate the region, especially the northern part of the Doce River, with a view to expanding coffee production and agriculture. Around 1850, a settlement was established in Mutum by Frei Bubbio, aiming to pacify and colonize the Indigenous people of the region (Marinato, 2007). In 1857, 46 immigrant settlers arrived in the region of Franscilvânia (now the municipality of Colatina), to the north of the Doce River, between the Pancas and São João rivers. Between 1861 and 1865, 400 North American settlers disembarked in the region of Baixo Guandu; however, these settlements failed, leading this population to migrate to other areas (Teixeira, 1974). Marinato (2007) associates the failure of attempts to advance settlement in the northern Doce River region with the presence and resistance of the Indigenous peoples, the Botocudos, to the invasion of their territories. In parallel, during this period, there was significant interest on the part of the province of Minas Gerais in expanding and improving connections to the Atlantic. Espírito Santo, particularly the lands near the Doce River, was considered strategic in this connectivity relationship, as Minas Gerais engaged in import and export activities through Rio de Janeiro and Bahia (Cravo, 2013).

Thus, the incursions for the exploration of nature and Indigenous peoples, the establishment of defense mechanisms by invading colonizers, and the attempts to settle immigrants and implement agriculture indicate an overlap with Indigenous territories along the banks of the Doce River until the imperial period. However, to the west of Itapina, the occupation of the Baixo Guandu region for agricultural production was established in 1889, promoted by Francisco Carvalho Milagres, who brought Italian immigrants to work on the plantations. Although land transportation was configured by rudimentary ancestral paths and trails opened by bandeirantes and drovers, navigation ensured the connection with other regions along the banks of the Doce River (Sartorio, 1996). This period is notable for the importance of rivers in human location and movement, as demonstrated in Figure 2

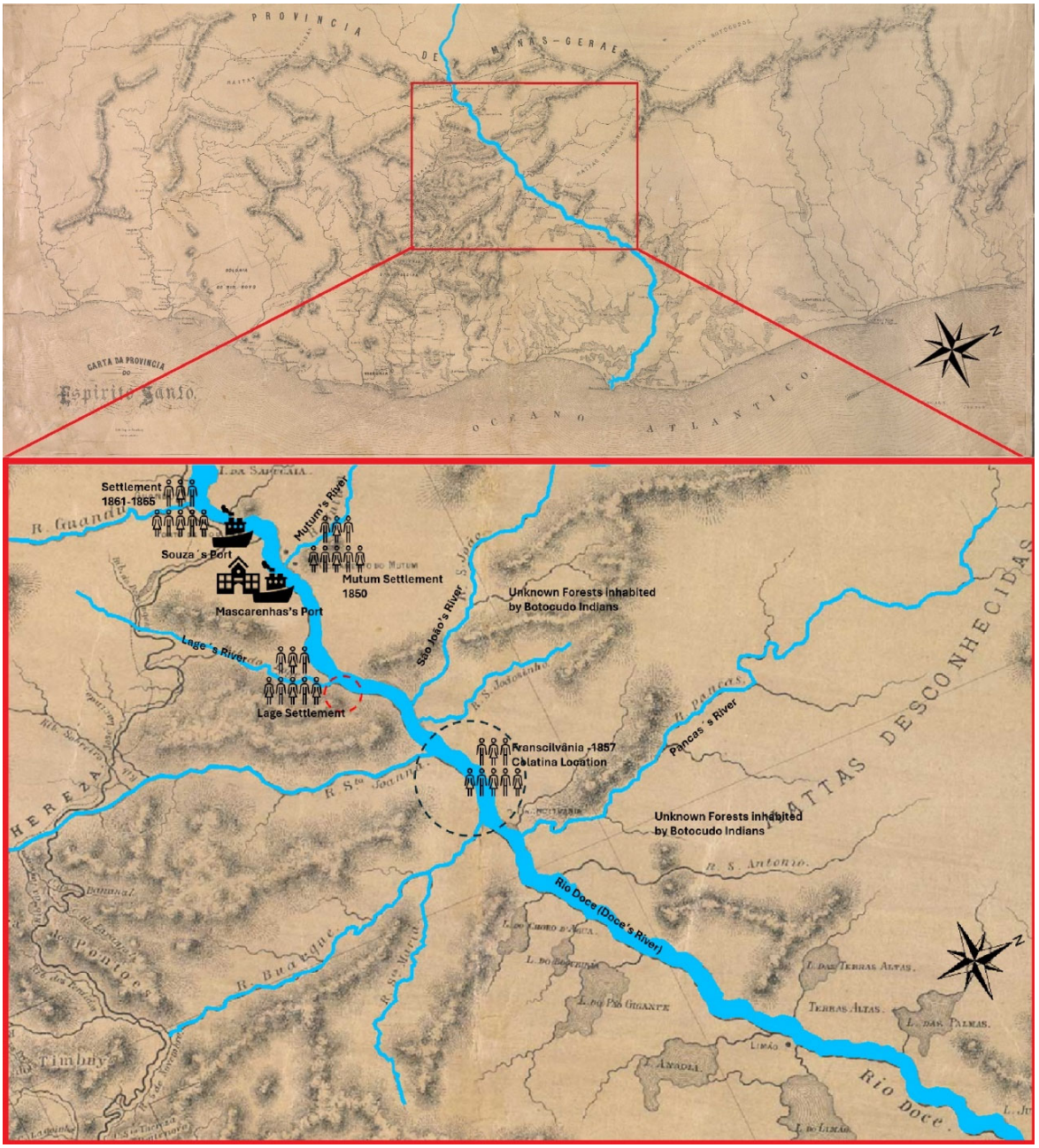

Figure 2. Excerpt from the Doce River with the location of settlements and ports in the 19th century. Source: Adapted from Biblioteca digital luso-brasileira, 2024.

The exact date of the founding of the Aldeamento de Lage, now known as Itapina, is unknown. It is known that it was located near the confluence of the Ribeirão Lage with the Doce River, as described by the inspector of the Indian Protection Service (SPI) in Espírito Santo, Lieutenant Antônio Estigarribia, in 1912. In his account, he mentions that the settlement consisted of a farm with chickens and pigs, and that there were "six huts made of straw and wood, one of which was the granary, where a large quantity of corn was stored [...]. Along the banks of the Ribeirão Lage, there was a settlement inhabited by the Munhageruns and Nac-Nanucs, who settled there in the second half of the 19th century and remained there into the early decades of the 20th century" (Tesch, 2018: 66-70 – our translation). These tribes were monitored by the SPI, and later, their remnants were taken to the Aldeamento de Pancas, eventually being transferred in 1940 to the Krenak reservation in Minas Gerais.

Growth and expansion of occupation with the coffee economy

According to Tesch (2018), the territorial formation of the current district of Itapina occurred with the arrival of immigrants from Cantagalo in Rio de Janeiro to the Ribeirão Lage region, south of the Doce River, where a sesmaria was demarcated and the headquarters of a coffee-producing farm was built. Navigation on the Doce River was only permitted at the end of the 18th century when Silva Pontes assumed the governorship of the captaincy of Espírito Santo. The steam navigation service between the Porto de Souza and Porto de Regência was granted in 1890. This navigability condition favored the migratory process of settlers from various origins starting in 1892, attracted by the possibility of obtaining lots and land for the cultivation of subsistence crops and coffee.

Itapina became a connection point, a way station between the rudimentary roads and the Doce River, interconnected with a steam navigation system that facilitated the movement of people and the flow of coffee produced on the farms south of the Doce River (Tesch, 2018). In addition to coffee, other products also circulated through the region, described by Jurandyr Pires Ferreira, then president of IBGE in 1959, as a river of great economic potential due to its smooth navigable access to the territory of Minas Gerais (IBGE, 1959).

The commercial village developed in the late 19th and early 20th centuries, thanks to its strategic location in relation to the Doce River. Initially, access to the village was achieved through both land transport, using animals, and river transport along the Doce River (Lordello, 2018).

In addition to the flow of coffee production and the receipt of various cargoes, another determining factor for the development of Itapina was the implementation of the Vitória-Minas Railway in 1907, which reinforced the longitudinal axis of development in the southern Doce River region. The railway line, created for the transport of cargo between Minas Gerais and the capital Vitória on the coast of Espírito Santo, boosted the local economy, facilitated the movement of people, and established connections between the village and neighboring urban and rural areas, such as Aymorés, Baixo Guandu, and Colatina.

This condition promoted Itapina as a commercial hub in the first half of the 20th century, even with the construction of roads and bridges in the Colatina and Baixo Guandu region (Tesch, 2018). The village was emancipated in 1923, receiving the name Distrito de Lage and being annexed to the recently emancipated municipality of Colatina (1921). In 1943, it was renamed Itapina (Tesch, 2018).

To the south, a primitive road connected Itapina to Figueira de Santa Joana, Lagoa, and Afonso Cláudio (now the ES-164 road). From the perspective of connecting productive areas and cargo flow points, a private truck was incorporated into the route in 1926, expanding cargo transport from Lagoa to the Santa Leopoldina region, totaling approximately 100 km to the south of Itapina (Sartório, 1996).

Complementing this infrastructure, the Companhia Vale do Rio Doce, established in the 1940s, implemented a road-rail connection with its own trucks and bus stations in Afonso Cláudio, Lagoa, and Figueira de Santa Joana. These stations facilitated and encouraged the use of road-rail transport, creating a constant flow of various cargoes, such as pigs, beans, and corn, with coffee being the main product. The company also promoted the transport of imported goods in the opposite direction, such as industrialized products, kerosene, and salt (Sartório, 1996).

These activities directly impacted the improvement of the road infrastructure between Afonso Cláudio and Itapina, which, although not paved, had wooden bridges and trestles replaced to accommodate motorized transport with greater load capacity, replacing animal traction.

Until 1928, a large part of the road network in Espírito Santo was concentrated in the southern portion of the Doce River. This characteristic began to change with the establishment of the Companhia Territorial de Colonização, which implemented a project aimed at building bridges and roads in the northern region of the Doce River (Sartório, 1996). Another relevant feature was the pathways and automobile road that connected Afonso Cláudio to Itapina, passing through settlements in Itaguaçu, as illustrated in the 1935 map (Figure 3).

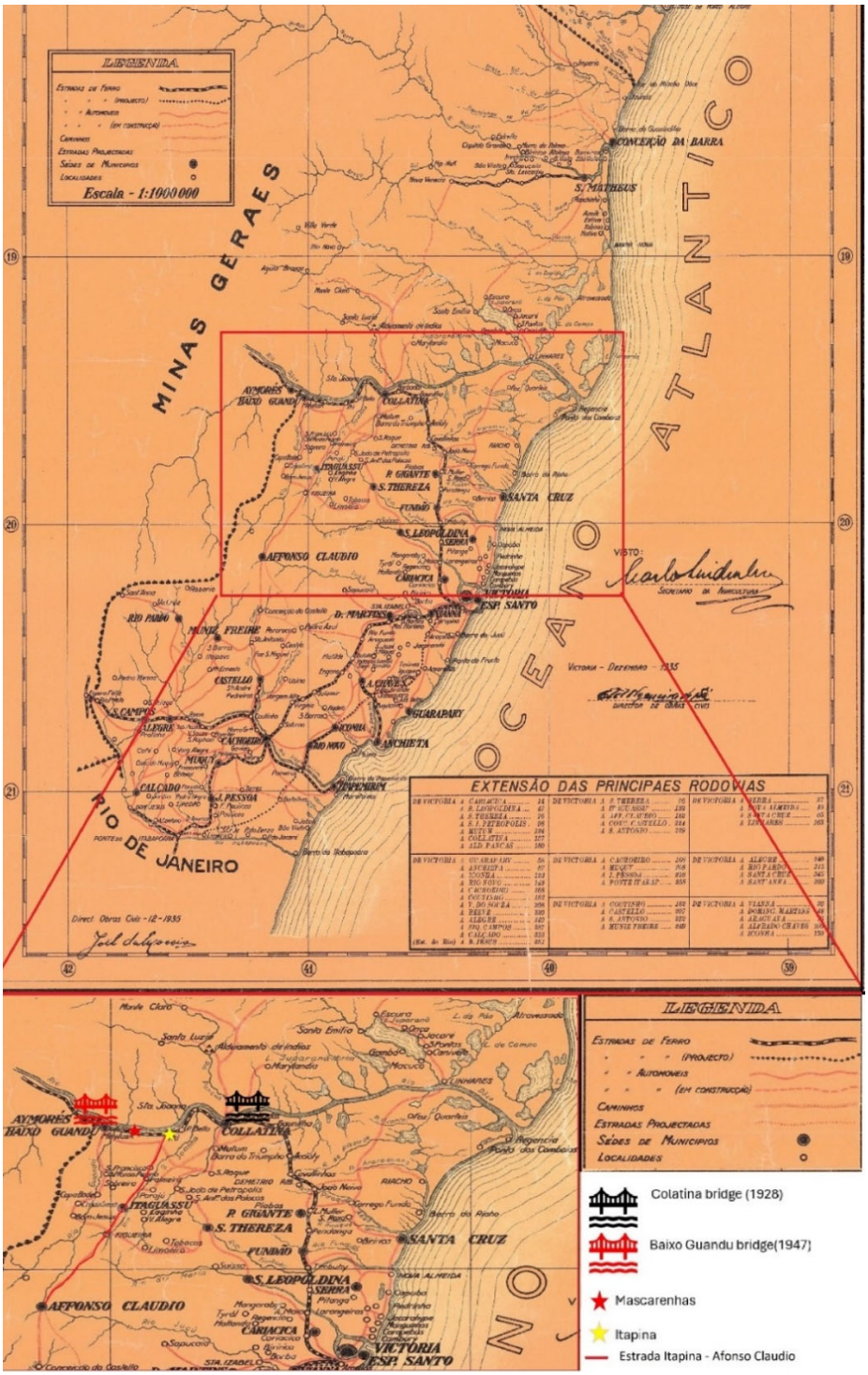

Figure 3. Map showing the main roads of Espírito Santo in 1935, highlighting the location of Mascarenhas, Itapina, and the bridges connecting the northern and southern banks of the Doce River near Itapina. Source: Adapted from Agências Postais, 2004.

In Brazil, the first paved roads were created to expedite the flow of coffee to the ports, dating back to the imperial period (Albergaria, 2023). The first railroads also emerged during this same period (IPHAN, 2014). However, it was in the first half of the 20th century, with the introduction of concrete and asphalt technologies, that there was a more intense expansion of the road system. Itapina, however, reached its peak before the arrival of the highways associated with this developmental

period. The convergence of paths, trails, and roads in Itapina, along with its close relationship with the Doce River and the Vitória-Minas Railway (EFVM), favored its development and economic rise until 1950 (Tesch, 2018).

Before the construction of the bridge in Baixo Guandu in 1947 (7.8 km to the north), Itapina's connection with the northern bank of the river was limited to river transport or road crossing at Colatina, where a bridge had been built in 1928 (25.7 km to the south). The new bridge in Baixo Guandu reorganized transportation flows and opened new fronts for investment in road infrastructure, such as the connection between Itapina and Mascarenhas, as well as the road in the Vale do Mutum on the northern bank. This situation persisted until 1979 when the bridge was destroyed by the force of a river flood (Sartório, 1996).

The bridges were catalysts for the occupation of the northern portion of the Doce River. In Colatina, the Florentino Avidos Bridge, inaugurated in 1928, also enabled the formation and densification of new neighborhoods and promoted improvements in access roads to the north, such as the establishment of the route between Colatina and Nova Venécia (1928-1930), which later consolidated the axis of the state highway ES-080 (Sartório, 1996).

Despite the improvements to the north of the Doce River, Itapina remained an important commercial hub, which justified the investment in a new bridge, initiated in 1956, in the center of its urban area. This new structure aimed to facilitate the crossing of the Doce River and connect productive areas to the storage and distribution facilities of the district (Tesch, 2018). The main connections in the region reflected the chain of coffee production and distribution until the eradication of coffee plantations occurred between 1962 and 1967, devastating 53% of the plantations in Espírito Santo (Partelli and Pereira, 2021).

New economic directions: eradication of coffee plantations and industrialization

Starting in 1956, national transportation policies directed investments and external financing toward the road sector, resulting in significant growth in Brazil between 1960 and 1970 (Sartório, 1996). This decision impacted the railway network, which, in 1959, extended 37,120 km. From 1962 onwards, several railways began to be decommissioned or replaced. Over a period of seven years, 1,595.10 km of railways were replaced by roads, of which 321.1 km were paved. By 1968, the railway network had been reduced to 32,054 km, a decrease marked by the replacement of railways with roads utilizing the same bed. Some exceptions occurred, such as the EFVM, which incorporated an additional 64 km during this period (Brasil, 1970).

In Espírito Santo, in 1959, there were 3,225 km of state highways, with only 20 km paved. This length of highways remained unchanged until 1966, and by the end of that period, 152 km were paved (Brasil, 1970). On one hand, state investments in highways focused on paving existing segments; on the other, President Juscelino Kubitschek's Metas Plan included Espírito Santo in the national connection project, significantly impacting the Itapina region, particularly through the implementation of the federal highway BR259. Initiated in the 1960s, BR259 facilitated the east-west connection between João Neiva in Espírito Santo and Felixlândia, a city near Governador Valadares in Minas Gerais (Orrico et al., 2005). The segment between João Neiva and Baixo Guandu, on the border with Minas Gerais, dates to 1968. In the stretch between Colatina and Baixo Guandu, BR259 runs north of the river before returning to the southern bank, approximately 7 km west of Itapina (Brasil, 1970).

This period coincides with the eradication of coffee plantations and changes in the economic base of Espírito Santo, which intensified the process of industrialization. Despite the completion of BR259 and the full operation of EFVM, the bridge that would connect Itapina to the northern bank of the Doce River, started in 1956, was not completed (Figure 4). From 1960 onwards, the local population began to decline, and the region underwent a process of stagnation, attributed by some authors to the redirection of flows and the unfinished bridge (Tesch, 2018). The economic decline of the following years, especially between 1962 and 1967 — the period of coffee eradication — also marks the process of industrialization in the state, with a strong presence of steelmaking on the coast of Espírito Santo, migration from rural to urban areas, and the predominance of investments in road transport



Figure 4. Doce River, Itapina, photo credit: Willian Henrique, 2019

This context is reflected in the population decline of Itapina, which recorded a 53% reduction over a period of 50 years. In 1960, the population reached 5,350 inhabitants, with significant drops in the following decades (IBGE, cited by Tesch, 2018, p. 128). The period between 1960 and 1970 was also marked by a population decrease in Colatina, which experienced a reduction of 27.86% during the same period. As a result, there were impacts on job availability both in rural and urban areas, as well as repercussions in commerce and transportation. The concentration of the population in urban areas led to migratory processes towards new economic areas, such as the steel industry in the capital, Vitória (Tesch, 2018).

Since 1947, improvements in the road connections crossing the Doce River, in the north-south direction, were directed towards Baixo Guandu and the headquarters of Colatina, with bridges and paving integrated into the route of BR259, which was completed in the 1980s (Orrico et al., 2005). By linking with the Fontelle and Florentino Avidos bridges, and more recently, the Sérgio Ceotto Bridge, BR259 diverted the routes that came from the south and passed through Itapina, generating the district's isolation from the main flows.

In 1986, the ES446 road and part of the ES164, between Baixo Guandu and Itaguaçu, were paved (Sartório, 1996). In 2018, paving began on the ES446, from Colatina to Itaguaçu (DER, 2018), a project that was completed in 2021 (DER, 2021). The roads connecting Itapina to urban centers and rural areas remained as unpaved local roads (Figure 5).

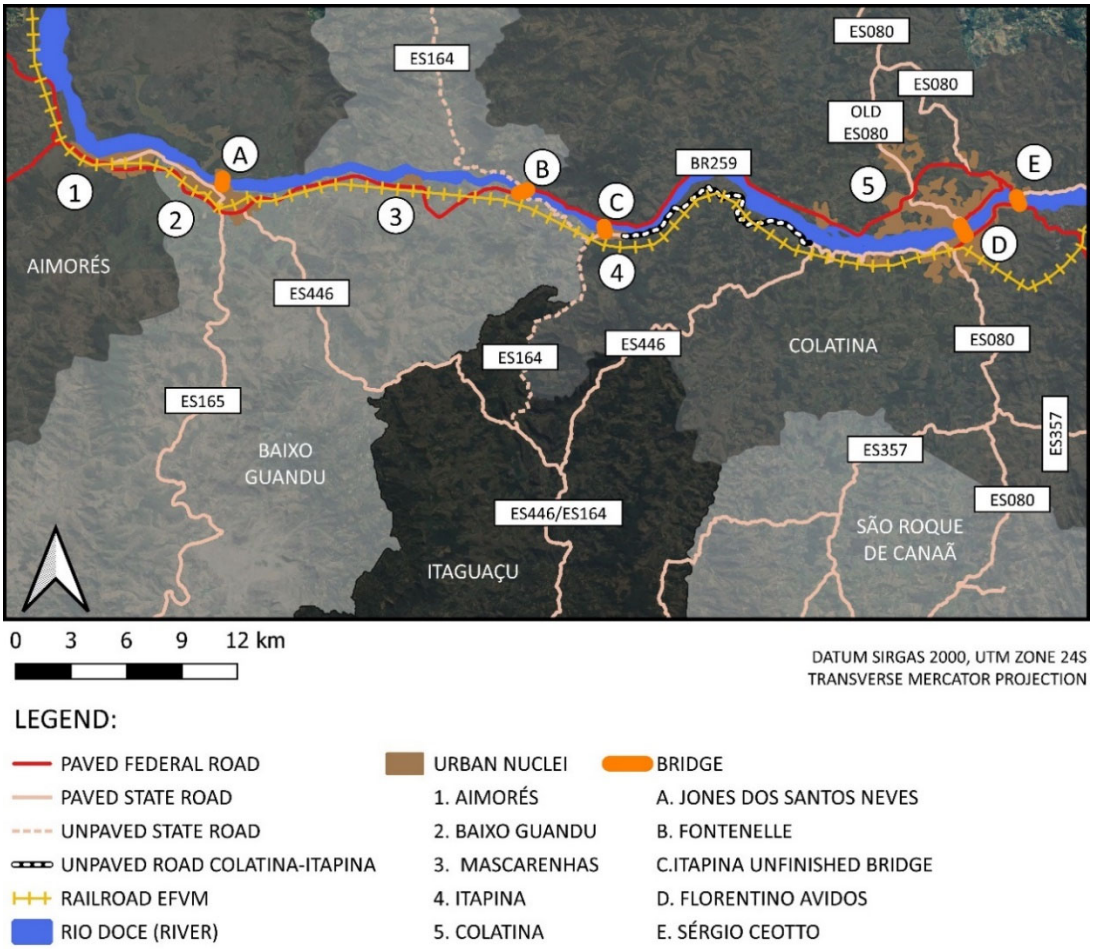

Figure 5. Current map of the road infrastructure and location of urban areas. Source: Adapted from the Qgis database, 2024.

Throughout the process of exploration and occupation of the Doce River, the riverbed and its banks have been modified and impacted by urbanization, transport networks and infrastructure, extractive activities, coffee cultivation, and the clearing of pastures. These actions not only suppressed native vegetation but also affected water resources, resulting in pollution and siltation, which caused environmental, social, and economic damage over time (Orrico et al., 2005). Additionally, this problem is compounded by the impacts of exogenous agents, such as mineral exploration, which peaked with the destruction caused by the collapse of the Samarco tailings dam in Mariana, Minas Gerais. This environmental crime occurred on November 5th 2015, and contaminated the Doce River all the way to its mouth (Organon, 2015).

Transformations and permanences

The road and transport context surrounding Itapina reveals a gradual loss of connectivity between the urban center and other areas, as well as with important trade and cargo transport routes. The Colatina-Itapina road, which runs along the southern bank of the Doce River, and the current ES164—an important north-south link that connected the area to Afonso Cláudio during the height of coffee production—still exist but no longer serve the same function. These roads are characterized by narrow, unpaved sections and are isolated from the ongoing improvements in road infrastructure and land transport routes. The ferry facilitates the crossing for people between the historic site of Itapina

and BR259; however, the reduction in population, along with the siltation and contamination of the river, has made trips less frequent.

This scenario is also related to the logics of morphological processes inscribed in the territory, which clarify the reasons for its current form, as pointed out by Panerai (2014). The driving forces of the improved highways direct and organize the agglomerations. The layouts are associated with the phenomena related to their creation, such as decisions and forces from the state or the market, marking the urban form and promoting order, symbolic stability, control, power, access, exclusion, economic function, or cultural values (Lamas, 2011). When routes are redirected, the exclusion of this territory from the context of new economic fronts promotes a stabilization of changes in its form.

When analyzing the spatial configurations, it can be observed that, in the first half of the 20th century, Itapina was an important nodal point in a vast region, serving as a point of arrival, departure, and modal transfer for journeys between productive rural areas and markets. The railway, the waterway, and the roads converged in the district, characterizing it as a local commercial, social, and cultural reference. The routes connecting rural areas to the urban center, configured by paths and roads running north-south along the river, as well as the railway, were associated with a rural landscape and the Doce River. Although the river is an important natural attribute for the emergence of the urban center, it also constituted a barrier to the growth and connection of Itapina with productive expansion to the north.

The economic and infrastructural changes in the region led to a process of hollowing out of activities in Itapina, resulting in population decline and abandonment of properties in the town. However, aspects related to the permanence of local attributes are observed, such as the urban form, built heritage, landscape, and cultural characteristics of the village formed until the 1950s (Bona and Almeida, 2019). This recognition materialized in the listing of the Historical and Landscape Ensemble of Itapina in June 2013 by the Secretaria de Cultura do Espírito Santo (Espírito Santo, 2013).

The periods identified from the road connections are associated with public policies and historical transitions, based on innovations introduced in the field of transportation that are exogenous to the locality. As demonstrated by Gimmler Netto, Pereira Costa, and Lima (2014: 32 – our translation), "[...] the evolutionary periods are based on innovations introduced into the urban landscape, which reflect economic, social, political, and cultural aspects of the rise and decline of certain forms [...] represent the synthesis between historical facts and innovations materialized in the urban landscape, determining formal characteristics."

The gradual consolidation of external road flows passing through Itapina and the secondary hierarchy of the highways providing access to the town contributed to the preservation of its architecture and urban layout. This contrasts with what occurred in neighboring cities, such as Colatina and Baixo Guandu, which were crossed by road transport for medium and long distances. Thus, in the context of urban centers near the Doce River, the crossing of road flows promotes more frequent formal changes than other modalities. Indeed, the railway and the operational river crossings did not bring about significant changes in the urban structure and landscape of Itapina after 1960.

Another condition that contributes to understanding the continuities in Itapina is the configuration of growth lines, characterized as "support for growth that occurs in a specific direction" (Panerai,

2014:60 – our translation). These lines can be represented by a road, a river, or a railway along which the agglomeration grows, taking into account the physical site and the poles it connects. The economic periods are reflected in the growth line of Itapina, which has been linked to the paths of invaders, the Doce River, and the EFVM railway, later becoming connected by an extensive road network.

The attempt to connect with the north through the Itapina Bridge failed, and its unfinished structure became a visual landmark of the town. The perception of the historical urban core as an important sector arises not only from the presence of a temporal segment but also from the typological similarity outlined in its preservation process.

On one hand, the economic stagnation and relative isolation of Itapina are associated with rearrangements of regional flows, aligned with economic development policies exogenous to the locality, which resulted in the transfer of important access points and connections to other cities. On the other hand, local groups maintained their relationship with space, preserving the conditions of the urban landscape. In the words of Panerai (2014), continuities activate a system of landmarks and references, facilitating everyday life and reinforcing local culture.

CONCLUSIONS

As Pereira Costa and Gimmler Netto (2015) explains, that historic urban landscapes are an important cultural asset, with a significance that transcends the community they are part of. The relation between routes, economic dynamics, and urban form points to a time span that preserved the landscape and elements revealing its origin, such as the river and train transport. Integration by water and the persistence of terrestrial routes indicate possibilities for maintaining its historical path. These factors, combined with its scenic and architectural heritage and the culture preserved by its residents, suggest the potential for reversing the current decline.

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Disruption, continuity, expansion, and reverberation
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Urban greenspace system planning and morphological evolution: a case study of Quanzhou, China

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ABSTRACT

Urban greenspaces have multiple functions and provide different ecosystem services for cities. The high-quality development requires an optimization in terms of layout and planning of urban greenspaces, leading to a widespread attention of urban greenspace morphology in recent years. The development of urban greenspaces is based on the Urban Greenspace System Planning (UGSP) in China, but how effective are the constructions of single greenspace and urban greenspace system under the top-down guidance of UGSP? Is UGSP the only factor which influence the construction of urban greenspace? From the perspective of urban greenspace morphology, this study aims to address this problem based on three rounds of UGSP and the corresponding construction situations of park system in Quanzhou, China. Firstly, we construct a database containing basic information of both planned and constructed park greenspaces in different periods, then, combine UGSP and satellite images, extract and measure morphological factors from the individual and system levels in three periods respectively. Secondly, we form our framework by selecting and reclassifying possible driving factors other than UGSP according to the regional history and relevant research. Finally, by evaluating and analyzing the greenspace morphology of planned and constructed parks, we identify driving factors and interpreter the evolution process of Quanzhou's park system. The results show that, from 1995 to 2020, there were 28.24% of parks development were influenced by the UGSP, morphological factors of planned parks, in terms of area (r=0.658**), shape (r=0.501**), type (r=0.331**), location (r=0.512**) and layout (r=0.204**) were positively highly significantly correlated with those of constructed park. While, the other morphological factors of parks are comprehensively influenced by various driving factors in urban space, which should be vital references for the future development of urban green space systems.

Keywords: urban greenspace, urban morphology, park system, driving factor

INTRODUCTION

As an important part of urban planning and development, the urban greenspaces (UGSs) contribute to the improvement of urban ecosystem and human well-beings. The Urban Greenspace System Planning (UGSP) provides a top-down guidance in the development process of UGSs in China. In 1992, China's state council issued the Urban Greening Ordinance, which stipulated the local city council assumed the responsibility to compile UGSP, while, in the Standard of Landscape Garden City, the compiling of UGSP became one of the evaluating indicator, both emphasized the vital role of UGSP.

With the constant publication of relevant policy and standard, the compilation and implementation of UGSP tend to be matured. In this process, experts and scholars have done a lot of research on UGSP in various aspects including policy (Liu and Wang, 2009), tool (He, Ye and Chen, 2015; Liu and Wang, 2009), theory and management (Zhang, Zhou and Yang, 2009; Li et al., 2016; Song and Zhang, 2016; Xiao, Cao and Li, 2020; Yang et al., 2010; Liu and Jiang, 2002; Yang, Li and Ye, 2019; Zhang, Guan and Li, 2018; Wu and Chen, 2000; Tan, 2005), which ensure the scientific and sustainable development of UGSP in the process of compilation and implementation. However, there is no study which focus in the influence of UGSP and its relation with the morphological evolution of UGSs. With the establishment of the National Territory Spatial Planning, a new round of UGSP is about to start. How to correctly understand the relation between UGSP and UGSs? How effective is the guidance provided to the construction of UGSs by UGSP? What factors may influence the guidance efficiency of UGSP? Which are crucial questions.

The identification of urban morphology can contribute to understand the laws and characteristics of urban development and predict future trends. Since the first International Seminar on Urban Form (ISUF) in 1997, different groups have come to agree that cities can be interpreted and analysed by three basic physical elements: buildings and their related open spaces, plots and lots, and streets. However, current research mainly focuses on the buildings, and lacking understanding of UGSs, which is an important part of urban open spaces (Zhu and Shi, 2021). Form, resolution and time are three basic elements of urban morphological research (Moudon, 1997). While UGSP controlling the form of UGSs in various scales in different phases of urban development, which means UGSP is a fundament of UGS morphological research in China. Therefore, urban morphology provides a theoretical framework for the questions mentioned earlier.

From the perspective of urban morphology, this study was based on Park Green Spaces (PGSs) in 3 rounds of Quanzhou's UGSP, constructed an evaluating framework for UGSs under the guidance of UGSP through correlation analysis, revealed the relation between UGSP and UGSs, then identified the driving factors which may influence the implementation of UGSP in urban space. The result may provide reference and guidance for compilation and implementation of UGSP in the future.

METHOD

Study Area

Quanzhou (24° 30′ -25° 56′ N, 117° 25′ -119° 05′ E) is a coastal city eastern China, bordered by Putian to the north, Xiamen to the south, and Taiwan to the east. It belongs to a subtropical maritime monsoon climate with superior climatic conditions. As of the end of 2022, the city's permanent population is 8.879 million. Since 1995, Quanzhou has carried out three rounds of UGSP. Quanzhou has achieved certain results in the construction of UGSs, in 2003, it was selected as the International Awards for Liveable Communities, then, in 2005, it was selected as a National Landscape Garden City. This study mainly focuses on the central area of Quanzhou city which divided by railways and natural water bodies. The study area is bounded by the Fuxia Railway on the north side, Jin River on the southwest side, and Luoyang River on the east side, including the central cluster, Beifeng cluster, Donghai cluster, and Chengdong- cluster, with a total area of approximately 156.19km2 (Figure 1).

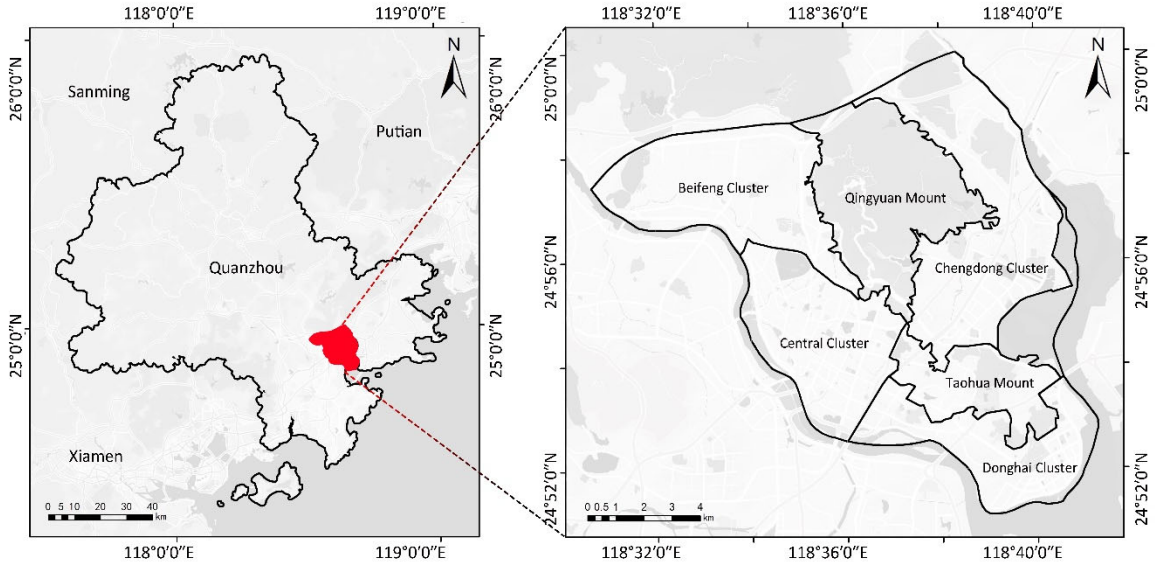

Figure 1. Study Area, satellite map source: https://www.google.com/maps/

Data Source

Currently, there were 3 rounds of UGSP in Quanzhou, which were respectively compiled in 1995, 2005 and 2010. Although both short-term and long-term planning target are compiled in UGSP, commonly a new round of UGSP would start before the achievement of long-term target because of the rapid urban development. The relations of different round of UGSP shown as Figure 2. Thus, this study selected clear and cloudless Landsat data in 1995, 2005 ,2010 and 2021 respectively (Table 1), which sourced from USGS (https://glovis.usgu.gov/), after data acquisition, preprocessing is carried out, including geometric correction, radiometric calibration, atmospheric correction, etc. Based on the UGSP documents and the interpretation results, we established a database of planned and constructed PGSs of Quanzhou on the ArcGIS platform.

Table 1. Data Source

c	Compilation Year	Data Source for Planned PGS	Implementation Year	Data Source for Constructed PGS
1995	1995	Landsat 4/5	2005	Landsat 7
2005	2005	Landsat 7	2010	Landsat 7
2010	2010	Landsat 7	2021	Landsat 8/9

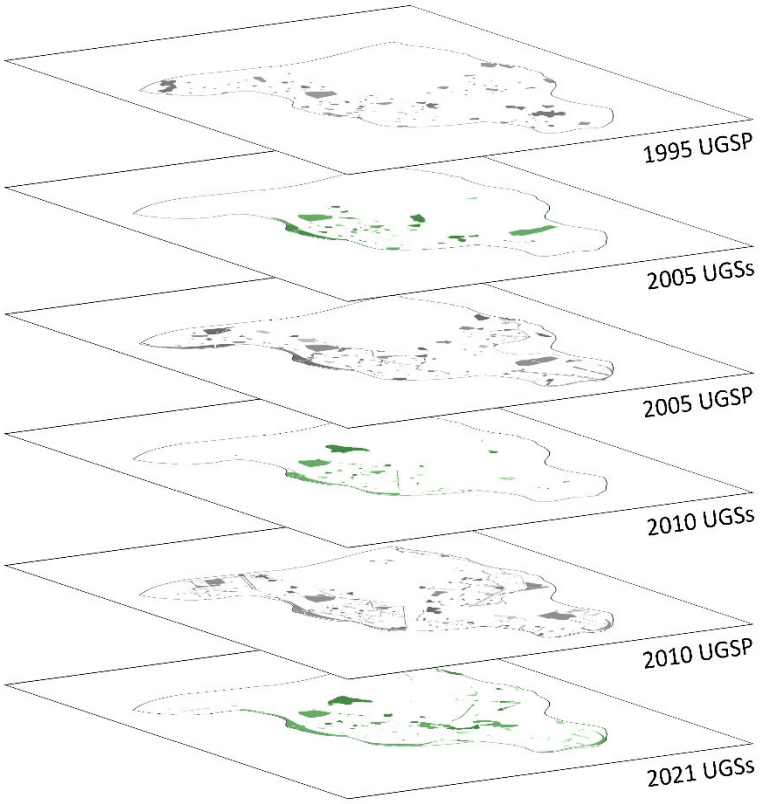

Figure 2. Relation of UGSs Development and UGSPs' Guidance

UPG Reclassification

There is a relatively long period between the compiling of three UGSPs, and the relevant regulations and standards are constantly changing, resulting in differences in the classification standards for UGSs. According to current classification standard named the Standard for Classification of Urban Green Space (CJJT 85-2002, detail shown in Table 2), this study sorted out the urban green regulations and historical materials of Quanzhou City reclassified the types of PGSs of different rounds of UGSP, in terms of their definition and functions, providing the same standard for research.

Table 2. Standard for Classification of Urban Green Space (CJJT 85-2002)

Category	Subcategory	Description
Park Greenspace	Comprehensive Park	Greenspaces with rich content, suitable for various outdoor activities, and complete recreational and supporting management service facilities.
	Community Park	Greenspaces with an independent area of land that features basic recreational and service facilities, primarily serving the local residents within a certain community for daily leisure activities.
	Theme Park	Greenspaces with specific content or form, equipped with corresponding recreational and service facilities.
	Small Park	Greenspace with an independent area of land that is smaller in scale or varied in shape, convenient for nearby residents to access, and possesses certain recreational functions apart from the other type of greenspace mentioned above.
Protective Greenspace	—	Greenspace with an independent area of land with functions of sanitation, isolation, safety, and ecological protection, which is not suitable for public access.
Square Greenspace	—	Urban public activity spaces primarily for recreation, commemoration, gatherings, and emergency shelter.

Affiliated Greenspace	Affiliated Greenspace of Residential Land	Greenspaces attached to various types of urban construction land.
	Affiliated Greenspace of Administration and Public Services Land	
	Affiliated Greenspace of Commercial and Business facilities Land	
	Affiliated Greenspace of Industrial and Manufacturing Land	
	Affiliated Greenspace of Logistics and Warehouse Land	
	Affiliated Greenspace of Road, Street and transportation Land	
	Affiliated Greenspace of Municipal Utilities Land	
Regional Greenspace	Landscape and Recreational Greenspace	Greenspace with good natural environment, open to the public, primarily serving functions such as leisure and recreation, tourism, entertainment and fitness, and scientific research, equipped with recreational and service facilities.
	Ecological Conversation Greenspace	Greenspace dedicated to ensuring urban and rural ecological security, improving landscape quality, and undertaking protection, restoration, and resource cultivation.
	Regional Facilities Protective Greenspace	Greenspace around regional transportation facilities and regional public facilities that serves functions of safety, protection, sanitation, and isolation.
	Production Greenspace	Nurseries, flower beds, and grass beds used for the production, cultivation, and trial introduction of various seedlings, flowers, grasses, and seeds for urban and rural greening and beautification.

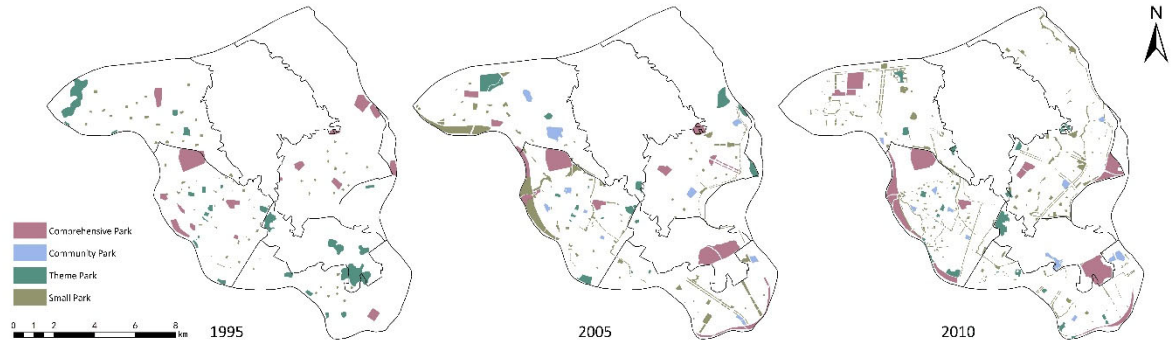

Figure 3. Planned PGSs in UGSPs

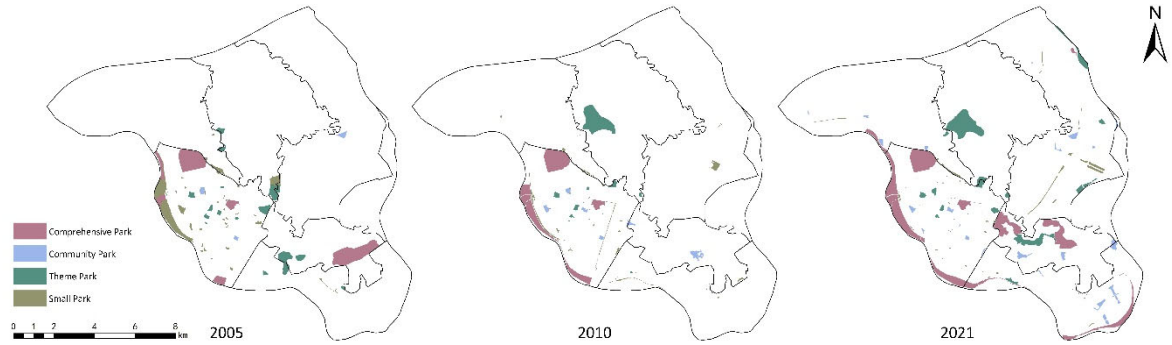

Figure 4. Constructed PGSs in Implemenatation Years of UGSPs

Morphological Factor Identification

Firstly, we overlapped planned PGSs and constructed PGSs of three rounds of UGSPs based on the Spatial Joint tool in ArcGIS, and selected the planned PGSs which were spatially connected with constructed PGSs. Then, through literature review and relevant research, the main morphological factors of UGS were pre-selected, including area, perimeter, shape, type, number of patches, location, etc. (Chen, Yang and Dai, 2023; Wu et al., 2023; Du, 2022; Guo, Hou and Shi, 2024; Yang et al., 2023; Sun et al., 2024; Yang and Xue, 2006; Ma and Lu, 2010; Gui, Wei and Huang, 2019). Finaly, we calculated the pre-selected UGS morphological factors of the planned and constructed UGSs mentioned above in FRAGSTATS and ArcGIS platforms, and conducted correlation analysis on SPSS platform.

RESULTS AND DISCUSSIONS

A Guidance Efficiency Indicator of UGSP

The correlation analysis results show that the planned PGSs is significantly positively correlated with the constructed PGSs in five morphological factors including area, shape, type, number of patches, and completion rate, indicating that UGSP provide guidance for the construction of PGSs in terms of morphological factors mentioned above (Table 3), and which were selected to evaluate the guidance of UGSP in this study.

Table 3. Correlation Analysis Result of Morphological Factors

Factors	Correlation Coefficient	P-value	Description
Area (AREA)	0.658**	0.000	Area of the PGS.
Shape Index (SHAPE)	0.501**	0.000	Standardization results of the area and perimeter of the PGS, describing its complexity.
Classification	0.331**	0.000	Types of parks and green spaces under current classification standards
Number of Patches (NP)	0.204**	0.007	The number of green patches a PGS divided by other urban land use
Built Area	0.512**	0.000	The area of the overlapping part of the planned PGS and its spatially connected constructed PGS
Perimeter (PERIM)	0.103	0.179	Perimeter of the PGS
Nearest Distance (NEAR)	0.013	0.864	The distance between the PGS and its nearest PGS

Based on the PGS morphological factors mentioned earlier, various evaluation indicators are constructed to quantify and analyse the guidance effectiveness of the PGSs in the three rounds of UGSP, and the technology roadmap is shown in Figure 5. We calculated the planned PGSs and the corresponding constructed PGSs with relation of spatial connectivity:

1) Area Ratio (AR), the area ratio of the planned PGS to the corresponding constructed PGS, indicating the guidance of UGSP in terms of area, which can be expressed as follows:

$$AR = \left| \frac{AREA_P - AREA_e}{AREA_p} \right| \quad (1)$$

where, AR is area ratio, $AREA_p$ is the area of planned PGS, $AREA_c$ is the area of corresponding constructed PGS.

2) Shape Ratio (SR), the SHAPE index ratio of the planned PGS to the corresponding constructed PGS, indicating the guidance of UGSP in terms of shape, which can be expressed as follows:

$$SR = \left| \frac{SHAPE_p - SHAPE_e}{SHAPE_p} \right| \quad (2)$$

where, SR is shape ratio, $SHAPE_p$ is the SHAPE value of planned PGS, $SHAPE_c$ is the SHAPE value of corresponding constructed PGS.

3) Built Ratio (BR), the ratio of overlapped area after Spatial Joint to the area of corresponding planned PGS, indicating the guidance of UGSP in terms of built accuracy, which can be expressed as follow:

$$BR = 1 - \frac{AREA_b}{AREA_p} \quad (3)$$

where, BR is built ratio, $AREA_b$ is the overlapped area, $AREA_p$ is the area of planned PGS.

4) Classification Accuracy (CA) is applied to determine the type consistency of planned PGS and corresponding constructed PGS. If the types are consistent, assign a value of 0; if not, assign a value of 1.

5) Patch Number Accuracy (NA) is applied to determine the patch number of planned PGS and corresponding constructed PGS, If the numbers are consistent, assign a value of 0; if not, assign a value of 1.

6) An efficiency indicator (EI) is constructed by integrating these morphological factors, and the lower the value, the smaller variation between the planned PGS and the constructed PGS, indicating that the better guidance effectiveness of UGSP; the higher the value, the greater variation between the planned PGS and the constructed PGS, indicating that the poorer guidance effectiveness of UGSP. The calculation formula is as follows:

$$EI = AR + SR + BR + CA + NA \quad (4)$$

where, EI is the efficiency indicator of UGSP; AR is area ratio; SR is shape ratio, BR is built ratio; CA is classification accuracy; NA is patch number accuracy.

EI of 576 planned PGSs have been calculated, then we employed Jenks Natural Breaks in ArcGIS, the calculating result is classified into two clusters with significant consistency. In the study area, if EI falls below or equals 3.25, the planned PGS is well guided by UGSP. Conversely, if EI exceeds 3.25, the PGS is poorly-guided by UGSP. Based on the calculating and clustering result above, we employed the quantity ratio of the well-guided PGSs to planned PGSs, indicating the guidance efficiency of certain PGS cluster. The calculation formula is as follows:

$$WGR = \frac{N_w}{N_p} \times 100\% \quad (5)$$

where, WGR is well-guided ratio; N_w is the number of well-guided PGSs; N_p is the number Planned PGSs.

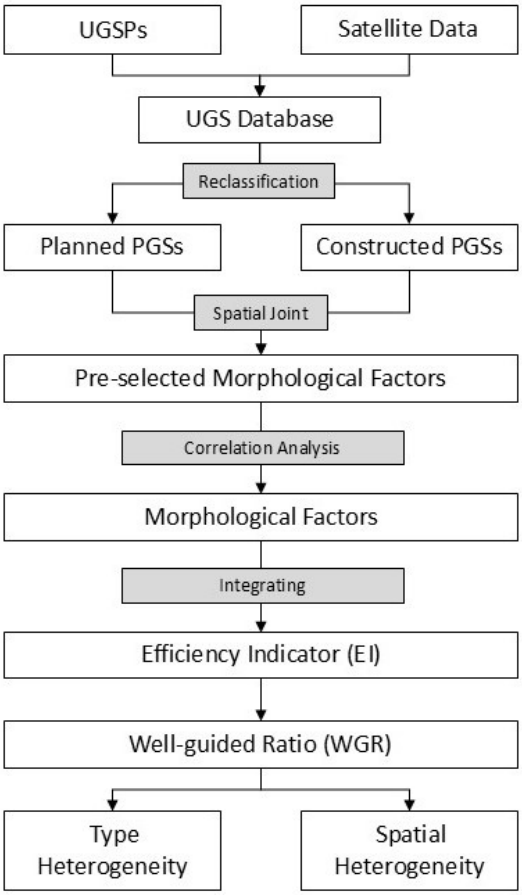

Figure 5. Technology Roadmap

WGR Heterogeneity of UGSP

There are 104 PGSs were well guided by UGSPs, the WGR of 576 planned PGSs in Quanzhou is 19.56%. Based on WGR calculations, the WGR of UGSPs exhibits heterogeneity in various aspects, which we will discuss in the following sections.

Type Heterogeneity

WGR of different types of PGSs in the three rounds of UGSP is shown in Figure 6. The community parks exhibit the highest guidance efficiency, while the small parks show the lowest. Overall, the WGR of community parks stands at 45.45%, the highest among the four types of PGS, indicating the best guidance efficiency of UGSP. Comprehensive parks and theme parks follow, with WGRs of 41.46% and 35.38%, respectively. Small parks have the lowest WGR at 12.25%, indicating the poorest guidance efficiency of UGSP. Due to the relatively large number of small parks, they significantly impact the overall WGR.

The high WGR of community parks can be attributed to their advantages in construction and management, as well as the increasing demand for public greenspaces at the community level by urban residents. Compared to comprehensive parks, community parks are smaller in scale, have shorter construction periods (Luo and Fu, 2016), and are easier to manage; compared to small parks, community parks have more comprehensive functions and higher recreational value. Additionally,

community parks are usually located near densely populated urban residential areas, closely integrated with the daily lives of urban residents. This proximity allows for better oversight of land use and construction quality by the surrounding community.

Theme parks maintain relatively high WGR, which is largely due to Quanzhou's emphasis on cultural heritage protection. Heritage parks make up a significant proportion of theme parks in the three rounds of UGSP in Quanzhou. As early as the 1995 UGSP, key national cultural relics such as Qingjing Mosque, Kaiyuan Temple, and Tianhou Palace were incorporated into the UGSP as theme parks. Due to the high historical and cultural value of these park green spaces, their form, quantity, and scale are strictly controlled and managed, making them less susceptible to other urban factors, thereby resulting in higher guidance efficiency.

The WGR of small parks is significantly lower than the other three types of PGS. This is because, in the 1995 UGSP, small parks were used as a "tool" to meet greenspace indicators, distributed as isolated points throughout the urban space without considering the rationality of greenspace construction. Both the 2005 and 2010 UGSP included plans for large numbers of linear small parks along main urban roads, again without considering the suitability of greenspace construction. In actual urban greenspace construction, these small parks, due to their small scale and unclear land ownership, either were not realized or became part of road affiliated greenspaces or protective greenspaces.

Related studies suggest that while amusement parks cannot replace the important role of large parks, they can optimize urban biodiversity (Gan, Guo and Yao, 2019), enhance community and social equity (Ye et al., 2023), promote the physical and mental health of nearby residents (Xu, Shi and Li, 2023), and improve urban microclimates (Peschardt and Stigsdotter, 2013). Therefore, the issue of their insufficient guidance should not be overlooked, as it has significant implications for the optimization of urban green space hierarchies.



Figure 6. WGR of different types of PGS

Spatial Heterogeneity

WGR of PGS in different urban clusters in the Three Rounds of UGSP (Figure 7). The central cluster demonstrates the highest WGR, with a more complete park system and similar spatial distribution characteristics across the three rounds of UGSP. Overall, the WGR of the central cluster is 36.12%, the highest among the four clusters, indicating the best guidance efficiency. The Beifeng cluster has the lowest WGR, both overall and in each individual round of UGSP, among the four clusters. Although the total planned PGSs in the Donghai and Chengdong clusters has been continuously increasing, the number of constructed PGSs is only in the single digits. The WGRs of these two clusters differ significantly from that of the central cluster. As shown in Figure 8, in the 2010, the park system within the central cluster is largely established, while constructed PGSs in the other clusters are more dispersed.

In the Beifeng cluster, although PGSs have been planned across the three rounds of UGSP, only three small park green spaces have been constructed in actual construction (Figure 8). The main reason for this is that, apart from the area around West Lake Park which is located at the border with the central cluster, the Beifeng cluster primarily consists of village construction land and agricultural and forestry land, which means this cluster is still in the early stages of urban development. Consequently, the demand for PGSs from the surrounding residents is relatively low.

The Chengdong and Donghai clusters are influenced by the nearby Qingyuan Mountain Scenic Area, and the Taohua Mountain greenspace which share the same mountain range. This reduces the recreational demand within the clusters. Numerous studies have confirmed that urban scenic areas have public and communal functions (Chen and Chen, 2018; Li, 2015), providing recreational, spiritual, and cultural benefits. This results in the planned PGSs near the mountain edges within these clusters remaining largely unconstructed. In contrast, most of the constructed PGSs in these two clusters are distributed along natural water bodies. Research indicates that waterfront areas are popular spots for visitors, offering unique recreational experiences to urban residents (Zhai and Wu, 2020).

This study illustrates that the guidance efficiency of PGSs is influenced by urban land use and landscape patterns. Therefore, it is essential to prioritize these areas mentioned above during the compilation and implementation of UGSP.

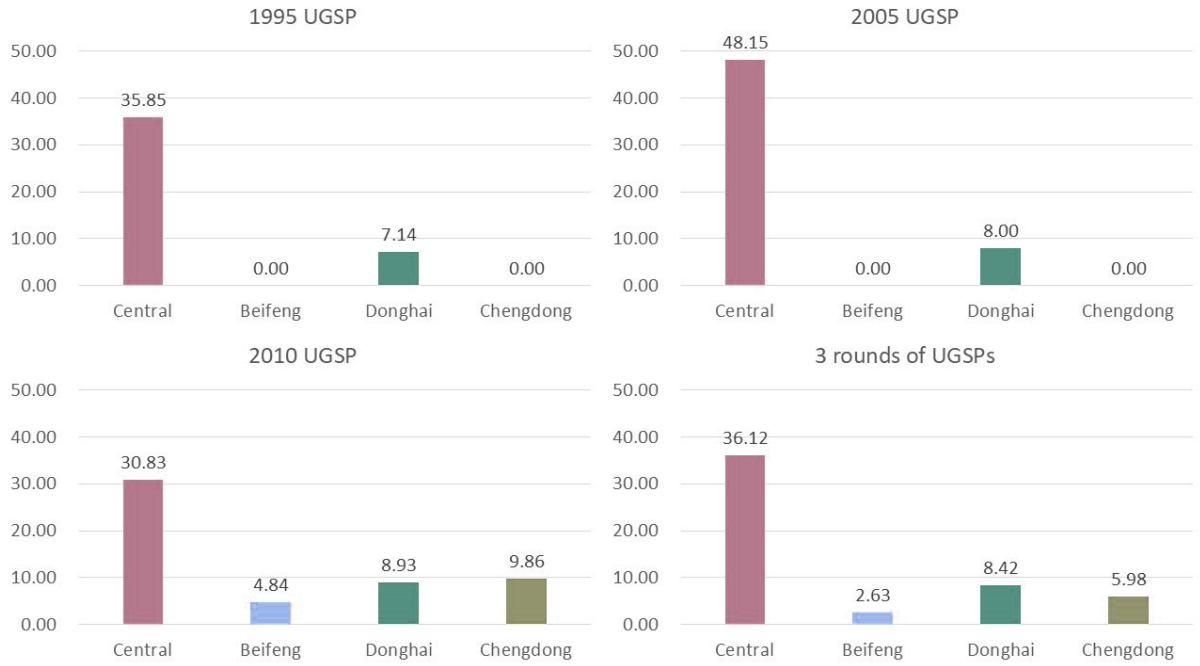

Figure 7. WGR of different clusters of PGS

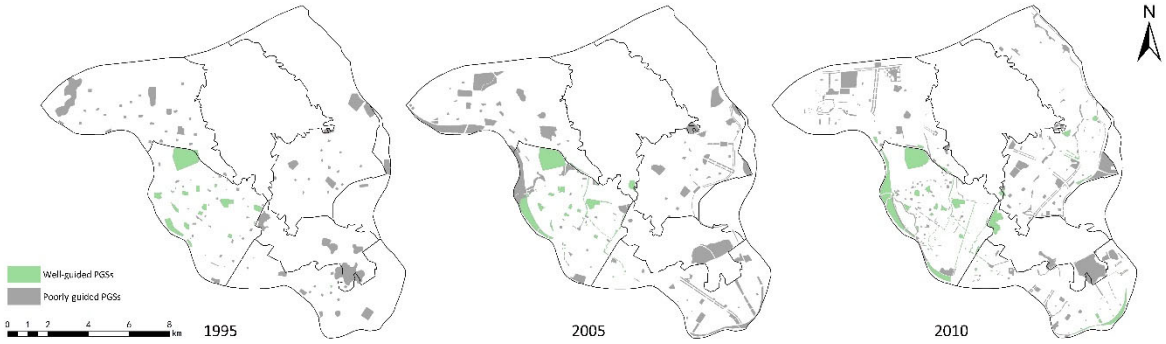

Figure 8. Well-guided PGSs and Poorly-guided PGSs of UGSPs

CONCLUSIONS

This study develops an evaluation indicator for the guidance efficiency of UGSP and identifies driving factors affecting the guidance efficiency of UGSP. Focusing on the PGSs in the three rounds of UGSPs in Quanzhou, the study measures and analyses guidance efficiency with the following results: From the perspective of UGSP, the guidance efficiency show heterogeneity. Regarding the types of PGS, community parks exhibit the highest guidance efficiency, while small parks show the lowest. In terms of spatial distribution, the central cluster has the highest guidance efficiency, featuring a more complete park system within the cluster.

Overall, the guidance efficiency of UGSP is influenced by various factors. Throughout the UGSs development process or within a specific round of urban green system planning, the guidance efficiency of different types of park green spaces varies. This variation is related to the robustness of relevant regulations and standards, the demands of residents around the UGS, the scale and value of the UGS, and the management and protection by relevant departments. Land use properties and landscape patterns also affect guidance efficiency. PGS in riverside areas have better guidance

efficiency, while those near regional greenspaces have lower efficiency. These research findings provide valuable insights for the compilation and implementation of UGSP. The evaluation method for guidance efficiency proposed in this paper also introduces a new research perspective in this field.

However, there are some limitations in this study. For instance, it only considers PGS with independent spatial connections between planned and constructed PGS. There may be cases where a small portion of the planned PGS is divided into multiple greenspaces during implementation, or constructed green spaces were originally planned as multiple greenspaces. Additionally, due to the small sample size of planned and constructed community greenspaces, the findings might not comprehensively explain its guidance efficiency. This paper primarily focuses on PGSs within UGSs, aiming to clarify the impact of UGSP on PGSs construction. While, UGSs include other types of greenspaces that are closely related to the living environment. Future research will expand on this methodology to the entire urban green system, identifying different guidance efficiency factors for various greenspace types. This will be done both longitudinally by increasing the temporal scope and horizontally by expanding the research scale, providing a foundational basis for the future compilation and implementation of UGSPs.

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System for validating urban mobility plans according to the minimum criteria required by law nº. 12.587/2012

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ABSTRACT

This article presents a methodology for analyzing the content of Urban Mobility Plans proposed by Machado in 2019, verifying the alignment of the minimum content required by Law nº 12.587/2012 and the Support Booklet, proposing a search codification for the minimum content for evaluating plans of small municipalities. Based on the methodology presented by Machado (2019) and using data from the Survey on the Status of Urban Mobility Plans made available by the Ministry of Cities as a source, the research sample was defined, delimiting, from all the municipalities, the Brazilian region to be studied and the UMPs of the municipalities to be analyzed. After defining the codes and search elements, based on the Support Booklet provided by the federal government and the coding proposed by Machado (2019), the codes were entered into qualitative data analysis software to obtain, process and organize the results. It should be noted that the lack of uniformity in the presentation of the plans was a limiting factor for the tool used in the content analysis methodology, as they could not be read by the MAXQDA software because they were files identified as images and not text. In order to optimize the validation of compliance with the minimum criteria required by law and what was presented by the municipality, it is important to calibrate the search elements to include words and terms similar to those searched for. Calibration can be carried out after the data processing stage, including the terms similar to the corresponding codes, re-running the search for each code and processing the data before starting the process of categorizing and counting the number of occurrences.

Keywords: methodology,municipality, categorize, evaluation.

INTRODUCTION

The National Urban Mobility Policy (PNMU), established by Law nº12.587/2012, is an instrument of urban development policy that aims to integrate different modes of transport and guarantee universal accessibility and mobility of people and cargo throughout the municipal territory (BRAZIL, 2012). Before Law nº12.587/2012, municipalities sought to implement standards and actions aimed at improving urban mobility only when financing or receiving resources from the Federal Government was involved. The promulgation of the Law highlights the obligation of urban mobility objectives that

are related to the municipality's territorial and urban planning and these objectives must produce satisfactory benefits consistent with the resources used (BRASIL, 2013).

The compliance of the objectives, principles and guidelines of the PNMU must be carried out with the Urban Mobility Plans (PMU) and are mandatory for municipalities with more than twenty thousand inhabitants, members of metropolitan regions, integrated economic development regions and urban agglomerations with a total population of more than one million inhabitants and members of areas of tourist interest (BRASIL, 2012). While the minimum content of the PMU is characterized in article 24 of Law nº12.587/2012through eleven topics that guide the implementation of the PNMU in Brazilian territory. The regulations and responsibilities are assigned to the three spheres of government: the Union is responsible for offering technical and financial assistance to the states, Federal District and municipalities, in addition to promoting the development of technologies and scientific knowledge that meet the principles and guidelines of the Law and, continuously, aligned with states and municipalities, promote the training of people linked to the PNMU. The states are responsible for providing urban intermunicipal public transport services or delegating the function to municipalities through a consortium or cooperation agreement; ensure the support and promotion of services that go beyond municipal territorial limits and propose tax and incentive policies for their implementation.

The responsibility of municipalities is to plan, execute and evaluate the PNMU, provide urban public transport services, train people and develop institutions linked to the PNMU and regulate urban transport services in their territory. For Oliveira (2012), the regulation may seem simple, but it proves to be innovative by stating that mobility must be considered when building cities and by reaffirming that planning should not be carried out only in the central regions of cities but throughout the entire city. Its territory, including territorial relations between municipalities and their districts. Carried out by the Ministry of Cities (MCID - BRASIL, 2023), the survey of the situation of Urban Mobility Plans shows that around 1,865 municipalities are required to develop and approve the PMU and, of this total, 1,582 cities have less than 100 thousand inhabitants.

Observing the difficulty faced by municipalities with up to 100,000 inhabitants in preparing their plans, the federal government, from 2019 onwards, began offering specific technical support for the development of PMUs in these municipalities with the Support Booklet and the digital system for preparing the initial version of the plan. However, this is not the only option for these municipalities, in the literature there are also specific scripts and strategies for cities that aim to develop their PMU (PIRES, 2020; WRI BRASIL, 2017; COSTA and MARTORELLI, 2016; BRASIL, 2007).

This article aims to validate the PMU content analysis methodology proposed by Machado in 2019, using as a search basis for analysis the content of the Booklet to support the development of urban mobility plans for municipalities with up to 100 thousand inhabitants developed by federal government. It is necessary to verify the alignment of the minimum content required by Law No. nº12.587/2012 and the Support Booklet and propose a search coding for the minimum content for evaluating PMUs in small municipalities.

The criteria established by IBGE for population arrangements will be adopted: small size for municipalities with up to 100 thousand inhabitants, medium size between 100 and 750 thousand inhabitants and large size for municipalities with more than 750 thousand inhabitants (IBGE, 2017a).

To achieve the proposed objectives, research classified as descriptive was carried out, as it proposed to describe the characteristics of a given event (GIL, 1991 apud SILVIA and MENEZES, 2005).

METHOD

As one of the Union's obligations described in the PNMU is to offer technical and financial assistance to the States, Federal District and municipalities, programs, events and tools were promoted with the aim of stimulating the knowledge and training of public managers for the development of the PMU jointly or not with the transfer of income to achieve the plan's goals. Below, some of the instruments made available by the Union will be presented.

The National Cities Training Program (PNCC or Capabilities) provides technical training to help cities execute regional and urban development programs and projects and build a fairer and more democratic society (BRASIL, 2020). Starting in 2013, as part of Capabilities, the National Secretariat for Urban Mobility (SEMOB) began to hold in-person Awareness Seminars for the Urban Mobility Policy and Plan to promote Law nº12.587/2012 and workshops for the preparation of the PMU. The purpose of the activities is to provide a moment for reflection, projection and exchange of experiences about urban mobility within the organization of each participating municipality (BRASIL, 2022).

The Reference Booklet for the Preparation of the Urban Mobility Plan was the support material released by the federal government in 2007 to guide municipalities with populations above 500 thousand inhabitants in the construction of their Transport and Mobility Master Plans (PDTM), item mandatory with the promulgation of Law nº12.587/2012 (BRASIL, 2007). The document was republished in 2015 after a technical review to add the new principles, guidelines and obligations required by Law nº12.587/2012 (ITDP Brasil, 2015).

These Reference informs that the itineraries and suggestions brought are generalizations constructed from the average characteristics of Brazilian cities, however the Notebook and the PNMU show inconsistencies by not considering the themes of promoting public transport and discussing cargo transport for municipalities small.

The municipalities with a population of up to 100 thousand inhabitants have, in addition to the Reference Booklet, three exclusive instruments made available by the federal government to assist in the preparation of their PMU: the Support Booklet, the Support System for the Preparation of Urban Mobility Plans and the video tutorial “Support Program for Mobility Plans”, available on TV Portal CNM’s YouTube channel. According to Brasil (2022), the support system is a computerized system that aggregates the information described by municipal managers and generates a preliminary version of the PMU with the minimum content required by the PNMU.

The methodology presented in the Support Booklet suggests a 14-item structure for the PMU, with the first three items being an introduction to the plan with presentation, history and characterization of the municipality and the remaining eleven items must deal with each minimum content described in Art. 24 of Law nº12.587/2012 (BRAZIL, 2019). Unlike the Reference Booklet, the Booklet indicates only four steps for the development of items referring to the minimum content foreseen in the PMU: diagnosis, objectives, goals and strategic actions. This instrument presents a description of each

mandatory topic, suggested material for diagnosing the situation and examples of objectives, goals and strategic actions.

The methodology proposed by the Booklet recommends the institution of the PMU in the form of a municipal law, even though Law nº12.587/2012 does not oblige the municipality to take this action. According to Martorelli in the video tutorial on TV Portal CNM (2020), approval in the form of a municipal law offers a guarantee for compliance and continuity beyond municipal management.

Metholodologies for PMU Analysis

The Law nº12.587/2012links the approval of plans with the release of federal resources for activities related to urban mobility in municipalities. As there is no obligation to establish the PMU through a Law or municipal decree, there is a decrease in the power of supervision by any citizen and a lack of guarantees in relation to the execution of the objectives and actions described in the PMU by subsequent administrations.

Carneiro (2018) proposed a qualitative analysis of PMUs from a traffic safety perspective using inductive, comparative and observational methods. With the proposal to analyze the conception and applicability of the PNMU, Machado (2019) proposed a PMU content analysis methodology different from that presented previously.

Machado (2019) analyzes the applicability of each PMU, checking the coherence between plan and theory, plan and Law and effectiveness of the actions proposed in the plan. To compose its analysis sample, the following criteria are adopted: approval of municipal legislation, complete PMU (text contains the phases of diagnosis, prognosis, action plan and means of financing and monitoring) and completion after approval of Law nº12.587/2012 until 2018 (research preparation period). Moraes (2021) sought to analyze the content of municipalities' PMUs from the perspective of active mobility, establishing as criteria PMUs developed after 2012 (law nº12.587/2012), the availability of the plan on municipal administration digital platforms and documentary sufficiency , defined in four items: objectives for active mobility, guidelines, strategies and action plans and mapping of proposals.

However, unlike Machado (2019) who analyzes the data obtained through frequency measurement, Moraes (2021) uses the word cloud tool to examine and discuss the assertiveness of the proposals for active mobility of the PMUs in his sample. The discussion is carried out on the cloud composed of the recurrence of all grouped categories, followed by the isolated clouds for each city studied. As it is not intended to obtain data on attributes of the PMU analyzed and the objective is to identify the minimum content required in the PNMU, without bias towards a theme, we chose Machado (2019) does not require the full reading of the PMU and verification of the content is identified based on the existence or absence of search elements, without the interference of the examiner's understanding of the text read.

Based on the methodology presented by Machado in 2019 and using data from the Survey on the situation of Urban Mobility Plans made available by the Ministry of Cities as a source, the methodology of this research is divided into four stages. First, to define the research sample, delimiting, from all municipalities, the Brazilian region to be studied and, subsequently, the PMUs of the municipalities to be analyzed. Next, the codes and search elements are defined, based on the Support Booklet provided by the federal government and the coding proposed by Machado (2019). Based on these definitions,

the PMU and codes are inserted into qualitative data analysis software to obtain, process and organize the results, making up steps three and four of the methodology.

To define the sample municipalities, data from the Survey on the status of Urban Mobility Plans made available by the federal government through the Ministry of Cities website was used. The MDR informs that the survey on the status of the preparation of PMUs is carried out through the responses of municipalities to a letter sent by SEMOB to representatives of city halls, with the last sending being carried out in February 2019, and emphasizes that it does not carry out any assessment of the content of PMUs, with municipalities having full responsibility for the information passed on to the federal government (BRASIL, 2023).

The files used for data processing are called Status of preparation of urban mobility plans in municipalities with up to 250 thousand inhabitants and List of municipalities required to prepare the urban mobility plan, which will be treated as Status 250 and List of municipalities, respectively, from this point. The spreadsheets used in this work were downloaded in May 2023.

The information contained in the Status 250 spreadsheet is arranged in columns called municipal code - IBGE, Region, UF, Municipality, Has an Urban Mobility Plan, Year of preparation, Approved by law or normative act, Legal Instrument, Law No. and Date of Law. In List of municipalities, the information is municipal code - IBGE, Region, Federative Unit, Municipality, RIDE, RM, Urban Agglomeration (AU) - IBGE 2021 and Population - 2010 Census (IBGE), also arranged in columns.

To find the status of preparation of PMUs in municipalities with up to 100 thousand inhabitants, the Population column - 2010 Census (IBGE) of the Municipality List spreadsheet was added to the Status 250 spreadsheet. For this purpose, the Excel PROCV search formula was used, using as value searched in both spreadsheets for the municipality code – IBGE. After obtaining the list, the Excel Dynamic Spreadsheet tool was used in the resulting spreadsheet, with the Region field in the lines area and Population - 2010 Census (IBGE) and Municipalities in the values area.

It was found that there are 1,582 cities with less than 100,000 inhabitants required to prepare the PMU and as the first selection to define the municipalities in the sample, the Brazilian region with the largest number of small municipalities required to prepare the PMU was used. As the Northeast region has the largest number of small municipalities required to prepare the PMU, 576 in total, this was the region selected to obtain the PMU for analysis. For the next step in composing the research sample, a filter was carried out in the Region column to select municipalities in the northeast region in the list with the status of PMUs of all municipalities required to prepare with a population equal to or less than 100 thousand inhabitants. The selection was copied to another spreadsheet to create a new dynamic table formed by the Has Urban Mobility Plan fields in the lines and values areas.

RESULTS AND DISCUSSIONS

It was found that 575 small municipalities in the northeast region received the letter sent by SEMOB, the exception was the city of Bom Jesus (RN) and there are no records of explanations from SEMOB or MCID for what happened. 315 cities declared that they did not have a PMU, 237 did not respond to the question and 23 declared that they had a PMU.

From the 23 municipalities that declared that they had a PMU to the federal government, two criteria were applied to compose the analysis material: 1) the preparation of the PMU after the year 2012 (Law nº12.587/2012 is in effect) until 2023 (the year the research was carried out); and 2) the availability of the plan in electronic form. The municipalities of Sento Sé in Bahia and Bonito, Pesqueira, São Bento do Una and Surubim in Pernambuco were excluded from the PMU search, as they declared the preparation and approval of the PMU before 2012, between the years 2006 and 2011 and did not declare to the federal government have updated their plans.

With the remaining eighteen municipalities, the plans were searched for through city hall websites and, when this search failed, an email was sent to the city hall or the municipal ombudsman's office and the request of the PMU through e-SIC of each municipality. The mobility plans for Santa Maria da Vitória, Tabuleiro do Norte, Santa Inês, Bananeiras and Ipojuca were not found on the websites of their respective city halls. The request was then made via email and e-SIC.

The municipality of Santa Maria da Vitória, Bahia, indicated Municipal Law nº12.587/2012 to the MDR as the law regulating its PMU, however this law establishes the municipality's Master Plan, which in turn does not mention the words mobility, vehicles, pedestrian once. , transport, bus or bicycle. Using the law and decree search tool made available by the municipality of Tabuleiro do Norte, Ceará, we found Complementary Law 002/2018, reported to the MDR as responsible for establishing the PMU in the municipality, but we are directed to the file of Municipal Law nº 998 /2018 that grants the title of Tabuleirense citizen to Mr. Antônio Pinheiro Granja. The request for information about the mobility plan was registered under protocol 20221122-0025 on the municipality's e-SIC portal and there was no response.

The request for access to Municipal Law nº101/2015 informed by the municipality of Santa Inês, Maranhão, to the MDR as a regulatory law for the PMU was made only through the Ombudsman's Office page available on the municipality's website, as there is no field for registration and requesting documents. No protocol number was provided to accompany the request, nor was the request returned until the completion of this work.

The municipalities of Bananeiras, Paraíba, and Ipojuca, Pernambuco, did not provide a number of laws or decrees to sanction their PMUs. The request made to the Bananeiras e-SIC did not generate a protocol number for monitoring, while the Ipojuca request was made through protocol 00010.000039/2022-60. As in the cases mentioned above, there was no response from the municipalities in these cases.

The remaining thirteen mobility plans were located on city hall websites using the transparency portal, search in the search bar using the number of the regulatory law or the words mobility plan or official gazette of the municipalities. The files were downloaded and renamed with the name of the municipality and state for insertion into the data analysis software . However, after including the files and each search code in the software, it was found that five files were not read, as they are printed documents that were scanned and, even though they had the .PDF extension like the other files, these they behaved like image files and not like text files, preventing the search for words by the MAXQDA software. For this reason, only the PMUs of Aracati, Currais Novos, Entre Rios, Limoeiro do Norte, Paulo Ramos, Serra Talhada, Vitória do Mearim and Zé Doca remained part of the research sample.

Definition of Codes and Search Elements

The definition of codes and search elements used was generated by combining the content of the Support Booklet for municipalities with up to 100 thousand inhabitants and the categories used by Machado (2019) in his content analysis. The codes were defined based on the eleven topics described as mandatory by Article 24 of Law nº12.587/2012, which was presented in chapter 2.2. and are also the basis of the Support Booklet's simplified methodology. In this way, the entire content of the Support Booklet was read and words related to the content of each topic were extracted to form the list of search elements.

It was found that the categories Road Safety, Infrastructure, Social Groups, Integration, Circulation Regulation and TPC Regulation by Machado (2019) can be directly related to topics II to VIII and X of the obligations required by the PNMU, thus their elements were added to the code elements extracted from the Support Booklet.

The 1176 elements from the data processing stage were counted and are distributed with: 169 occurrences for Public Transport; 233 in Road Circulation; 322 in Infrastructure; 91 in Accessibility; 20 in Modal Integration; 31 in Cargo Transport; 9 in Generator Pole; 173 in Parking Lots; 4 in Access and Circulation; 67 in Financing Mechanisms and Instruments and 57 occurrences for Assessment and Update. To verify whether the PMUs in each municipality meet the minimum requirements stipulated in Law nº12.587/2012, the results obtained were organized by municipality and corresponding code and are presented in Table 1.

Table 1 - Number of Occurrence: Code x Municipality. Source: author (2023).

	Aracati (CE)	**Currais Novos (RN)**	**Entre Rios (BA)**	**Limoeiro do Norte (CE)**	**Paulo Ramos (MA)**	**Serra Talhada (PE)**	**Vitória do Mearim (MA)**	**Zé Doca (MA)**
Public Transport	80	6	12	20	2	17	3	29
Road Circulation	92	6	13	52	10	32	2	26
Parking lots	97	4	3	26	10	17	1	15
Infrastructure	198	6	7	64	7	23	2	15
Cargo Transport	2	1	3	5	-	8	1	11
Financing Mechanisms and Instruments	51	1	4	1	2	1	1	6
Assessment and Update	25	1	11	12	-	6	-	2
Accessibility	29	3	9	17	4	23	4	2
Generator Pole	2	-	2	2	-	1	-	2
Modal integration	10	1	-	1	1	6	-	1
Access and Circulation	-	-	2	-	-	2	-	-

The codes Accessibility, Road Circulation, Parking, Infrastructure and Financing Mechanisms and Instruments were recorded in all plans analyzed. Cargo Transport was not registered only in the PMU of the city of Paulo Ramos. Assessment and Update and Modal Integration was not present in the plan of two municipalities and no Generator Pole element was not registered in three plans in the sample.

The Access and Circulation code was the least recorded in the research, being present only in the PMUs of the municipalities of Entre Rios and Serra Talhada, with two occurrences in each plan.

The analyzes carried out in this work are not intended to establish statistical correlations between the codes and elements sought, but to offer aspects, clues and trends that can guide future research on the topic. As only the PMU in the municipality of Serra Talhada, Pernambuco, presented at least one occurrence of all the codes sought, it is concluded that only this municipality addresses all the minimum content required in Law nº12.587/2012 in light of the proposed methodology.

Regarding the methodology presented by the Support Booklet, only the municipality of Aracati presents the four suggested stages: diagnosis, objectives, goals and strategic actions. The plans for Currais Novos, Entre Rios, Limoeiro do Norte and Paulo Ramos mention the need to carry out the diagnostic stage to achieve the proposed objectives, but do not provide or inform how to obtain data from this stage. Although not mandatory, the Support Booklet and other instruments made available by the federal government suggest the establishment of the PMU through some legal instrument such as a law or municipal decree and only the municipalities of Aracati and Vitória do Mearim did not comply with this suggestion. Table 2.

Table 2 – Characterization of the cities in the sample. Source: Author (2023) based on the IBGE 2022 Census.

UF	Municipality	Population	Territory [km²]	PMU pages	Returned Elements
BA	Entre Rios	38,098	1,187.77	19	66
CE	Aracati	75,112	1,227.20	498	586
CE	Limoeiro do Norte	59,560	744.53	44	200
MA	Paulo Ramos	20,341	1,168.61	36	36
MA	Vitória do Mearim	30,805	716.72	3	14
MA	Zé Doca	40,801	2,140.11	11	109
PE	Serra Talhada	92,228	2,980.01	17	136
RN	Currais Novos	41,318	864.35	5	29

The city of Aracati (CE) presented 586 occurrences, being the highest number of results in the search. Next we have the municipalities of Limoeiro do Norte (CE) and Serra Talhada (PE) with 200 and 136 occurrences, respectively. Regarding the number of PMU pages, the city of Aracati (CE) also has the largest plan, with 498 pages. The difference between the plans for the next two cities is more than 450 pages, with Limoeiro do Norte (CE) having 44 pages and Entre Rios (BA) having 19 pages.

The large difference between the number of pages of the plans analyzed can be explained by Aracati and Limoeiro do Norte having benefited from the Urban Development Program for Regional Poles of Ceará, promoted by the Secretariat of Cities of the States of Ceará, which allowed the obtaining of

financial resources for hiring consultancies and consortia to prepare the PMU (CEARÁ, 2023). The PMU in the city of Aracati was carried out by IDOM Consultoria Ltda. hired in 2016 by the Secretariat of Cities of the State of Ceará to advise the municipalities of Sobral, Coreaú, Forquilha and Aracati in the preparation of their plans (CEARÁ, 2016).

The city of Limoeiro do Norte had its PMU updated by the Prodeurb Ceará Consortium, made up of the companies Tecnotran Engenheiros Consultores Ltda., Instituto da Mobilidade Sustentável – Rua Viva and Cadaval Arquitetura e Urbanismos Ltda, contracted by the government of the state of Ceará through contract nº.028/CITIES/2016 to assist in the preparation and updating of PMUs in the municipalities of Jaguaruana, Quixeré, Massapê, Santana do Acaraú, Irauçuba, Russas, Morada Nova, Limoeiro do Norte, Tabuleiro do Norte and Jaguaribe (CEARÁ, 2018).

The cities of Paulo Ramos (MA) and Vitória do Mearim (MA) are the cities with the PMUs with the lowest number of pages, 4 and 3 respectively, and with the smallest population, approximately 20 and 31 thousand inhabitants. Vitória do Mearim is also the city with the fewest results, with only 14 words divided between seven of the eleven codes searched.

CONCLUSIONS

As around 1,865 municipalities are required to develop and approve the PMU (BRASIL, 2023), the full reading of its texts to verify the content and adequacy to the requirements of Law nº12.587/2012 appears to be an unexecutable form by the government, as it would require a lot of reading and analysis time for a team, in addition to allowing subjectivity in the examiner's interpretation because, as we have seen throughout this work, the plans do not have a uniform structure, presentation or number of pages.

The content analysis methodology proposed by Machado (2019) and used in this work presented itself as a valid option for verifying PMU content in a massive and impersonal way. By searching for words throughout the text using qualitative data analysis software , full reading of the plans is not necessary and allows the analysis of many pages in a few hours.

In this work, more than 600 pages from eight different mobility plans were analyzed in less than eight hours, considering the stage of processing the results obtained, excluding terms that did not fit the expected context. Among the words most returned by the MAXQDA software we have sidewalk with 201 returns, parking with 157 and public transport with 87 results. The word sidewalk belongs to the Infrastructure code, which was the most cited among all the plans in the sample, 322 occurrences.

However, during the research, the need to include a code calibration step was identified to include synonymous terms that were not considered in the first search because they were not cited in the Support Booklet or in the work of Machado (2019), such as bicycle parking in the same direction as the bicycle rack and traffic restrictions in the same direction as the circulation restriction.

It is worth noting that the lack of uniformity in the presentation of plans was a limitation for the tool used in the content analysis methodology. As explained in chapter 3.1. and 3.3. five PMU located were not read by the MAXQDA software because they were files identified as images and not text.

The establishment of the PNMU through Law No. 12,587/2012 was a milestone for Brazilian urban mobility. Following its sanction, municipalities now have legal support to prioritize non-motorized transport over motorized transport and public transport over individual transport, potentially reversing years of investment and prioritization of individual motorized transport in urban centers.

As the Ministry of Regional Development informs that it does not carry out any evaluation of the content of the PMU, the results presented in the survey on the situation of the Urban Mobility Plans are merely a compilation of the information sent by city halls through letters sent by SEMOB (BRASIL, 2022), The present work proposed as its objective to validate the PMU content analysis methodology proposed by Machado in 2019, using as a search basis for analysis the content of the Booklet to support the development of urban mobility plans for municipalities with up to 100 thousand inhabitants developed by the federal government. To validate the methodology, one of the specific objectives was to verify the alignment of the minimum content required by Law nº12.587/2012 and the Support Booklet.

As the Support Booklet presents the eleven topics described as mandatory by Article 24 of Law nº12.587/2012 and a simplified four-step methodology (diagnosis, objectives, goals and strategic actions) it was verified that this tool made available by the federal government and the PNMU requirements are aligned.

It was found that the coding proposed in this work to search for the minimum content of PMUs and presented in Table 3 proved to be an initial reference for evaluating the content of PMUs in small municipalities, as the use of words and synonymous terms that were not present in the Support Booklet or in the coding proposed by Machado (2019).

The methodology proposed by Machado (2019) proved to be efficient for identifying the minimum content required by Law nº12.587/2012 since a calibration step of the search codes was added to add synonyms for the searched terms.

Therefore, it is proposed as a suggestion for future work the inclusion of the calibration stage of the search elements to include words and terms similar to those already searched, with the calibration being able to be performed more than once after the data processing stage, including the terms analogous to the corresponding codes, running the search again for each code and processing the data once again before starting the process of categorizing and counting the number of occurrences.

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What remains? Historical linear settlement structures in Vienna and their imprint on today's urban fabric

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ABSTRACT

Vienna's present municipal territory covers over 150 historic villages with medieval and early modern origin; the majority of these can be categorized as linear settlement types, mostly Straßen- or Angerdörfer. While some of these villages have been completely absorbed by the city, others are still clearly recognizable in their original form. Although the degree and type of transformation varied, their functional role within the urban texture is fairly comparable: they currently either serve as an urban sub-centre or a development axis.

The study aims to investigate these historic settlement sites in various regions of Vienna, ranging from the Vienna Woods' foothills and valleys to the plains of Transdanubia. The analysis includes villages that have manged to structurally survive on the fringes of the city, villages that have been integrated into the urban street network while maintaining their unique structural and functional characteristics, as well as the highly urbanized and assimilated assemblies. The focus hereby lies on the comparison of several parameters, including historical farmhouse types, property cadastre information and the different village layouts. The evolution or persistence of these features over the last 200 years is traced using map sequencing in four selected time frames.

The papers' intention is to illustrate how these structures have changed over centuries and to reveal potentials for their further development. It is crucial to have a fundamental understanding of these villages, their forms and functions, and how they have been incorporated into the urban texture; especially in the context of ever-growing cities, that are expanding beyond their historical borders and continuing to absorb rural structures into their fabric. The development in recent (international) urban history emphasises the high relevance of urban morphological knowledge; not least because of this we are deeply convinced, that this insight ultimately will help determine a course of action for the discussed historic structures' structural and functional activation as well as their climate-friendly adaption.

Keywords: Vienna, linear settlement, rural settlement, urban fringe/periphery, permanence & persistence, cultural heritage

INTRODUCTION

Vienna is defined by a compact and dense urban structure, which mainly results from urban development processes in the 19th century. Especially in the second half of the 19th century, the urban area west to the Danube, where the city centre is located, underwent two significant major urban expansions (Stadterweiterungen), in the years 1850 and 1890, which still define today's cityscape in terms of urban layout and architecture. These urban expansions correlated with a rapid increase in the population, and made Vienna one of the largest metropolises in the world with over 2 million inhabitants around 1910. In the course of these urban developments, pre-established historic suburbs (Vorstädte) and agricultural villages (Vororte) of the former hinterland, were incorporated and gradually remodelled over time.

With the regulation of the Danube (1870-1875) – which until then had been a highly unpredictable and therefore dangerous river, meandering relatively erratically through the hinterland, constantly changing its course and regularly flooding the surrounding area – and the subsequent construction of new bridges, the city was able to expand beyond the former topographical and hydrographical lines and to incorporate the land to the east. Thus, although the first urban agglomerations had already emerged in this part of the city around 1900, the area east of the Danube mainly developed in the 20th Century.

The originally rural areas around Vienna were characterised by linear settlement structures that were later incorporated as the city grew outwards. The analysis of the preconditions for the development of these linear settlements has been performed in Vienna (Tobisch/Loeschenbrand/Psenner 2023) as well as in the nearby Pannonian Basin (Loeschenbrand/Tobisch/Psenner 2023) in earlier works. Thereby, the significance of socio-political processes in colonisation, as well as the significance of geographical factors such as topography, proximity to water, and prevalent wind direction could be demonstrated.



Figure 1. Typical linear Settlement with farmsteads along a main street, the Gründerzeit developments in the background indicate the approaching urbanisation. Ottakringerstraße (Stauda 1903, ONB: data.onb.ac.at/rep/BAG_1903875)

For the in-depth morphogenetic analysis of the linear settlements, a historico-geographical approach is employed, which consists of the analysis of these villages through time using a chronological sequence of maps. (Kropf 2017:18) This process is illustrated on the basis of 6 villages[49] using four selected time frames. Next to the current perspective, the following time frames were considered: Franziszeische Kataster[50] 1817-1829, Franzisko-Josephinische Landesaufnahme[51] 1869-1887, Generalstadtplan[52] 1912. These time periods were selected because the corresponding map material is based on reliable national surveys and was recorded with sufficient accuracy. Up to now, the study primarily focuses on the developments of the 19th century; later time frames from the 20th century will be included. Especially interesting insights to the genesis of the built structure are expected with the analysis of the plans of the second half of the 20th century, when with the beginning of a general motorisation the increasing number of cars brought about a major urban transformation.

[49] The six villages discussed in this paper are examples from the east and northwest of Vienna. To complete the overall study, Vienna's south will be analysed in the winter term of 2024/25, keeping the methodology and the research-led teaching approach identical. Nonetheless, the research conducted thus far offers initial results on the morphogenetic development of Vienna's linear settlements as well as on the typological genesis of rural building typologies in an urban context.

[50] Historical cadastral map decreed in 1817 by emperor Franz 1st for the purpose of enabling uniform taxation based on land and building ownership in Cisleithania, the cadastre was finished in 1861.

[51] The third military survey of the Habsburg monarchy was conducted 1869-1887, it was initiated by emperor Franz Joseph 1st and portrayed the entirety of Austria-Hungary.

[52] The general city plan, portraying the entirety of the municipal area of Vienna at that time.



Figure 2. Overview of Vienna with district boundaries and the investigated villages. ©Loeschenbrand/Tobisch/ Psenner.

Following Conzens categorisation of the urban form, the selected settlements are considered in their basic elements: The streets and the resulting network, the plots and their configuration into blocks, and the buildings themselves. (Conzen 1960) The development of these elements, their preservation, their change or their disappearance over time is traced documented in the analysis. In line with the authors of the *Atlas du Territoire Genevois* (1993), we use the following terms – originally French – in relation to the precise definition of the preservation of historical structures: *structural permanence* and *structural persistence*. The atlas provides a precise definition and differentiation of the two terms:

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Permanence is defined by the "invariable character of an element" (Léveillé et al. 1993: 10), when cadastral lines precisely overlap and elements have the same position, form, and size.

Persistence is determined more by change. The Atlas gives the following examples on the subject of persistence: elements that replace and take over the position in a property; cadastral lines that roughly match but are neither permanent nor disappearing; a trail that becomes a street or road but still stays on the same path/route; a sequence of plot-lines that, for example, depicts a canalized watercourse (ibid.: 10).

The transformation of the street network has already been of earlier studies, which demonstrate that a majority of the historically relevant links are characterised by either permanence or persistent and can therefore still be identified in today's street network. (Loeschenbrand et al. 2024)

When it comes to a typological analysis the chosen examples of Vienna's linear settlements can be broadly categorized as either the type Angerdorf or the type Straßendorf. The paper does not cover detailed definitions and explanations, nor does it encompass every subtype description. However, both kinds depict compact village structures, which are additionally distinguished by a degree of linearity. While the main street serves as the spine of a Straßendorf, a centrally positioned open area surrounded by side streets forms the core of an Angerdorf – e.g. Leopoldau, Fig. 5 ,The plot or building structures are identical in both settlement types.

Research Project

The paper looks at the specifics of the different incorporation processes, the typological changes that occurred within the villages in terms of architecture, and the morphological remnants that may be observed in the current property parcelling. The study on which this text is based is carried out as part of the international DUT research project *EMC2 - The Evolutive Meshed and Compact City*[53], which – on a national level – is addressing the spatial development of Vienna's periphery and urban fringes (Loeschenbrand et al. 2024, Tobisch et al. 2024). From an urban morphological perspective, it is obvious that in order to anticipate future developments it is necessary to know the history and evolution of urban structures in detail. Therefore, an in-depth knowledge of the morphogenetic processes and the spatial development of these zones is required; for this reason, the paper provides

BACKGROUND

Dynamics in 19th century Vienna

The primary observation period for the map sequencing with four-time frames is the 19th century. In this period, Vienna experienced a number of notable social, economic and spatial transformations, that continue to strongly influence the cityscape and urban layout today. Especially in the second half of the 19th century a rapid increase in population led to over 2 million inhabitants by 1910, which made Vienna one of the largest cities in the world at the turn of the century (Psenner 2023, 36f). This was connected to major urban development interventions and essential infrastructural initiatives, such as several bridge and railway projects and the regulation of the Danube in the early 1870s and the levelling of the entire terrain (Psenner 2018 and Psenner 2023, 38f). The newly developed areas *(Stadterweiterungsgebiete)* on the outskirts of the city followed a radially-concentric logic. Within just four decades the two city fortifications – the inner city-wall and the outer wall *(Linienwall)* – were

[53] In the transnational research project *EMC2 - The Evolutive Meshed and Compact City*, we are working together with partners from France, Italy and Sweden on the feasibility of translating Carlos Moreno's 15-minute city concept to the urban periphery. The urban fringes in Gothenburg, Nice, Lille and Vienna are being analysed, as well as the *Zwischenstadt* landscape on the Ligurian coastal strip between Massa and Viareggio. At the national level, we are working on a deeper understanding of Vienna's peripheral zone by means of specific morphological studies and analyses. The national team is based at the Institute of Urban Design and Landscape Architecture, at TU Wien and is working on the issue of the "evolutive mesh" around Vienna under the lead of Angelika Psenner: https://urbanism-tuwien.at/forschung/projekt/emc2 und https://emc2-dut.org[53] Some of the used data and material was produced as part of research-led teaching at the Institute of Urban Design and Landscape Architecture at TU Wien. The taught and applied working methods are explained in detail in the methods chapter.

demolished and prestigious projects such as the *Ringstraße* – which was not so much a street as a ring-shaped urban development area with a central, all public buildings embracing boulevard around the inner city-centre – were realized. Horse-drawn and later on electrified trams and railways were introduced. This new public transport system was constantly improved by increasing the speed and the manageability of greater distances and thus promoting the expansion of the city.

These developments had an increasing impact on the surrounding linear settlements discussed here. With regard to their agricultural use the geographers Hans Bobek and Elisabeth Lichtenberger in their fundamental work on Vienna's "bauliche Gestalt und Entwicklung" distinguish between *Weinhauer-dörfer* (villages with vineyards) in the west (Bobek/Lichtenberger 1978: 67) and *Ackerbaudörfer* (villages with arable fields) in the south and east (ibid.: 254). The regions to the west and east of the city are relevant to this paper. Around 1840 there were two different types of linear settlements in the west of today's city area:

Villages that were located closer to the former city limits of Vienna, that had already shifted away from wine to increased milk production in the 18th century and developed into early holiday destinations for the summer. Subsequently, these villages experienced intense densification and commercial enterprises often settled there – such as the linear settlement *Penzing*.

A number of Linear settlements in a more peripheral location near the Viennese woodlands, which were also characterised by an increased dairy farming. They were often used as summer resorts for the bourgeois and aristocratic class, their urbanisation is therefore mainly dominated by country houses (ibid.: 67).

In general, various urbanization processes with different typologies can be observed in the context of the linear settlements in the 19th century, from the progress of grid structures, e.g., in the surroundings of *Ottakring* (ibid.: 99ff) to groups of villas and row houses (ibid.: 102ff).

With the new eastbound bridges and the regulation of the Danube in the 1870s, the city of Vienna was finally set to expand to the east. Some of the historical linear settlements, such as *Stadlau*, were used as bridge-heads, where urbanization processes started and industry settled (Bobek/Lichtenberger 1978: 102ff). The linear settlements in peripheral location were expanded with lower densities and with row houses (ibid.: 103); over some time, they largely retained their rural character.

Building types in Vienna's linear settlements

Originally, linear settlements were made up of mostly single-storey farm buildings, which were lined up in a regular pattern left and right of the central street. The special shape of the distinctively deep and narrow plots was formative for the architectural form of the buildings and their spatial configuration. In the 6 linear settlements analysed in the study, plot widths of 13m, 15m, 20m, and 30m were identified.

Although the Straßendorf could theoretically be extended relatively easily in length, the majority of plots – which originally measured a relatively uniform 30-35 metres in width (Dungl 1988: 44ff) – were divided, particularly in the estate process: they were often halved or quartered in length. Thus, in the second half of the 15th century the province of Lower Austria, which surrounds the City of Vienna was dominated by such *Viertellehen* and *Halblehen* (Grüneisen 1979: 90, cited in Dungl 1988: 44). Over the centuries, armed conflicts, fire and several major floods led to repeated destructions within the linear

settlements in the Vienna basin, but in most cases, they were constantly rebuilt or occasionally newly laid out (Hinkel 1994: 13).

First relevant studies on the classification and typologization of the here discussed Lower Austrian village structures and the corresponding farm-building types were carried out in the 20th century. The work of Adalbert Klaar with the "Siedlungsformenkarte" (1942) and the book "Die Siedlungsformen Wiens" (1971) provides a significant foundation for the Austrian context. With further work by other scientists, multiple definitions of individual farm house types emerged. As for example, Klaar defines the building footprint of the *Zwerchhof* as a C-shape (Klaar, 1942: 27), whereas the architect Klaus-Jürgen Bauer, describes it as being a L-shape (Bauer, 2023: 161). Regional differences in understanding; e.g., the aspect of whether a cross-standing barn is still counted as part of the main building footprint, can be explanations for different interpretations. Bauer also often describes the Zwerchhof as the result of a later expansion of a former *Streckhof* (Bauer, 2023: 161), which addresses the aspect of the structural adaptation and genesis of building structures and farm types.

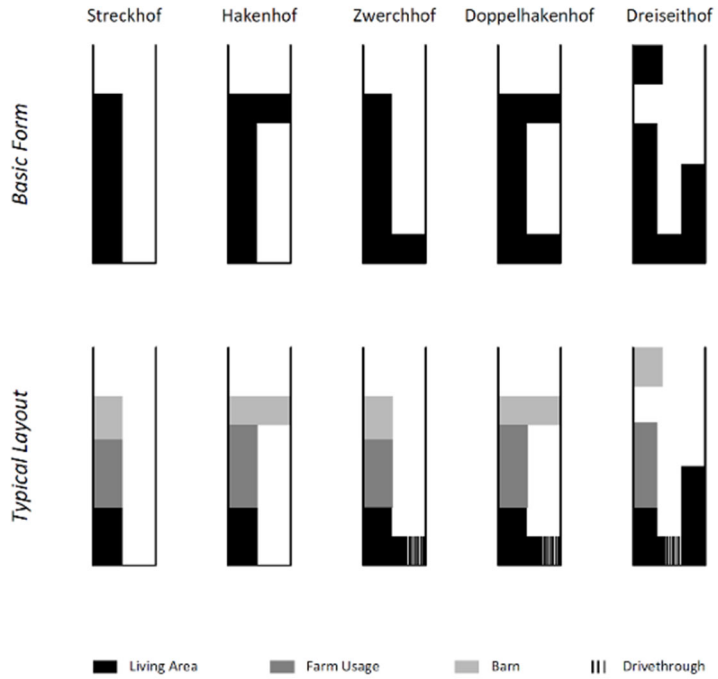

Figure 3. Basic form and configuration of the typical farmstead types ©Loeschenbrand/Tobisch/Psenner.

The following building types determined the characteristic farm houses in the chosen research field in and around Vienna: Streckhof, Hakenhof, Zwerchhof, Doppelhakenhof, Dreiseithof. The aim of this study was to carry out a simplified typological categorisation of the farmstead types present in the case studies on the basis of the respective building floor plans. This requires a clear definition of the types, which, however, often cannot fully take into account the complexity of ground plans and their genesis or the precise but sometimes differing definitions of Klaar, Bauer or Kräftner (1987). In our research we use the following list of structural building types; with the corresponding catalogue of features:

The Streckhof is a narrow, rather elongated building, with a living area oriented towards the street front; with an agricultural usage behind this and the stables extending parallel to it – always in the same alignment.

The *Hakenhof* type results when the barn is rotated by 90° thus creating an L-shape ground floor plan.

Bauer's definition is adopted for the *Zwerchhof*: a Streckhof that is extended to the street side with a transverse building – again an L-shape, but mirrored.

The *Doppelhakenhof* means that there is a transverse building on the street side as well as in the backyard, thus resulting in a C-shape.

The *Dreiseithof* type also forms a C-shape. According to Klaar (1942: 26) and Kräftner (1987: 116), his courtyard opens up towards the main street and is closed by a gate. The examples in our research area, however, show a mirrored situation, where an attached building is positioned along the streets, with two further side-buildings extending into the interior of the plot.

Other renowned building types related to linear settlements such as the *Gassenfronthaus* or the *Weinhauerhaus,* were not taken into consideration individually because their floorplan layout does not differ significantly from the farm types already described. The Weinhauerhaus comes in various forms and – according to Kräftner – lacks a clearly set arrangement (Kräftner 1987: 140). Kräftner describes the Gassenfronthaus as being the "latest organic farm house type to be progressively developed, where traditional building types have been merged with new ideals and requirements to a new symbiosis" (ibid.: 132; translated by paper authors). Here the living area is oriented towards the street side. After 1850 the Gassenfronthaus increasingly replaced existing farm types, such as the Streckhof, Hakenhof or Zwerchhof (ibid.:132ff).

The Viennese farmstead types

Building typology studies on farmstead types such as the Streckhof or Zwerchhof generally focus on rural areas in the surrounding of Vienna, primarily in the provinces of Lower Austria or Burgenland. Although these studies can also be applied to Vienna – since historically speaking the linear settlements in today's Vienna urban area were located in Lower Austria until the end of the 19th century – an explicit Vienna-related discussion on the villages and their building types is missing. For this reason, in-depth research was necessary, in which we analysed a selection of 20 buildings in detail in the 6 villages covered here. The relevant planning documents were retrieved from the building authority archives – this alone being a rather time-consuming task – and their genesis analysed in detail. The aim was to gain an understanding of the specific local building configurations and floor plans in comparison to the prototypical floor plans (Fig.3, Fig.4), to obtain an overview of morphogenetic developments of Viennese farmstead types and in this way to gain a relevant initial assessment of those special building types for the main study.

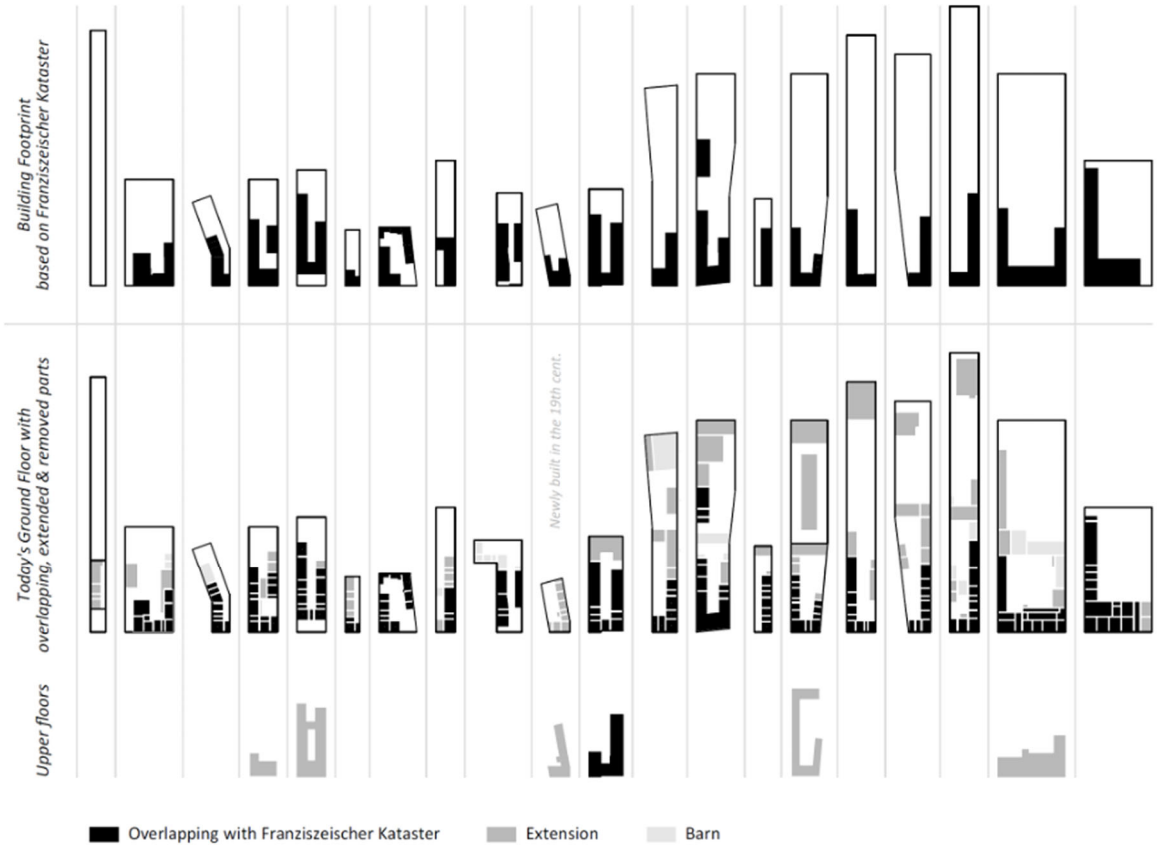

Figure 4. Illustration of the building genesis in relation to the Franziszeische Kataster; based on the 20 selected building examples in our 6 case studies. ©Loeschenbrand/Tobisch/Psenner.

The entire archive file repertoire of over 20 objects was taken into consideration and the individual conversions, extensions and modifications that emerged from this analysis were examined. The oldest planning documents still available date from to the 1870s, with plans from a *Gassenfronthaus*. Other than that, plans of conversions in the 19th or 20th century, often including sewer plans for the respective properties[54], provided insights into the organisation of the floor plan. This procedure made the individual development stages of the buildings visible; and ultimately abstracted and schematic floors plans were created on the basis of those findings (Fig.4).

Since original planning documents or drawings of the respective buildings were not available, because of the distinctly rural character of the original settlements – far away from the meticulous administrative power of the capital – the schematic floor plans were compared to the building footprint based on the Franziszeische Kataster (1817-1829). The black regions in our illustration (Fig. 4) represent the floor plan sections that overlap with the Franziszeische Kataster, the dark grey areas represent the building parts that were added later, and the light grey colour code indicates the parts of the building that were removed (being mostly the wooden barns). This micro-level investigation and analysis reflects the variability and complexity within the farmstead types and provides initial insights into the morpho-genesis of the individual plots and farm structures. Even though this background research is not further part of the paper, it shows the potential for further research, e.g.,

[54] Especially as they localise the connection of the house sewer to the public sewer and thus allow conclusions to be drawn about the overall organisation of the building.

METHOD

Village morphology & building types

The morpho-genetic development of the selected historical linear village structures is analysed on the basis of four observation periods: beside the current state, 3 historical states were selected: Franziszeische Kataster 1817-1829, Franzisko-Josephinische Landesaufnahme 1869-1887, Generalstadtplan 1912. On a quantitative level, the mere extent of the preserved historic building structures and farmstead types – or parts thereof – was recorded. In addition, a qualitative evaluation was made of how the historical buildings have developed typologically, i.e. not least in terms of utilisation structure, with a focus on the farm types (in the sense of building typology).

The paper describes a work in progress: the investigations carried out so far cover the linear settlements in the east and north-west of Vienna. Surveys of those in the south of Vienna are currently being prepared and will be carried out in autumn – for this reason, the latter are not yet the subject of this text. Three villages each from the northwest and east were selected – NW: Untersievering, Ottakring and Penzing; E: Großjedlersdorf, Leopoldau and Stadlau. In order to present a comprehensive picture, the selected linear settlements were to reflect as many different conditions as possible, from a strongly preserved village character to heavily transformed and urbanized structure.

The analysis of the villages was carried out together with students from the TU Wien: in a seminar designed as research-led-teaching, each student analysed one linear settlement.

For this research activity a common standard with plural work steps were defined: the teaching supervisors (us researchers) predetermined this standardised method in advance in a corresponding pre-test. The students' work was continuously checked and corrected if necessary. The aim was to identify historical buildings and farmstead types on the basis of the building footprints. Due to the inaccuracy of the original map material, a certain bias (interpretation errors and imperfections) is to be tolerated in individual cases in this approximation.

In a first step, the linear settlements were vectorized on the basis of the *Franziszeische Kataster* and the individual farmsteads and buildings were assigned typologically due to their building footprint: Streckhof, Zwerchhof, Hakenhof, Doppelhakenhof, Dreiseithof, other, special objects, outerbuildings and context. In order to narrow down the observation area of the individual linear settlements, a 15-minute catchment area was determined using the demo version of the Travel Time web application (Fig.5). The category *other* was set in order to indicate buildings with footprints that cannot be clearly assigned. The category ‘special objects’ represent churches, monasteries, vicarages or castles.

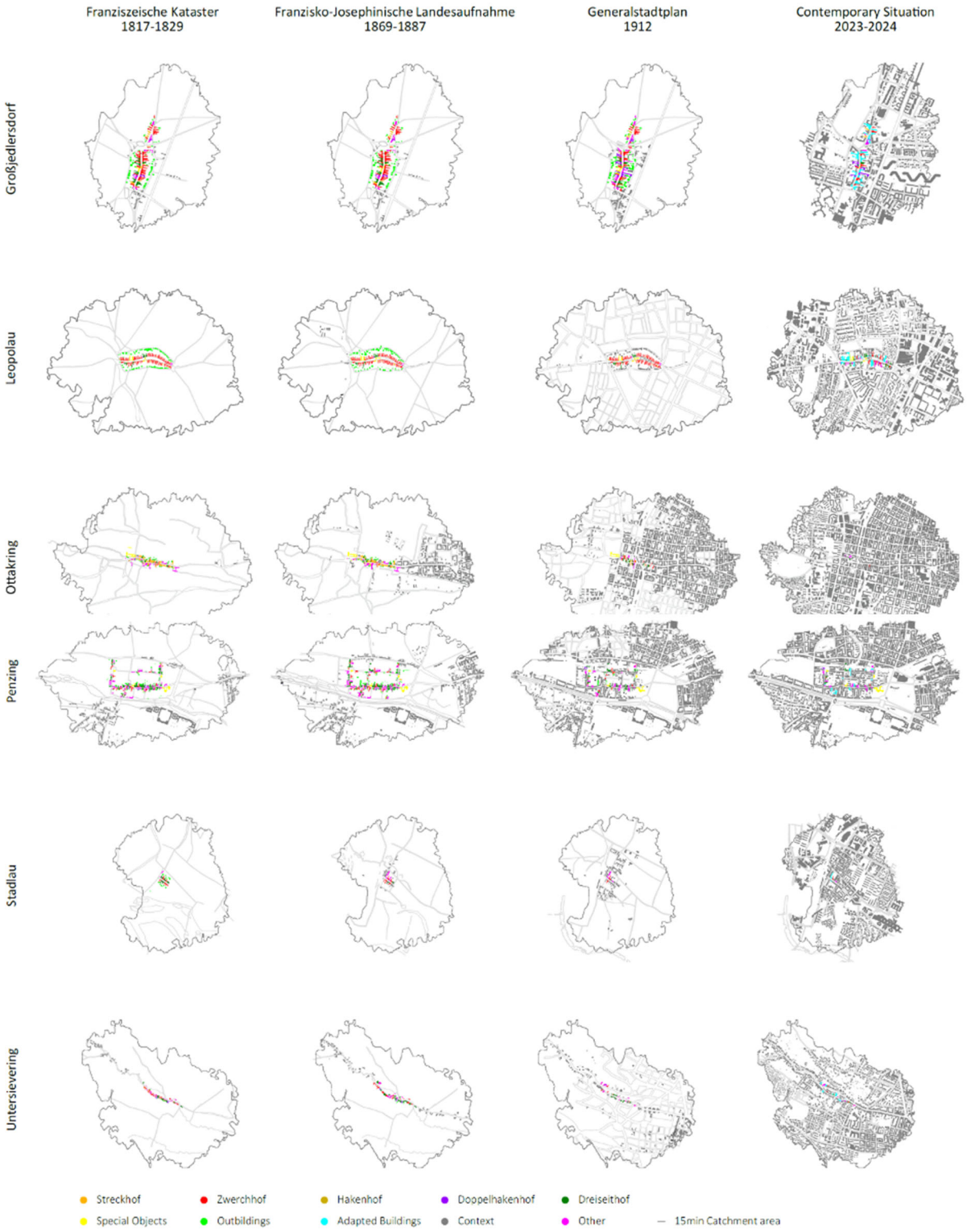

Figure 5. The graphic representation of the 6 linear settlements in the four periods analysed with their respective typological classifications. ©Loeschenbrand/Tobisch/Psenner.

This categorisation was followed by a comparison with the *Franzisko-Josephinische Landesaufnahme* (1869-1887) and the new vectorization and typological classification. This principle was repeated in the next two time frames. For the final analysis, the current state in the 2020s, the category *adapted* was added. The intention was to identify farmstead types which, despite their historical components,

have changed so much in the course of conversions or extensions in the 20th and 21st century that they can no longer be regarded as original. On-site surveys and digital map services were used to determine the category *adapted* (Fig.6).

		Großjedlersdorf				Leopoldau				Ottakring				Penzing				Stadlau				Untersievering			
Building Type	Total	1817-1829	1869-1887	1912	2023-2024	1817-1829	1869-1887	1912	2023-2024	1817-1829	1869-1887	1912	2023-2024	1817-1829	1869-1887	1912	2023-2024	1817-1829	1869-1887	1912	2023-2024	1817-1829	1869-1887	1912	2023-2024
Strockhof	119	17	4	-	-	4	4	4	-	37	36	6	-	1	3	-	-	-	-	-	-	3	0	-	-
Zwerchhof	500	20	29	21	7	77	77	72	17	14	11	12	1	30	34	13	4	5	5	2	1	24	16	5	3
Hakenhof	9	-	-	-	-	1	1	1	-	3	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Doppelzeilenhof	40	-	2	9	6	-	-	-	1	7	2	-	-	3	2	1	1	-	-	-	-	2	3	1	-
Dreiseithof	280	4	10	8	2	7	7	6	16	9	10	8	1	49	60	27	9	5	2	-	-	10	16	10	4
Other	300	6	5	16	3	2	2	2	8	19	15	1		59	59	27	19	2	2		1	23	9	13	7
Special Object	71	3	3	3	1	5	6	7	4	3	2	6	-	7	7	6	6	-	-	2	-	-	-	-	-
Adapted	69	-	-	-	20	-	-	-	21	-	-	-	2	-	-	-	15	-	-	-	2	-	-	-	9
Context (M.S.)		-	-	-	6	-	-	-	26	-	-	-	32	-	-	-	145	-	-	-	7	-	-	-	45
Subtotal excl. Context, Adapted		50	53	57	19	96	97	92	46	92	78	34	2	149	165	74	39	12	9	4	2	62	44	29	14
Subtotal excl. Context		-	-	-	39	-	-	-	67	-	-	-	4	-	-	-	54	-	-	-	4	-	-	-	23
Total buildings along main street		-	-	-	45	-	-	-	93	-	-	-	36	-	-	-	189	-	-	-	11	-	-	-	68
Percentage of historic objects incl. Adapted along main street, 2023-2024					87%				72%				11%				29%				36%				34%
Percentage of historic objects excl. Adapted along main street, 2023-2024					42%				49%				6%				21%				18%				21%
Percentage of historic objects excl. Adapted along the main street in relation to the number of objects from 1817-1829					38%				48%				2%				26%				17%				23%
Percentage of Adapted along main street					44%				23%				6%				8%				18%				13%

Figure 6. Evaluation of the collected data for the six linear settlements. *©Loeschenbrand/Tobisch/Psenner.*

Structural permanence respectively persistence on a plot-level

In the second phase of the analysis, the overlaying of plans was used to determine the extent to which historical layouts of plots and parcels in the immediate surroundings of historical linear settlements can still be found in today's cadastral plan. For this purpose, the vectorized version of the *Franziszeische Kataster* was overlaid with the current land cadastral plan of the City of Vienna[55], and compared with each other.

A rectangle of 1500 x 1000 m (150 ha) was defined around the 6 selected villages as observation area. Two levels were examined: Firstly, the extent to which plots and properties have been preserved and are still characteristic – shown as a framed area. Secondly, the extent to which today's paths or roads can already be found in the *Franziszeische Kataster* as paths, roads or plot boundaries – shown with a dashed line.

RESULTS AND DISCUSSIONS

Village morphology & building types

The linear settlements surveyed in their historical form vary in terms of size and scope: Leopoldau and Ottakring consist of about 100 buildings. Großjedlersdorf and Untersievering are half the size with about 50 objects. Penzing – with 150 buildings – is a special case, as there are additional buildings along the cross streets in the direction of the main road running parallel to the north, whereby the settlement centre (running west-east) corresponds in size and length to a linear settlement with 100 buildings. Stadlau, as a second special case, represents a small linear settlement structure with 12 farm buildings.

In order to investigate the question of permanence or persistence and to clarify the extent to which historical building patterns and typologies are still reflected in the cityscape, two parameters were determined. Firstly, what is the percentage of historical buildings in today's streetscape?[56]. For the

[55] They are both available on the website of the City of Vienna at https://www.wien.gv.at/kulturportal/public/ and https://www.wien.gv.at/flaechenwidmung/public/.

[56] The survey is carried out once with and once without taking into account the category *adapted.*

evaluations, only the buildings along the main street within the historic village boundaries were taken into account. Including the category *adapted*, Großjedlersdorf with 87% and Leopoldau with 72% are still strongly characterized by historical buildings and patterns. without the *adapted* category, the value for these villages is 40-50%, which indicates a comparatively high proportion of historic buildings with a building footprint similar to the original farmstead types. The example of Ottakring illustrates how, in the course of new urban development processes in the 19th and 20th centuries a historic linear settlement structure has almost completely disappeared, with only individual properties creating relevant points of reference. If it was not for the large residential buildings in Ottakring, which count as one object in the statistics, the figures - now 11% and 6% – would be even lower. Penzing, Stadlau and Untersievering are still characterized by about a third of historical structures, if the adaptions are taken into account – without the value being around 20%.

Secondly, the number of historical buildings excluding adaptions and the *context* category was compared with the building stock of the period 1817-1829. The results roughly correspond to the assessment of the percentage of historical buildings (excl. adapted ones) in today's streetscape. However, the aforementioned aspect of the influence of large residential structures in Ottakring is recognizable here – this value is now 2%.

With regard to the development curves in the individual linear structures, it can be stated that the linear settlements of Großjedlersdorf and Leopoldau, which retained their historical character the most, also show little structural development in the 19th century, with the major changes only taking place in the 20th century. For the most part, steady declines can be observed in the other village structures.

When looking at all six villages together, the Zwerchhof is by far the most prevalent style during the four time frames examined here. Many buildings of the category *other* have been found in Penzing and Sievering, making buildings of this category the second most common. The proportion of building layouts similar to the Dreiseithof, is also significantly high. There are hardly any Hackenhöfe in the 6 case studies. The percentage of significantly extended or transformed historical farmstead types, which was summed up in the *adapted* category, differs greatly in the six linear settlements.

Structural permanence respectively persistence on a plot-level

The evaluation of the overlay of the cadastral maps requires a more differentiated analysis. (Fig. 7) The high proportion of historical properties in Großjedlersdorf and Leopoldau is also reflected in the fact that the characteristically narrow elongated plot division – which is in no way comparable with the Gründerzeit plot grid – has been permanently inscribed in the city map. However, the original already narrow long plots were often divided into two or more plots, as described above. In this way, the former rear-sides of the linear settlements became new front-sides. In addition, there are plots and fields – most of which still agriculturally used – in the directly neighbouring areas of the respective observation areas of Großjedlersdorf and Leopoldau that still correspond to the parcels of 1829. Similarly, a large number of paths and streets around Großjedlersdorf and Leopoldau correspond pretty much exactly to the historic situation.

Figure 7. Overlay of the Franziszeische Kataster with the current cadastral map in the respective linear settlement. ©Loeschenbrand/Tobisch/Psenner.

The disappearance of Ottakring shows that most of the plots and properties in the area under consideration now represent other urban systems; which in the Ottakring case are increasingly

organized in (Gründerzeit) grid structures. Penzing still has some areas that can be compared with the state of 1829. As in Großjedlersdorf and Leopoldau, the longitudinal plots have been halved or divided in some other way. With the addition of new streets, the original linear settlement of Penzing also increasingly developed into a grid system. The original plot structure of the linear settlement of Stadlau is still recognizable today, although here too the long parcels have been divided into several plots. The geographical or topographical conditions in Untersievering and a comparatively low population density result in paths and parcelling largely matching the situation of the *Franziszeische Kataster*. Particularly in the peripheral Untersievering, for example, large parts of the parcels and paths or streets correspond to the situation in the *Franziszeische Kataster*.

CONCLUSIONS

As already stated, the research presented in this paper is part of an ongoing wider study. As part of this comprehensive research project, the first convincing representations of the morphogenetic processes were generated using the building footprint-based map evaluation procedure. The two-dimensional map analysis carried out here and the evaluation of the building floor plans (building heights were not taken into account, as the relevant data is missing) enabled an approximation of the actual building stock. However, the extent to which the architectural structures actually still correspond to historical building types, and whether they are permanent or persistent, requires further qualitative assessments, including those based on site inspections. The category *adapted* was therefore introduced as part of the map analysis.

We see the need to incorporate more qualitative aspects into the study, thus, the results of the background research concerning the Viennese farmstead types offer potential. In any case, this type-focused background research will also be carried out for the south of Vienna and thus expanded further. Irrespective of this, the first influencing factors and parameters that determine the level of transformation of linear settlement structures in Vienna have already crystallised:

- the geographical location,
- the spatial proximity to centres,
- the direct connection respectively the historic main road as part of today's primary network

appear to be decisive parameters for the degree of change and transformation of the villages studied. The overlay of the historical and current cadastral maps revealed initial findings and patterns, but certainly requires further investigation.

Despite various transformations, the linear settlements in Vienna continue to strongly characterize the cityscape of the outskirts and suburbs. They represent important facets of social identification in today's urban fabric. Therefore, when it comes to the spatial development of the urban fringes, these villages should be integrated in the best possible way without trying to preserve them in a purely visual heritage-like manner, but rather by maintaining or (re)strengthening their spatial qualities and their distinctive identity-building character.

This paper and the ongoing research contribute to recognizing and understanding the fundamental qualities of linear settlements.

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The independent region of Palestine (a world of independent regions)

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ABSTRACT

The Refugee Pattern Language for 'Palestine refugees and internally displaced people' IDP is an outgrowth of a larger project called: 'The Sugar in the Milk – A Refugee Pattern Language RPL.' While we are working on a generic (design, planning, and building) pattern language that addresses nine - twelve refugee domains with 12 patterns each, we are also conducting particular case projects with their own domains, such as patterns for Palestine and its displaced people. In this context, we found it necessary to explore and investigate beyond the refugee problem, just to understand this case in its historic, geopolitical, land, and peoplehood dimensions.

Starting with the assumption that the world would be a better place if made up of 'Independent Regions' or small countries with 5-20 million population, because larger countries tend to dominate smaller countries or they use smaller countries to serve their own larger geo-political interest. With the Palestine-Israel conflict, we have a highly complicated and complex socio-spatial case of almost biblical proportions, that urgently needs to be resolved, after a hundred years of war on Palestine, with hidden qualities such as the colonial settler system, supremacy, and apartheid as a system of control and domination of another group of people, thereby creating countless refugees. An emerging world order, as well as regional transformation within the Middle East, is considered a new promising tendency for finding a way towards the formation of an Independent Palestine. In this emerging configuration, Israel could be seen as an important 'Independent Region' by itself in transformation. This paper works with five patterns in the Pattern Language Method to start to address some of these problems: INDEPENDENT REGIONS - THE INDEPENDENT REGION OF PALESTINE - THE COLONIZATION AND OCCUPATION OF THE PALESTINIAN TERRITORIES - REFUGEES IN PALESTINE, THE WEST BANK, GAZA AND ADJACENT COUNTRIES – A HOUSE IS NOT A HOME.

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Keywords: refugees, pattern language (pl), palestine-israel, independent regions, land and peoplehood

INTRODUCTION

We are thankful to the Sao Paolo ISUF conference organizers that they have acknowledged the notion of disruption as a major conference theme in addition to the three themes of continuity, expansion and reverberation. Disruption is referred to with the following sub-themes:

"1. Disruption: climate change, global warming, heat island, rising sea levels, pandemic, healthy cities, migrations, conflicts, etc." (ISUF Program, Sao Paulo, https://isuf2024.org/)

Destabilization, disruption and conflict need to be recognized at all levels of scale in the social-spatial world from global to local and including different modes and relevant causes and kinds of conflicts for different socio-spatial situations and events. While disruption has become a major issue on many fronts, it may be best understood in two categories, natural disruption, and man-made disruption, whereby disruption in nature is more often than not connected to man-made causes.

For the last 70-75 years, one lifetime, most parts of the world enjoyed the longest time of peace and prosperity. Over the last decade, this peace has come into question with the transitional process of an emerging multi-polar world, and accompanying conflicts and discrepancies. We must acknowledge that the world is in a period of transformation and restructuring, that shows up in many places on the surface of the earth, as well as the space above, and possibly hidden in the waters below. And we need to study these new transformations. https://www.youtube.com/watch?v=t-edUqSmkoI

Study and research: Overall, in our research and plans, we study spatial, social, and related life giving regions and cities, towns and neighbourhoods, building clusters, houses for refugees, gardens, and communities, as well as streets, parks, and public buildings. Furthermore, we focus on the processes that create and form these physical social and spatial urban settlement, with the pragmatic objective to create or recreate healthy urban and regional places for all, including refugees.

Preface

For the complex and complicated pattern language case 'The Palestine-Independent Region' PaIR, it seems appropriate to lay out foundations that place this research in a proper context of relevant subthemes, background, and premise.

1. Refugees: This paper is part of a larger enterprise of refugee pattern language research, that started seven years ago. The Refugee Pattern Language for 'Palestine's refugees and internally displaced people' is an outgrowth of an extensive project: 'The Sugar in the Milk – A Refugee Pattern Language RPL' with deeply humanistic aspirations. This paper includes limited history of the production of refugees in Palestine since 1948 and its unusual distribution into huge camps in the surrounding countries that required basic unpacking. (See Figure 7)

2. Investigation: The consequent investigation into the backgrounds of refugees and the ongoing base conflict revealed more and more facts, that have created a very difficult if not disturbing picture of a situation that needs to be corrected almost immediately. Here, eminent Jewish and Palestinian scholars, in particular, were indeed very helpful in revealing hidden or subdued dimensions, that are going unresolved since more than 80 years such as colonial settlement and its perils that one scholar calls an 'outdated business model.' (Richard D. Wolf)

3. Revealing Events: The events in Gaza with 39,000 people unnecessarily killed (July 25, 2024), had a particularly strong impact because they helped to slowly reveal a terrible amoral system of war crimes, genocidal tendencies, and brutal killings that anybody who followed the full view of events in Gaza and in the Westbank on tv and online, could evaluate and make up his own mind.

4. Furthermore, my background (HN) first as a German and later also as a US citizen have affected particular views that needed adjustments on several accounts since the Student Revolt 1966-74):

- German and US restrictive laws on criticizing Israel (i.e. artificial standards and laws).
- Student protests in Germany and the US for inner and outer liberation and freedom.

5. My hope for the new generation today, in particular the students in the two countries US and Germany, who have suffered from police and counter protesters physical violence, to keep a clear head and open mind, with an understanding of the double standard and hypocrisy of outdated laws, and ideological behaviour against free speech, freedom and liberation. It is the new generation of students who understand the big problems in the world with a fresh outlook on conflict, economic, and ecological issues. They want to solve outdated problems expediently to have time to deal with the real larger issues for survival on earth.

Disclosure

Our work in the last seven years on the ever-increasing and worsening problem of refugees worldwide has confronted us with new challenges, particularly in the complex Palestine-Israel case, starting with finding large refugee camps in Palestine and larger camps in surrounding countries of Israel-Palestine, since 1948. This fact alone has started to hint at a number of hidden dimensions that need unravelling beyond the challenge of refugees. Why are millions of Palestinian people still living in camp cities for 75 years in surrounding countries and occupied territories? Other facts that needed unpacking relate to Zionism, colonialism, as well as apartheid, landgrab and peoplehood (Finkelstein, N. 2024).

Here again, my background as a German citizen, is relevant, with moral and legal obligation to Jewish people and the Israel State, personally, and by ‘raison d’etat’ of the German Constitution, and other kinds of laws that are supposed to protect Jewish population against antisemitism and worse. While I have followed these rules freely since high school, recent questions that Germany’s official law in the constitution may not be the right way of addressing the problem of Palestine’s subjugation by Israel, culminated in the accusation of Germany’s complicity of ethnic cleansing and genocidal tendencies by Israel, is coming to the fore, at the international court of Justice ICJ in Den Haag. (Sharp, A. 2024)

As a citizen of the United States (HN,) I have more freedom, and access to pursue questions on the Palestine conflict than in Germany. But even here, there are various forces and players that try to hide their activities or try to create more laws to prevent open discourse that also needs unravelling i.e. some kind of McCarthyism tendencies. It became more and more important to shed light on these tendencies and ongoing events that have followed me since my childhood, some without proper answers. In contrast to Germany, however, the US provides more openness to pursue and discuss these issues, in large part because of Jewish and Palestine scholarship. Still, the biggest issue to be unravelled is the killing of 42,000 Palestinians as of October 25, 2024 in front of the world’s eyes and justifying this atrocity with the right of Israel security to defend themselves. How about Palestine?

Finally, I also have to ask how my primary interest as an architect and city planner in creating beautiful and peaceful places, buildings, parks and neighbourhoods, fits together with my interest in social justice and peace, well-being, health, prosperity, especially in extremely difficult socio-spatial situations such as the Israel-Palestine conflict. The quick answer to myself is that going from unjust to just, from destructive to peaceful is for me a continuum and equal to creating beauty in an ugly world.

METHOD

For much of the research on refugees the Pattern Language method is applied, largely because it is action-oriented in its base format of Problem – Discussion – Solution. In other words, if you do not have a solution or at least a suggestion, you do not have an action pattern. In addition, patterns are connected by links to create a larger format of supporting and connecting elements and efficiency to a connected Pattern Language, helping to deal with the complexity at hand.

The research on the individual patterns uses quantitative and qualitative methods as well as the critical dialectic method in the form of discovering hidden dimensions of difficult and complex situations. Especially helpful material is provided by eminent scholars that help to understand the history, as well as social and power relations, such as Zionism, apartheid, and colonial settlement… (Finkelstein, Wolf, Said, Harari, Hedges, Khalidi, Pappe, et al). The terrible attack by Hamas on October 7, 2023 and the disastrous genocidal attacks by Israel on Gaza were followed in the news and online media and had a significant impact on what is called the Gaza conflict (also called a war by Israel) which consequently affected the forming of this paper including the adjustment of the term pattern.

In addition to social and spatial aspects, there is a strong underlying quality that we may describe here as a humanizing quality or humanistic pragmatic-approach. The focus is on refugees, migration, and the conflicts that create them, that is on the extensive man-made disruption side which includes, war, terrorism, destruction, forced displacements, etc. that rightfully might be considered Anti-Patterns. But the overall objective, of course, is to find ways to reach the positive side of Good-Patterns, that is, patterns for peace, wholeness, healthy cities and independent regions, living neighbourhoods, vibrant streets and buildings, and beautiful parks and organic gardens… and healthy prospering people.

Table 1. THE INDEPENDENT REGION OF PALESTINE (Pattern Language PaPL) Table of Content

Cluster 1	**The Independent Region of Palestine (and the Reality on the Ground)**
	• Independent Regions
	  ○ A World of Thousand Independent Regions
	  ○ The Larger World- and Regional Transformation
	• The Independent Region of Palestine

Cluster 2	**Destabilization and Planning and Architecture of Occupation**
	• Occupation and Colonization of the Palestinian Territories (Original Sin Maps)
	• Refugees In Palestine The West Bank, Gaza And Adjacent Countries
	  ○ The City and Regional Planning of Occupation
	  ○ The Regional Planning for the De-Architecturization of Gaza
	  ○ Settler colonization and appropriation of Palestine land, Houses and Life
	• A House is not a Home

Cluster 3	**The Gaza Disaster as a Turning Point?** • The Arena Refugees in Gaza and Apartheid Refugees in the West Bank https://www.youtube.com/watch?v=VS2pcj18I7w (Strained US-Israel Relations.. Al Jazeera) • Total Destruction of Gaza and Apartheid in the Westbank ○ Palestinian houses with families efficiently bombed based on AI Technology ! Gaza as a laboratory for testing new weapons provided by the US and Germany • Modern Technology, Social Media, and the Opening of the World‘s Eyes

Cluster4	**Liberation of Palestine and Pacification of Israel** • IRREVERSABLE NEXT STEPS: The Formal Recognition of Palestine as a State and the Formation of the Independent Region of Palestine o The Guarantees for Security and Safety o A Boundary that Connects and Divides… o The Careful Integration of Israel into the Middle East
Next Steps	**Palestine and Israel as two Independent Regions** Outlook

Note: The Refugee Pattern Language for 'Palestine's refugees and internally displaced people' PaPL is an outgrowth of a larger project called: 'The Sugar in the Milk – A Refugee Pattern Language RPL.' In this case study paper we have only space for five patterns from Cluster One and Two, marked with black points in table above.

RESULTS AND DISCUSSIONS

Cluster one:
The independent region of Palestine pattern

Independent Regions (IR) are more suitable for providing a better, more peaceful, and more orderly world than the recent and current system of large hegemonial countries; this is supported by several characteristics of an IR such as a limited size of up to 20mio population and the nature and limits of human government, and others. A WORLD OF THOUSANDS INDEPENDENT REGIONS follows as a proposal of a structure for governing and cooperating in a world of smaller countries or Independent Regions that collaborate with each other, without dominating or attacking each other.

The need and opportunity to build up Palestine as a new Independent Region is emphasized by using data from its disturbing history with the Zionist Colonization and the forced upon misery with the unilateral formation of Israel in 1948 and its subsequent subjugation and occupations since that time. Embedding the new State and Independent Region of Palestine within the Mid-East World Region is a major objective for Palestine with Israel as another Independent and cooperating Region 'in spe.'

INDEPENDENT REGIONS (Pattern APL 1)



Illustration 1: Bird flying freely in the Sky Neis

***Metropolitan areas* and larger regions *will not come to balance until each one is small and autonomous enough to be an independent sphere of culture,* autonomous state, and land.**

There are four separate arguments which have led us to this conclusion:

1. *The nature and limits of human government.*
2. *Equity among regions in a world community.*
3. *Regional Planning Considerations.*
4. *Support for the intensity and diversity of human cultures.*

Therefore: Whenever possible, work toward the evolution of independent regions in the world, each with a population of 2and 10 million (1977); each with its own natural and geographic boundaries; each with its own economy; each one autonomous and self-governing, each one with a seat in a world government, without the intervening power of larger states or countries.

Figure 1. A short summary version of Pattern 1. 'Independent Regions'. APL, 1977 in the Problem::Discussion::Solution format (non-original text in straight letters).

First Response from Palestine:

- The total population of Palestine is estimated at 5-7.5mio people (depending on internal and external counting in surrounding countries and Israel). The number fits well into the concept of IR population size between 3-15 or 5-20 million people.
- Palestine does not have its own natural and geographic boundaries.
- They do not have their own economy.
- They also do not have an autonomous and self-governing administration.
- They do not have a full seat in the UN, but they enjoy a limited associate member status;
- They rely and depend on various intervening powers of larger states and countries (mostly Israel as occupying power) in controlling their internal and external affairs.
- In fact, the Palestine Region is not independent at all, has no state, and is no country in 2024, even though they were promised statehood already in 1947, 77 years ago, while, at the same time, they had to give up large parts of their land for the birth of another country.
- But recently they have huge amounts of international support and growing recognition.
- Based on strong international support and promise of an Independent Region and a political neutral state, they can provide a convincing case for their own State.
- In addition to having no full state, the largest problems for Palestine are two: a. The continuous loss of land from Israel (from 100% - about 22%) and the issue of a second class peoplehood.
- Overall, we can say, that Palestine was crippled, economically, politically, even physically, religiously, culturally, robbed of their land, degraded of being full and whole people, and placed into an ever ongoing subjugation of various forms.

Links: Create THE INDEPENDENT REGION OF PALESTINE as quickly as possible so that Palestine emerges and contributes to A WORLD OF THOUSAND INDEPENDENTT REGIONS. *Within each region encourage the population to distribute itself as widely as possible across the region THE DISTRIBUTION OF TOWNS (APL 2) with POLITICAL NEUTRALITY as a safeguard for Israel.*

THE INDEPENDENT REGION OF PALESTINE (Pattern)

Problem: After 75 years of Submission, Occupation, and war on Palestine, the Palestinian People need their own Independent Region, Country and State – Now.

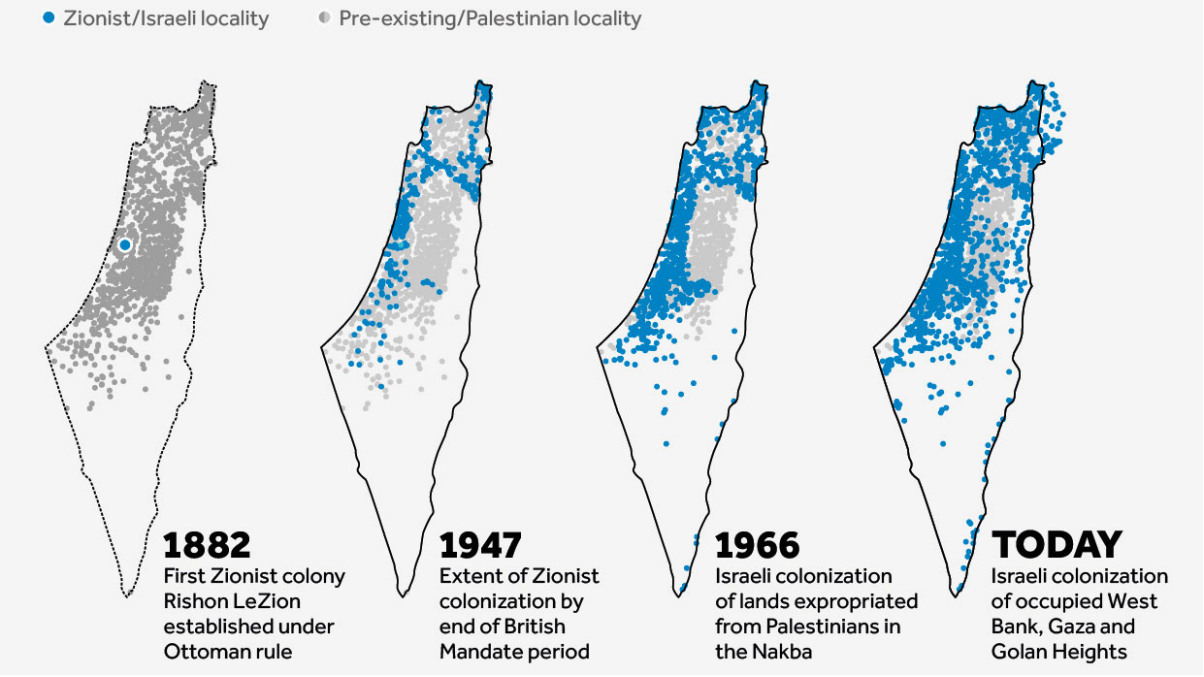

Figure 2. The Zionist Colonization of Palestine. Source: visualingpalestine.org (2019); Data source: bit.ly/vp101data

Discussion: Since the 1948 violent expulsion from their Homeland in Palestine, known as Nakba (Chaos) accompanied by atrocities, with about 750,00 million people expelled and part of them killed, the Palestinians have been chased out of their homeland, with less and less land over the years, to the point that very little is left, and more and more is taken violently even today because Palestinians have very few rights to oppose.

Given the terrifying history of Palestinian people and refugees over the last 75 years, culminating in the total physical destruction of Gaza in 2024, it is high time to establish a Palestinian country, state, and if possible also as an Independent Region with liberating strength and forces that includes liberty, freedom and beauty, and paths and processes to achieve some of those as Franz Fanon taught us already for Algeria. (Fanon, 1961)

The fundamental option that urgently needs to be put into place is a country on its own, a place that has been defined in Pattern 1. Independent Region, and 2. A world of Independent Regions, with less than 20 million people, with its own democratic system and its own culture and regional spatial system. Various options that are being discussed include:

2. The two-state solution: the approach to the two-state solution has been part of the discussion from the very beginning of the establishment of the Israelian Zionist state, in principle, but also as part of the overall arrangement and possibly compensation for being expelled in the Nakba. However, this solution has been opposed and practically almost made impossible, by Israel and its Western allies, in particular the US and Europe (including Germany). It seems therefore appropriate to focus on the formation of a Palestine country and independent region first and then try to bring the two, Israel and Palestine, together as neighbours.

3. The one-state solution: The way this is currently being discussed, is not focusing on Palestine as the original population needing a region, a state, but it is discussed as a framework, where

the whole region becomes one state together with the Israeli and Palestine population. But while this sounds innocent, it has meant for 75 years so far that the Israeli government has subjugated the Palestinians in a form of what is known as a apartheid, which means that the Palestinians are all treated as second-class citizens. Given this history, it may be understandable that the Palestinian population has little trust in such a solution. However, the Jewish scholar Ilhan Pape considers a combined democratic state as a serious option in the long run. This is relevant because for Palestine Israel is not a democratic state, it is a Jewish democratic state. Its Arab citizens do not have the same rights. First, Israel would have to become a democracy to give this proposal even a starting consideration.

However, a more sophisticated pragmatic solution could certainly entail two countries, or independent regions, where Palestinians who happen to live in the new Israel, have the option to continue to live there, and Israelis who happen or are willing to live in the new Palestine state, also have the choice to continue to live there. This wise progressive proposal was told to me by my colleague Professor Howard Davis. While this proposal is welcome, here we want to emphasize first, what the Palestinians need, and proceed from there. And right now they need their own state and their own Independent Region based on the 1967 borders. What is worrisome in this context, is the secret and continuous planning and building by Israel in the occupied territories with new colonial setlements as part of one larger Israel from the river to the sea as Noam Chomsky so eloquently pointed to already in his 2014 presentation to the UN. (Chomsky, 2014)

Consideration/Solution: The cruel events surrounding the Israel – Palestine Conflict in the spring of 2024, with 35,000 or more Palestinians killed, 75,000 wounded and crippled and over a thousand Israelis killed, it is critical to find a solution to this ever-increasing conflict, and establish a Palestinian Independent Region with immediate statehood right after the end of this war in 2024. This region needs to become truly independent, without any continuing apartheid control and subjugation of Palestinians by Israelis. While New Palestine needs liberation and freedom, Israel needs security and safety for all its citizens as a central element in place.

Links: 1. Impact of the New World- and Regional Order on the Formation of a State of Palestine. 2. Safe Boundaries 3. Constructing a new Independent Region; 4 Reconstruction of Gaza; etc…

Cluster Two: (Patterns and Anti-Patterns)
Destabilization, refugees, and the architecture and planning of occupation

This cluster emphasizes the destabilization of Palestine society and environment as a long planned and organized process in a deliberate way by Zionist supremacy, colonialism, apartheid, physical destruction of buildings and infrastructure and the elimination of people, through the means of ethnical cleansing and indeterminate killing. Regional and Urban colonial Planning as well as the architecture of occupation played a dominant role in the destabilization with the creation of multifaceted (multi-times refugees) within their own territories from which they could not escape.

- The Colonization and Occupation of the Palestinian Territories
- Refugees in Palestine the West Bank, Gaza and adjacent Countries
- A House is not a Home: (includes ChatGPT, Lookx)

The colonization and occupation of the palestinian territories pattern

Problem: Israel as a Zionist and colonist society which is using the occupied Palestine Territories at their will since at least 1948, and 1967, violating numerous international laws on the way, destroying buildings and infrastructure, hiding the facts, killing Palestinians, and expropriating and stealing houses in East Jerusalem in an organized and systematic fashion.

Today, the Palestinian territory encompasses Gaza Strip, the West Bank with the Jordan River, and East Jerusalem. The area has been occupied, controlled, and exploited by Israel since the 1967 war, leaving less and less space for Palestinians accompanied by less and less peoplehood for Palestinians.

Rashid Khalidi in his book 'The Hundred Years' War on Palestine – A History of Settler Colonialism and Resistance, 1917-2017,' describes this period from the Palestine perspective and its people's horrendous experiences, starting with a letter by Theodor Herzl one of the early main Zionist leaders. "He had already begun to give thought to some of the issues involved in the colonization of Palestine, writing in 1895."(Khalidi, 2020, p.4)

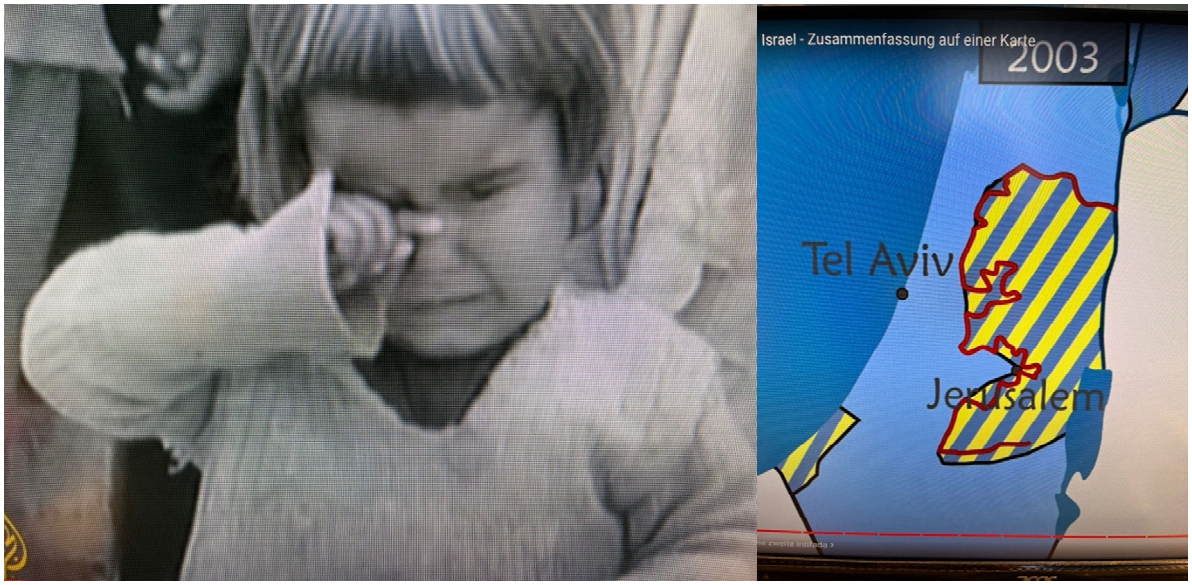

Figure 3. (Left) Palestine refugees 1948 Nakba (Source: unknown),Right: Ariel Sharon's building of a wall grabbing more land from Palestine 2003 (https://www.youtube.com/watch?v=W51ENoykVN4 Geo-Geschichte 2024)

> *We must appropriate gently the private property on the states assigned to us. We shall try to spirit the penniless population across the border by procuring employment for it in the transit countries, while denying it employment in our own country. The property owners will come over to our side. Both the process of expropriation and the removal of the poor must be carried out discretely and circumspectly. (Khalidi, p.6) (see also Herzl, 1960).*

What has been written more than hundred years ago, as an instructive suggestion, demonstrates the power of an idea that became true showing the reality of Zionism. With the proclamation of Israel as a Jewish State 1948, David Ben Gurion, Head of the World Zionist Organization, the fate of Palestine took a deep hit, from which it did not recover until today. The 1948 expulsion of almost all Palestinians (Nakba) created huge refugee camps in the surrounding countries, only the people in Gaza stayed until today, becoming refugees in their own country because Egypt refused to take them in.

> *"By the summer of 1949, the Palestinian polity had been devastated… Some 80 percent of the Arab population, that at war's end became the new state of Israel had been forced from their homes and lost their land and property. At least 720,000 of the 1.3 million Palestinians were made refugees… Israel controlled 78 percent of the territory of former Mandatory Palestine, and ruled over 160,000 Arab Palestinians…" (Khalidi 2020, p. 58)*

Khalidi refers to the Nakba as grounded in the defeat (1936-1939 great revolt) and willed by the Zionist state-in-waiting as well as foreign interferences and fierce inter-Arab rivalries. For him, the Nakba was only made possible by massive global changes during and after World War II. The 1947 UN committee agreed to the partition of Palestine. Arabs did not agree but Zionists did, the first time officially recognized with their own territory. Hostilities started between Arabs and Zionists. (Figure 4a)

1948 FIRST ISRAEL ARAB WAR AND NAKBA: Zionists prepare for war with the help of Europe with weapons, financial, and practical support. Golda Meir receives 30 million US Dollars from the Jewish community in America for starting the civil war. Plan Dalet by Ben Gurion. Hagana conquers the street from Tel Aviv to Jerusalem and destroys villages along the way plus a massacre in Deir Yasin. May 14, 1948 Ben Gurion declares Israel as an independent state and starts war against the Arabs. June 11, UN formed a peace treaty that benefits Israel with additional weapons from Russia and Check Republic. After a fire pause, in only 10 days, Israel pushes the Arabs to the East.

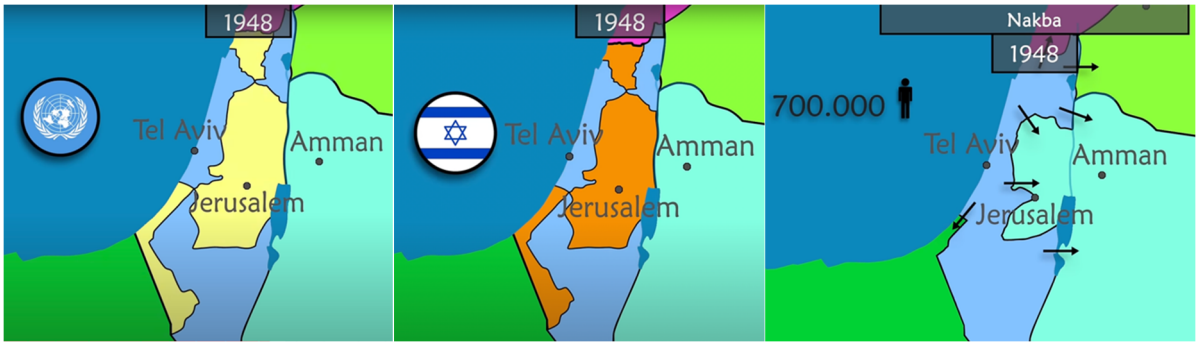

Figure 4: Die Geschichte von Palestina und Israel – Zusammenfassung auf einer Landkarte : 4a The land partition by UK and UN; b) Formation of Israel State and Government within their allocated area in blue; 4c loss of huge amount of lands taken away from Palestine by Israel, Jordan and Egypt. The Nakba Catastrophe original sin. (https://www.youtube.com/watch?v=W51ENoykVN4 Geo-Geschichte 2024)

A Palestinian government is formed in the Gaza strip, supported by the Arab states with the exception of Jordan, which wants to annex the area. (Figure 4b) Various peace treatises are worked out in which Palestine loses additional large amounts of land to Israel including West Jerusalem. Gaza is allocated to Egypt, and the West Bank is allocated to Jordan (Figure 4c). More than 750,000 Palestinians were expelled, killed, or massacred in what is known today as the Nakba or Catastrophe, and Israel is born with its own original sin. Large Refugee camps are established in Gaza, West Bank, and the surrounding countries. Israel refuses the return of these refugees to their home country in now Israel-occupied territory until today. Only 150,000 Arabs still live in Israel at that time.

1949 Israel opens up for their own refugees and immigrants, especially from Yemen and Iraq.1952 In only three years the Israel population doubles to 1,400,000.The causes of the 1967 war, apparently, are less clear, but what is clear is that Israel defeated the armies of three States, Egypt, Jordan and Syria, decisively, by destroying their warplanes on the ground before the war even started. Egypt's moves in the Sinai apparently created incitement in Israel that provided the casus belli and allowed

Israel military to launch a long planned, US supported, pre-emptive first strike; "…one that smashed the Airforce of three armies and changed the face of the Middle East." (Khalili 2020, p.98)

A new US-Israel axis resulted in Security Council Resolution SC 242, 1967, drafted by the US, and interpreted by Israel as keeping all the occupied territories they gained in the war, and colonize and use them until today. All of this against international law and the world community. The resolution "treated the issue as a state to state matter between the Arab countries and Israel, eliminating the presence of Palestinians." (Khalili, 2020 p.106) This diplomatic trick resulted in the fact that Palestinians had no more rights since they 'did not exist.' Most important, in terms of land grabbing "242 effectively legitimized the 1949 armistice line as Israel's de facto boundaries, thereby indirectly consenting to its conquest of most of Palestine in the 1948 war." "…a whole new layer of forgetting, of erasure and myth-making, was added to the induced amnesia that obscured the colonial origins of the conflict between Palestinians and the Zionist settlers." (Khalili, 2020)

Although most land expropriation by Israel and its settlers was accomplished after the 1967 war, more expropriation continued, i.e. by Arial Sharon, forming a new land-grabbing wall around the West Bank including Jerusalem (Figure 3b), and this is still going on today with settlers, who are used to the long established colonial system, taking what they want and displacing Palestinians at the same time. The goal was always about expropriating land and denying peoplehood, as Herzl advised long time ago

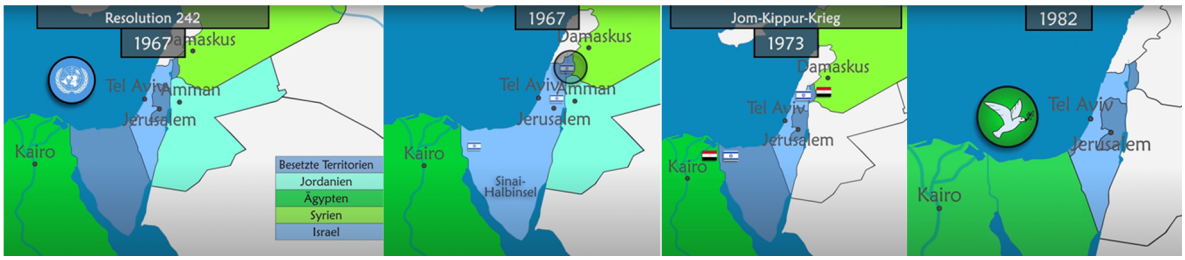

Figure 5: Die Geschichte von Palestinien und Israel – Zusammenfassung auf einer Landkarte. a. b. In the third war 1967 more land was expropriated by Israel (Resolution 242) and c. In the Ramadan War of 1973 Arab countries tried to recover lost areas. In 1982 Israel invaded Southern Lebanon attacking Palestinian Refugee Camps. (https://www.youtube.com/watch?v=W51ENoykVN4 Geo-Geschichte 2024)

even though several rulings by the International Court of Justice, as well as reprimands by the UN (i.e. the current ICJ preliminary ruling on the Gaza genocide case), have determined land grabbing behaviour as illegal, and against international law. However, this system has continued for over 100 years, so that there are now 600,000 colonizers living in the Westbank with new Israeli settlements, houses, land, gardens, and beautiful agricultural land with olive trees, all stolen from the Palestinians.

Therefore: It is hard to believe that this gruesome history was going on all along in our modern times, long after WWII, without being openly discussed or even acknowledged. It is time to directly confront these facts. Today, the internet and other sophisticated recording and communication systems help us to get a better view of this hidden history, and still ongoing practices, bring the truth to the front, and correct this illegal situation. The international community needs to grant statehood for Palestine as an Independent Palestine IR during already during the Gaza 24 conflict. It would help, to establish solid guarantees for Israel's own security, with Palestine neutrality and integration in the Middle East Region and with cooperation, mutual help, and co-existence. https://www.youtube.com/watch?v=W51ENoykVN4 (second Intifada 2000-2003)

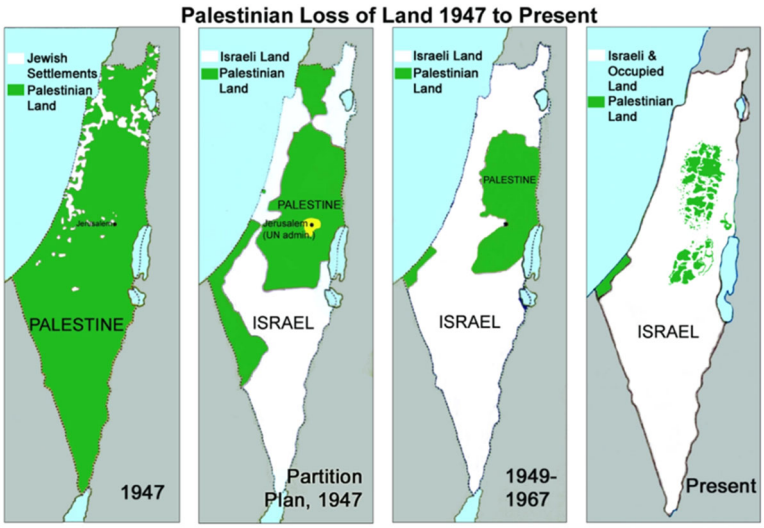



Figure 6a: Palestine land reduction over time from 100% to 22% with imminent danger of nihilation of Palestine. It is critical, that occupied territories since 1967, are returned to Palestine as the base land for a new Independent Region of Palestine and the advance to new peoplehood in Palestine in a new independent state with equal rights for all. 6b. Safa Khalib:"Telling the Battle of the Nakba story is a battle against time." Midleeasteynet.net. https://s10probus.co.uk/israel-palestine-the-background-by-david-worth-24th-may-2021/

Links: IRREVERSIBLE NEXT STEPS: The Formal Recognition of Palestine as a State and the Formation of the Independent Region of Palestine (see cluster 4, p.4)

Refugees in Palestine, the west bank, Gaza and adjacent countries pattern

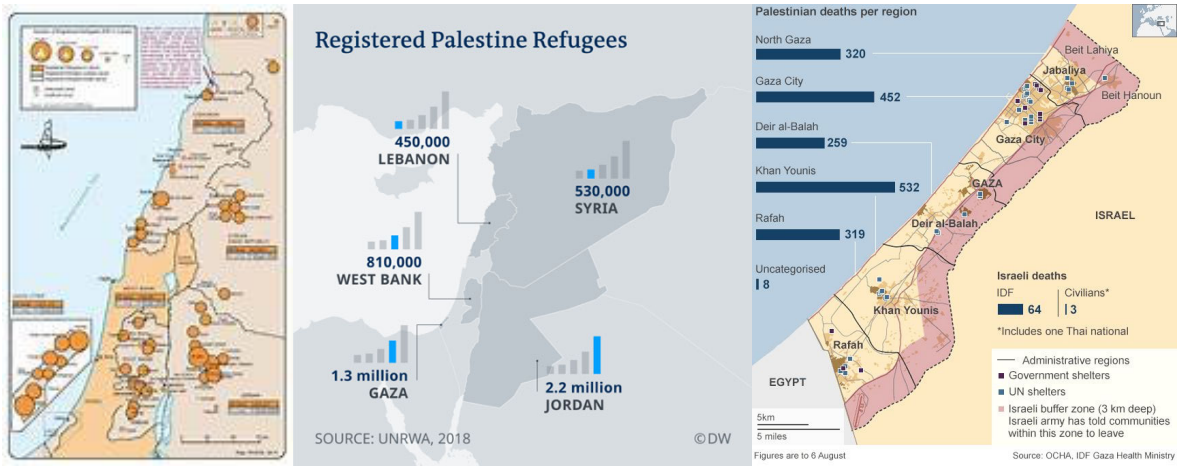

Figure 7. Distribution of Refugee camps in West Bank, Gaza and adjacent Countries (Source: a) Passia http://www.passia.org/maps/view/72) b) DW UNRWRA 2018; c) OCHA, IDF GAZA HEALTH MINISTRY, 2024.

Problem: Millions of Palestinian refugees and their children and grandchildren refugees are living in camps in the West Bank, Gaza, as well as Jordan, Syria, Lebanon and other places. They want to return to their lawful homes, gardens, and land in Israel and the occupied territories. Some of them wait since 1948, and want to return home and die at home.

Refugees and refugee camps in Palestine and adjacent countries started out as a reminder of Israel 's original sin to expel almost a million people from their home and land after the 1948 birth of Israel, with no country and state for Palestine as originally promised and intended in the UN resolution.

Displacement is all too familiar to Palestinians. Many fled their homes during the 1948 Arab-Israeli war in a forced migration, and catastrophe. After the establishment of Israel, many sought temporary shelter in the Jordan-controlled West Bank and the Egypt-controlled Gaza Strip. Thousands fled once again after the 1967 Six-Day War, in which Israel captured control of the territories, and currently in 2024, millions are fleeing from one place to another within Gaza as refugees with no place to go and open for being killed in front of our eyes. Trying to make the killing of Palestinians a new normal, is certainly one of Israels' most serious miscalculations that needs serious correction.

As we can see from sources like the UNWRA map above, the majority of Palestinians – over 5 million – are refugees. About one third of the Palestinian refugee population are spread out across 58 UNWRA-administered refugee camps in the Occupied Palestinian Territories (OPT), Jordan, Lebanon, and Syria. In addition, there are an estimated 10,000 unregistered refugees in Iraq, and a further 50,000 in Egypt." United Nations Relief and Works Agency in the Near East (UNWRA, 2018 and 2024)

Therefore: After living more than 75 years in Palestinian refugee camps distributed into more than six countries, it is time to bring all refugees and their families back to home, in a new independent region, country and state of Palestine. It is time to not only formulate a clear path to Independent Palestine but also to take practical actions to bring refugees back in to their home land. And do not fill up Gaza with new Israeli colonizing settlers or other new Israeli Occupation Plans.

A house is not a home pattern

Problem: A house is not a home when you are forced to rebuilt it every few years.

It is not unusual that in areas of natural disasters, such as earthquakes, flooding, firestorms, and other disasters by "the hand of god," houses may be partially or fully destroyed and need repair or total rebuilding from the ground up, in extreme cases 2-3 times in the lifetime of a family, father and mother. Rebuilding might be a matter of resilience and necessity, be it partial repair or total new building altogether. But if the force of nature destroys one's house too often, as might happen because of the effects of climate change in our times, the house will start to lose its quality of a permanent home, one might start to consider to rebuild in another safer area and create a house that one can also call a reliable and safe home.

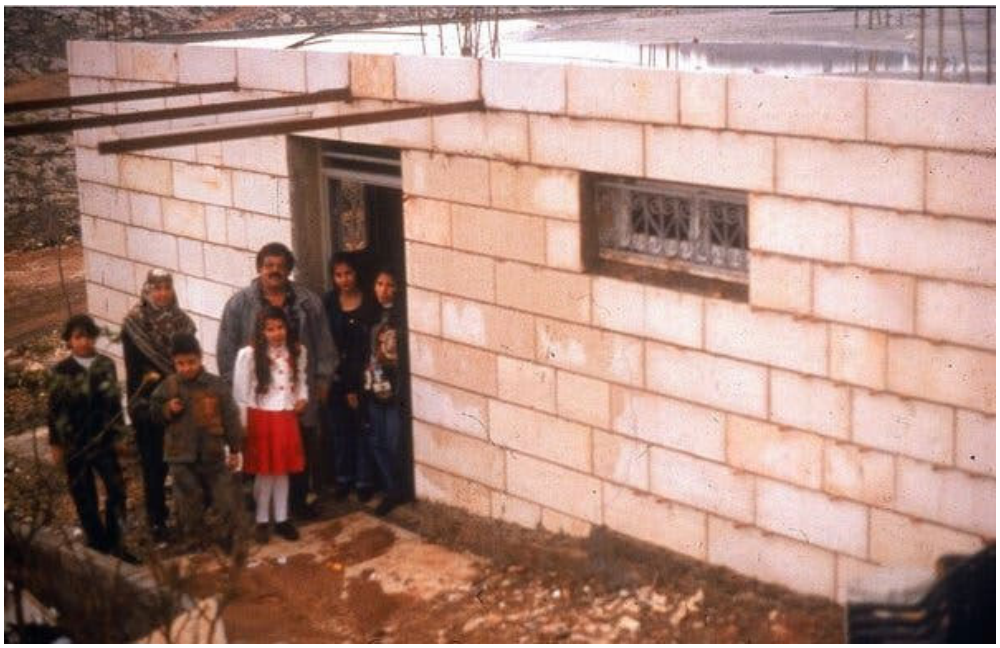

Figure 8. Palestinian Refugee House (Courtesy of Jeff Halper) in NYT, March 25, 2024

Links: INDEPENDENT REGIONS – OCCUPATION AND COLONIZATION OF THE PALESTINIAN TERRITORIES (ORIGINAL SIN) - REFUGEES IN PALESTINE THE WEST BANK, GAZA AND ADJACENT COUNTRIES

If the house is destroyed by war, like in WW I, one can rebuild it; and if it is destroyed a second time by war, as might have happened in WW II, one still can rebuild it a second time, hopefully without losing too much of the quality of home, and withstand the wish or tendency of trying to abandon and look for a house and home at another place.

However, if the house is intentionally destroyed by state terrorists every few years, one might definitely try to look for a better place of a house elsewhere, unless one has no other place to go, and can muster the fierce determination to keep a house alive that still might contain a few qualities of home by rebuilding and rebuilding. This is what happened 'pars pro toto' to a Palestinian family reported by Imam Fayad, who is a member of this family. NY Times, March 25, 2024.

> *"On July 9,1998 a small house in Anata, a village Northeast of Jerusalem, was destroyed for the first time. Home to the Shawamreh, a Palestinian family of nine, the house was built four years earlier in a part of the West Bank over which Israel military has control. House demolitions occur routinely in this territory, where Palestinians like Arabiya and Salim Shawamreh are denied building permits on land that they have purchased and rightfully own. NYT, March 25, 2024*
>
> *This house became a target for repeated demolitions because the family refused to leave. Each time Israeli authorities razed it, the family rebuild it, alongside volunteers from the Israeli Committee Against House Demolitions. Now known as Beit Arabiya, the house has become a symbol of resilience." NYT, March 25, 2024*

But one also has to consider the Sisyphus moment, when the rebuilding of the house becomes a continuous alternating process of building, destruction and rebuilding, as an eternal process. In Greek mythology this is what happened to Sisyphus, who was punished by the gods for some crime, to forever roll a heavy stone up the hill, only to have the stone roll back to the base of the hill, and then start the process again forever and forever. But while the Sisyphus moment can be seen a serious

consideration totally changing the spirit of the rebuilding. it is also the wrong solution to the problem in such a precarious situation of Palestine life and society. It is a means of ethnical cleansing and a violation of international law as well as a crime against humanity.

Suggestion/Solution: The slightly bitter solution to the problem is more along the lines of "A house can be temporary, but the home is permanent." And while this may be a useful temporary solution of such a foundational problem of keeping a home, in the end, you still want to create, design, and build a house that is also a home with a garden, a view, and a prospect of a good future.

Below, we have tried to work with an Alternative History of development for the Shawamreh family house by modelling possible histories, based on the original house to the left in 2023).

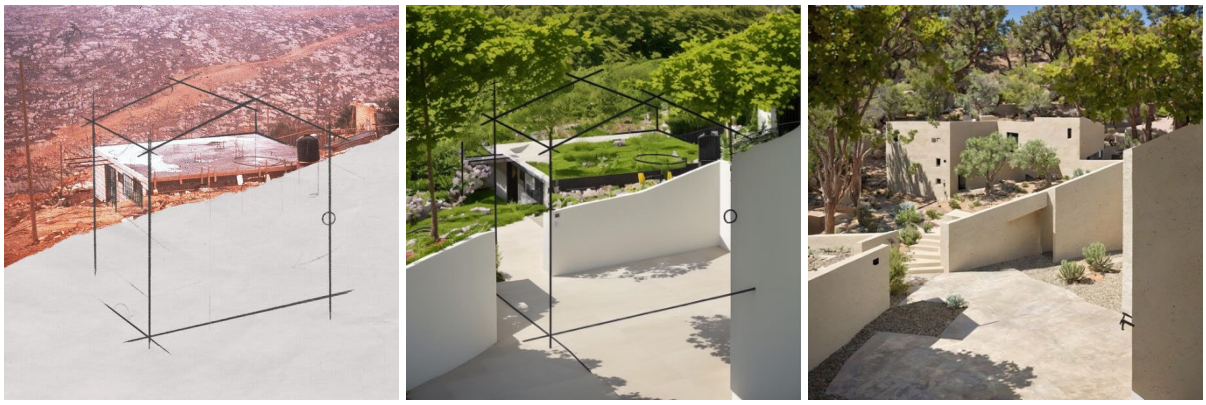

Figure 9. (Left) Building in 2023 (NYT) Shoshana Schultz, (Middle) Alternative history with AI (Hajo Neis and Zayla Jacobson, 2024) (Right) Alternative history with AI (Hajo Neis and Zayla Jacobson, 2024)

Links: INDEPENDENT REGIONS - MODERN TECHNOLOGY, SOCIAL MEDIA, AND THE OPENING OF THE WORLD'S EYES

CONCLUSIONS

The investigation into the refugee situation and Palestine as an Independent Region, has led to larger issues that needed to be understood first to come closer to our objective and support the immediate formation of a Palestine State as an Independent Region to solve the refugee problem as well as unpacking other serious problems such as Apartheid, Zionism, neocolonialism, and supremacy of one ethnic group over another ethnic group.

In essence this epic 100 year conflict seems to be about land, with one ethnic group invading another ethnic group to grab as much land as they can and also try to eliminate or neutralize the indigenous people in different ways, and start their own new state, not as an independent region, but as a region that can live only with the support of large powers such as first France, Britain and since the end of WWII the United States. This conflict has produced large number of refugees, millions in fact, many living in camps since 1948 in surrounding countries, Gaza and the Westbank. They want to come back.

There also seems to be a strong fire wall for the creation of an independent Palestine State or Region, directly or indirectly. Most Israelis are currently not interested, and Netanyahu has and will do almost anything to avoid a Palestinian State. Example: On July 17, 2024 the Israel Parliament voted again against an Palestine State, as they have done many times before. (Public TV News Report in Germany)

From more liberal voices, you will hear most often "Palestinians deserve their own state." But then after a pause it goes "I believe the time is not now." And this is how it goes since 75 years. They will

also claim that the Palestinian people do not want their own state, because they want to destroy Israel and recover the land from the river to the sea, while de facto it is Israel that does everything to grab all space between the river and the sea. Zionism ideology and Palestinian life are two different things.

In fact, we see it the exact opposite of creating a Palestine state right now, especially because of the terrible disaster that is going on in Gaza. Nevertheless, after such a cataclysmic event, there is a very good chance to try just that, create new state for Palestine supported by the international community and the emergence of a new world order demanded by the global South. It is important for Palestine, to be a real 'Independent Region" with neutrality and cooperation with its neighbour Israel, and without being dominated. Given 100 years of war on Palestine, this time is as good as any. And with it, we see the release of the refugees who are sitting in their refugee camps in the surrounding countries, the Westbank and Gaza, and be able to return to their new independent region, and homes.

But as Noam Chomsky in his speech to the United Nations in 2014 very ominously warned us: While all these negotiations and political moves are going on, the Palestinian Territories are subject to further killing and land appropriation by settlers and the Israel Government, and that is the real event, that is going on all the time as the main Israel hidden policy and activity without anybody even talking about, as a slow and decisive death and the elimination of Palestine. And as we can observe now in front of our eyes, it only got worse. https://www.youtube.com/watch?v=1f1wXGKd9Ss . Consequently, "it may be necessary for the international community to formally impose the new Palestinian state on Israel." (Sachs, J. 2024) https://www.youtube.com/watch?v=Rchfx5qGdtg . We will continue to work on this huge problem with more research, fresh ideas, and pattern formation.

Acknowledgements

Thanks to Sara Ishikawa for providing books that made this work richer. I also want to thank the "stateless" Motasem Amleh from Palestine, who studied electrical engineering in Ukraine only to escape from war with his Ukrainian wife and two children to a small German Town, where I met him. Furthermore, I need to thank my student colleague Achmed from Palestine, and I acknowledge the student Taheri, whom we tried to help prevent extradition to Iran at the University of Frankfurt 1969.

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Adapting urban forms to rising sea levels: sustainable design and resilience in Guayaquil's delta context

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ABSTRACT

This study addresses the pressing need for cities situated in deltas to adapt their urban morphology and strategies in response to rising sea levels, a challenge further intensified by climate change. The case study focuses on Guayaquil, the second-largest city in Ecuador, situated in the Guayas River estuary. The research highlights the city's significant socio-economic and geographical segregation issues, along with an increasing vulnerability to coastal flooding. The study emphasises the integration of water into the urban design of precarious areas, proposing the transformation of public spaces, architecture, and daily life to shift the perception of water from a mere threat or economic resource to a central element in sustainable urban planning. The study analyses Isla Trinitaria, one of Guayaquil's most vulnerable localities affected by rising sea levels, in order to explore adaptation strategies that promote adaptability and integration with the aquatic environment across disciplines. The investigation employs a hybrid interdisciplinary methodological approach that integrates qualitative analyses with empirical explorations in a cross-scale and cross-layer articulation. The study proposes the development of an innovative multidisciplinary framework for climate adaptation. This approach not only contributes to Guayaquil's resilience in the face of climate change but also provides scalable, sustainable urban development models for delta cities worldwide. The significance of this study lies in its contribution to the field of urban design, promoting sustainable development and urban design strategies to confront the impacts of rising sea levels.

Keywords: delta cities, urban adaptation, rising sea levels, climate change, Guayaquil

INTRODUCTION

This investigation aims to develop strategies for the current dynamics and evolving challenges of climate change, with a particular focus on enhancing resilience and adaptability in deltaic and coastal cities across three scales: regional, urban, and architectural. Central to this strategy is the evaluation of water not merely as a threat but as a potential dimension within the morphological and planning dimensions of cities.

The current research questions the urbanisation processes and operational behaviours in cities. According to Graaf (2012), cities exhibit linear resource flows characterised by parasitic behaviour.

They consume resources from nearby and distant areas while expanding into adjacent ecosystems. These resources are converted into waste materials, CO2, heat, and wastewater, which are not utilised productively but discarded, negatively impacting local surrounding regions. This condition results in resource depletion and adverse urbanisation effects on the land.

Urban planning and design strategies in delta regions are undergoing a significant reassessment of how we design with nature, climate, and cities for mutual benefits (Lo, 2016; MacHarg, 1969; Meyer & Nijhuis, 2013). This perspective challenges the traditional view of cities as static entities focused solely on survival. Instead, it proposes that cities are evolving complex systems in the local and regional context. According to Alongi (2008), change is an intrinsic characteristic of Earth's ecosystems, with organisms constantly adapting to spatial and temporal conditions due to climate and other physical factors-" To exist is to change... []"(Bergson, 1922, p. 22). These ecological and biological transformations, driven by natural and anthropogenic disturbances, play a vital role in introducing and testing adaptive strategies within ecosystems (Odum & Barrett, 2005).

This research aims to explore a multi-scale and multi-layered framework and develop tools that help articulate different strategies within the urban context, contributing to the city's adaptability and resilience. The investigation hypothesis is that adaptability can only be achieved when different scales and layers are articulated with each other, enabling them to respond effectively to climatic imperatives.

The research is structured as follows: The first section explores the global and local situation, as well as its implications for the city of Guayaquil in the face of climate change and sea level rise. The following section explores interdisciplinary concepts and tools to enable cities to adapt and be resilient, predominantly for coastal and deltaic cities. The following section explores the implementation of the concepts and patterns explored in the qualitative section to build the framework for adaptation at the regional, urban and architectural scales.

Background and context

Since the 16th century, the water-land environments have been transformed, dredge, and expand to benefit humans (Meyer & Nijhuis, 2014). The world's largest cities are situated in coastal and delta regions. Due to climate-related conditions, these urban environments are particularly susceptible to the increasing risk of extreme weather events and sea level rise. The current situation has already begun to affect millions of people (C 40 Cities, 2022).

The Intergovernmental Panel on Climate Change (IPCC) (2021) provides conclusive evidence that human activities have led to global warming. As stated by the IPCC (2022), climate change is causing pervasive and potentially irreversible damage to ecosystems, urban areas, and human health. There is evidence that species are migrating to higher latitudes and elevations, with many ecosystems facing irreversible impacts. Furthermore, the intensification of heat waves contributes to the retreat of glaciers, which in turn affects the functioning of hydrological systems. The report identifies significant adverse effects on global physical and mental health, including increased mortality from extreme heat, an elevated incidence of climate-related diseases, and the expansion of vector-borne diseases. Similarly, exposure to wildfire smoke, dust, and allergens has been linked to an increased prevalence of cardiovascular and respiratory issues.

The population exposed to a 100-year coastal flood could increase by approximately 20% with a 0.15 m rise in global mean sea level relative to 2020, doubling at a 0.75 m rise and tripling at 1.4 m in the absence of additional adaptation measures. The increase in sea level represents an existential threat to some small islands and low-lying cities. The report suggests that by 2100, global assets at risk in coastal floodplains could be valued between US$7.9 and US$14.2 trillion. The costs associated with maintaining and reconstructing urban infrastructure are set to rise significantly, with considerable disruption anticipated, particularly in areas with permafrost and along coastlines (IPCC, 2022). As sea levels rise, the functionality and safety of coastal infrastructure, including ports and freshwater resources, will be increasingly compromised. Sea level rise is contributing to the salinisation of coastal aquifers and sedimentation (Meyer & Nijhuis, 2016).

UN-Habitat (2016; 2017) emphasises the urgent need to regenerate and adapt urban ecosystems, particularly in Latin American cities, where a significant portion of the population resides in low-lying coastal areas. The New Urban Agenda stresses the urgent need for climate change adaptation in coastal cities, noting that the cost of inaction could lead to severe economic consequences, with potential damages exceeding one trillion dollars annually by 2050 due to rising sea levels and other climate-related events. Additionally, climate-related extreme weather events in Latin America and the Caribbean have shown a marked increase, with economic damages surpassing 120 billion dollars during the 2001-2005 and 2011-2015 periods (United Nations, 2017, p. 66).

The last century has been marked by considerable urbanisation processes all over the globe (UN-Habitat, 2020). Deltas have seen substantial transformations in the landscape and the coastlines since the Industrial Revolution. Today, nearly 44% of the global population lives within 150 km of coastlines (Meyer et al., 2010; UN Atlas of the Oceans, 2010). On a global scale, half of the population resides in urban areas (New Urban Agenda, 2016; United Nations, 2014). Cities are often the first locations to experience the impacts of climate change and face rising temperatures, increased flooding, storms, and other complications driven by anthropogenic activities (IPCC, 2022). In this context, climate change and sea level rise could displace up to one billion people by 2050, disproportionately impacting low-income populations. Informal communities are often the most affected by the non-democratic distribution of resources (IPCC, 2023; United Nations, 2017).

The challenges introduced by climate change are inherently dependent on the developmental stage and geographic context of the area of study (Mirza, 2011). Extreme weather events related to climate change in Latin America and the Caribbean show an increasing trend, with economic impacts surpassing 120 billion dollars in both the 2001-2005 and 2011-2015 periods (United Nations, 2017). Deltaic areas present a duality of being strategically positioned for commerce and rich in fertile soils for agriculture while also being extremely vulnerable to climate change due to the proximity of the territory to extensive water systems and the ocean. These regions are critical to the global economy and are valuable ecosystems. Given that over 80% of global trade in high-volume goods is conducted by sea, the economic repercussions on international trade and the economies of affected nations could be substantial (World Bank, 2023).

Deltas often accommodate large populations in sensitive environments dominated by water. As such, urbanising deltas are particularly susceptible to threats from climate change and rapid urbanisation, including increased flood risks and the loss of ecological and socio-cultural values (Garner et al., 2021;

IPCC, 2022; Meyer, 2014). Transforming urbanising deltas into resilient and productive entities is essential for sustainable development and climate adaptation. The collective interactions and relationships of geographic localisation, coupled with unchecked urbanisation processes and extractive economic-centred activities, have significantly contributed to a non-resilient transformation for delta environments. The situation poses substantial threats to this environment in the face of rising sea levels. Delta regions worldwide are currently facing significant land-use transformations. A primary shift, driven by globalisation and technological advancements, involves the expansion of ports and port-related industries (Meyer, 2014; Meyer & Nijhuis, 2014; Saeijs, 2006).

Natural barriers and dynamic ecosystems in delta regions have undergone significant natural changes over time. However, these systems are experiencing degradation due to human interventions, leading to a decline in their ecological integrity. According to Alongi (2008), while climate change could lead to a global loss of 10-15% of mangrove forests, the immediate concern is the ongoing deforestation rate of 1-2% annually. The current distribution of mangrove forests is primarily influenced by historical sea-level changes dating back to the Holocene era (Saintilan et al., 2020). Mangroves possess inherent features to help against sea-level rise and storm damage but also mitigate the impact of extreme weather events like hurricanes, cyclones, and tsunamis. Various studies have demonstrated that mangrove forests effectively attenuate wave energy, reducing wave height significantly as waves travel through them, with attenuation rates ranging from 63.7% to 94.7% (Brinkman, 2006).

In the 20th century, Latin America saw a massive demographic shift due to deteriorating rural conditions and industrialisation, leading to extensive urban migration; in the same form, these demographic shifts were replicated at the national level (Carpio Vintimilla et al., 1987; Milton & Villavicencio, 1988). This migration has resulted in concentrated urban populations and rapid spatial expansion, particularly in urban cores and fringes. Currently, about 84% of the Latin American population resides in urban areas, making it one of the most urbanised continents globally. Despite this expansion, Latin American cities still maintain higher densities than those in developed regions. Latin American cities' urban development patterns, reflected in Guayaquil's urban growth, as described by Borsdorf and Dattwyler (2009), exhibit fragmented urban patterns shaped by profound socioeconomic challenges and disparities. These dynamics have led to urban landscapes characterised by widespread and decaying housing, a product of the gradual impoverishment of the labour force under a neoliberal model that prioritises profit maximisation and uneven wealth concentration.

Guayaquil, Ecuador's second-largest city, located in the lowlands along the Pacific coast, faces critical water challenges, including flooding and water scarcity. Much of the city's development has taken place on plains, floodplains, and areas that previously consisted of mangroves and salty estuaries (CAF, 2017). Despite being surrounded by water, seven out of ten residents have access to contaminated drinking water, and 12% of households in the poorest southern areas lack adequate sewage systems. Furthermore, over 80% of industrial wastewater, rich in organic pollutants, is discharged untreated into the sewage system or directly into rivers, exacerbating the city's environmental and public health issues (World Bank, 2019). Guayaquil spans 34,449 hectares, with 92% of its area urbanised, while the remaining land consists of water bodies like the Guayas River and Salado Estuary. The city supports a population of approximately 2.75 million. The city's economy is predominantly informal, with about 46% of economic activities occurring in this sector, resulting in high levels of underemployment (42.9%) and unemployment (9.6%) (INEC, 2010). The rapid urbanisation and ecological degradation in the territory have increased its vulnerability to climate change, particularly to flooding from rivers,

sea, and rainfall. This is exacerbated by the El Niño-Southern Oscillation (ENSO) and heavy rain concentrated between January and April (CAF, 2000, 2017). It is defined as the fourth city in the world most vulnerable to sea-level rise, with economic damage projections under high-end and RCP 8.5 sea-level rise scenarios potentially reaching $546.5 billion by 2100 (Abadie et al., 2020).

Urban transformation processes have historically resulted in the parallelisation of the city's structure, where the dichotomies of the formal and informal collectively shaped the urban landscape. Formal structures are those intentionally planned within the urban fabric, whereas informal structures arise spontaneously, driven by the population's initiatives, often without formal construction knowledge and using substandard materials (Davis, 2006). According to the United Nations (2017), Informal settlements are particularly vulnerable to climate change, as it disproportionately impacts impoverished communities.

In Guayaquil, approximately 70% of the city is within some level of the informality spectrum (INEC, 2010). The shortage of affordable housing has led to the emergence of informal settlements in areas such as Isla Trinitaria (1980s), Guasmo (1960s), Monte Sinai (1970s), Los Esteros (1980s), Bastión (1990s), and La Alborada (2000s) (Carpio Vintimilla et al., 1987; Delgado, 2013). Isla Trinitaria, located in southern Guayaquil within the Ximena parish. The island covers 860 hectares, with 455 hectares of urbanised informal settlements and a 395-hectare natural reserve. Urbanisation began in the 1980s following the construction of the Perimetral Road, leading to rapid informal development driven by rural-to-urban migration. Initially occupying estuarine locations, most homes now sit on solid ground due to landfills. The island, with a population of approximately 120,000, is organised into around fifty cooperatives.

In addition to rainfall-induced flooding, floods from rising tides and increased river discharge will significantly affect areas near water bodies, including mangroves and rivers. Many informal settlements in Guayaquil, established during the city's rapid expansion since the 1960s, are in these vulnerable zones. The Andean Development Corporation (CAF) has identified these settlements as particularly susceptible to heavy rainfall. Due to inadequate construction methods, these areas lack the necessary measures to cope with current climatic conditions. With rising temperatures, heavy rainfall events will become more frequent, disproportionately impacting these vulnerable populations. The risk of landslides, exacerbated by heavy rainfall, poses a significant threat to both life and infrastructure, especially in the city's peripheral areas with pronounced topography. According to CAF (2017), 53.4% of Tarqui parish, 49.4% of Pascuales, 35.3% of Febres Cordero, and Monte Sinai 68.75% are susceptible to landslides.



Figure 1. SLR 2030 RCP 8.5, return of 100 years. Blue: Water Bodies, Pink: Inundation. Data from: coastal.climatecentral.org. Created by the author.

Figure 1 illustrates the impact of a sea-level rise under the RCP 8.5 scenario with a 100-year return period, highlighting significant risks to large areas of the island, particularly the natural reserve, southern regions, including the port, residential zones, and northern regions near the estuary. A one-meter rise indicates substantial damage, while a two-meter rise suggests widespread inundation. This underscores the urgent need for strategies to enhance Isla Trinitaria's resilience. Current research inadequately addresses the specific vulnerabilities of informal settlements like Isla Trinitaria.

Key concepts and theoretical framework

The section is structured around tools and their potential applications and articulations across different scales: regional, urban, and architectural, as well as key concepts and terminologies related to climate change adaptation strategies. To approach the challenges posed by climate change and sea-level rise in cities demands a multidisciplinary approach. Based on a qualitative interdisciplinary analysis, the following four concepts have been identified as essential current and future scenarios adoption: 1) Mitigation, which is defined as the potential to reduce the adverse effects of physical hazards, including those of human origin, by decreasing threat levels, exposure and vulnerability (IPCC, 2022); 2) Adaptation, which involves altering infrastructure and systems to reduce societal vulnerability to climate impacts. The term also refers to the capacity of individuals or groups within a system to influence and enhance resilience; 3) Resilience is defined as the ability of a system to absorb disturbances and recover effectively; and 4) Transformability that addresses the system's ability to undergo fundamental changes in response to significant forces (Kabisch et al., 2017; Walker et al., 2004).

Due to the island's informal configuration, various intervention mechanisms have been explored to find bottom-up and top-down approaches that facilitate the transition to a more resilient model. Harvey (2013) argues that the neoliberal approach to urban development often exacerbates social inequalities and environmental degradation-“The right to the city is far more than the individual liberty to access urban resources: it is a right to change ourselves by changing the city.’’(Harvey, 2008, p. 1). Similarly, Davis (2006) highlights the precarious conditions in which millions live and how environmental changes worsen these conditions.

At the architectural scale, adapting the urban morphology of Isla Trinitaria presents an opportunity to create jobs, promote sustainability, and build resilience, integrating circular design and participatory design principles in the process. Building on this foundation, we argue that the true nature of

architecture is inherently participatory, as proposed by Katoppo and Sudradjat (2015). They contend that participatory design is integral to architectural practice, fostering engagement and collaboration among all stakeholders. Moreover, Roth (1999) emphasised that human-centred design research must involve those who will ultimately use the product. The author advocated for participatory processes within design, arguing that they facilitate rapid development and result in more effective and user-centred outcomes.

Given the complexity of informal settlements and their precarious situation, project interventions must be carried out in a very bottom-up manner, involving the inhabitants in workshops both to approach and inform about the problem, as well as in the creative and design process, and in the creation of more flexible guidelines for the population, which are not strictly governed by norms but by the availability of material, social, and implementation resources. Carroll (2006) emphasised the importance of incorporating an active participatory process throughout the entire design phase, where users are directly involved in setting design goals and planning prototypes. This approach contrasts with traditional methods that engage users only after the primary concepts and prototypes have been established. Many projects fail to be adequately implemented due to the theoretical and practical disconnection from reality of the informal dimension.

In the current context, the global construction industry is responsible for approximately 39% of global CO2 emissions (UN, 2019), with cement production generating 1 kg of CO2 per kg of cement produced, compared to bamboo's significantly lower CO2 footprint of -14,89 kg of CO2 per kg (Gu et al., 2019). The excess production of CO2 compels a re-evaluation of materials that can capture CO2, their implementation and recycling, and the new employment opportunities they can offer. The study of vernacular architecture offers critical insights into the logical responses to local climatic conditions by utilising available resources (González Couret, 2018). Camino Solórzano (1999) posits that the traditional three-room stilt house, prevalent since the colonial period, has persisted in rural regions with minimal alterations. This architectural form is particularly well-suited to the imperatives of the coastal climate. Bamboo and wood have been prominent materials used in the construction of Ecuador's coastal region. It has been used in the vernacular typologies of coastal areas in the country, significantly differing from the typologies of the Andean highlands in terms of morphology. These structures are elevated from the ground to adapt to the changing conditions of rivers and rainfall in their locations. However, according to Gonzales Couret (2018) these typologies have gradually disappeared in the country due to the integration of cement and models not being adapted to the context.

At the regional and urban scales, both planning and implementation tools are suggested as being of equal importance. Assessment mapping and scenario mapping emerge as critical tools for developing city planning strategies (Salewski, 2013). Geoinformation systems (GIS) tools, along with social, environmental, climatic, and urban data, are used to create maps that highlight areas of intervention (Berchtold, 2016).

Given the multi-actor and multi-component nature of cities, they cannot be seen as isolated entities in the landscape. Cities have influences on the local, regional and global scale (Gausa, 2022a; Sassen, 2001; Schröder & Maddalena, 2019). According to Gausa (2022a), this transition has led to the emergence of the "Metapolis," a multifaceted and interconnected system where diverse elements

coexist and interact simultaneously. They operate as multi-layered systems where various factors interact and sometimes conflict with each other. According to Meyer (2010), the “Layer Approach” can be constructed based on the following components: 1) The foundational layer (land, soil, water, and rock), 2) The infrastructural layer (transportation and utilities networks), and 3) The top layer (human activities and urban patterns). Furthermore, Gausa (2022b) and Schröder et al. (Schröder & Maddalena, 2019) emphasise the need for an integrated environmental framework that connects urban areas with natural landscapes, merging ecological and technological elements to create resilient and interconnected urban environments. Barker and Cutts (2016) present a multi-scale framework for urban climate adaptation, focusing on resilience at regional, urban, neighbourhood, and building levels. At the regional scale, they highlight tools such as forest infiltration, flood insurance, and wetland restoration. Urban strategies involve implementing blue-green infrastructure, including flood storage areas and parks. For neighbourhoods, they recommend reed bed systems, permeable surfaces, and rain gardens. At the building level, the strategies include rainwater harvesting, green roofs, energy efficiency measures, and typological adaptations like amphibious, elevated, and waterproof buildings to improve flood resilience.

McHarg, in his pioneering work Design with Nature (1969), contributed to landscape architecture by integrating ecological principles into planning and design. In this context, a multi-functional landscape can be intentionally designed to incorporate environmental processes and human needs into a cohesive framework (Fry, 2001; Wiggering et al., 2002). Despite advancements in landscape ecology, particularly in the analysis of landscape patterns and their interactions, landscape management decisions remain limited (Nassauer & Opdam, 2008). The success of landscape projects is critically dependent on the effective integration of ecosystem services—such as biodiversity conservation, resource provision, waste management, and cultural value enhancement—within the design and planning processes (Lovell & Johnston, 2009).

The following strategies have been identified as the most effective strategies during the literature research for flood adaption: ecosystem-based adaptation (EbA), ecosystem-based disaster risk reduction (Eco-DRR), nature-based solutions (NbS), green-blue infrastructure (GBI), green infrastructure (GI), and sponge cities. The ecosystem approach is a strategy that supports the sustainable management of land, water, and living resources with the objective of promoting conservation. The Millennium Ecosystem Assessment (2005) defined ecosystem services provide essential support, regulation, and promotion of human well-being. EbA is a strategy that focuses on leveraging biodiversity to build resilience, while Eco-DRR is a strategy that aims to reduce disaster risks through sustainable ecosystem management (Lo, 2016). Sustainable Land and Water Management (SLWM) is an approach that seeks to balance economic and social gains with the preservation of ecological functions. Strategies such as EbA and Eco-DRR also enhance carbon sequestration. It provides opportunities for ecosystem restoration, which in turn supports livelihoods and contributes to overall environmental resilience (Lo, 2016; Millennium Ecosystem Assessment, 2005).

NbS are strategies inspired by natural processes to enhance resilience and climate change adaptation in cities and natural environments. NbS employs reforestation, blue-green infrastructure, and urban green infrastructure to improve carbon storage and mitigate flooding. Sponge cities, inside the spectrum of NbS, represent innovative, sustainable approaches to urban water management and ecosystemic restoration for water-land territories, coastlines and inner territories adjacent to water bodies. The Chinese "Sponge City Program" (SCP), which was launched in 2013 and implemented in

30 pilot cities, is focused on developing innovative solutions to address urban flood risk, improve stormwater purification, and enhance water storage for future use (Qi et al., 2020). The Sponge City concept involves a multifunction that helps the resilience of the city while serving as a recreational space and positively influencing the lack of green areas in large metropolises in China.

The Industrial Revolution and new technologies systematically transformed the land with slogans such as "fighting against the water." Today, it is undergoing significant changes, and such slogans are obsolete. This new perspective represents an approach that embraces the concept of "working with nature" (Meyer et al., 2010, p. 23), "Room for the river" (Deltares, 2007), and "making space for water" (Barker & Coutts, 2016, p. 57), along with Nature-based solutions, and ecosystem interventions. The "Room for the River", initiated in 2007 in the Netherlands, is a resilient approach that integrates periodic flooding while aiming to balance its impacts and benefits. The project involves restoring natural floodplains in less vulnerable areas to protect more critical zones. By 2015, the project had lowered and broadened floodplains, restored wetlands, enhanced natural water storage, biodiversity, and recreational spaces, created river diversions, and established temporary water storage areas with a cost of 2,3 Billion euro (Deltares, 2007; The Minister & of Infrastructure and the Environment, 2007). Urban flood management strategies that integrate the environment and the city have emerged in response to the changing paradigm of urban environments and climate change. The "LifE" (Long Term Initiatives for Flood-risk Environments) project, funded in 2007 by the UK government's Department for Environment, Food and Rural Affairs, promotes sustainable practices for flood integration without relying on structural defences (Barker & Coutts, 2016, p. 57). The strategy emphasises enhancing the environment's natural capacity to absorb water, creating multifunctional spaces that serve as reservoirs, energy sources, and recreational areas. Initial master plans and case studies were developed for Hackbridge, Peterborough, and Littlehampton, focusing on non-defensive, adaptive approaches to urban inundation scenarios (Barker & Coutts, 2016; Waterstudio & Baca, 2009).

Lundy and Wade (2011) affirm that effective water management in urban areas requires a multidisciplinary approach that recognises the benefits of multi-functional green-blue infrastructure in urban environments. The authors argued that to adapt to rising sea levels, cities must adopt an integrated approach to land use and water systems in cities. Furthermore, the research suggests that a collaborative process with communities and stakeholders is essential for the exploration and implementation of the project. We must consider stormwater and groundwater management and land subsidence in relation to sea level rise. We must also take into account water balance, including freshwater supply and protection. The authors also suggest that in the case of disaster, we must adopt a multi-risk approach and use priority budgeting and creative financing to ensure long-term security (C 40 Cities, 2022).

A multidisciplinary report by Molenaar (Molenaar et al., 2018) addresses the specific flood risks in Guayaquil, particularly during periods of intense rainfall. The project focuses on mitigating coastal and pluvial flooding through the strategic placement of semi-permanent structures designed to manage water storage within recreational and underground spaces. Swyngedouw (1997) uses Guayaquil as a case study to explore water management within the "policy ecology of power," arguing that the urbanisation of water reflects a broader economic model that integrates society and nature into a system that benefits a select few while marginalising others. This model reinforces the extractive use of natural resources, particularly in the context of agro exports. Carofilis Cedeño (2018) provide a

historical analysis of the transformation of the Guayas River, examining the interaction between urban development and ecosystems. Their study highlights the complex relationship between Guayaquil's urbanisation and its territorial appropriation, offering insights into the interdependencies between urban growth and environmental change.

METHOD

The research comprehensively explored interdisciplinary literature and reference cases in the context of cities, climate adaptation and flooding using the following databases: Google Scholar, Elsevier, JSTOR and ResearchGate, selected for their comprehensive collections of peer-reviewed research, and books in the fields of ecology, urban and regional planning and architecture. The qualitative approach aimed to identify key strategies and concepts to develop a cross-scale climate adaptation framework for deltaic and coastal cities. The framework integrates adaptation strategies into urban morphology, providing guidelines for addressing climate change in cities. The research declares that adaptability is achievable only when different scales are effectively articulated. The concepts from the literature were synthesised into a framework (see Figure 2) to facilitate the articulation of the tools across the various disciplines, scales and layers.

RESULTS AND DISCUSSIONS

This research acknowledges the complexity of cities in their various dimensions and the intricate interactions among all contributing factors. It posits that cities cannot be viewed as isolated from nature but must be understood as dynamic entities shaped by social, natural, and morphological contexts. The study suggests that interventions must be grounded in a thorough qualitative and quantitative analysis of the context, integrating tools like assessment and scenario mapping to explore the vulnerabilities of the city and its inhabitants. The goal is to develop strategies that accommodate changing climate conditions and the dynamic nature of urban environments, leading to more resilient, sustainable, and equitable outcomes.

A multi-scale and multi-layer framework (see Figure 2) is proposed for urban adaptation in deltaic and coastal regions, focusing on integrating flood management within urban morphology, planning, and climate adaptation. The framework divides urban environments into three scales: regional, urban, and architectural. This research proposes that the city and the territory are constructed of three interconnected layers: Bottom (ecosystems, land, soil, and water), Middle (infrastructure and urban form), and Top (human activities). These layers are closely articulated, with interactions often surpassing individual dimensions, necessitating a flexible methodology that guides planning without being confined by rigid definitions. This approach fosters continuity across layers, enabling tools and concepts to adapt and function cross-scale, cross-layer, and discipline. Apart from the layers briefly discussed, due to new intangible dimensions, space must be analysed, including the informational dimension (digital) within city planning.

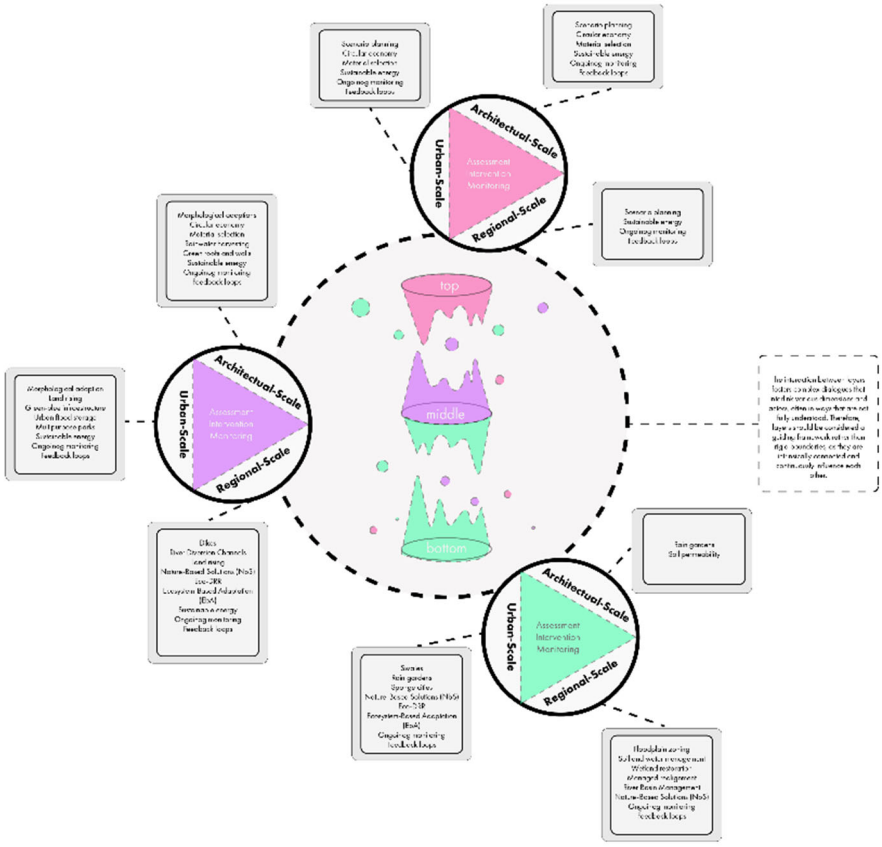

Figure 2. Adaptation Framework: Integrating Cross-Scale and Cross-Layer Approaches. Created by the author.

CONCLUSIONS

Cities are in a period of readjustment, in which the adaptation of the current and future state will dictate the urban morphology and how these will adapt to the outcomes imposed by climate change. The current research suggests that cooperation with the environment across different scales is a potential route to more sustainable and resilient models in the face of changing climate conditions and their existing vulnerabilities. Guayaquil's current situation reflects a deteriorated city, where the urban impact is noticeable on the environment. This situation reflects capitalism's urban development, supported by extractive practices, on land, water, and people. The socio-urban construct shows the consequences of inefficient resource repartition and poor infrastructure.

The research proposes a framework that articulates strategies across scales and layers (see Figure 2), emphasising the integration of water within cities' physicality and the acceptance of flooding as a natural part of urban life. The research indicates the necessity of creating more frameworks for interdisciplinary studies for scenario planning and possible adaptation strategies that harmonise the differences between actors, scales, and layers of a territory, as well as the repercussions of these strategies in urban morphology. The research underscores the importance of a multi-scalar approach in achieving effective urban interventions, starting at the architectural scale with an integration of bottom-up and top-down processes. The strategy aims to cultivate collective resilience by reintegrating overlooked typologies and employing a cross-layer, cross-scale integration of tools. By embracing an interdisciplinary methodology, this approach leverages diverse techniques across various layers and scales, ultimately fostering a cohesive and resilient urban model.

Cities can enhance their social and spatial resilience by adapting their morphology to the natural flow of water. However, the research suggests that these strategies are not universal and must be adapted to the specific climatic, social, political, economic, and ecological conditions of each project. The research offers a potential framework for future interdisciplinary and multi-scale strategies for coastal and deltaic cities. The aim is to create more sustainable, adaptive, and resilient urban environments and better understand the natural process and the implications of cities beyond administrative borders. The investigation suggests that an articulated, multi-scale, and cross-disciplinary approach could be beneficial, where the interventions at one scale reinforce and complement those at other.

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Assessment of drainage systems and rainwater usage in big metropolis in face of climate change – a case study about the city of São Paulo, Brazil

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ABSTRACT

Cities are socio-ecological systems that constantly face challenges, one of which is the impact generated by climate change. The characteristics of heat islands are also known. The urbanization process changes the urban landscape and, consequently, the microclimate. The city of Sao Paulo emerged on top of a hill surrounded by the Tamanduatei and Anhangabau rivers, a strategic location for defense and transportation. With the disorderly growth of railways, canalization and confinement of water courses resulted in valley bottom avenues. This practice proved to be a factor in worsening flooding problems in the city. Extreme weather phenomena can be defined as occurrences of floods, storms, heat waves and prolonged droughts. Sao Paulo also suffers, in addition to the impacts of the El Niño and La Niña effects, from the effects caused by the urban heat island and climate change, conditions that directly affect the rainfall regime in the city. To mitigate such impacts, the search for adaptation and resilience must be constant. Solutions were adopted in different locations around the world and those can be alternatives to mitigate risks of events caused by extreme effects in the city of Sao Paulo, considering the concepts of smart, resilient and sustainable cities. Environmental concerns have transformed the recovery of urban rivers into a global trend. Specifically, the city of Sao Paulo contains even greater challenges in this aspect, considering its historical and geographical characteristics. It is possible to conclude that green and blue infrastructures are the most suitable for seeking measures that make a city more intelligent, resilient and sustainable.

Keywords: climate change, smart, sustainable cities

INTRODUCTION

Water is essential for the occupation of territories and maintenance of life (Bacci and Pataca, 2008). However, sustainable management of this resource is necessary in urban spaces. Projections indicate that the city of São Paulo, together with the metropolitan region, will continue to grow until 2030 (Nobre et al., 2010). To make matters worse, studies indicate that climate change can significantly affect the planet, especially in climate extremes and in developing countries located in the tropical region (Marengo, 2008).

Justification and objectives

- Climate change;
- Impacts on the urban space;
- The applicability in the city of Sao Paulo, considering its characteristics;
- Report the experience of several locations that have suffered or are suffering from extreme weather phenomena;
- To evaluate the applicability of the related actions in the context of the city of Sao Paulo;
- Discuss the adoption of measures related to blue and green infrastructures as alternatives to improve the environmental quality of the urban environment

Hypothesis

"The implementation of measures related to blue and green infrastructure in urban space can improve environmental quality and contribute to the city of Sao Paulo becoming smarter, more resilient and more sustainable."

METHOD

This research can be considered qualitative in nature, with characteristics of an exploratory case study depending on the perspective adopted. Eisenhardt (1989) stated that case studies can collect data using multiple sources of evidence, such as documentary analysis, data collection and observations. To prepare this work, a bibliographical survey was carried out based on national and international articles and publications. The keywords used were related to the topic of climate change, the respective impacts on the urban environment, the urbanization of the city of São Paulo, and alternatives for improving environmental quality in cities.

RESULTS AND DISCUSSIONS

Considering the latest generation of climate models, the probability of major heat waves occurring in the coming years is significantly high. Studies show that climate scenarios point to a tendency for the global average temperature to increase, as well as extreme events such as heat waves, droughts, forest fires, floods and also increased levels of atmospheric pollution (Geirinhas et al., 2018). The impacts of climate change are expected to have serious consequences in the coming decades. In cities, the effects will be more severe (Rafael et al., 2017). Studies have shown that climate changes occur in regions where there is human intervention (Hingane, 1996). On the other hand, the existence of climate fluctuations independent of human action was also verified (Alcoforado, 1999). The increase in the global average temperature can result in drastic changes in rainfall patterns, such as a significant increase in rainfall and frequent floods in specific areas, simultaneously accompanied by a significant reduction in rainfall and severe droughts in other regions (Campbell et al., 2009).

Furthermore, the combination of global climate change and increased urbanization results in environmental problems, such as extreme weather and poor air quality. The phenomenon of heat islands is also known: urban areas have higher temperatures compared to adjacent rural areas

(Borrego et al., 2014). The intensity of the heat island is related to urban morphology and also to the size of the city. The urbanization process is the result of the transformation of natural surfaces, altering the urban landscape and consequently, the microclimate. Some factors that impact this process and enhance such thermal anomalies are vegetation, water and pollution (Romero et al., 2019). An aggravating factor in this scenario is that, in Brazil, cities' Master Plans, in general, do not include preventive actions for extreme events or climate change (Giulio et al., 2019). Scientific evidence has shown that climate change poses a serious risk to water resources in Brazil.

Furthermore, the impact caused to the national economy due to climate variability in past years is also considerable (Marengo, 2008). In parallel, it was found that the use of environmental information can play a strategic role for urban management (Côrtes et al., 2015). Sao Paulo de Piratininga was founded on a hilltop, just like the references of its colonizers, the village was similar to Portuguese cities (Oliveira, 2008). At that time, the periodic floods of the Tamanduatei and Anhangabau rivers were considered positive, as the hill was transformed into a peninsula, guaranteeing safety in the summer months. Furthermore, the establishment of commercial relations in the town of Sao Paulo was due to the navigation potential of the Tamanduatei River, which served to transport products from more distant farms or the coast (Gouveia, 2016). Population growth came together with the evils of civilization: Sao Paulo had precarious basic sanitation and preventive hygiene was moving at a slow pace. Swamps and floods tormented the population with a high rate of infant mortality (Mota, 2003).

Therefore, the city center was undergoing urban reforms and regulations, while the city expanded. With the aim of minimizing intense traffic in the city center, “Plano de Avenidas” consisted of the implementation of three avenues, outlined in a “Y” system: Avenida Anhangabau Inferior – currently Av. Prestes Maia – and Avenidas Nove de Julho and Itororo – current May 23rd. The Y system is the natural route of the Anhangabau stream and its main tributaries: the Saracura and Itororo, or Bexiga, streams. Then began the widespread practice of channeling and confinement of water courses, which gave way to valley bottom avenues. The practice proved to be a factor in worsening flooding problems in the city, as the waters continued to follow their original route, however, the percolation in the soil was replaced by the waterproofed surfaces of the avenues (Gouveia, 2016).

Extreme climate phenomena can be defined as occurrences of floods, storms, frosts, heat waves and prolonged droughts. In Brazil, a historical pattern of regularity in the climatic effects of the El Niño and La Niña phenomena was observed (Araújo, 2012), which, respectively, are characterized by the warming and cooling of the surface of the Tropical Pacific Ocean. Such occurrences interfere with meteorological conditions, especially the wind regime in the equatorial and subtropical zones, influencing precipitation and temperature in different locations around the world (Pereira et al, 2011). El Niño results in increased precipitation in the southern region of Brazil and reduced rainfall in the north and northeast. The opposite situation is observed during La Niña, with droughts in the South and increased rainfall in the Northeast. Such climate changes cause events that directly impact economic issues (Araújo, 2012), in addition to social, urban and public health issues. Studies have shown that endemic vector-borne infectious diseases (also called arboviruses) and waterborne diseases are sensitive to climate variations (Confalonieri, 2003).

Next, solutions adopted in different locations around the world will be presented to mitigate or reverse the effects caused by extreme weather phenomena. Porto, Portugal, suffers the effects of the urban heat island (Lopes et al., 2021). In order to reverse this situation and also to combat climate change, the Municipal Plan for Afforestation of Porto (PMAP) was prepared, which defines the implementation strategy based on pedestrian safety, identification of roads subject to afforestation and identification of suitable species. The Plan aims to plant trees in 200 kilometers of streets in Porto and improve the hydrological cycle in floods that occur in winter, protection as barriers to winds and reduce air pollution (Gonçalves, 2023).

About Rotterdam, the Netherlands has 25% of its territory below sea level. Delta Works is the largest and most elaborate flood defense (Alcoforado, 2022). The project has approximately 30 kilometers of dams that close the estuaries of three rivers and connect five islands, resulting in freshwater lakes that do not suffer from the tides (Petruzzello, 2022). In addition, there are projects for lakes, garages, parks and plazas that have an additional function: water reservoirs at times when the seas and rivers overflow.

In Dubai, the region's desert climate has high temperatures throughout the year and low rainfall (Guitarrara, 2021), as the water droplets formed by the clouds evaporate before reaching the ground, resulting in a shortage of rainfall. Investment in technology was used, starting with the launch of drones that measured temperature, humidity, and electrical charge within a cloud, to then make the droplets large enough to reach the surface (Neumam, 2021). The result was the torrential rain that occurred in Ras al Khaimah, located north of Dubai. The artificial storm was stimulated by four drones (Carvalho, 2021).

Located in Southeast Asia, Hong Kong has a subtropical climate (Chan et al., 2009) and a large part of its territory with mountainous relief (Simões, 2018). During the rainy season, the city is threatened by intense storms, especially in the months of May and June. Four rainwater drainage tunnels were built, in addition to 360 kilometers of river channels and 2400 kilometers of drainage pipes to transport rainwater, according to the Rainwater Drainage Manual (Beckers et al., 2012). The fifth version of the Manual, published in 2018, includes considerations on climate change as well as the concepts of blue and green infrastructure.

Even surrounded by the sea, Australia is part of the driest inhabited continent in the world. Between 1995 and 2012, the country suffered from the Millennium Drought. As a result, the New South Wales (NSW) government has implemented a number of measures to improve the health of the state's rivers, including the Sydney Metropolitan Water Plan (Anderson, 2006). As a measure to improve rainwater collection, the city implemented rain gardens, that slow down runoff (Rosa, 2018). In contrast to the dry season, 2022 was the wettest year in Sydney's history, as a result of the effects of La Niña (Rosenthal and Miller, 2022).

New York suffers from the effects of the urban heat island (Green, 2021), in addition to floods and vulnerability in relation to sea level rise (Neves, 2023). Two plans were launched: Cool Neighborhoods, in 2017, and East Side Coastal Resiliency, in 2020. The first aims to combat extreme heat, with the investment in green infrastructure and planting trees in high-risk neighborhoods, in addition to painting roofs white to reflect heat (Green, 2021). The second one began after Hurricane Sandy, in 2012. The resilience plan consists of raising the waterfront around Wall Street, by planting trees to

drain rainwater, reinforcing the sanitary sewage system, 4 kilometers of elevated parks and protective walls, and is scheduled for completion in 2026, with the installation of floodgates to contain high tides.

Some solutions to improve urban environmental quality in the city of Sao Paulo are:

Urban forestry management: The increase of permeable areas in the city is essential, as they allow the infiltration of water and contribute to the reduction of the flow speed. Trees also preserve watersheds and help improve the quality and quantity of drinking water (Meneguetti, 2007). Despite the benefits, urban afforestation needs investment and maintenance, or results in the risk of causing problems in the environment;

Revitalization of watercourses: Attempts to clean Pinheiros and Tiete rivers are recurrent. The new project to clean Tiete River is expected to be completed in 2026 (Maes, 2023). Regarding Pinheiros River, the interventions remain in progress within the initial schedule. There has already been an improvement in water quality (Fonseca, 2023).

Stormwater management: The city of Sao Paulo has a Decree that regulates the environmental quota, under the terms of Law No. 16.402. The environmental quota is a set of occupation rules that aims to make each lot contribute to the improvement of environmental quality (Prefeitura de São Paulo, 2016).

Risk and disaster management: Due to environmental and social conditions, the main natural hazards result from hydrological, climatic and morphological phenomena, with floods being the most recurrent, followed by droughts and landslides.

CONCLUSIONS

From the bibliographical survey carried out, it is possible to observe that climate change has a significant impact on cities, in numerous ways. The natural effects resulting from changes in the climate, such as torrential rains, heat waves, droughts and forest fires, cause disasters and losses in different aspects, including environmental, social and economic, such as floods and floods, damage to buildings, impacts on public health with the spread of diseases and interference with the water supply, in addition to losses in agriculture and livestock.

It is also found that such effects can be mitigated through initiatives that involve the study and dissemination of information regarding climate and possible climate changes and urban planning, considering the implementation of blue and green infrastructure. In relation to the emergence and development of the capital of Sao Paulo, it is observed that the city of Sao Paulo was founded following the Portuguese model of urbanization at the time. Initially, the location between rivers was considered strategic, both for defense and transportation. However, the disorderly growth, and, therefore, the consequent precariousness of basic sanitation, which occurred due to the sudden population increase, resulted in the emergence of epidemics, associated with river floodplains.

Thus, during the period of implementation of the Avenues Plan in the city of Sao Paulo, watercourses were neglected when planning road works. This positioning results in recurring situations of floods and flooding, present to this day. In addition to issues related to the road system, it is also noteworthy

that, when replicating the Portuguese urban model, local climatic conditions were not considered, an aggravating factor for this problem. Therefore, to mitigate the effects caused by factors disregarded when the city was urbanized, the search for adaptation to the current situation through solutions to improve environmental quality, as well as the use and dissemination of climate information can be alternatives for management. strategy of urban space in the city of Sao Paulo.

With the analysis of actions taken in different locations around the world to combat the effects of extreme weather phenomena, it is possible to verify that the impacts of the urban heat island affect cities located in different regions and climates, as well as droughts and floods. It is also concluded that investment in green and blue infrastructure - implemented in Porto, Rotterdam, Hong Kong, Sydney and New York - may be the best alternative in the search for the resilience of cities in adapting to climate change. It is worth noting that this study did not consider unusual or non-existent extreme weather phenomena in the city of Sao Paulo, such as blizzards and sandstorms.

Furthermore, despite the geographical distance, similarities are observed between the city of Sao Paulo and the cities analyzed, especially in the impact factor of extreme weather phenomena. On the other hand, there is a significant divergence between Sao Paulo and cities such as Rotterdam, Hong Kong, Sydney and New York. As seen previously, they all suffer from flooding, however, these are coastal cities, while the capital of Sao Paulo is located on a plateau and approximately 80 kilometers from the coast. In this way, it is possible to affirm that the urbanization of the Brazilian metropolis, based on the plugging of rivers, resulted in negative impacts on the city that cause losses to this day. Furthermore, the actions taken in these cities can be alternatives to mitigate the risks of events caused by torrential rains in the city of Sao Paulo.

In relation to the dry period that occurred in 2014 and that eventually occurs during winter, the artificial rain solution adopted in Dubai can also be an example to be followed. It is possible to state that all the metropolises studied in this work have actions to seek to improve environmental quality, whether through intelligent, resilient or sustainable measures.

The management of urban afforestation and the revitalization of watercourses can be considered resilient and sustainable solutions, as their benefits help to mitigate the effects caused by extreme weather phenomena, demonstrating resilience, in addition to contributing to the improvement of environmental and economic aspects and social aspects of urban space, as they reduce the risk of flooding and consequently, avoid the respective losses, in addition to promoting the well-being of the population.

Rainwater management and risk and disaster management rely on intelligent, resilient and sustainable measures, as they mitigate the impacts of extreme events, add benefits in the social, economic and environmental spheres, in addition to including investment in technology, as was the case in Dubai. Specifically in this case, which can be an alternative for the city of Sao Paulo in times of drought, artificial rain could be strategically positioned in the most wooded regions of the city, as well as in parks and lakes, so that it would be possible to alleviate scarcity and avoid inconvenience simultaneously.

Regarding the SMS alert already implemented in the state of Sao Paulo and other regions of the country, despite being a preventive measure with investment in technology, it is worth highlighting

the need for digital inclusion of the most disadvantaged sections of the population, as mentioned previously.

Furthermore, considering that the management of urban afforestation is characterized as green infrastructure, and the revitalization of watercourses and rainwater management are characterized as blue infrastructure, it is possible to conclude that green and blue infrastructure are the most appropriate to seek measures that make the city more intelligent, resilient and sustainable.

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Between borders: migrants, spaces, and socio-spatial relations in Cyprus

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ABSTRACT

Migration plays an important role in shaping socio-spatial dynamics, especially in regions of political and territorial division. This paper introduces an ongoing study that investigates the socio-spatial impacts of migration in Cyprus, an island divided between the Republic of Cyprus and the largely un-recognized Turkish Republic of Northern Cyprus, separated by a UN-patrolled buffer zone. Focusing on migrant reception centres, urban neighbourhoods, and public spaces, the study explores how migrant communities navigate and transform urban environments. Through spatial and social data analysis, this research seeks to uncover patterns of spatial segregation and integration, emphasizing the agency of migrants in urban transformations. This study contributes to the understanding of how migration processes in divided contexts can influence urban policy and social inclusion. The paper introduces current events in the island that influence the way discourses have shaped narratives on migration and the spaces being used by migrant communities. The methods to be applied in the research relate to the analysis of specific case studies in the Island. The study seeks to uncover insights into spatial and social segregation/integration in these areas, and their impact on the living conditions of migrants populations. As migrant communities influence established spatial hierarchies, the research underscores their role in shaping space making processes and urban transformations. Ultimately, this work emphasizes the importance of viewing such spaces as dynamic assemblages of individuals, groups, and institutions, and understanding spatiality not just as physical infrastructure but as a lens through which to examine the everyday politics and material practices of communities.

Keywords: migration, cyprus, social and physical infrastructures, urban transformations, spatial segregation/integration

INTRODUCTION

Migration has become a critical factor in shaping the socio-spatial dynamics of cities, influencing patterns of integration, exclusion, and urban transformation (McAuliffe and Triandafyllidou, 2021). As societies increasingly need to accommodate diverse populations, understanding the socio-spatial ramifications of migration is essential to creating just and inclusive cities. In Cyprus, migration plays a critical role, shaped by the island's complex history, geographical position, and divided status. Cyprus, a geographically and politically divided island, has become both a transit point and destination for migrants. The island’s particular socio-political context, with the Republic of Cyprus (RoC) in the south

and the largely unrecognised state Turkish Republic of Northern Cyprus (TRNC) in the north, separated by a UN-patrolled buffer zone, offers a compelling case for analysing how migration reshapes urban spaces and social relations.

This paper is part of an ongoing three-year project that aims to examine the interplay between migration flows and socio-spatial relations in Cyprus, considering the historical, political, and cultural contexts that shape these interactions. By exploring the experiences of migrants and the spaces where these communities, inhabit, work and resist in, the study seeks to contribute to a better comprehension of the socio-spatial transformations occurring in Cyprus. The paper presents an initial overview of the current situation in the island and highlights possible paths for the ongoing project. This work contributes to ongoing discussions on migration and urban spatiality, framing these spaces as essential sites for observing the agency of migrants as cities are reshaped by those who inhabit them.

The paper is organized as outlined: The first section briefly reviews the relation of migration with urban space, contextualises Cyprus particular condition as bridge and border for Europe and highlights recent events around migration and rising tensions in the island. The second section introduces a three-part methodology for the project, focusing on spatial and social data analysis through case studies. The results section presents three potential thematic cases where migrant space-making practices are significant, followed by a discussion of the broader implications of studying such spaces. The conclusion reflects on the study's potential contribution to the field.

Migration and space-making

Migration involves more than just the movement of individuals, it plays a fundamental role in the everyday production of urban spaces. Drawing from diverse methodological approaches, disciplines, and perspectives, the work wants to situate migrant space-making practices within a broader discussion of urban transformation. Migrants actively participate in shaping the “city as a thing in the making” (Simone, 2010:3) where people’s everyday actions cumulatively reshape urban environments, even amidst exclusionary state policies. The theoretical framework of the project draws from migration and refugee studies, urban spatial theory, and critical perspectives on architecture and urban space. It aims to align with critics on conventional architectural and policy responses to migration, which often focus on crisis management and materialize in refugee camps (Awan, 2024), while also challenging the colonial, patriarchal, and racist underpinnings of the concept of integration (Astolfo et al., 2021).

Space-making practices refer to the processes by which physical, social, and symbolic spaces are created, contested, and negotiated by various actors in society. These practices involve not only the construction of physical environments but also the ways in which individuals and groups shape spaces through social interactions, cultural practices, and political activities. Space-making practices related to migration are processes through which people on the move actively reshape and negotiate their physical and non-physical environments (Boccagni, 2017; Trimikliniotis et al., 2015; Miellet, 2021), both in host countries and in transient spaces (Maqusi, 2021). These practices involve an interplay between physical adaptations, social networks, and cultural expression, as migrants and refugees carve out spaces for survival, identity, and community. Space-making is closely linked to the idea that spaces are not passive containers but actively shaped by human agency, power dynamics, and societal

structures (Lefebvre, 1991). By focusing on the layered production of space the study points to understanding how migrants not only inhabit urban spaces but also actively produce them. This transformation extends beyond the physical; it involves the formation of subject-citizens in neighbourhoods, where relations of conviviality and conflict shape urban landscapes.

Cyprus: bridge and border

Cyprus holds a particular position as a member state of the European Union, geographically separated from mainland Europe by hundreds of kilometres. The island is situated closer to Turkey, its often contentious northern neighbour, and the unstable Middle Eastern region—Syria, Lebanon, Palestine, and Israel. The historical backdrop of Cyprus is marked by a legacy of conflict and division (Hitchens 1997). Since Turkey's occupation of its northern region in 1974 and the declaration of the Turkish Republic of Northern Cyprus (TRNC), the island has remained divided with the Republic of Cyprus (RoC), an European Union member state, governing the south of the island. Between the two regions lies the United Nations Buffer Zone, also referred to as the Green Line, a demilitarized area patrolled by the United Nations Peacekeeping Force since 1964.

Cyprus's geographical and geopolitical position has made it a strategic location. It has long been a site of both emigration and immigration, resulting in a complex multi-diasporic landscape (Teerling & King, 2011). Cyprus had historically been an exporter of migrants. As a former colony British colony, various Cypriots moved to the UK, Australia, US and South Africa (Anthias, 1992). Post-1974, Cyprus became part of the Southern European model of immigration, attracting labour migrants, refugees, and expatriates from various regions (Trimikliniotis, 1999). More recently, regarded as a gatekeeper of the EU (Mainwaring, 2014), Cyprus serves as both a bridge and a border between Europe, the Middle East, and Africa. As one might expect, living between borders profoundly influences the lives of those who inhabit these areas and those who navigate and challenge these boundaries. Migrants frequently face significant challenges in the island, including exploitation, limited access to social services, and legal barriers to integration (Trimikliniotis et al., 2015). These difficulties are compounded by the island's division, leading to divergent migration policies and administrative practices in the south and north of the island (Achiri and Klem 2024). Despite these challenges, the presence of migrants has contributed to the island's cultural and demographic diversity, particularly in urban centres where migrant communities form distinct socio-spatial enclaves (Philippou, 2008).

Following the economic challenges brought by the war and partition, Cyprus experienced significant growth in the 1980s, driven by the expansion of the service sector, tourism, and investments. Greek Cypriots, displaced from the north provided cheap labour force that contributed to this economic recovery (Trimikliniotis and Demetriou, 2005). During this time, the RoC maintained restrictive immigration policies, as there was little demand for foreign labour. However, by the late 1980s, sustained economic growth created labour shortages, prompting to the implementation of a guest-worker system in 1990. This system issued temporary work permits, typically in low-skilled sectors such as domestic work, agriculture, and construction. These permits, renewable annually, were tied to specific employers, limiting workers' job mobility (Trimikliniotis, 2001). The policy successfully attracted foreign labour but also led to a rise in irregular immigration. International events, such as the collapse of the Soviet Union, the Gulf War, and the conflicts in Palestine and in the Balkans, contributed to this influx.

The historical context of Cyprus has greatly influenced contemporary discussions on migration, Mainwaring (2012a) notes that this has happened particularly through two main factors: first, the island's militarization and second, concerns over demographic security. Military presence on the island is highly visible, with Turkish troops stationed in the TRNC and local conscripts serving in the Turkish Cypriot Security Forces, patrolling the northern side of the Green Line. Meanwhile, the RoC's National Guard patrols the southern side, and compulsory military service remains in place in the Republic of Cyprus for all male citizens. What is more, British colonial legacy persists in the form of two active sovereign base areas, Akrotiri and Dhekelia (Clogg, 2015). The second point of tension in discussions on migration involves demographics. Turkish immigration to Northern Cyprus following the 1974 partition had heightened Greek Cypriot concerns over the population makeup (Mainwaring, 2012a). The RoC government views these immigrants as 'illegal settlers', claiming that their numbers surpass those of the Turkish Cypriot population (Miltiadou, 2006). Academics argue that the demographic situation is more complex, with large numbers of temporary residents, including students, migrant workers, long-term settlers, and their children—some of whom have acquired TRNC citizenship (Hatay, 2005). Demographic concerns are persistently raised, with politicians and leaders of the Orthodox Church of Cyprus—a highly influential stakeholder in the context—amplifying fears of a demographic shift in the country (Gomez, 2024). Nationalism, fuelled by both militarization and demographic concerns, remains strong. Within this framework, foreigners—particularly low-paid migrants, asylum seekers and refugees—are often viewed with suspicion, while wealthier expatriates, like British retirees and tourists, are more easily integrated due to their economic positions (UNHCR, 2023). These debates highlight an unwillingness to accept that Cyprus's multicultural society has been shaped by many waves of immigration and emigration.

In the last decades, Cyprus has experienced a significant rise in arrivals of asylum seekers, placing pressure on the island's reception facilities (UNHCR, 2024). The Syrian civil war and instability in neighbouring regions have contributed to the influx, with asylum applications increasing dramatically (UNHCR, 2024b) (see figure 1). As noted by Mainwaring (2012b; 2014). Cyprus has leveraged its position as a southern European frontier state to secure greater influence within the EU. By framing migration as a crisis and emphasizing the disproportionate burden on its resources, Cyprus has managed to lobby for greater EU 'solidarity' in the form of financial assistance, refugee relocation programs and policy reforms. This approach has only reinforced a securitized view of migration, where border control and asylum restrictions take precedence over humanitarian considerations. Cyprus has struggled with the reception and integration of migrants, many of whom face overcrowded reception centres, limited employment opportunities, and social marginalization (Fischer, 2024).

Rising tensions

Media and political discourses surrounding migration in Cyprus reflect patterns similar to those observed in many European Union countries, where immigration and migrant groups are frequently portrayed in a negative light. The language used to describe (irregular) migration across the Mediterranean often distorts power dynamics (Mainwaring, 2012a) depicting migrants as invaders, while framing wealthy European nations as vulnerable and defenceless. This narrative overlooks the vast economic inequalities between the countries on the northern and southern shores of the Mediterranean and neglects the legacy of European colonialism, which continues to shape migration patterns and influence the political, economic, and social realities of these regions (Mayblin and Turner, 2021). Furthermore, it fails to acknowledge the ongoing economic exploitation and power

imbalances in the global system that perpetuate migration. The conflict-driven coverage in European media can fuel anti-immigrant sentiment and influence voting behaviour among audiences (Eberl et al., 2019).

An analysis by Trimithiotis and Voniati (2023) of media coverage specific to Cyprus reveals that sensationalist reporting, coupled with the portrayal of migrants as threats, reinforces xenophobic political narratives that advocate for even stricter migration control policies. Media representations of migrants in Cyprus - including refugees and asylum-seekers- primarily depict them as a threat to security, the local economy and the nation's existence and culture (Kadianaki et al., 2018; Avraamidou et al., 2019).

Recent events highlight rising tensions. In August and September 2023, racialized individuals, - including migrants and refugees - experienced violent, pogrom-like attacks in Limassol and Chloraka (Al Jazeera, 2023). Shops owned by migrants were targeted, resulting in injuries to several people. Racist incidents have become increasingly common in these areas, with delivery workers often facing racially motivated assaults (Mantzipa, 2023). NGOs supporting migrants have also faced significant challenges. In early 2024, the headquarters of KISA (Action for Equality, Support, Antiracism) was attacked with a makeshift explosive device, highlighting serious safety concerns for human rights advocates (Amnesty International, 2024).

Public demonstrations in streets and public spaces have become common. In April 2024, hundreds gathered in Nicosia to advocate for equal rights for all migrants in Cyprus. This protest honoured Anisur Rahman, a Bangladeshi man who died while attempting to flee a police raid in Limassol. Protesters demanded equal healthcare access and an end to the dehumanization of third-country nationals (Kades, 2024). The experiences of migrants in Cyprus highlight how the nation's restrictive asylum policies often obscure the everyday realities and agency of migrants (Fischer, 2020). The ongoing tension between fulfilling international obligations to protect refugees and managing national resources is becoming increasingly apparent in current debates. As the instability in the Middle East worsens, concerns have grown over the potential impact on migration flows to Cyprus (France24, 2024).

The worsening of the situation for migrants and asylum seekers in the island in recent years has to do with political developments and policy responses. The Cypriot government has been lobbying the EU to designate certain areas in Syria as safe (Al Jazeera, 2024). In April of 2024, declaring that 'the flows are unmanageable' (Stamouli, 2024), Cyprus suspended asylum applications from Syrians without specifying how long the measure would last. In September 2024, Human Rights Watch (HRW) accused Lebanon and Cyprus of collaborating to prevent Syrian refugees from reaching Europe and forcibly deporting them back to danger in Syria, citing pushbacks by the Cypriot Coast Guard (Human Rights Watch, 2024).

Migration patterns, debates and issues are further complicated by Cyprus's division. Irregular migrants often arrive in the TRNC via ferry routes before crossing the Green Line into the RoC. Some also enter the RoC on legal visas but overstay or violate visa terms (Baldwin-Edwards & Kraler, 2009). Many migrants and refugees travel in stages from countries such as Turkey, Syria, or Lebanon, eventually crossing the Green Line to reach the Republic of Cyprus and apply for asylum (Trimikliniotis & Demetriou, 2005). A result of such movements is the situation of individuals who remain trapped in

the UN-patrolled buffer zone, caught in limbo between a government refusing to accept them due to their entry from the northern part of the island, and the UN, which insists that Cyprus is bound by international law to provide protection (Al Jazeera, 2024; Smith, 2024).

For those who manage to apply for asylum and have their claims reviewed, the situation remains far from simple. As of April 2024, over 26,000 asylum applications remain pending (UNHCR, 2024b) , further highlighting the strain on the asylum system. Long processing times have worsened the challenges faced by newly arrived migrants (UNHCR, 2024a). Additionally, Cyprus experiences stark disparities in the treatment of asylum applications from different regions, with certain nationalities facing higher rejection rates, as seen in Table 1 (AIDA, 2024; Fischer, 2024). With around 96% of asylum applications denied, Cyprus ranks among the leading European countries in terms of deportations, proportionate to the number of asylum seekers in the country (see Figure 1 and Table 1).

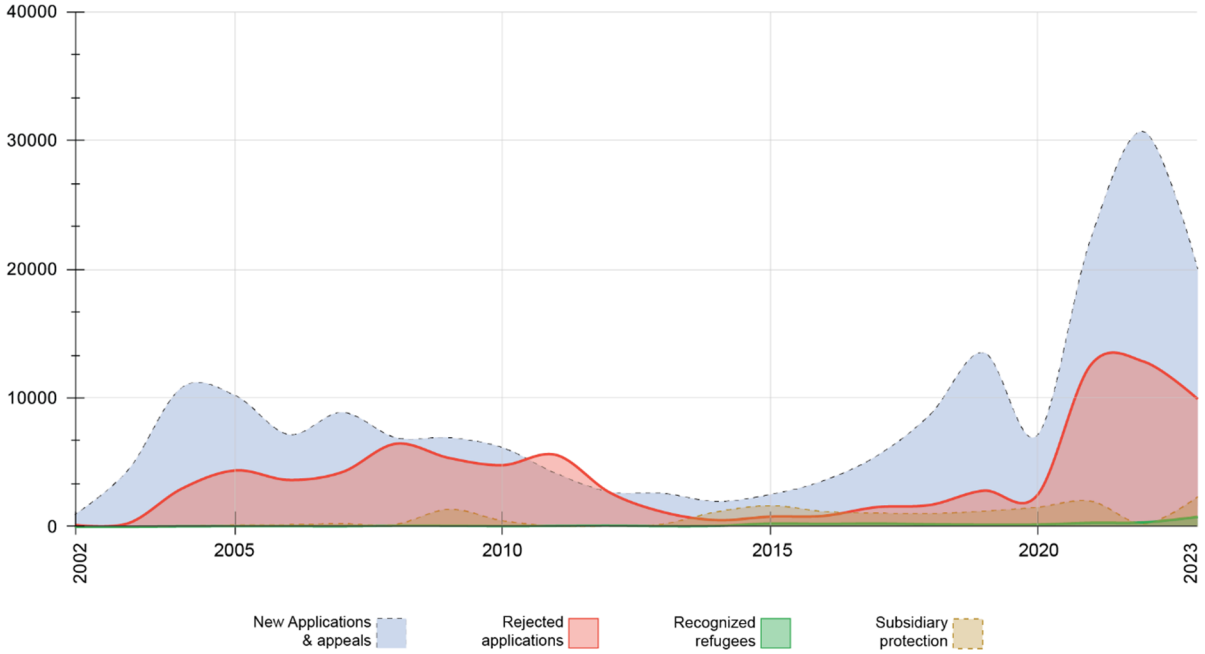

Figure 1. Asylum Applications in Cyprus from 2002 to 2023. New applications and appeals in blue, rejected applications in red, recognized refugees in green and applications granted subsidiary protections in yellow. Data Source: UNHCR, 2024b, visualization by Author.

Table 1. Granting of protection status (Asylum and subsidiary protection) rates for 2023 by country of origin. Source: Cyprus Asylum Service. Percentages calculated by Cyprus Refugee Council. (AIDA, 2024)

	Overall rejection rate	**Refugee rate**	**Subsidiary protection rate**
Syria	0.04%	2.06%	97.8%
Nigeria	98.4%	1.5%	0.06%
Afghanistan	20%	79.3%	0.66%
DRC	95.2%	4.23%	0.49%
Cameroon	89.9%	4.72%	5.36%
Somalia	32.2%	28.17%	39.59%
Pakistan	99.8%	0.19%	0%
Bangladesh	99.4%	0.57%	0%
Iraq	52.38%	10.95%	16.6%

India	100%	0%	0%

METHOD

This section highlights the methodological intentions for the three year project. The study adopts a multi-scalar approach, analysing migrant spaces across various urban environments in Cyprus. Key case studies include reception centres, migrant neighbourhoods in Nicosia, and public spaces that have become sites of migrant resistance. Spatial data will be collected through open-source databases and field observations, while social data will be gathered through engagement with NGOs. This dual approach will potentially allow for the analysis of how space is negotiated in these contexts. The research will adopt a mixed-methods approach to analyse the socio-spatial dynamics of migration in Cyprus, focusing on how migrants navigate and transform urban spaces. The methodology unfolds in three interconnected stages, allowing for a multi-scalar analysis that incorporates policy review, spatial change analysis, and the lived experiences of migrants. Table 2 summarizes the Stages and methodological approach proposed for the research.

Multi-Scalar Analysis of Migration on the Island

This phase focuses on understanding the broader migratory policies and infrastructures in place for migrant reception and integration. The stage envisions three main routes of methodological approach:

- Literature and Policy Review: entails a review of academic literature and government documents concerning migration policies in the EU and Cyprus, especially those related to the reception and integration of asylum seekers and refugees.
- Site Visits: Visits to key locations, such as refugee reception centres will help contextualize the policies within their spatial environments.
- Semi-Structured Interviews with Experts and Policymakers: Conducting interviews with key stakeholders, such as government officials, policymakers, and NGO representatives, will offer valuable insights into the execution and challenges associated with migration policies in Cyprus.

Spatial Analysis of Change in the Case Studies

This stage focuses on analysing how and if migration flows have physically altered urban environments in key case study areas.

- Diachronic Mapping: Historical and contemporary maps will be used to examine spatial changes in the urban fabric over time.
- Urban Morphological Analysis: A detailed analysis of the spatial layout, land use, and building typologies in migrant-inhabited areas will be conducted.

Lived Experiences Related to Space-Making Practices by Migrants

This phase will focus on capturing the everyday spatial practices and experiences of migrants, particularly in how they navigate, shape, and make space within Cypriot cities.

- Observations Through Activities with NGOs: Participant observation will be conducted during activities organized by NGOs.

- Semi-Structured Interviews: Interviews with migrants will be conducted to gather personal narratives about lived experiences, focusing on how urban environments are navigated and contested.

Table 2. Stages and methodological approach proposed for the research

	Main Focus	**Methodological approach**
Multi-Scalar Analysis of Migration on the Island	Understanding the broader migratory policies and infrastructures in place for migrant reception and integration. Recognition and Selection of cases to be analysed	Literature and Policy Review Semi-Structured Interviews
Spatial Analysis of Change in the Case Studies	Analysing how migration has physically altered urban environments in key case study areas	Diachronic Mapping Site Visits Urban Morphological Analysis
Lived Experiences Related to Space-Making Practices by Migrants	Capturing the everyday spatial practices and experiences of migrants, particularly in how they navigate, shape, and "make" space	Observations Through Activities with NGOs Semi-Structured Interviews

Data Analysis: The qualitative data gathered through interviews, participant observation, and site visits will be analysed through thematic coding. This will involve identifying recurring themes and patterns related to migration governance, spatial segregation, resistance, and community formation. Special attention will be given to the ways in which migrants engage in everyday acts of spatial negotiation, adapting to and reshaping their environments despite the constraints imposed by policy and socio-political exclusion. Additionally, the spatial data collected through GIS mapping will be integrated with qualitative findings to provide a multi-layered analysis of the physical and social dimensions of migrant spaces in Cyprus.

Ethical Considerations: Conducting research with vulnerable populations, such as asylum seekers and refugees, requires careful attention to ethical considerations, particularly regarding consent, reciprocity, representation, and flexibility (Darling, 2014). While policy experts and NGOs may provide information with less personal sensitivity, interviewing migrants and refugees presents more significant ethical challenges. Ensuring informed consent will be a central priority in all interviews and interactions. This entails clearly communicating the research purpose, explaining how the information will be utilized, and ensuring that participation remains completely voluntary. The author is also mindful of the dynamic nature of fieldwork, where unforeseen changes may arise. Even though such changes cannot always be anticipated, a commitment to a reflexive approach will be maintained, acknowledging the positions of power and privilege held by the researcher throughout the process.

The proposed methodological framework is a work in progress, but it is hoped that it will enable a multi-scalar understanding of migration in Cyprus, linking macro-level policies to micro-level spatial and social practices. The combination of policy analysis, spatial mapping, and lived experience research can potentially offer an approach to exploring the socio-spatial dynamics of migration in the context.

RESULTS AND DISCUSSIONS

As mentioned, the spatial dynamics of migration in Cyprus are shaped by the complex intersections of political division, socio-economic precarity, and the island's unique position as a gatekeeper to Europe. The project hypothesis argues that Migrant communities have an impact on Cypriot cities, both in terms of physical infrastructure and social integration. This section presents three key spatial categories where the presence of migrants is particularly evident as areas of possible exploration for the case studies to be selected for the research. These include reception centres, migrant neighbourhoods, and public spaces. These spaces are not merely containers of people and activities but are actively reshaped by peoples' daily practices and interactions with the urban environment.

Reception Centres: Pournara as a Site of Isolation and Control

The Pournara First Reception Centre, located on the outskirts of Nicosia, provides a stark example of the socio-spatial exclusion faced by migrants upon their arrival in Cyprus. Originally intended as a temporary facility for newly arrived asylum seekers, Pournara has expanded significantly in recent years to accommodate the growing number of migrants arriving on the island (UNHCR, 2024b). The physical isolation of Pournara, surrounded by fields and industrial zones, not only limits migrants' access to the broader urban fabric but also reinforces their exclusion from Cypriot society. Accounts on experiences in the camp highlight dire conditions (Fischer, 2024). While the reception centre was originally designed to house 350 people for 72 hours, its capacity has since grown to over 1,000 residents, with many asylum seekers staying for months at a time (UNHCR, 2024a).

Migrant Neighbourhoods: Spaces of Integration and Ghettoization

Beyond the reception centres, many migrants who manage to secure a more permanent status in Cyprus settle in specific urban neighbourhoods. These neighbourhoods have become vibrant but contested spaces, where issues of integration, economic survival, and social marginalization are at play (Philippou, 2008). While communities create trans-local networks, establishing businesses and forming social connections, they are often framed by public discourse as ghettos—spaces of exclusion and racialized difference. The creation of migrant enclaves in Cypriot cities reflects broader patterns of socio-spatial segregation, where economic precarity and racial discrimination limit migrants' ability to integrate into the mainstream urban fabric. These neighbourhoods are often under-resourced and stigmatized, both by local authorities and the media, which tends to sensationalize the presence of migrant communities as a threat to social cohesion. Cases in the city centre of Nicosia will be explored in the project.

Public Spaces: Resistance and Visibility in the Urban

Public spaces in Cypriot cities, such as parks, squares, and streets, have also become important sites for migrant visibility and resistance. Migrants use these spaces not only for leisure or economic activities but also as platforms for asserting their presence and rights within the city. Public spaces can become arenas for political contestation, where migrants engage in acts of resistance against their exclusion from mainstream society. In Nicosia, public spaces being used to challenge the state's treatment of migrants and to demand better living conditions and legal rights will be explored. Acts of resistance highlight the agency of migrants in shaping the urban, despite the restrictive policies that govern their presence. By occupying public spaces, migrants disrupt the spatial hierarchies that seek to confine them to the margins of the city.

The transformation of urban spaces in Cyprus materialised in reception centres like Pournara, migrant neighbourhoods in cities like Nicosia, and public spaces used for resistance and visibility all illustrate

the interplay between migrant agency and state control. These spaces, while often framed by exclusionary policies and socio-political marginalization, are actively reshaped by the practices and struggles of communities. Understanding these spaces as sites of negotiation, contestation, and adaptation can bring to light the need for the development of more inclusive policies that acknowledge the contributions of migrants to the urban and social fabric of Cyprus.

CONCLUSIONS

The hope is that the findings of the study will highlight the significant socio-spatial transformations driven by people on the move in Cyprus. Two key implications are anticipated: the role of migrants in challenging spatial exclusion and the potential of exposing the violence embedded in migration and integration management within this context.

Although the research does not aim to offer concrete solutions, it seeks to encourage reflection on the current situation. The findings may have significant implications for urban policy in Cyprus, particularly in terms of migrant integration and spatial justice. This study will explore the socio-spatial dynamics of migration in Cyprus, focusing on how migrant communities both shape and are shaped by the urban environments they inhabit. By examining the unique political and spatial context of Cyprus—a divided island with a history of colonialism and contested sovereignty—the research will reveal that migrants are not passive recipients of state policies, but active agents who transform urban spaces through their everyday practices and acts of resistance. The study will emphasize the importance of viewing urban spaces not merely as static infrastructures but as dynamic, contested arenas where migrant agency, state control, and socio-political struggles intersect.



Figure 2 . Graffiti on a construction site fence in Nicosia, Cyprus, voicing support for migrant struggles, anti-racism efforts, and the call for borderless solidarity. photo credit: Author, 2023

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Between memories, existences, and affections: socio-environmental vulnerability in alto da serra, Petrópolis - Rio de Janeiro

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ABSTRACT

This article investigates the intersection of memories, existences, and affections in the Alto da Serra neighborhood in Petrópolis after the 2022 floods, highlighting the social, cultural, and emotional dimensions of urban landscapes in contexts of socio-environmental vulnerability. Utilizing the cartography of affections, the research explores the emotional and spatial dynamics that shape the identity and resilience of the community, revealing the symbolic layers of the territory and the formation of local symbols based on the residents' experiences. The analysis is based on Raffestin's (1995) tetraglossia, which encompasses the territories of the everyday, exchanges, reference, and the sacred, highlighting the intersection of environmental injustice, vulnerability, and community resilience. The active methodology of the "Viver Cidades+, inclusion and urban diversity" group captured the voices of the residents through the game-device "A cidade que eu vivo," promoting an inclusive dialogue sensitive to the material and emotional needs of the residents. The 2022 tragedy underscored the urgency of inclusive public policies that promote socio-environmental justice and community participation.

Keywords: social memory, socio-environmental vulnerability, cartography of affects, community resilience, urban landscapes

INTRODUCTION

Landscapes: between memories, existences, and resistances

According to Jean-Marc Besse (2006), the landscape is everything that the eye can see, understood not only through the act of observing but also by participating in the experience, being perceived as the objective place of existence. This essay explores how different landscapes generate varied feelings in the individuals who inhabit them, highlighting the importance of mapping contemporary issues through landscapes that reflect social, economic, and political practices and values. Contemporary disruptions, such as climate change and migration, further complicate these dynamics.

Neil Brenner (2019) reinforces that urban transformations often result in unequal environmental impacts, with marginalized communities suffering more intensely. This amplifies the need for resilience and adaptation. Anne Tsing (2019) adds that global landscapes, though filled with ruins, can still generate new forms of life and existence, taking advantage of disturbances to create resilient environments. Tsing argues that "feral life" emerges from human disturbances in unpredictable ways, creating new interactions and forms of existence.

Tsing's narrative intersects with Ailton Krenak's (2019), who views the "end of the world" not as a singular event but as a continuous experience, particularly for indigenous peoples who face the destruction of their cultural ties and connections with nature due to colonial infrastructures. Both highlight resilience and the capacity for regeneration in the face of human disturbances. While Tsing discusses "ferality" as a natural response to human interference, Krenak emphasizes the continuity of indigenous resistance. Together, they invite us to rethink the relationship between humans and non-humans, recognizing that life persists and transforms, challenging the notion of total control and pointing to a resilient coevolution in a constantly changing world.

Social memory, existence, and resistance in transforming landscapes

The dialogue between Tsing (2019) and Krenak (2019) suggests that the end of the world, rather than being catastrophic, is an ongoing experience. Landscapes constantly transform through sociocultural processes and human and non-human actions, dismantling community bonds and connections with nature due to modernity. Krenak (2019) argues that modernization displaces people from rural and forest areas to favelas and peripheries, erasing identities and memories, replacing them with a homogeneous vision of humanity.

These perspectives lead to a discussion on how social memories are shaped by human actions and resilient responses from non-humans. Social memory, in the context of environmental disasters, becomes a field of resistance. Recalling and retelling traumatic stories is crucial in constructing a collective identity that challenges marginalization. Farias and Pinto (2016) question whether those who endure traumatic experiences can narrate their lives when facing death or the dissolution of subjective arrangements. This inquiry underscores the importance of testimony as a form of resistance and identity recovery.

For marginalized communities, survival mechanisms are born out of adversity, forming resilience against marginalization and a reclamation of landscapes through memories. Actions in landscapes, in response to fear of uncertainty, unite communities to face daily challenges. Marginalized communities

suffer from stigmas and stereotypes, resisting the lack of recognition of their practices. In this context, Spivak (2010) argues that the subaltern, excluded from political and legal representation, faces significant challenges in representing themselves autonomously. This struggle preserves their identities, asserting their place as rights-bearing subjects. It is crucial to create spaces where these voices can be spontaneously expressed as manifestations of memory.

This brings forth the concept of social memory. Jô Gondar (2016) views social memory as transdisciplinary, ethical, and political. Memory is produced in the present to reflect on the past with a view toward the desired future. Social memory is always connected to ethics and politics. Another essential perspective is the significance of forgetting in maintaining identity, which can be challenged and shaped by different forms of forgetting, such as segregation and historical silence. Memory is not reduced to representation since collective representations cannot fully capture society's dynamic nature. Social memory is influenced by emotions, sensations, creation, innovation, beliefs, and desires (Gondar, 2016).

In this light, reflection arises on the role of social memory in traumatic events, alongside efforts to document and resist forgetting. There is a paradox between erasing perceptions of lived traumas and giving voice to these experiences. However, such initiatives build a collective memory that transcends individual suffering, fostering solidarity and promoting resistance against marginalization and social amnesia. It is crucial to recognize that, while silence may be a survival strategy, testimony seeks meaning amid trauma, transforming memory into resistance. This introspection of experiences shapes the identity and resilience of vulnerable communities.

Socio-environmental vulnerability and environmental injustice

The concept of socio-environmental vulnerability addresses the intersection between social and environmental conditions, highlighting how these influence communities' ability to deal with threats and climate change. Vulnerability involves exposure to social, environmental, political, or economic risks (Braga, Oliveira & Givisiez, 2006). Its three main components are: risk exposure, reaction capacity, and degree of adaptation (Esteves, 2011).

When discussing landscapes and memories, we explore the ability of marginalized communities to adapt and resist environmental and social disruptions. Conceptualizing socio-environmental vulnerability also requires considering environmental justice. Low-income communities often accept risks to obtain better opportunities, exposing themselves to significant dangers (Zhouri & Oliveira, 2012). Environmental injustices stem from a developmental perspective that neglects social, cultural, and ecological issues.

Thus, understanding socio-environmental vulnerabilities requires a multidimensional approach that considers the interactions between social, economic, and environmental factors (Rammê, 2012). Fair and effective public policies must recognize and value the resilience of marginalized communities, promoting environmental justice that proposes an adequate redistribution of social goods to correct inequalities, values community participation, equity in resource distribution, and sustainability to address contemporary socio-environmental dynamics (Rammê, 2012).

Henri Acselrad, Cecília Campello Amaral Mello, and Gustavo das Neves Bezerra highlight that environmental injustices disproportionately affect vulnerable social groups, reflecting historical and geographical asymmetries (Acselrad et al., 2009). Similarly, Ricardo Abramovay argues that sustainability must be integrated into development strategies, promoting a more just and regenerative social metabolism (Abramovay, 2012). Based on this, we argue that recognizing the intersection between environmental injustice and socio-environmental vulnerability enables the development of more inclusive and effective approaches that promote socio-environmental justice and community resilience.

This entire debate seeks to affirm that landscape analysis reveals a complex web of interactions shaping territories and community identities, intertwining social memory, existence, and resistance to socio-environmental vulnerabilities through the fight for environmental justice. From this perspective, the landscape becomes a dynamic, interconnected space, a palimpsest of memories, existences, and resistances that manifest in a continuous effort of adaptation and survival, challenging power structures and promoting a more equitable understanding of human-environment relations.

CARTOGRAPHY OF AFFECTS AND ITS MULTIDIMENSIONAL INSTRUMENTS

Social cartography is an action-oriented concept that challenges the state's monopoly on map-making, advocating for the inclusion of marginalized social groups in the cartography of their own territories (Acselrad, 2009). This concept redefines cartographic practice, allowing communities to map their own territories and specific issues, using cartography as a tool of resistance against hegemonic spatial domination (Santos, 2011).

Suely Rolnik (2016) introduces "sentimental cartography," focusing on the emotional dimension of cartography. This approach emphasizes the importance of capturing emotional dynamics that influence individuals' relationships with their territories, offering a sensitive reading of human landscapes. It maps psychosocial landscapes, tracking transformations and the formation of new worlds to express contemporary emotions (Rolnik, 1989).

This methodological approach transcends the mere physical representation of spaces, enabling a deeper understanding of subjective and emotional experiences in the constitution of landscapes. Affective cartography allows for mapping not only objective structures but also affective ties, memories, and resistances that define communities' relationships with their environments, revealing the emotional and social dynamics that shape the resilience and collective identity of marginalized communities.

To apply this theory in field analysis with an ethnographic perspective, we draw on Raffestin (1995), who establishes an intrinsic relationship between language and territory through a fourfold schema for reading the landscape: everyday territory, exchange territory, reference territory, and sacred territory. Everyday territory is perceived through discontinuity and encompasses safety, love, and belonging. Exchange territory is in constant flux, based on power relations. Reference territory is linked to individual and collective memory and history, while sacred territory is associated with religion and the construction of the sacred (Raffestin, 1995).

Analyzing the territory of Alto da Serra through this territorial language and emotional framework is essential, especially following the 2022 flood disaster that claimed over 240 lives and transformed the

local landscape. Understanding the territory and the practices that constitute the Alto da Serra landscape requires empathetic dialogue with residents, considering their traumas, fears, and insecurities, and recognizing urban spaces as human and non-human relationships imbued with emotional dimensions.

The concept of "emotion city" suggests that urban space gains significance through our relationship with the world, shaped by both perceptual processes and sociocultural meanings (Coelho, 2015). This concept enables us to study a collective view of the city, understanding how collective identity is formed and highlighting the emotional dimension in the significance of public spaces, improving collective urban experiences.

Raffestin (1995) further distinguishes between the **Language of Landscape** and the **Language of Territoriality**, enabling us to understand spaces or agents as either structural or symbolic. The Language of Landscape refers to the visible, physical structure of a place—**the seeing**—while the Language of Territoriality pertains to the cultural and social meanings—**the living**. In our analysis, this approach allows us to comprehend the dynamics of the territory and the formation of collective identity, analyzing both the structural and symbolic elements of the landscape.

Our fieldwork strategies incorporated a multidimensional reading of the territory, initiated through the game “The City I Live In”, which captured residents' perceptions of Alto da Serra, revealing the potentialities and tensions in constructing the local landscape amidst memories, existences, and resistances shaped by socio-environmental vulnerabilities. The organization of results and discussions is structured around the narrative of Alto da Serra in Petrópolis, memories and vulnerability contexts, the game “The City I Live In”, and the landscapes of Alto da Serra—existences and emotions.

THE PLACE ALTO DA SERRA IN PETRÓPOLIS, MEMORIES, AND CONTEXTS OF VULNERABILITIES

Considered one of Brazil's first planned cities, Petrópolis (Figure 1) had its urban design commissioned by Emperor D. Pedro II and developed by Major Júlio Frederico Koeler in 1846 (Figure 2). One of the main directives at the time was that the city should be settled only along river courses. However, this design strategy proved ineffective over time, as territorial expansion became necessary in areas closer to the city center, where life technically unfolds (Alvarenga, Blaudt, & Garin, 2023).

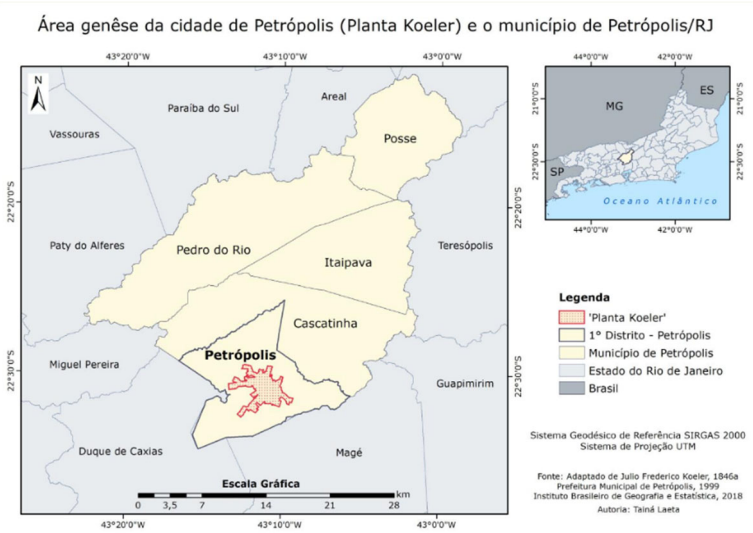

Figure 1. Boundaries of the Petrópolis area - "Koeler Plan". Source: Laeta, Fernandes & Fernandes (2022).

Initially, the city was designed to serve D. Pedro II's court. However, its proximity to Rio de Janeiro and the construction of the BR 040 highway in 1928 increased demographic density. The establishment of industries, particularly textile factories, attracted a working population to nearby areas, leading to settlements on the slopes surrounding the originally planned sectors (Alvarenga, Blaudt, & Garin, 2023).

The Alto da Serra neighborhood, previously known as Villa Theresa (Figure 2), exemplifies this process of demographic intensification. The neighborhood's development was driven by the inauguration of the train station and the arrival of the railway (Figure 3) in 1883, with its last operation in 1964 (Diário de Petrópolis, 2010). The establishment of factories, such as the Dona Isabel Textile Factory (1889) and the Cometa Textile Factory (1903), made the neighborhood a central hub of industrial activity (Reis, 2021).

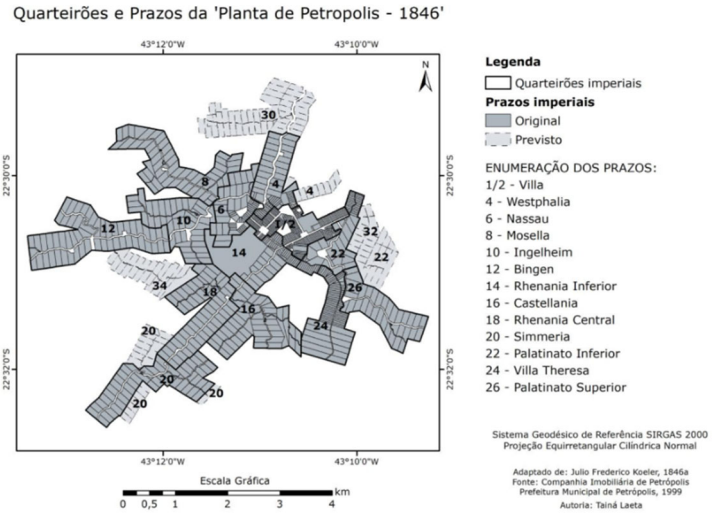

Figure 2. Imperial blocks and land grants on the Koeler Plan – 1846. Source: Laeta, Fernandes & Fernandes (2022).

In addition to its commercial dynamics, the former Villa Theresa — now Rua Teresa, part of the Alto da Serra neighborhood — was, in the 19th century, the only possible route for those coming from Rio de Janeiro to the center of Petrópolis. During this time, the street served both residential and

commercial purposes. However, by the 1970s, due to the city's geographical challenges that hindered expansion, the factories in the neighborhood went bankrupt, leading former workers to establish clothing businesses along the street and in nearby areas. This shift shaped the current dynamics of Rua Teresa, now considered the largest open-air shopping area in Latin America (Sou Petrópolis, 2023).



Figure 3: Freight train leaving Alto da Serra, passing in front of Rua Chile towards the station in the city center. Source: Personal collection of Mr. Walmir, n.d.

The unassisted urbanization in the neighborhood led to the removal of vegetation and the impermeabilization of the soil, causing the extinction and pollution of water sources and an increase in erosion processes, commonly associated with housing disasters (Lopes apud Campos & Parola, 2022). Petrópolis, located in the Serra do Mar, has rugged terrain and a tropical altitude climate, resulting in torrential rains (Campos & Parola, 2022).

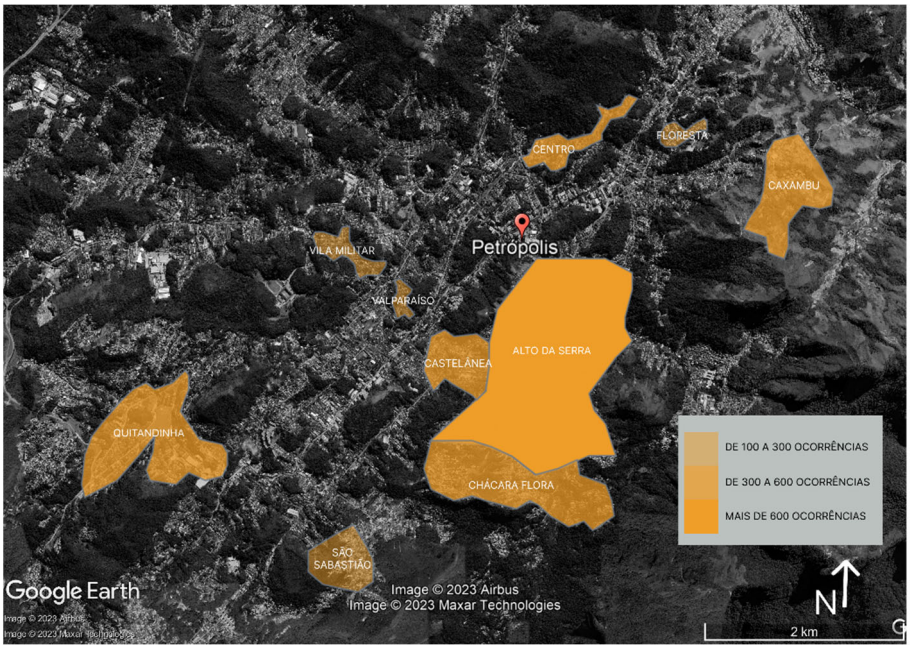

Figure 4: Map of incidents recorded by neighborhood on the day of the tragedy by region. Source: Author, with data from the Petrópolis Civil Defense, 2024.

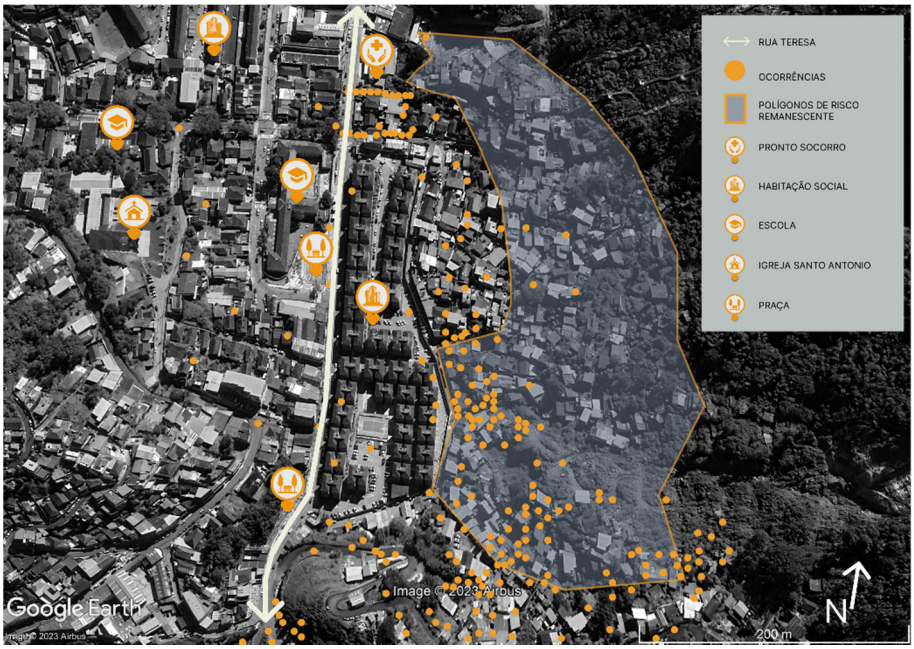

Figure 5: Revised map of the Morro da Oficina region with the location of recorded incidents and remaining risk polygon. Source: Disaster in Petrópolis in the summer of 2022: general aspects and Civil Defense data (Blaudt, Alvarenga, & Garin, 2023).

The combination of irregular urbanization with Petrópolis' natural conditions leads to tragic events, such as the one on February 15, 2022. A storm accumulated 259 mm of rain in six hours, severely impacting the Alto da Serra neighborhood, with 2,407 incidents reported (Figures 4 and 5). The most severe landslide occurred in Frei Leão Pathway and Ferroviários Street, destroying approximately 90 homes and causing the deaths of around 80 people (Alvarenga, Blaudt, & Garin, 2023).

Access to dignified housing and a balanced environment is a right, but many face precarious housing conditions without adequate infrastructure, resulting in environmental and social impacts. The public authorities' omission is evident, as no one would choose to live in a high-risk area (Campos & Parola, 2022). The city reflects the structural problems of societies, where economically dominant classes select the best territories, leaving minority groups with the remaining areas.

It is worth noting that Petrópolis was conceived as an agricultural colony with clear social and spatial segregation since the Koeler Plan. The 1st and 2nd class land grants (Figure 6) were reserved for nobility and artists, concentrating activities in the city center, while the 3rd and 4th class grants were assigned to artists less involved in agriculture and to farmers, respectively (Laeta et al., 2022). The Alto da Serra neighborhood, formerly known as Villa Theresa, carries the stigma of socioeconomic marginalization, demonstrating social segregation since the city's foundation. The territorial structure, conditioned by land use, perpetuated inequalities that persist in Petrópolis today, highlighting the need for inclusive and effective approaches that connect historical elements to contemporary dynamics of unassisted urbanization and environmental vulnerabilities.

We emphasize that promoting socio-environmental justice and community resilience requires public policies that value community participation, ensure equitable resource distribution, and foster sustainability. With a sensitive approach to community involvement, this research aimed to understand the physical and symbolic dimensions of Alto da Serra through the game that maps the memories and emotions of Petrópolis residents—"The City I Live In."

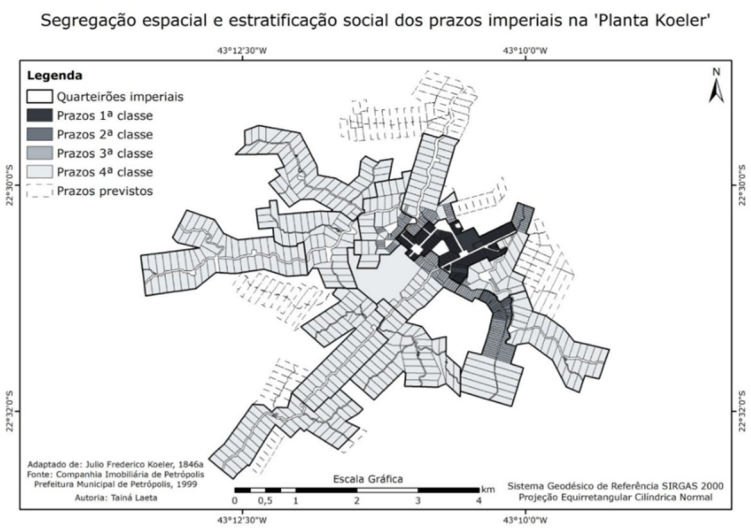

Figure 6: Imperial land grants and class division, following the occupancy guidelines of the provincial report. Source: Laeta et al., 2022.

The game, "The City I Live In"

To understand the multiple dimensions of socio-environmental vulnerability and community resilience in Alto da Serra, a methodology was adopted that captured the physical, social, and emotional experiences of the residents. The cartography of affections emerged as an essential tool, allowing for the mapping of memories and emotions that shape the lived landscape. The research group "Viver Cidades+, inclusion and urban diversity" used the conversational device "The Cite I Live In" (Figure 7) to promote a sensitive and inclusive dialogue, reflecting the residents' perceptions of the territory and their future aspirations.

On June 17, 2023, a cartographic activity was conducted in the event hall of the St. Anthony's Church, aiming to capture the physical, environmental, and social issues of the communities affected by the February 2022 floods. Based on the theory of Szaniecki and Anastassakis (2023), the activity engaged participants using a vector map of the neighborhood with reference points and questions about their relationship with Alto da Serra.

Participants included long-time residents of the neighborhood, some of whom were directly affected by the 2022 tragedy, and members of the St. Anthony's Church choir, who demonstrated a strong connection to the community and religious value to the region. In total, nine people participated, representing a wide age range and revealing the complex relationship between the community and its territory. The discussions highlighted the affection and belonging to the neighborhood, as well as the traumas and challenges faced. This approach captured the memories and affections that form the collective identity of Alto da Serra. Additionally, the analysis of the discussions, based on Raffestin's (1995) tetraglossia, will explore how the landscapes, existences, and affections of the residents intertwine, revealing layers of meaning that permeate the territory.

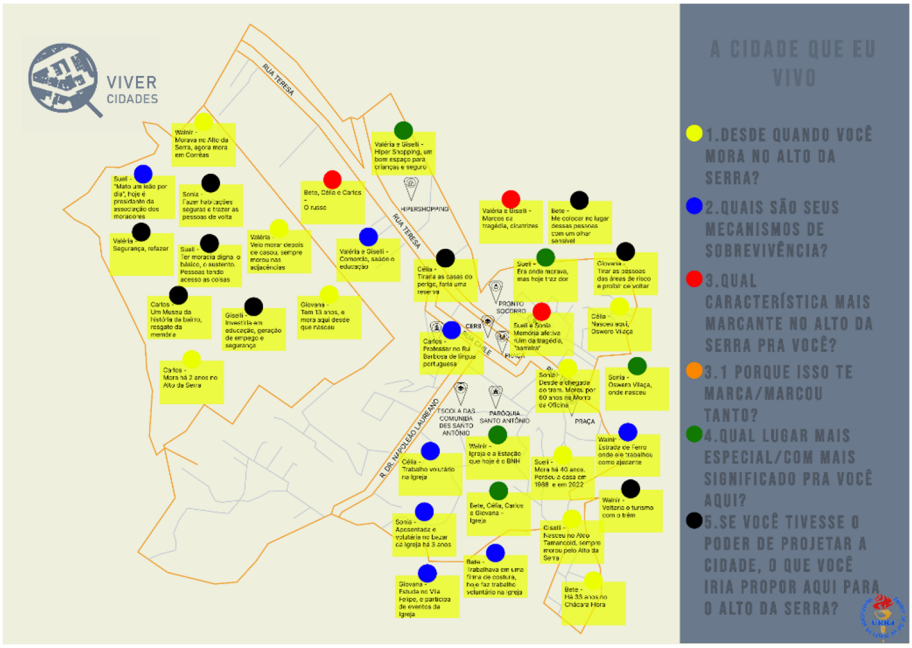

Figure 7: Game based on the social cartography methodology "The City I Live In." Each question has a corresponding color, with the responses being linked to the colors during the session, using post-it notes to record the main issues raised by the participants. Source: Viver Cidades+, 2023.

The landscapes of alto da serra, existences, and affections

Based on the field notes, we conducted a detailed analysis of the participants' statements, focusing on understanding the territory and its multiple dimensions. Using Raffestin's (1995) tetraglossia — everyday territory, exchange territory, reference territory, and sacred territory — we identified how these dimensions emerge in the residents' narratives, revealing emotional and symbolic layers that constitute the place. This approach articulated the concepts of the cartography of affections and the complex relationships between memory, existence, and resistance, highlighting the intersection between environmental injustice, socio-environmental vulnerability, and community resilience practices in Alto da Serra.

A statement that exemplifies the everyday territory well is from Resident B, where a contradiction becomes apparent after she praises her neighborhood:

> *[sic] Resident B: "So, everything here is good. Alto da Serra is a good neighborhood to live in for me. We have everything, we have a good emergency room, a pharmacy, we have everything we need here in Alto da Serra. So, Alto da Serra is a good neighborhood. Does it need improvement? Yes, it does. Our transportation is very bad, it is. So, these are things that, now, after last February's tragedy, made our situation much worse. So, we need to improve our neighborhood again, to try to bring it back to what it was, not what it was in the old days, but what it was just a short time ago, because we need many improvements." (Field Notes, June 17, 2023, emphasis added).*

Resident B begins by praising the neighborhood, highlighting its positive aspects, but soon reflects on the deficient infrastructure, especially urban mobility. This discrepancy highlights socio-spatial vulnerability, where the right to the city is unequally distributed. Despite the lack of infrastructure and the tragedy, she cannot imagine living anywhere else, reflecting a strong sense of belonging and attachment to the territory.

Another statement by Resident B reinforces this point:

> *[sic] Glauci [Researcher Viver Cidades+]: So, you live in Alto da Serra?*
>
> *[sic] Resident B: My life is in Alto da Serra. [...]. I can't imagine living anywhere else, okay? I can't see myself outside of here (Field Notes, June 17, 2023).*

Through this statement, we observe Resident B's positive affection for the place, as well as the strong sense of identification and belonging to the neighborhood where she grew up. Despite the lack of infrastructure and the recent tragedy, Resident B cannot envision living elsewhere. This feeling of belonging and attachment to the territory echoes the emotional and affective dimension discussed in the cartography of affections (Kastrup & Passos, 2013). Everyday life in Alto da Serra is shaped by the need for security, love, and belonging—fundamental elements in the construction of the everyday territory, as proposed by Raffestin (1995).

The analysis of these accounts reveals that the everyday territory in Alto da Serra is composed of both structural and emotional elements. While urban mobility and basic infrastructure are critical to the residents' quality of life, the way they are emotionally impacted by their daily routines is equally important. The cartography of affections has mapped these dimensions, offering a profound understanding of the social and emotional dynamics that shape the Alto da Serra community. Residents recognize both the available resources and the structural shortcomings they face. This highlights the urgent need for public policies that ensure the equitable distribution of urban resources, thus promoting socio-environmental justice and fostering community resilience. To achieve socio-environmental justice in Alto da Serra, it is essential for public policies to address both the material needs and the affective and emotional bonds of the residents.

An analysis of the territory of exchanges further reveals how economic and social interactions shape the lives of residents, especially within contexts of socio-environmental vulnerability. A statement from Resident A, regarding "housing allowance", a financial aid provided by the Federal Government to the population affected by the tragedy, sheds light on these dynamics:

> *[sic] Resident A: I said it because, thank God, I pay my bills. I don't need anyone to pay for me; I work for that. But it's complicated. And they target the weakest point. Ah. For people, that point is money. Unfortunately, right?*
>
> *[sic] Glauci [Researcher, Viver Cidades+]: It's the money, right?*
>
> *[sic] Resident A: Yes. Because not everyone has it, right? Unfortunately, now with this situation, any money that comes in is a gain for many, unfortunately.*
>
> *[...]*
>
> *[sic] Resident A: It's a bargain. It's a bargain. Unfortunately. It's complicated. The poor face a lot of complications. (Field Notes, June 17, 2023).*

This dialogue highlights the power of money in the lives of affected residents. In a vulnerable situation, the government opts for short-term, palliative solutions, as noted by Brenner (2019), who emphasizes

how urban transformations result in unequal impacts, with marginalized communities suffering the most. Financial aid exposes the fragility of public policies that should equitably ensure the right to the city. Zhouri and Oliveira (2012) stress that low-income communities accept significant risks in exchange for better opportunities, exposing themselves to considerable dangers. Thus, the territory of exchanges in Alto da Serra is shaped by the interdependence between the residents' economic needs and public authority actions. Palliative solutions, like “housing allowance”, while aiming to mitigate the immediate effects of the tragedy, perpetuate a cycle of vulnerability, underscoring the urgency for more inclusive and sustainable approaches that uphold the dignity and autonomy of affected communities.

In the territory of reference, the memory and ancestry of residents play a crucial role in shaping space and constructing collective identity. Moradora B’s statement highlights the importance of old memories of the neighborhood and the perceived changes over time:

> *[sic] Juliana Baur [Viver Cidades+ Researcher]: Moradora B. So you’ve been living here, as you mentioned to us, right?*
>
> *[sic] Moradora B: Yes, I’ve lived here forever. I’m from the time when we still had the train in Alto da Serra. Eh eh, there were almost no buses because sixty-five years ago there was none of this, none of what the other Serra is today. Back in my time, we knew everyone, but now we hardly know anyone, of course, only the very old ones. I, I was born here. Back then it was called Morro da Oficina (Field Notebook, June 17, 2023).*

Moradora B reveals a strong emotional connection to the neighborhood and a nostalgia for a past when the community was more cohesive and integrated. This sense of belonging, along with the reference to the train (Figure 3) that once existed in Alto da Serra, highlights the intrinsic relationship between collective memory and the territory. According to Raffestin (1995), the analysis of the territory of reference involves the historical and ancestral connection of the residents to the place, influencing their perceptions and interactions, marked by the memory of a more integrated social dynamic. Gondar (2016) emphasizes the role of social memory in constructing collective identity and resisting marginalization, as seen in Moradora B’s efforts to preserve the community’s memories and identity amidst urban transformations. Tsing (2019) and Krenak (2019) explore the resilience and adaptation of communities to environmental and social disruptions, illustrating how the memory of old landscapes serves as an anchor for the residents. Thus, the territory of reference in Alto da Serra becomes a palimpsest of memories and experiences, forming a collective identity that resists change and preserves the essence of the place. The residents' narratives reveal how social memory and collective identity are shaped by urban and socio-environmental dynamics, reinforcing the need for public policies that value and protect these memories and identities.

Lastly, in the territory of the sacred, the spirituality and religiosity of the residents of Alto da Serra emerge as central elements in building collective identity and community resilience. Moradora A's testimony reveals how faith and hope play a crucial role in moments of crisis:

> *[sic] Moradora A: "[...] I participated from the first to the last body being removed there. So, I had friends who, we could see, I couldn't take away their hope. You understand? I already knew because the firefighter had told me, 'There's no use because they aren't alive.' But she, she held on to that hope, that faith, you understand? So I, in the same way, tried to encourage her,*

> *but you know how it is, right? Keeping that hope even knowing that it wasn't there. [...]" (Field Notes, June 17, 2023, emphasis added).*

Moradora A emphasizes the importance of faith and hope as mechanisms of resilience and emotional support during the tragedy. Spirituality provides a refuge and source of strength for residents, allowing them to face pain and loss with a sense of purpose and community. This is also evident in Morador I's words regarding the St. Anthony Church (Figures 8 and 9), which stands as a landmark in the landscape of Alto da Serra and serves as a gathering place, reinforcing the territoriality of the neighborhood through shared practices and connections.

> *[sic] Resident I: St. Anthony Parish is the heart of our neighborhood. It's where we gather, celebrate, and find comfort, especially after the tragedy.* ***Faith gives us the strength to carry on and reminds us that we are not alone*** *(Field Notebook, June 17, 2023, our emphasis).*

This reflection by Resident I emphasizes the significance of sacred spaces as points of reference and emotional support for the community. The parish is not merely a place of worship but also a center for social and emotional support. Raffestin (1995) describes the sacred territory as a space imbued with religious and cultural meaning, offering a sense of continuity and security to the residents.



Figure 8: Church of St. Antônio Parish, Alto da Serra. Source: Personal collection of Mr. Walmir, n.d.



Figure 9: View of Alto da Serra from the churchyard of St. Antônio Parish today. In the background, Morro da Oficina. Photo: Glauci Coelho, June 17, 2023.

The analysis of the sacred territory in Alto da Serra should be based on the discussions by Tsing (2019) and Krenak (2019) regarding community resilience and adaptability in the face of adversity. Spirituality, along with memory and ancestry, provides a support structure that allows marginalized communities to resist external pressures and maintain internal cohesion, representing an essential dimension of identity and community unity. Faith and hope offer critical emotional and spiritual support for residents, highlighting the importance of inclusive and sensitive approaches that recognize and value these dimensions in the formulation of public policies and the promotion of socio-environmental justice.

CONCLUSIONS

This investigation into the memories, existences, and affections in Alto da Serra, Petrópolis, after the 2022 floods, revealed the complexity of the socio-environmental and emotional dynamics affecting the residents. By employing the cartography of affections and the participatory methodology of the game “The City I Live In,” we mapped the interactions between inhabitants and their territory, highlighting the importance of collective memory and community identity in building resilience in urban spaces. The analysis of the everyday, transactional, referential, and sacred dimensions of the territory demonstrated how emotional and social relationships shape the landscape and residents' perceptions of their environment. The collected narratives show a strong attachment to the place despite adversities, underscoring the need for public policies that promote socio-environmental justice and community inclusion. Thus, the intersection between socio-environmental vulnerability and environmental injustice drives us to consider the urgency of approaches that value resident participation in decision-making and equitable resource distribution. This study emphasizes the importance of considering affective and symbolic dimensions in urban management, fostering more human and sensitive planning to meet the needs and aspirations of communities.

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Cities and climate change – considerations based on ESG & SDG global compact reports

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ABSTRACT

The urban unsustainability and their climate change impacts generate vulnerabilities and greater efforts to transform cities in the face of catastrophes due to droughts, floods, extreme temperatures, among others. Taking as a basis the data, terms and definitions recommended by the UN on SDGs and ESG, this article brings analyses and considerations of the relationships between urban form and climate change, considering these and the other SDGs as indicators of service presented by the voluntary ESG reports made available on the Compact Global platform (ONU). Global Compact reports (ONU) are considered highly reliable and highly rational to determine qualitatively and quantitatively the relationships between cities and climate change, as well as parameterized definitions understood and guides to be followed. There was a compilation of data from voluntary reports in which companies indicate compliance with the SDGs obtained on the Compact Global platform, which concentrates global reports on ESG. It considered two samples, one without selecting the area of activity and the other for adherence to real estate, given the formal market and financial link of ESG reports. It was observed that the indication of compliance with the SDG, Cities and Climate Change, has a participation of over 70%, which leads to relational observations of participation and trends in the other SDGs, both for companies in general and for those operating in real estate. From this scenario, the oceans and seas, poverty, water and terrestrial ecosystems stand out as having the worst conditions of service for both samples. These low service take-ups by companies, in terms of the formal market, bring to light the great effort that companies, societies and cities need to transform not only how they serve to improve their SDGs. This statistical analysis is very important to build a urban form more sustainable and adapt to climate changes.

Keywords: ESG-UN, SDGs, cities, climate change

INTRODUCTION

According to the 2030 Agenda, cities must address parameters in accordance with the 17 Sustainable Development Goals (SDGs) regarding sustainable development in the face of the climate changes foreseen by the United Nations Organization (UN) (2015). These parameters must consider

transformations in urban form over time according to region, historical, social and cultural context, and economic conditions (UN-Habitat, 2020a).

Second, Wong (2001), the urban form and the understanding of spatial organization influence a city's environment, quality, and sense of place with two significant principles: theoretical and practical implications. Urban morphology, technological changes, income, wealth, preferences, economic restructuring development processes, and public sector actions are the main factors shaping the urban form. These indicators reflect the contemporary urban reality of an area characterized as a city space and its capacity for sustainable development. About 80% of the two SDG indicators contain an urban component, and its morphological factors corresponding to about one-third of the indicators are measured locally (UN-Habitat, 2020b).

Considering that companies establish business strategies of institutions and companies with financial implications such as “responsible investment” based on the bases and principles of ESG (Environmental, Social and Governance), or Corporate Social Responsibility (CSR) performance, environmental, social and governance needs to be disseminated. These responsible investments of companies can be aligned with the 17 SDGs, thus improving the structure of the city and involving the urban form. Ting-Ting et al (2021) observed that there is no unified concept of ESG actions between institutions, organizations and companies, reducing credibility, authority and doubts of adesões. Most of the ESG assessment systems are defined by a team of specialists, generating subjectivity. In the context, ESG urgently requires a quantitative basis for information on social, corporate and practical responsibility.

Machado (2024) highlights that many actions of markets, governments, and other institutions are needed to absorb the impacts of climate change and adapt city areas against flooding and heat waves in valued areas. Environmental inequality mainly affects people who live in vulnerable areas, leading to increased mortality, reduced wages, and reduced productivity and learning, among other things, in addition to altering the conditions of city growth and development.

On the one hand, the global and ambitious SDGs have directives that guide companies and organizations to contribute with quantified and substantiated results without ESG. Furthermore, the parameters obtained from two SDGs, Cities and Climate Changes, have direct ESG correlations and are integrated into declarations and reports. It is essential to know that there are expected differences and interdependencies on environmental, social, and economic issues. The SDGs can even transform or evolve for scenario analysis, starting when the status of the formal real estate market is declared. ESG. In other words, observation adheres to the contemporaneity of what is produced as real estate and local assets transformed by being human, and the human parameters and sustainable development are auxiliary as cities do not confront climate changes.

This article aims to underscore the importance of understanding the relationships between the variables taken as two SDGs in the face of climate change. This understanding, whether it's based on consolidated functioning or science, is vital for the successful implementation of sustainable urban development and for the achievement of the SDGs and ESG on the UN platform.

Database and communications on ESG

In the global context, actions to address the global problems foreseen in the SDGs are related to implementing risk analyses, but the increasing pace of organizations may fail to manage ESG issues and generate impacts on reputation, customer loyalty, and financial performance (COSO; WBCSD, 2018).

In many cases, the media reports to civil society and the organization when there are incidents related to pollution, customer and employee safety, ethics and management oversight, denigrating the image of companies, instead of having the role of communicating actions to mitigate and adapt to climate change. Environmental issues can generate short-term impacts on business and reflect their anticipated effects on the long-term market, mainly on cash flows depending on the associated risks. COSO and WBCSD (2018) highlight some environmental disasters caused by companies in the infrastructure, cities and construction sectors that suffered ecological impacts:

• 2010: In the area of infrastructure and energy construction, BP's deep-water oil platform explodes, killing 11 workers, injuring 17, and creating an environmental disaster.

• 2011: In the area of urban infrastructure, Flooding in Thailand disrupted the automotive sector, technology networks, and supply chains.

• 2013: In the area of constructed buildings, the collapse of a building killed more than 1,100 workers in Rana, Bangladesh, a manufacturing hub used by more than 25 global brands.

• 2014: Drinking water in Flint, Michigan was found to have high lead content, generating high risks to the environment and ecosystems. • 2015: Air pollution in cities: Millions of Volkswagen cars were recalled after the company admitted to falsifying emissions tests.

• 2016: Samarco (Vale and BHP) dam collapse that killed 19 people and caused iron ore and mining waste to spill into rivers, tributaries and into the sea.

Considering such environmental disasters and ESG issues, new tolerance limits for activities to mitigate the environmental impacts of pollution in the face of climate change are required. Such potential environmental impacts, linked to extreme weather situations such as floods and droughts, can affect both urban forms due to the need for adaptations to urban infrastructure and real estate, as well as business activities and the entire construction production cycle.

In Brazil, the primary conditions for ESG analyses are reports and communications regarding services and company reports by the United Nations Global Compact. Searches for the term ESG did not result in any company publications, but only six news items about Brazilian companies on the international page – “Compact Global”. It is worth noting that the global page of the “United Nations Compact Global” (2023) includes 7,264 communications in progress, in addition to 40 recommended websites, 12 events, 83 news items, 19 participations, and a library with publications. It proves that the term ESG and its indicators still lack more accessible formal structures, such as public data at the national level, justifying the joint effort and consistent knowledge for sustainability.

METHOD

The methodological procedures to identify the correlation and adherence of the SDGs in ESG by companies and institutions consist of:

1- Selection of the database and communications on sustainability – ESG

2- Definition of parameters to analyse the correlation between ESG as a basis and the methodology under considerations and delimitations on the SDGs.

3- Methodological development and correlation analysis between SDGs and ESG

Due to their absence in the Brazilian platform, the data search for international publications within the UN platform, Compact Global, could have been improved. After tabulation as indexes, an analysis of the possible differences between the areas, including architecture and urbanism, under the scope of voluntary declarations and reports of the formal market is carried out. Thus, the term real estate has become adherent to the market condition and its investments, to which the term ESG is appropriate.

In this sense, the term real estate refers to a portion of land and any natural or artificial improvements defined where natural annexes are part of the land and include trees, water, valuable mineral deposits, and resources such as oil, and artificial improvements include buildings, roads, sidewalks, and fences. In relation to categories, real estate can be divided into residential and commercial, and industrial properties are considered a subdivision of commercial properties (SEGAL, 2024). Therefore, regarding the SDG's compliance with the companies' reports, we sought to compile the checklist presented in the reports with excerpts of the general activities.

Given the lack of reports and communications on the Brazilian Global Compact platform, 7,264 ESG communications and reports available on the international website of the United Nations Global Compact, i.e., “Compact Global” (2023), were selected. First, the consistency of the communications was checked, and the consistency of the data was observed, i.e., the data was assessed to determine whether the download links were effective and contained the file that could be opened. Since some links did not have an unavailable file or interrupted access, 27 units were selected without choosing a filter by area or activity link with real estate. In this sample, the compartmentalization of data from the reports that companies voluntarily publish was considered according to their indication of compliance among the 17 SDGs.

In a second selection, the ESG reports related to real estate were considered, consolidating a sample of 105 units. The construction and compartmentalization of data by companies were tabulated in an Excel spreadsheet, considering the score “zero” for no citation and “1” for citation of compliance with each reported SDG, thus presenting the sum of indications from the reports constituting the samples (Table 1). In this way, it is possible to identify qualitatively and quantitatively the strategic actions of real estate properties in general and other specific real estate services. It allows the projection of actions related to each SDG, presenting the general practice of the formal market and the macro analysis of companies in relation to ESG factors.

Table 1. Number of indications of SDG compliance by companies operating in general and in real estate and the percentages of reports for each sample

ODS		GERAL COMUNICATION	% ESG GERAL	REPORT REAL ESTATE	% ESG REAL ESTATE
Poverty	1	10	0.37	45	0.43

Hunger	2	7	0.26	46	0.44
Health	3	12	0.44	76	0.72
Education	4	16	0.59	75	0.71
Gender	5	24	0.89	84	0.80
Water	6	11	0.41	45	0.43
Energy	7	16	0.59	77	0.73
Economic	8	24	0.89	94	0.90
Infrastructure	9	17	0.63	78	0.74
Inaqualities	10	18	0.67	61	0.58
Cities	11	17	0.63	78	0.74
Consumption and Production	12	18	0.67	82	0.78
Climate	13	22	0.81	94	0.90
Life bellow water	14	7	0.26	40	0.38
Life and land	15	9	0.33	57	0.54
Peace, Justice and Strong Institutions	16	13	0.48	62	0.59
Partnerships	17	16	0.59	59	0.56
		257	**9,52**	**1183**	**10,97**

RESULTS AND DISCUSSIONS

Assess the proportion of compliance with the SDGs by ESG reports and communications using the radar chart format. This format allows, through a matrix, to compare the aggregated values of several data series and highlight adherences and possible conditions of fragility and/or potential. Figure 1 shows the general results of the SDGs declared in the reports. The highest adherence was for the SDGs: Gender with 89%, Economy with 89%, and Climate Change with 81%. It shows that reports based on the very definition of the terms that carry the acronym ESG, where Governance by Economy and the basis for financing and investments, Social by the main relationship is Gender and therefore Environmental by Climate Change, thus raising the question of whether these statements of greater compliance if carried out by companies in their practices, are sufficient to meet sustainability.

In compliance with approximately sixty percent of the declarations made by companies, there is Inequality, together with Consumption and production (18 or 0.67), Education and Energy (16 or 0.59), Cities and Infrastructure (17 or 0.63) and Global partnership (16 or 0.59), referring in the same way as the terms with the most significant focus, which are social, in this order, including Inequality and education, in which many of the reports indicate training and inclusion actions. The items of energy and infrastructure are reading as the drivers and bases for the means of production, and which correspond to the environment and whose resources impact business economic conditions and therefore the global partnership, the conditions of commodities, exports, and imports, transfer and bases of innovations, among other relations of international relations that economically and

financially articulate companies and markets. The SDGs suggested are Society (48%), Health (44%), Water (41%), Poverty (37%), Terrestrial Ecosystems (33%), which suggests that these are objectives that must meet. However, it can seem that these are companies in the formal market and supported by procedures that comply with licenses regarding impacts on terrestrial ecosystems, as well as the use, Consumption, and emissions of liquid effluents and part of the services that require health conditions for both employees and the surrounding area, it must consider that these are current practices and are underway by many of the companies and therefore few point to practices that go beyond operating conditions to more consistent goals for sustainability as common development objectives. ● The two worst SDG compliances for the sample of companies, in general, appear as compliance indications in 7 of the 27 reports, corresponding to 26% of this sample, which are Hunger and Oceans and seas, for which the objectives taken as externalities to the main actions and activities with a focus on sustainable financial responsibility are indicated.

To verify the behaviour of companies in the face of the opportunity for voluntary ESG reporting and provide analyses that demonstrate the adherence of the variables, an indicator of the reality and practice of companies in the construction and real estate sector, a quantitative and qualitative methodology based on the construction of a sample of data on SDG compliance in voluntary ESG reporting. For example, previously described and which were only available on the international platform, “Compact Global,” and with a search selection of reports in which companies classify themselves as operating in real estate.

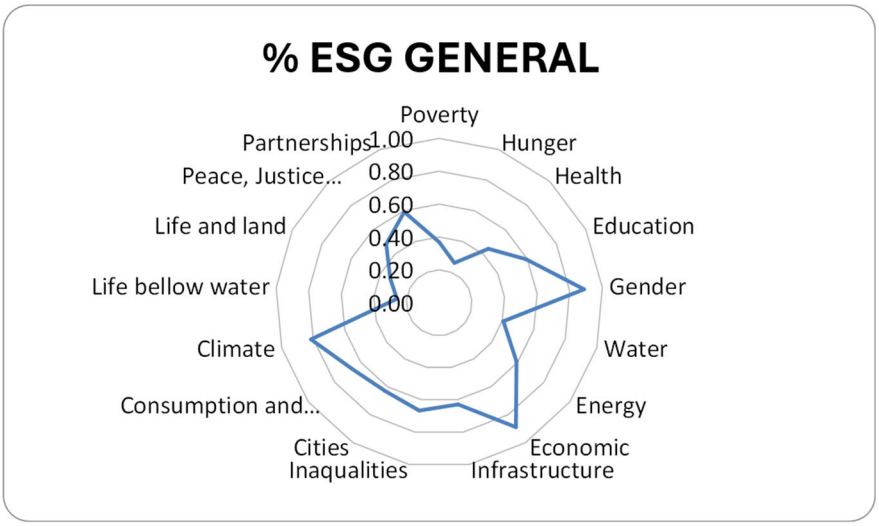

Figure 1. Diagram of quantitative adherence to the SDGs of companies operating in the general market. credit: authors.

These notes use radar diagrams plotted in Figure 2, which allows the comparison of aggregated values from several data series. This highlights adhesions and possible conditions of fragility and potential, highlighting individual maximum service points.

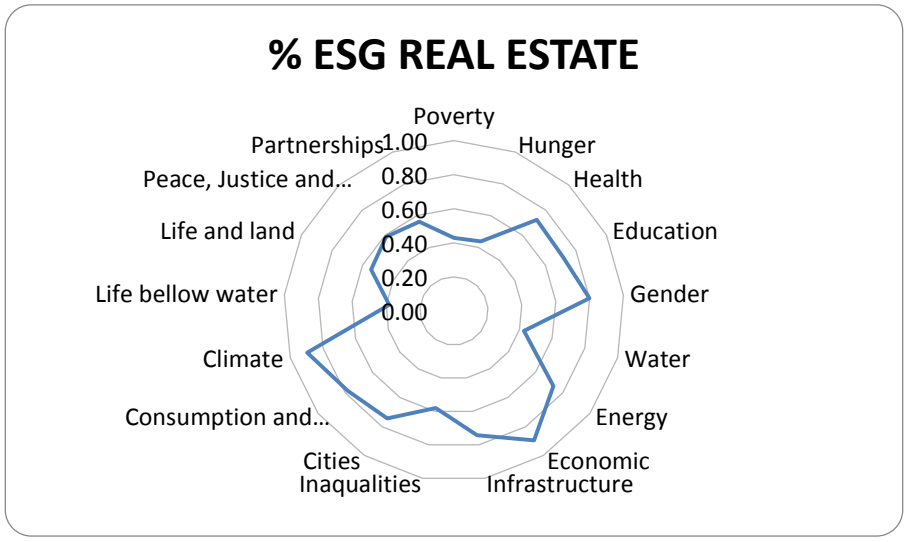

Figure 2. Diagram of adherence to the SDGs of companies operating in real estate. credit: authors

The economy and climate change are cited in the range of 90% to 80%, with both 94 indications of the 105 reports, that is 0.90. Compared to companies in general, the Gender SDG loses a mathematical representation, which is not substantial, from 0.89 to 0.80 for real estate. The main adhesions also show a noticeable reduction from 0.90 to 0.89 for the Economy and Climate Change SDGs from 0.90 to 0.81. Therefore, it can be said that there is no major strategic change in the main action for the SDG as a "flagship." The SDGs are in the range of 80% to 60%: gender (0.80), Consumption and production (0.78), Infrastructure and Cities (0.74), energy (0.73), Health (0.72), and Education (0.71).

Regarding the comparative performances of the real estate sector and in general, the Gender SDG follows the previous higher range. The real estate sector's services exceed 10% in the sense of better services for Consumption and Production, education and Energy (16 or 0.59), and Cities + Infrastructure (17 or 0.63). Global partnership services are equivalent, but the real estate sector is 10% behind in the Inequality item. From 60 to 40%, we have Society (0.59), Terrestrial Ecosystems (0.54), Water and Hunger (0.43), and Poverty (0.44).

Therefore, real estate surpasses general-purpose companies by around 10% for Society and Poverty. It is equal in the water category and superior to general-purpose companies for hunger and terrestrial ecosystems by 20% and 30% for education and health. The worst indicators for companies that declare themselves ESG adherents and indicate the SDGs are represented by oceans and seas 38%. For companies operating in real estate, this drops to 26% of the attention for general-purpose companies.

Figure 3 illustrates the comparative analyses indicated below. With the emergence of ESG, a new guideline that aims to integrate construction products into the links of the chain, it is crucial to stay updated. This guideline is very favorable, as it addresses certain variables related to the governance and economic-financial conditions of the company that are not specified in green certifications.

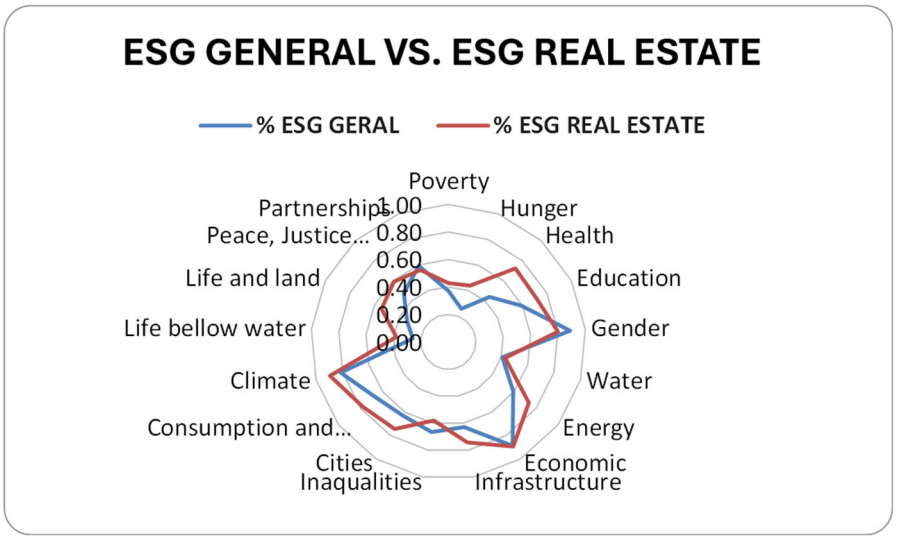

Figure 3. Comparison between diagram of adherence to the SDGs of companies operating in general and real estate. credit: authors

The integration of certification seals for construction and real estate projects into ESG reports, including the governance, social and environmental aspects regarding the business and financial aspects, is a service within the complexity of corporate actions. This complexity underscores the need for a comprehensive understanding of sustainability, as these actions are not always transparent with the environment and the actions of society.

Thus, the interpretation was about the values of the environmental footprint by-products and arguments about how global climate change is characterized. With the need to reduce greenhouse gas emissions, energy consumption, and the depletion of non-renewable resources, sustainability became the quality of performance of an intricate process and the way of acting used to obtain each production.

The desirable integration of ESG and building certifications and the understanding of the relationships between the variables of each of the actions lead to a new and broader look at what the life cycle and life cycle cost of products may be, more holistic but not diffuse, to provide the opportunity to offer conditions to link ESG and SDG data and reported items to specific actions of buildings and real estate properties and how they make up the territory and the urban forms of construction and occupation.

From this condition, this analysis of service trends can be brought; in the case of this article, it is to gather SDG services under ESG reports, thus having at its core the search for construction of alignments within the complexity that is sustainability, a way of adhering to variables that are requirements for sustainability, but that are not standardized and are not under the same metric, methodology applied in this study and gathered in Table 2.

The ESG guideline, a significant development, is designed to integrate construction products into the chain's links. This is crucial because it addresses certain variables related to the company's governance and economic-financial conditions.

Integrating certification seals for construction and real estate projects into ESG reports is a significant step. This comprehensive approach, which includes the governance, social, and environmental

aspects alongside the business and financial aspects, provides a clear view of corporate actions and their impact on the environment and society.

Thus, the interpretation that was had about the values of the environmental footprint being characterized by-products and arguments about global climate change, the need to reduce greenhouse gas emissions, energy consumption, and the depletion of non-renewable resources, sustainability became the quality of performance of an intricate process and the way of acting that is used to obtain each production.

The desirable integration of ESG and building certifications and the understanding of the relationships between the variables of each of the actions to lead a new and broader look at what the life cycle and life cycle cost of products may be, more holistic, but not diffuse, to bring the opportunity to offer conditions to link data and reported items of ESG and SDGs to specific actions of buildings and real estate properties and how these make up the territory and the urban forms of construction and occupation. From this condition, an analysis of service trends can be made. In this article, the aim is to group the SDGs under the ESG reports together. Thus, the core objective is to seek alignments within the complexity of sustainability, a way of adhering to variables that are requirements for sustainability but are not standardized and are not under the same metric, the methodology applied in this study and gathered in Table 2.

Table 2. Tends of companies operating in general and in real estate

ODS		257 report for 27 comunications	
		GERAL COMUNICATION	% ESG GERAL
Poverty	1	10	37.04%
Hunger	2	7	25.93%
Life bellow water	14	7	25.93%
Life and land	15	9	33.33%
Water	6	11	40.74%
Health	3	12	44.44%
Peace, Justice and Strong Institutions	16	13	48.15%
Education	4	16	59.26%
Energy	7	16	59.26%
Partnerships	17	16	59.26%
Infrastructure	9	17	62.96%
Cities	11	17	62.96%
Inaqualities	10	18	66.67%
Consumption and Production	12	18	66.67%
Climate	13	22	81.48%
Gender	5	24	88.89%
Economic	8	24	88.89%

ODS		1183 reports for 105 comunications	
		REPORT REAL ESTATE	% ESG REAL ESTATE
Life bellow water	14	40	38.10%
Poverty	1	45	42.86%
Water	6	45	42.86%
Hunger	2	46	43.81%
Life and land	15	57	54.29%
Partnerships	17	59	56.19%
Inaqualities	10	61	58.10%
Peace, Justice and Strong Institutions	16	62	59.05%
Education	4	75	71.43%
Health	3	76	72.38%
Energy	7	77	73.33%
Infrastructure	9	78	74.29%
Cities	11	78	74.29%
Consumption and Production	12	82	78.10%
Gender	5	84	80.00%
Economic	8	94	89.52%
Climate	13	94	89.52%

In this Table of trends, the real estate sector, perhaps due to its specificity, has the highest level of service in seven SDGs, between 100 and 82%, compared to only 3 items for the services in general. In the medium level of service, there are items that should bring up the profiles related mainly to the locations of service that are far from the basic vulnerabilities and precariousness and not those of consolidated urban centres.

Notably, the themes with the most significant global amplitudes and impacts are under the worst trends, with Oceans and Seas standing out. Poverty, water, and terrestrial ecosystems were the two

segments used in these data analyses. The topics of hunger and health have also been added for companies operating in general.

As a critical analysis of the context and the analyses presented up to this point, it is still worth considering and absorbing the limitations that even robust studies in sample compositions incur that can lead us to improvements. Still, it is considering that any tangible requirement, such as environmental resources, is not monitored by a standardized methodology and quantifications or even within a common scientific and statistical formulation and that there is no one for the monitored part, social, economic, political and go governance-related a structured and common way.

The trend diagram is a demonstration of evidencing the situation of materiality. Still, it starts from this inconsistency of possible relationships and for Don L Stevens Jr. and Anthony R Olsen (2004):

> "Environmental studies invariably involve populations distributed in space. Traditionally, such studies have focused on relatively small, well-delimited systems. However, some of the environmental issues we face today, such as global warming, long-range transport of air pollutants, or habitat alteration, need to be localized. Understanding and quantifying the extent of symptoms of widespread concern requires large-scale study efforts, which in turn require environmental sampling techniques and methodologies that are designed to address regional, continental, and global environmental problems."

The proposal, designed to address the dispersion and disconnection of variables as indicated by Don L Stevens Jr. & Anthony R Olsen (2004), is a significant step towards formalizing the contribution of sustainable works, including certified ones, to global sustainability and development. By seeking the relationships presented by the basic definitions of the SDGs and relating them to common practices in the real estate market, this proposal has the potential to inspire a greater advancement towards sustainability.

This analysis is grounded and characterizes that sustainable real estate products enable advancement in ESG strategies in a significant gain when compared to the insertion of services to real estate properties that elevate this service as being of great relevance to the condition of the sustainable quality of the product and without this condition, the formalization and indication of sustainability and its communication are faced with fragility and consistency and as proclaimed by Stevens Jr; Olsen (2004), which is fallible to the public's belief, resuming the condition that all parties should assess carbon emissions for proper integration of the bases.

Even if the analysis is structured to provide considerations on cities and climate change based on a data section on real estate from ESG reports, there is still a specific section parallel to the conditions of each country when it is taken as a reference. When companies in developed and underdeveloped countries find themselves, specificity is not achieved due to the lack of data offered on the Brazilian platform, UN Global Compact.

The situation of the base data generalization does not bring the asymmetries of historical contexts that intertwined in inequalities in infrastructure supply and socio-economic conditions by developing or precarious countries and regions. These factors affect the capacity to live in specific places.

These are structuring factors for selecting land use that impact other urban morphological variables in the long term (WONG, 2001). This consideration highlights the assumption of generalized indicators, but adherence to Stevens Jr. and Olsen (2004) is currently different on a large scale. However, it is necessary to consider the result of companies that SDGs already prepared and that the potential for transformation of cities is resumed, as they are inelastic variables that have a long-term impact on urban morphology.

Another point that stands out from this analysis is the results of the 2022 Brazilian CENSUS (IBGE, 2022), which shows that São Paulo has less than 6% inadequate sanitation, and Rondônia has more than 60%. This variable represents the unsustainability that influences the indicators of compliance with the SDGs.

CONCLUSIONS

The fragility, strength, and vigor of sustainability indicators tend to be unique and specific actions for a company, but this must go beyond the fact of belonging to and depend on an entire sector and its size. It is necessary to define its business strategy and objectives, which stakeholders are the primary ones in solving fragility and maintaining and even improving its potential so that its services to the global variables that have been demanded by environmental, social, and governance issues in a world that requires imperative values are expanding.

When it comes to ESG assessment, the role of professionals is paramount. Despite the lack of progress, there are scientific bases and references, such as the COSO and WBCSD guide (2018), that underscore the importance of professionals in sharing risk management results. Their contribution is crucial for a comprehensive understanding of the internal and external business context.

Therefore, our approach to sustainability should be one of optimism and action. By fostering a positive mindset, we can be more open to innovative actions and integrations that drive positive change.

Based on a tripod Environment, Social, and Governance, the requirement to address the complexities of actions and results and impacts with dependencies and related megatrends such as the SDGs, it becomes relevant for companies to look for ways that can identify the specific characteristics of natural, human, and social capital or other capital that the company can identify as a chain that demonstrates and predicts that a specific impact factor results in changes in the natural environment and a capital (or other capital) and consequently changes impact different interested parties, elucidating a path of dependence and interdependence as this study sought to follow and present. The universe of real estate developments will constitute a significant and fundamental sample space for ESG methodologies, in addition to the certifications that have been applied for some time, to be implemented under the risk of losing markets or reputations and, mainly, because we can foresee that the demands on them will increasingly constitute universes of pressure by the various agents that make up the chain of external and internal clients and will be characterized by factors of internal organization of cities and these as influencers of the form and structuring of urban morphology.

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Comparative study on morphological indicators based on evaluating urban ventilation efficiency

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ABSTRACT

Indicators that characterize form and performance play a crucial role in urban morphology. Traditional indicators of morphological characteristics include the density of urban blocks, floor area ratio, average height, and average openness; some indicators express the space of urban streets or squares, such as aspect ratio, sky openness, and so on. Given the need to study the performance of the urban physical environment, researchers have explored the indicators that can express the performance of the urban physical environment, including the indicators that express the urban space (H/W, SVF) and some new density indicators, such as λp and porosity (Po), and theoretically confirmed the validity of these indicators. However, prior studies have also found that the same indicators have different correlation in different studies. This is due to different study have different study case with different morphological features at different scales. In urban climate studies, study areas are always divided by different sized grids. It is necessary to analyze these metrics in-depth and explore the mechanism of correlation between these metrics and urban ventilation performance as well as the working conditions of use. In this study, two typical areas in Nanjing, China, were selected as study cases: a complex commercial area sa non-homogenerous area and a single residential area as homogenerous. Then, the study areas are divided by four sized grids (with 200m, 100m, 50m, and 25m). Based on this, the effectiveness of four indicators, namely H/W, SVF, λp, and Po, in assessing the efficiency of urban ventilation and the utilization conditions were investigated. We found that 100m is the best sized grid to study the correlation ventilation and urban morphological; SVF and λp have better correlation in both cases; and homogenerous area has better correlation between ventilation and urban forms than non-homogenerous.

Keywords: urban morphology, environment performance, indicator, ventilation efficiency

INTRODUCTION

Characterising urban forms has always played a crucial role in urban morphology. With the development of digital platforms and analytical methods such as GIS, the demand for urban design has become more refined, and quantitative research on urban morphology has been emerging. Different scholars have proposed different indicators to express different urban form characteristics. For example, coverage ratio, floor area ratio and average height are put forward to describe the building density in study area. Height and width ratio and spatial openness can be used to express the

openness of urban streets and squares. These indicators can be used to research the process of urban form formation, the correlation with other non-physical performances, as well as the basis for urban form policy and urban design control.

Simultaneously, atmospheric scholars have recognized the pivotal role of urban morphology in affecting physical performance (i.e., solar, ventilation, and thermal performance). They've also proposed a series of urban form indicators to study this relationship, linking urban form to function in physical performance. At the earliest, Oke (1981, 1988) found that sky view factor (SVF) can reflect the urban heat island and height-to-width ratios (HWR) can relate with flow regimes of street canyons[1]. The roughness length formula proposed by Lettau used the ratio of area “seen” by the wind in the approach toward one characteristic individual obstacle to the lot area [2]. Plan area density (λp) is also a common indicator linking ventilation [3].Adolphe (2001) invokes the porous media theory and proposes indicators including Mineralisation (M), Rugosity (Hm), Porosity (Po) to correlate various physical performances in urban spaces[4]. Among all physical performance aspects, sunlight exposure is recognized as having the most distinct correlation with urban morphological characteristics, while wind and thermal conditions are deemed to be more complex. Wind and thermal environments are often considered inseparable, but the focus of this study is specifically on the performance of ventilation.

Interestingly, the urban form indicators proposed by atmospheric scholars are often similar sense to those proposed by urban morphologists in a mathematical computational. If these indicators can effectively correlate urban wentilation performance in real cities, they can be used to control and optimise urban ventilation. In fact, some of these indicators have already been used to control urban performance. However, the correlation of these indicators with ventilation in real cities is not the same as the theoretical correlation. Oke (1988) found that HWR can characterize the flow patterns of symmetrical canyons[1]. Li, You, Peng, and Ding (2024) found that more than 60 per cent of the spaces in real urban settlements have airflow patterns that cannot be correlated with their HWRs, even though the spaces studied are regular street canyons comprised of equal height and length buildings[5]. Moreover, research subjects with different morphological characteristics can also lead to varying degrees of association between the same indicators and ventilation performance. For instance, Yang, Qian, & Lau (2013) analyzed the correlation between the Sky View Factor (SVF) and the mean velocity ratio (WVR) in high-rise residential areas of Shanghai, yielding an R-squared (R^2) value of 0.62[6]. In contrast, Li, You and Ding (2022), who concentrated on urban forms in the city center, found a significantly lower R^2 value of 0.277 for the same correlation between SVF and WVR[7]. In addition, different study units and sizes in different studies also affects the correlation between morphological characteristics and ventilation performance[8]. One of the most common methods is to divide the urban area into research units using grids of different sizes. Side lengths of 25m, 50m, 100m, 200m are common grid sizes.

In summary, prior studies have also found that these indicators are not exact in expressing the physical properties of the city, especially in assessing the ventilation effectiveness of the town, and their accuracy varies depending on the environmental conditions and the morphological characteristics of the assessed opposite direction. For this reason, we try to explore that the correlation between different urban morphological indicators and ventilation performance in different cases with different morphological features under different sized grids. This study can be divided as five steps: Firstly, we

select study cases with different morphological features; Secoundly, study areas are divided by different sized grids; and ventilation data is getten on CFD simulation; Next, urban morphological indicators and ventilation indicators are caculated; Finally, correlation between ventilation and urban form are studied; Finally, we analyze the limilations of different morphological indicators and Impact of different study areas on correlation.

METHOD

Study case

In order to discuss the validity of different morphological indicators related to urban ventilation performance under different textures in real urban, it is necessary to find representative research areas with different morphological characteristics. Wowo Ding's team classified Chinese urban texture into homogeneous and non-homogeneous texture. Homogeneous texture generally refers to the texture composed of uniformly arranged buildings with similar volume, form and height, which is mainly distributed in urban residential neighbourhoods. Non-homogeneous texture is irregularly arranged by buildings with different volume, form, and height, which is mainly distributed in the city commercial center, cultural and sports building area, traffic hubs, as well as the scenic areas and so on. Therefore, we took two typical districts in Nanjing as study areas. Hexi residential area is a typical homogeneous texture, and Xinjiekou commercial centre area is a typical non-homogeneous texture (Figure 1).

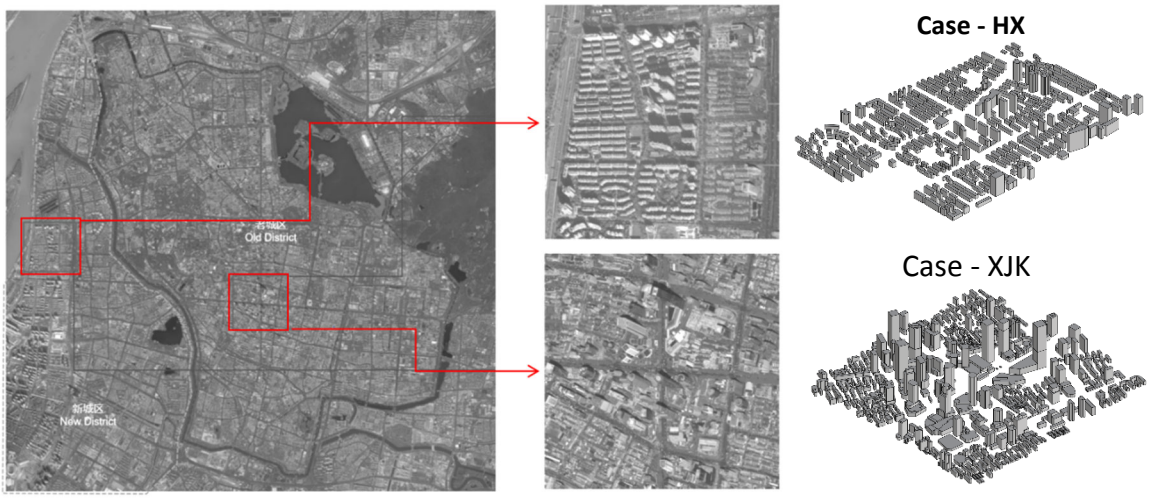

Figure 1. Study Case Selection. Photo credit: Authors

Calculation Method of morphological indicators

Plan area density (λ p)

Plan area ratio (λ p) is the area ratio of all building footprints to the study area (Figure 2), which can show the building density. It can be calculated using Eq. (1):

$$\lambda p = \frac{\sum S_{_build}}{S_{_space} + \sum S_{_build}} \quad (1)$$

where $S_{_build}$ is the the footprint of any building; the $S_{_space}$ is total area of all spaces. From a morphological perspective, an increase in λp reflects a higher concentration of buildings. When λp is zero, it indicates that there are no buildings in the study area. Conversely, when λp equals one, it suggests that the area is fully occupied by buildings. Within the range of 0 to 1, the study area exhibits a coexistence of built structures and open spaces. From a ventilation perspective, a λp value of one implies that the area is entirely filled with buildings, precluding any airflow. As λp increases, the potential for ventilation decreases, establishing a negative correlation between λp and the quality of air circulation.

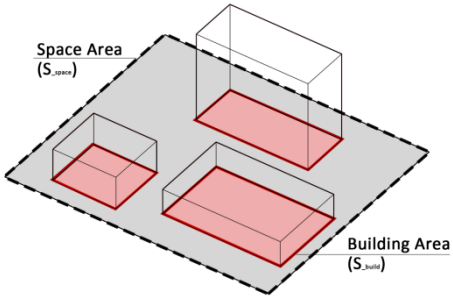

Figure 2. Caculation of λp

Porosity (Po)

Porosity (Po), which is the ratio of the volume of voids to the total volume within a study area, is used to describe the distribution of holes or gaps within a material or structure (Figure 3). The formula for calculating porosity is as follows:

$$\mathrm{Po} = \frac{Vol_{_space}}{Vol_{_space} + \sum Vol_{_build}} \tag{2}$$

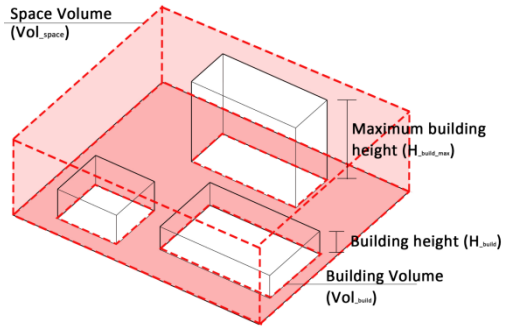

Figure3. Caculation of Po

Where $Vol_{_space}$ represents the total volume of space, while $Vol_{_build}$ is the volume of any building within the study area. $Vol_{_space}$ can be understood as the ratio of the maximum height of the tallest building within the study area ($H_{_build_max}$) to the total area of space within the study area, as follows:

$$\mathrm{Vol}_{\mathrm{space}} = H_{_build_max} \tag{3}$$

From a morphological perspective, the larger the proportion of space, the higher the Porosity (Po). It is noteworthy that when the study area contains no buildings and is completely open space, there is

no height, so the total volume of the study area is zero. Mathematically, Po cannot be calculated in this case. However, by definition, when the section contains no buildings and is entirely open space, Po equals 1. When the buildings fill the entire section with uniform height, Po equals 0. From a ventilation perspective, the higher the Po, the better the ventilation within the study area.

Sky view factor (SVF)

The sky view factor (SVF) refers to the ratio between the visible sky and the sky hemisphere at a given point (Figure 4). Two calculation methods were used to obtain the SVF in study area, which are the multipoint method and the simplified single point method. Li (2021) found that the correlation between SVF and ventilation is better by the multipoint method. Therefore, this study chose the multipoint method ro caculate SVF, noted as $SVF_{_ave.}$ $SVF_{_ave}$ is the mean value of all $SVF_{_single}$ in study area. $SVF_{_ave}$ and $SVF_{_single}$ can be calculated using Eqs. (4)-(5):

$$SVF_{ave} = \frac{\sum SVF_single}{n} \tag{4}$$

$$SVF_single = \frac{S_sky}{S_sphere} \tag{5}$$

where *n* represents the number of measurement points arranged within the study area. $S_{_sky}$ refers to the area of the sky projected onto the view sphere from the measurement point, and $S_{_sphere}$ denotes the surface area of the view sphere corresponding to the measurement point. From a morphological perspective, $SVF_{_ave}$ has similar morphological meanings to the Space Openness Index (SOI). It can characterize the openness of space in terms of form. The greater the SVF, the more open the space is. When SVF has no value, it means that the buildings fill the entire study area; when SVF is equal to 1, it indicates the absence of any buildings arround the study area when 0 < SVF < 1, it signifies the presence of at least one building within the study area or its vicinity. From a ventilation perspective, the higher the SVF, the better ventilation performance.

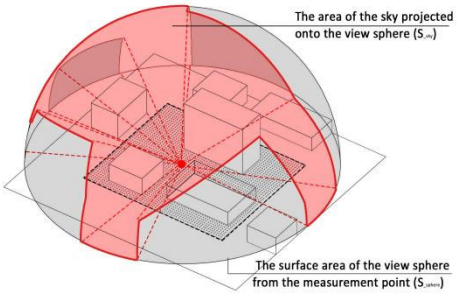

Figure 4. Caculation of SVF

Aspect Ratio (HWR_2_ave)

Oke (1988) used HWR of a ideal canyon perpendicular to the wind direction to correlate to ventilation[1]. But in real urban area, Li (2022) found that the HWR in one direction can not reflect the complex morphological features of the surroundings [5]. Therefore, we try employing the average of

HWRs in two orientations (aligned with and across the wind direction) to represent the characteristics of urban morphology (Figure 5), noted as $HWR_{_2_ave}$. It can be calculated using Eq. (6)-(8):

$$\mathrm{HWR}_{_2_\mathrm{ave}} = \frac{1}{\mathrm{n}} * \sum \frac{HWR_{_vertical} + HWR_{_parallel}}{2} \tag{6}$$

$$HWR_{_vertical} = \frac{\sum H_{_vertical}}{W_{_vertical} * 2} \tag{7}$$

$$HWR_{_parallel} = \frac{\sum H_{_parallel}}{W_{_parallel} * 2} \tag{8}$$

Where $HWR_{_vertical}$ is the aspect ratio of the building interface perpendicular to the wind direction, and $HWR_{_parallel}$ is the aspect ratio of the building interface parallel to the wind direction. $H_{_vertical}$ and $H_{_parallel}$ are the building heights perpendicular and parallel to the wind direction of the building interface, respectively. $W_{_vertical}$ and $W_{_parallel}$ are the widths between the building interfaces perpendicular and parallel to the wind direction, respectively. From a morphological perspective, $HWR_{_2_ave}$ can characterise the degree of enclosure of a space; the larger the $HWR_{_2_ave}$, the more enclosed the space is within the study area. similarly to the SVF_{ave}, where buildings stain the entire study area, there is no value for $HWR_{_2_ave}$.The value of $HWR_{_2_ave}$ depends on the degree of building enclosure in both directions of the test point, and is related to the cut location of the points contained in the average value of the points included in the cut location. Theoretically, the larger the $HWR_{_2_ave}$, the worse the ventilation.

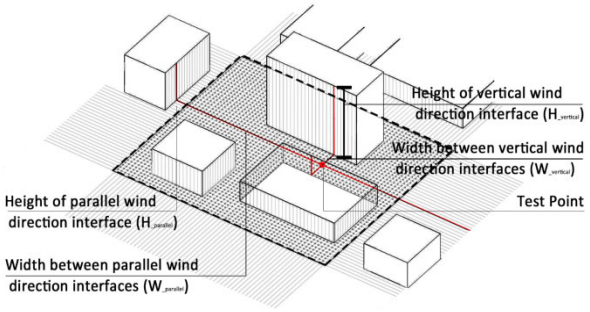

Figure 5. Caculation of $HWR_{_2_ave}$

CFD numerical simulation and Ventilation performance indicator

To predict the wind environment in the study area, Computational Fluid Dynamics (CFD) simulation was performed to simulate the wind field at pedestrian height (h=2m) in the area with south (S) wind direction. Reference wind speed is 2.8 m/s.

We chose the widely used mean velocity ratio (WVR) to evaluate the ventilation efficiency. The WVR is the average value of all velocity ratios the pedestrian heght (2m) of the space. The higher the value of the WVR in the area, the better efficient the ventilation of the area.

$$WVR = \frac{1}{n} \times \sum_{0}^{i=n} \frac{V_{ped_i}}{V_{\infty}}$$

Where Vped_i is the value of wind speed at pedestrian height and n is all the value points in the study area.

RESULTS

Study units by grids with different sizes

The study areas of Hexi and Xinjiekou are divisied by different sized grids. The division results can be categorized into three types by the situations of buildings in the study units: vacant units with no buildings (NBC), units with only partial buildings (PBC), and units completely filled with buildings (FBC). As the grid size continues to decrease, proportion of NBC and FBC increase, while the proportion of PBC decreases in Hexi and Xingjiekou.

Due to units with FBC are completely occupied by buildings, there are no ventilation data available, and thus these units do not participate in the correlation study. The presence of FBC is more prevalent in Xinjiekou, which may be attributed to the commercial building with larger footprints. In the Xinjiekou, FBC accounts for 1% in the 50m grid and 5% in the 25m grid. In Hexi, only two FBCs are included in the 25m grid (accounting for 0.125%)(Figure 6).

There are a larger number of NBC in Hexi than in xinjiekou.It is due to the strict adherence to sunlight spacing in residential design, leading to the inclusion of larger open spaces in the Hexi case. In addition, the presence of a significant amount of vacant land on the riverside in Hexi. In the 100m grid of hexi, NBC accounts for 5%; in the 50m grid of hexi, it accounts for 15%; and in the 25m grid, it accounts for 33%. In Xinjiekou case, the NBC account for 4% in the 50m grid and 20% in the 25m grid(Figure 6).

It is noted that units with FBC have no any ventilation data, and units with NBC have same values of λp and Po, separately. The four indicators can not reflect the surrounding morphological features due to their calculation method. Therefore, when the proportion of FBC and NBC is large, it may affect the correlation between the four morphological indicators and ventilation. However, the calculation methods of SVF and $HWR_{_2_ave}$ can reflect the surrounding morphological features. The units with NBC do not reflect the values of SVF and $HWR_{_2_ave.}$ Since FBC+NBC closed to 30% in a 25m*25m grid in both two study areas would have an impact on the correlation of λp and Po with ventilation, 25m*25m grid are not examined in the four indicators(Figure 6).

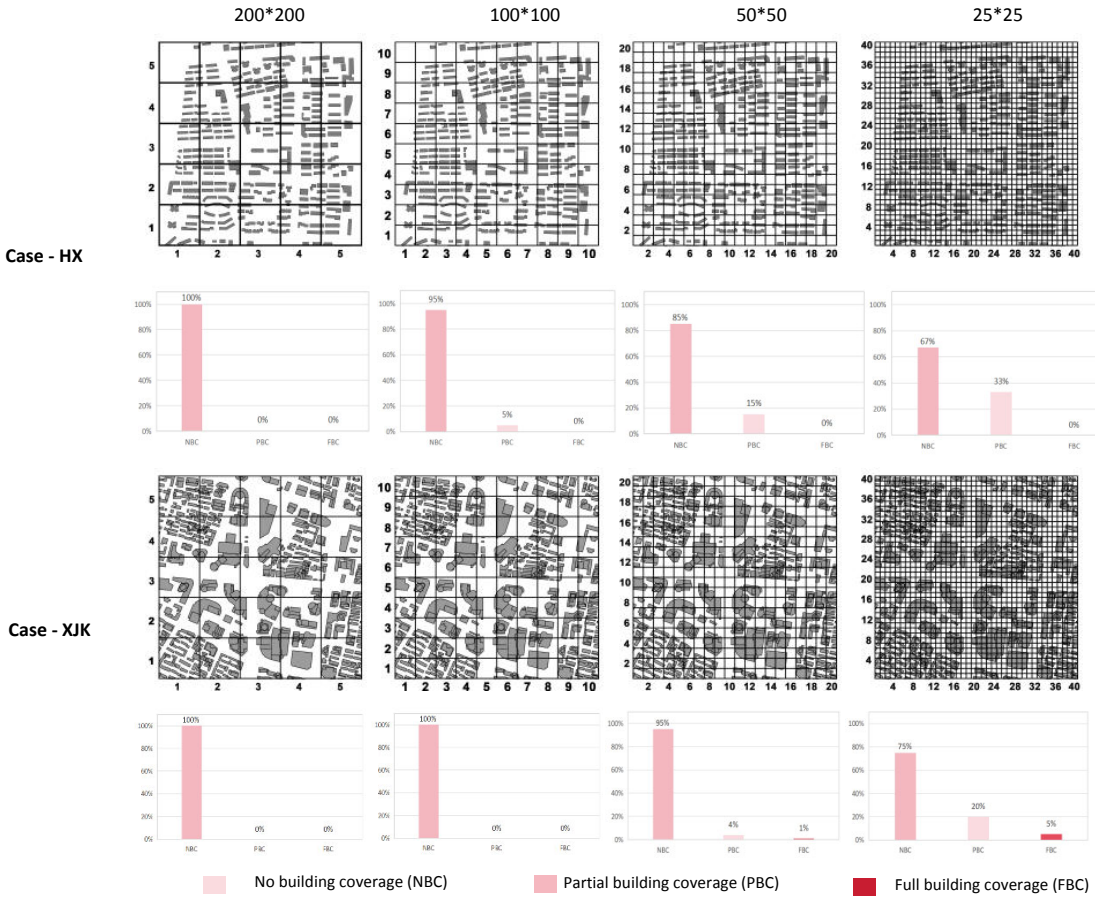

Figure 6. The study areas' dividision results

Results of morphological indicators

Whether it's Hexi or Xinjiekou, it can be observed that the larger the unit size, the smaller the threshold values for the four morphological indicators. This could be due to the fact that the larger the unit, the larger the range of buildings and spaces it contains, and the data obtained for each morphological indicator tends to be closer to the average. Therefore, a smaller grids might be able to capture finer morphological characteristics.

It can be seen that several indicators essentially conform to morphological significance (Figure 7). In Hexi, the northwest corner is the most open, hence these units have the smallest λp, the largest Po, the largest SVF_ave, and the smallest $_{HWR_2_ave}$; next are other units that include spaces such as squares, where λp are relatively small, Po are relatively large, SVF$_{_ave}$ is relatively large, and HWR$_{_2_ave}$ is relatively small; finally, there are other areas with denser buildings, where λp are relatively large, Po is relatively small, SVF is relatively small, and HWR$_{_2_ave}$ is relatively large. In Xinjiekou, the intersections, squares, and main roads are relatively spacious, so this area has a relatively small λp, a relatively large Po, a relatively large SVF$_{_ave}$, and a relatively small HWR$_{_2_ave}$; whereas in the old residential areas at the four corners, the buildings are denser, resulting in a relatively large λp, a relatively small Po, a relatively small SVF, and a relatively large HWR$_{_2_ave}$.

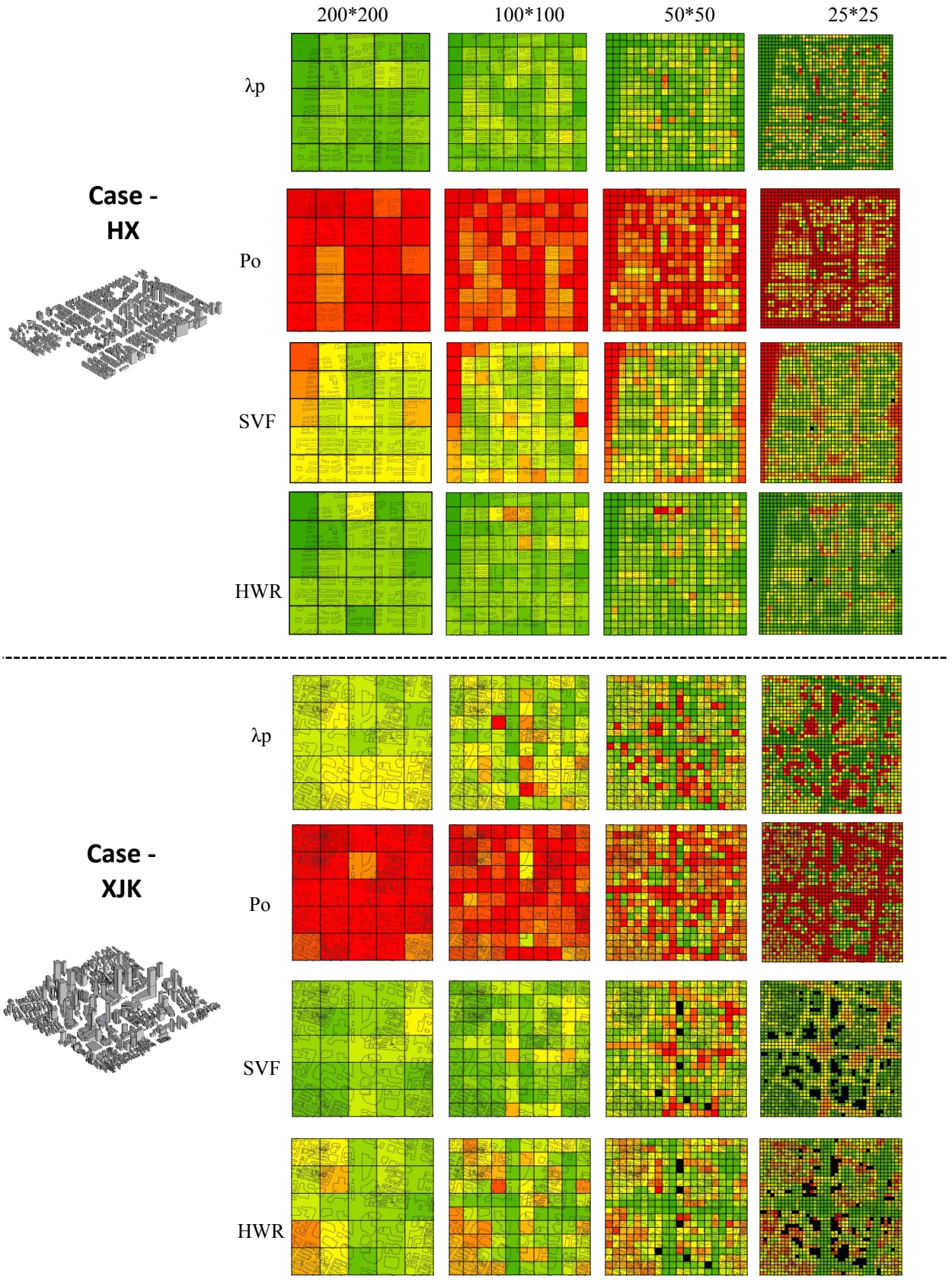

Figure 7. The morphological indicators results

Ventilation performance in the study area

Through the Computational Fluid Dynamics (CFD) simulation, we obtained the wind speed contour maps for Hexi and Xinjiekou (Figure 8). It can be observed that in Hexi, the wind speed is significantly higher in the open space areas and along the main roads that are parallel to the wind direction, and relatively lower within the residential areas. In Xinjiekou, the maximum wind speed is also concentrated on the roads that are parallel or nearly parallel to the wind direction, while the minimum wind speed is focused in the grids of the old residential areas at the four corners.

After dividing the two study areas by different sized grids, every units' WVR are caculated as Figure 8. It was found that in Hexi, the highest WVRs are located in the northwest corner and its vicinity, and are relatively smaller within the residential areas; in Xinjiekou, the highest WVRs are at the roads or intersections parallel to the wind direction, while the lowest WVRs are concentrated in the units of the old residential areas at the four corners. The results of the WVR are similar to those of the morphological indicators, where the lager the grid size, the more the WVR values are averaged out, resulting in smaller threshold values. Overall, the WVRs of study units generally conform to the ventilation conditions.

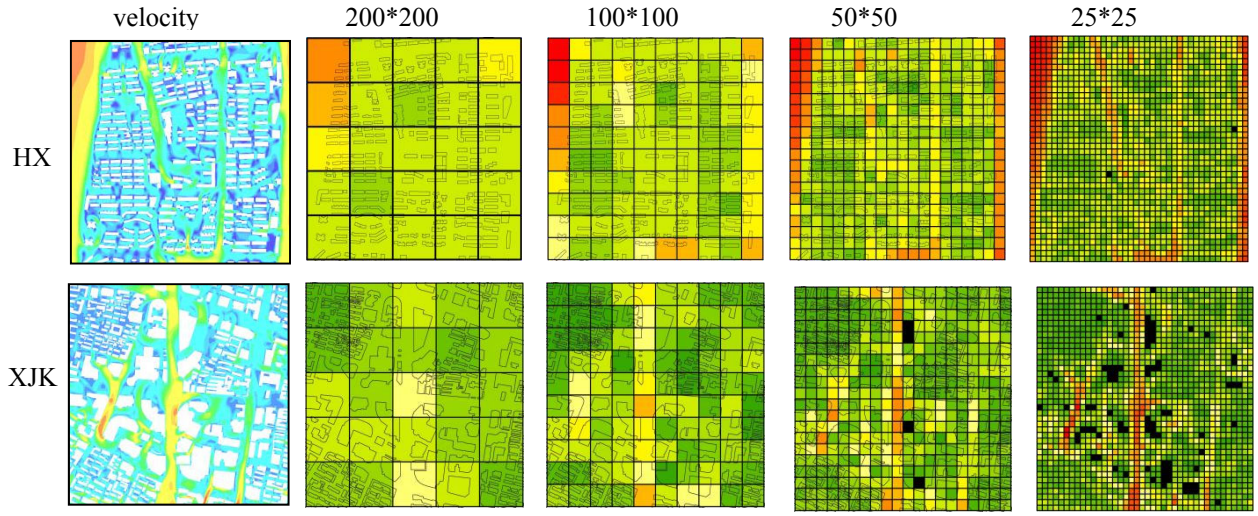

Figure 8. The ventilation indicators results

ANALYSIS

Correlation between morphological indicators and ventilation performance for study units with different sized

In four grids of Case A, as λp and HWR increase, the ventilation performance becomes worse; as Po and SVF increase, the ventilation performance becomes better; In Case B, all four indicators show the same trend as Case A in grids of 100m, 50m, and 25m. But in grids of 200m, four indicators did not correlate with ventilation performance (Figure 9).

Of these, λp and po had the best correlations at grids with side length of 100m and 50m in both cases; they have relatively poor corelations at grids with side length of 200m and 25m. SVF and HWR have better correlation in grids of 100m, 50m, and 25m. Four indicators have better correlation in grids with 100m and 50m. But grids with 100m are less computationally intensive. Therefore, it is better to use a grid with 100m.

With grids of 100m, it can be seen that the correlations of four indicators are better in Case A than in case B. Moreover, in Case A,.SVF shows a strong correlation, followed by λp, Po and HWR show weaker correlations; while in Case B, SVF, HWR and λp all show weak correlation, Po is almost irrelevant. So, we can see Po and HWR have relatively weaker correlation. this may be due to the limitation of these two indicators' caculated methods.

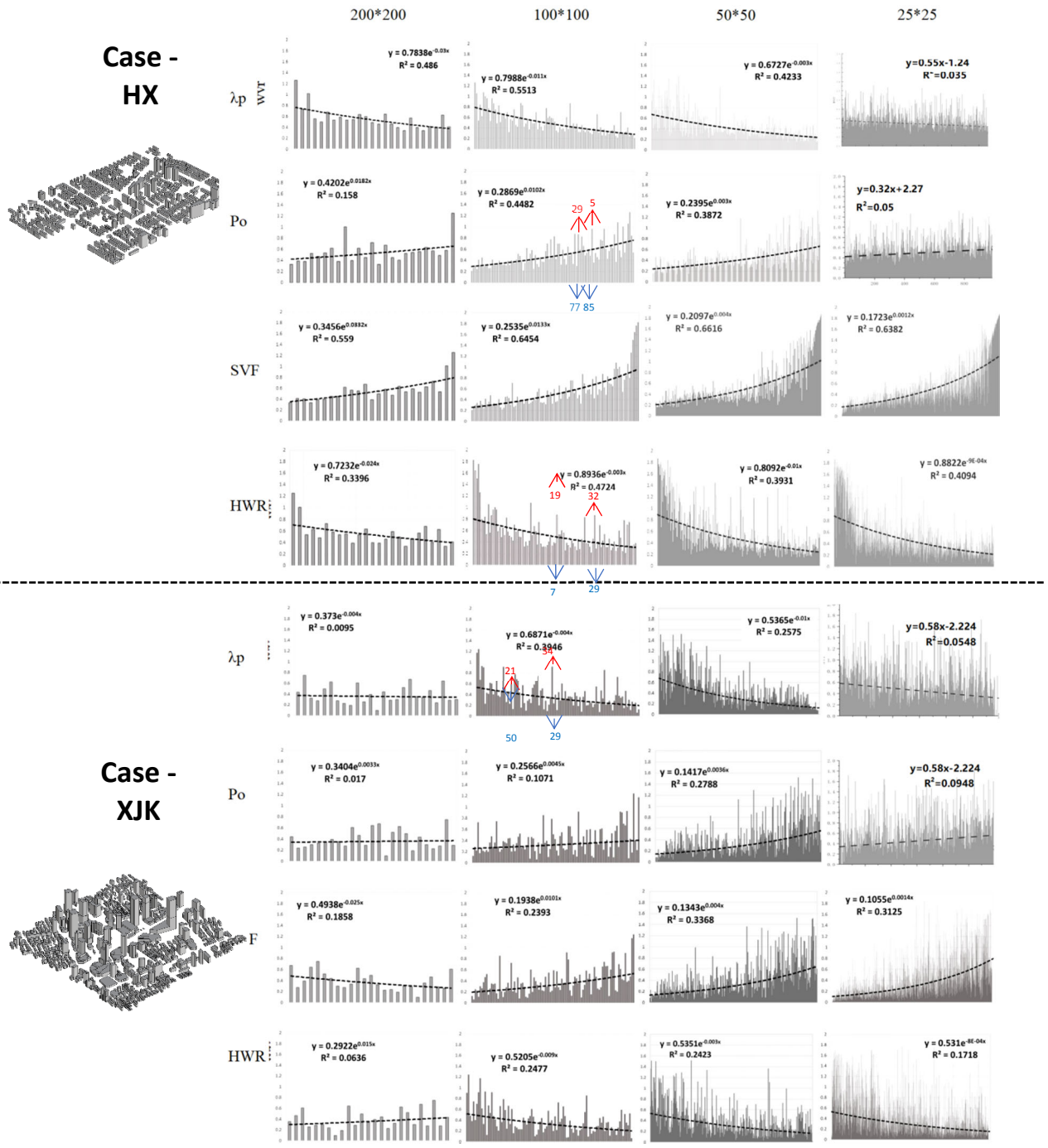

Figure 9. The correlation between urban forms and ventilation performance in two cases under four sized grids.

Impact of cacaulation method of indicators on correlation

Limitation of Po

The calculation of Po emphasizes the difference between the total volume of the study unit and the total volume of buildings within it. This can lead to situations where the total volume of several small and low buildings is the same or similar to that of fewer large and tall buildings. For example, H-S19 and H-S77 have similar Po values, but H-S29 has a higher WVR while H-S77 has a lower WVR. This is due to the fact that, although both H-S29 and H-S77 contain a taller building, H-S29 has another building with a larger volume, while H-S77 has more buildings but with smaller volumes. The sum of the volumes in the latter is similar to the sum of the volumes in the former, hence the similarity in Po. However, the space and buildings in H-S29 are more concentrated, while those in H-S77 are more dispersed. As a result, H-S29 experiences less obstruction to airflow, leading to a higher WVR(Figure 10).

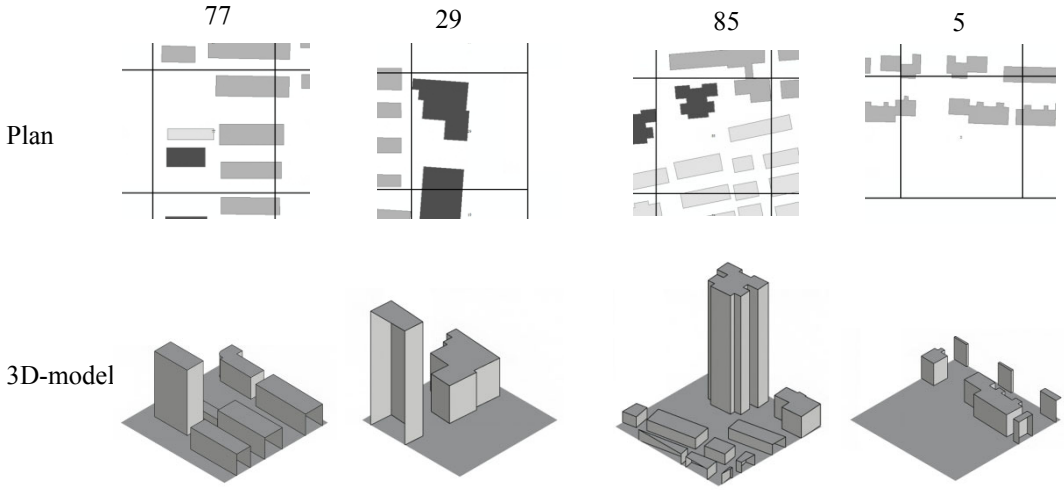

Figure 10. The limiration of Po

Limitation of HWR$_{2_ave}$

The HWR_2_ave can not identify the direction of space. Additionally, the HWR_2_ave value is affected by the data from two specific directions. For instance, H-S 7 and H-S 19 have similar HWR_2_ave values. H-S 19 has a completely open space running north-south on its east side, while C7 has a completely open road running east-west. Both of these open areas are similar in width, leading to a similar HWR for this part of the space. The presence of high-rise buildings in H-S 19 increases its HWR_2_ave value. Although the buildings facing north-south in H-S 7 are shorter, the density is higher, which results in a similar HWR_2_ave for both H-S 19 and H-S 7. However, the direction of the spaces and the degree of enclosure by surrounding structures are completely different for the two areas. The space on the right side of H-S 19 is parallel to the wind direction, which significantly increases its WVRcompared to H-S 7(Figure 11).

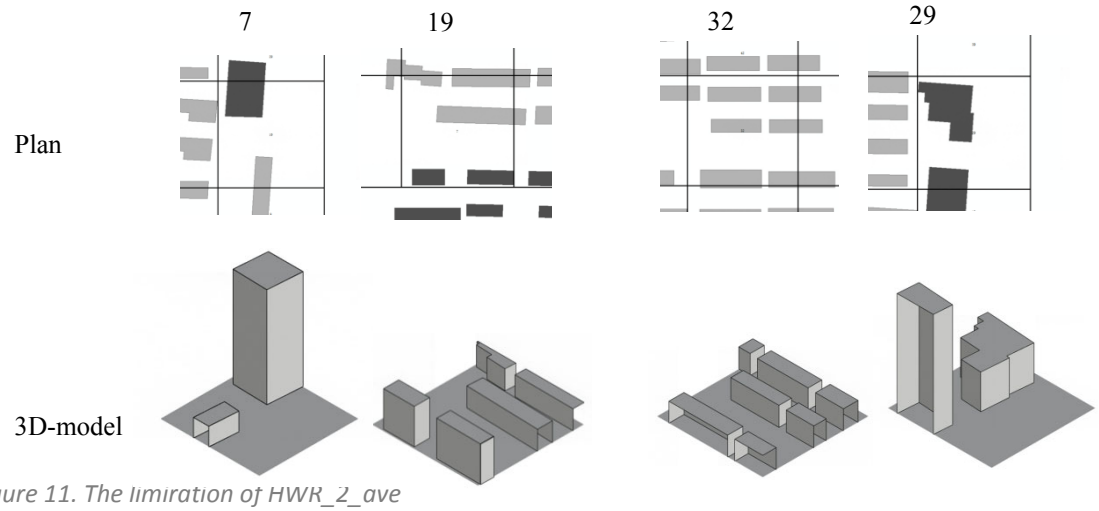

Figure 11. The limitation of HWR_2_ave

Impact of complex morphological features on correlation

Section 3.4 indicates that all indicators show better correlation in Hexi than in Xinjiekou, suggesting that the more complex urban form in Xinjiekou affects the ventilation performance of the space. Therefore, it is necessary to further explore the impact of more complex urban forms on ventilation performance. We select the 100*100m λp in Xinjiekou as a case.

Compared to Hexi, the differences in building footprint and building height in Xinjiekou are larger, both of which can affect the correlation between morphological indicators and ventilation performance. For example, there is a significant difference in the building footprint and the number of buildings within X-S34 and X-S93, yet they have similar λ p values. Althogh X-S34 have only two buildings, but the two buildings' footprints are large. So, the λ p of X-S34 is similar with X-S93 that have several buildings with larger footprings. And wvr of X-S34 is large. This interferes with the correlation between λ p and ventilation performance. Additionally, the location of high-rise buildings can also affect ventilation performance. For instance, X-S21 and X-S50 have similar λ p, but X-S21 have larger wvr. This is because in X-S21, the higher building faces the wind direction, leading to the airflow concentrating near the ground and enhances the WVR of X-S21 (Figure 12).

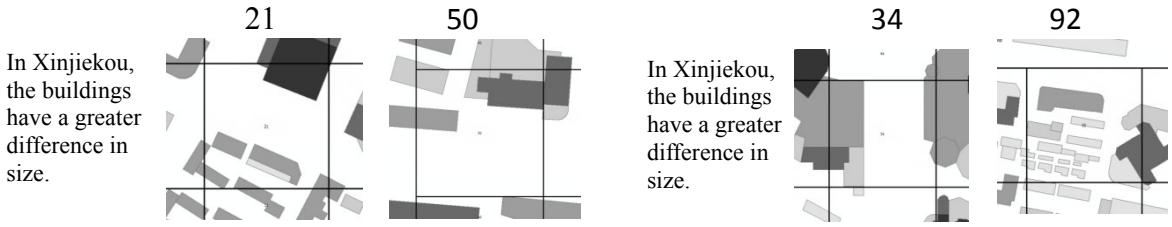

Figure 12. The imapact of complex morphological features on correlation.

CONCLUSIONS

This study uses the Hexi residential area and Xinjiekou commercial centre district in Nanjing as study cases. The two study case are divided by two sized grids (100m*100m and 200m*200m). Based on the

two grid sizes, four morphological indicators (λp, Po, SVF, HWR_2_ave) and ventilation performance indicators (WVR) are calculated, respectively. The study also provides a detailed comparison of the impact of different sized grids, morphological indicators, and cases with morphological characteristics on ventilation performance. The conclusions are as follows:

Among these indicators, λp and SVF have a better correlation with ventilation performance in both morphological characteristics, followed by Po and HWR_2_ave. Po are unable to distinguish between a study unit containing multiple buildings with modest height and a study unit with a few buildings with large height. HWR_2_ave cannot identify the direction of space within the grid. And the HWR_2_ave value is affected by the data from two specific directions.

Among the two grid sizes, 100m*100m and 50m*50m are better choice because theses grids shows better correlation in most morpohpgical indicators in both case studies. But grids with 100m have less computation. Therefore, it is better to use a grid with 100m.

In the homogeneous texture, the correlation of the four indicators with ventilation is better. This is because in the non-homogeneous texture, there are differences in building height variations and building footprint area, which affect ventilation performance. However, these four indicators cannot recognize these morphological features.

From the research results, it can be seen that the correlation of the four indicators is limited in both two cases, especially in Xinjiekou. This is mainly influenced by the limitations of the indicator algorithms and the diverse characteristics of urban form. Therefore, future research is needed to further study morphological characteristics and to supplement morphological feature indicators.

Acknowledgements

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Does being poor in Juiz de Fora imply less access to public leisure spaces?

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ABSTRACT

Leisure public spaces are essential components that promote recreation and diversity in urban environments, providing numerous social benefits to cities. Furthermore, these spaces positively influence the environmental quality of urban areas and the physical and mental health of their residents. However, the distribution and accessibility of these spaces do not always serve the entire population, revealing significant barriers to enjoying leisure in the public domain. The objective of this paper is to analyze access to public squares in Juiz de Fora (MG) based on urban configuration, considering different income and racial groups. The methodology employed includes an analysis of urban configuration through the Theory of Space Syntax, utilizing the Step Depth measure, spatial analysis with QGIS geoprocessing software, and correlation analysis of spatial and socioeconomic data. The results indicate that the distribution and accessibility of the city's squares are not equitable for the entire population, regardless of income or racial background, with particularly adverse conditions for lower-income groups. The configurational analysis of the squares revealed that most are situated in areas of higher integration, which exacerbates the lack of access and negatively affects populations in less integrated areas, regardless of whether they have low or high average incomes. This study concludes that the level of access identified in this research remains insufficient to ensure public leisure and high quality of urban life for the entire population.

Keywords: access, space syntax, income, race, leisure

INTRODUCTION

Leisure refers to time spent away from work, providing opportunities for relaxation and recreation. Open public spaces designed for leisure are essential components of urban environments, positively impacting human health both directly and indirectly. They promote social interaction and enhance environmental quality (Campos and Castro, 2017; Loboda and Angelis, 2005; Oliveira and Mascaró, 2007). Despite these benefits, such spaces are often limited or unevenly distributed within cities.

Leisure activities and consumption patterns among the middle class significantly drive urban transformations (Serpa, 2018). As a result, leisure spaces are often compromised and distributed unequally, primarily affecting the most disadvantaged populations. Considering the significance of

public leisure spaces as essential components for the well-being of communities, it is equally important to understand how access to these spaces can be evaluated and improved.

In the mid-20th century, structuralist trends that utilized computational tools gained significant prominence in recognizing and analyzing the existing conditions of urban space (Hillier, B., Leaman, A., & Stansall, P., 1976; Hillier & Hanson, 1997). The advent of computing technology, coupled with advances in mathematical knowledge, facilitated the discovery of underlying structures in urban design (Hillier, B., Leaman, A., & Stansall, P., 1976). Among the pioneering researchers in this field was Hillier, who sought to understand the relational dynamics between space and society using computational tools (Hillier & Hanson, 1997).

The urban form and its spatial relationships serve as the foundation for the Theory of the Social Logic of Space, or simply, the Theory of Space Syntax. This theory emphasizes the geometry of settlements, adopting a morphological perspective that highlights the significance of a city's shape as a crucial axis of investigation. It has made substantial contributions by interpreting how the configuration of the urban network affects accessibility and mobility. Through its methodology, the theory offers a means to evaluate, among other variables, the ease or difficulty of navigating urban roads. Bafna (2003) asserts that society utilizes space as a vital resource for self-organization, resulting in the configuration of inhabited spaces. The urban fabric can favor certain areas over others, whether in terms of access or urban mobility, thereby influencing route choices and either encouraging or discouraging the use of specific pathways (Medeiros, 2006; Hillier et al., 1993).

The justification for selecting Juiz de Fora lies in its status as the fourth most populous city in Minas Gerais. It has undergone urban development and real estate speculation similar to that of larger urban centers. The city's strategic geographic location—situated between BR-040 and BR-267 and in proximity to major urban centers such as São Paulo, Belo Horizonte, and Rio de Janeiro—along with its extensive array of services, shops, healthcare institutions, and esteemed educational facilities, has attracted significant migratory movements. This influx has contributed to the horizontal expansion of the city’s urbanized area. Intense urban sprawl has resulted in precarious housing clusters, which, coupled with a lack of planning, exacerbate socioeconomic issues and lead to population segregation (Chaves, 2011). As a consequence, access to urban and community public facilities remains limited.

This paper aims to analyze access to public leisure spaces for different income and racial groups in Juiz de Fora, based on its urban configuration. The hypothesis tested is that areas inhabited by a middle-to-high-income white population have a greater supply of, and consequently easier access to, public squares. The methods employed are grounded in urban configuration analyses through the Theory of Space Syntax. The Step Depth measure was selected to assess the configurational access to public leisure spaces using QGIS software, in addition to conducting a correlation analysis between spatial and socioeconomic data. This article is structured as follows: it begins with a review of the existing literature on public leisure spaces and space syntax. Next, it describes the research methodology employed in this study. The findings are then presented and discussed in detail. Finally, the concluding section summarizes the key insights and suggests areas for future research.

Public leisure spaces

The physical dimension of a city consists of both built and open spaces. Open spaces encompass all areas not covered by buildings, referring to any space open to the sky (Guzzo, Carneiro, and Júnior,

2006). These spaces include avenues, streets, squares, parks, backyards, and both public and private gardens, among others. Such elements are essential to daily life, as they contribute to the landscape and urban form, as well as to the history and collective memory of the city (Queiroga, 2011).

Open spaces play a crucial role in urban life, as many activities take place in streets, avenues, squares, parks, and similar areas. These spaces serve an integrated function that encompasses leisure, aesthetics, and ecological considerations (Cavalheiro and Del Picchia, 1992). Collectively, they influence the dynamics of cities and human behavior. Numerous benefits are associated with the creation and maintenance of open urban spaces, ranging from the enhancement of microclimates to their importance for social and cultural practices.

The concept of leisure can be viewed as a privilege that allows individuals to enjoy their time and the city, while also playing a crucial role in fostering relationships among citizens (Rolnik, 2000). Leisure serves both personal and social functions and aligns with the public dimension of society. Open spaces designed for leisure and recreation include public squares, urban parks, botanical gardens, green areas, and any open space that offers opportunities for relaxation, distraction, and enjoyment.

Public squares are urban open spaces designed for active leisure, contemplation, and social interaction. These areas often incorporate vegetation and typically feature urban furniture and recreational equipment (Guzzo, Carneiro, and Júnior, 2006; Brasil, 2020). The existence of these spaces provides numerous benefits to the quality of urban life. They enhance the habitability of the urban environment by facilitating social practices, outdoor gatherings, and expressions of community life, which promote human development and foster relationships among individuals (Oliveira and Mascaró, 2007).

Furthermore, they promote both direct and indirect contributions to the physical and mental health of individuals, primarily in areas characterized by predominant vegetation. The health benefits manifest directly, as the natural environment causes a sense of well-being, reducing stress and contributing to the ability to concentrate and maintain attention (Gressler and Günther, 2013). Additionally, there are indirect benefits, as the improvement of environmental quality—attributable to the presence of vegetation—makes the surroundings more enjoyable and encourages physical activity (Campos and Castro, 2017).

Despite their numerous advantages, public open spaces are often limited or unevenly distributed in urban areas. In Brazilian cities, there is a greater focus on the design and maintenance of public spaces intended for circulation, such as streets and avenues, often at the expense of those designated for leisure (Hijoka et al., 2007). Furthermore, local management through urban planning tends to privilege certain sectors of cities, frequently influenced by pressure from opinion makers or groups within the real estate market.

Space syntax and access

In the early 1970s, Bill Hillier and his colleagues at the Bartlett School of Graduate Studies in London developed a theory known as Space Syntax. The main goal of this theory is to understand the relationship between space and society by examining how spatial patterns carry social information. The theory gained systematization and ambition in Hillier and Hanson through the publication “The

Social Logic of Space" in 1984. Space Syntax employs a spatial-morphological approach, utilizing a set of analytical, descriptive, and quantitative tools to analyze the spatial configuration of urban and built environments. Since its inception, the theory has expanded into a comprehensive framework with a wide range of applications.

One of the main starting points of space syntax is that human society uses space as an essential resource to organize, and by doing that, the inhabited space starts to be configured (Bafna, 2003). According to Medeiros (2006), configuration could be understood as an articulation form or arrangement of structures in a system. It is the relation of a variety of spaces in an urban system and can be associated with morphology because it contemplates senses of position and pattern.

The application of analysis techniques of space syntax to comprehend the morphological logic of urban networks, especially related to urban growth, provided the discovery of the relationship between movement and configuration (Hillier *et al*., 1993). According to the authors, the configuration of the urban network is the main generator of patterns of movement, capable of shaping different social transactions. The spatial elements through which people move, such as avenues, streets, alleys, squares, and so on are linked together to form a global pattern. The influence generated by the urban network in the movement pattern, termed "natural movement," affects potential flow distribution even before land use and occupation are established (Hillier *et al*., 1993).

> In agreement with Hillier *et al*. (1993), natural movement could be defined as:
>
> Natural movement in a grid is the proportion of urban pedestrian movement determined by the grid configuration itself. Natural movement, although not always quantitatively the largest component of movement in urban spaces, is so much the most pervasive type of movement in urban areas that without it, most spaces will be empty for most of the time. It is also the most consistent, so much so that it is difficult to avoid the inference that natural movement is the raison d'être of the urban grid itself (Hillier *et. al*, 1993, p. 32).

For instance, it is possible to observe in Figure 1 (a) that the main street will be used, regardless of the chosen route, as it is a necessary path. On the other hand, Figure 1 (b) shows that flow concentration will be distributed beyond the main street, among the other horizontal roads.

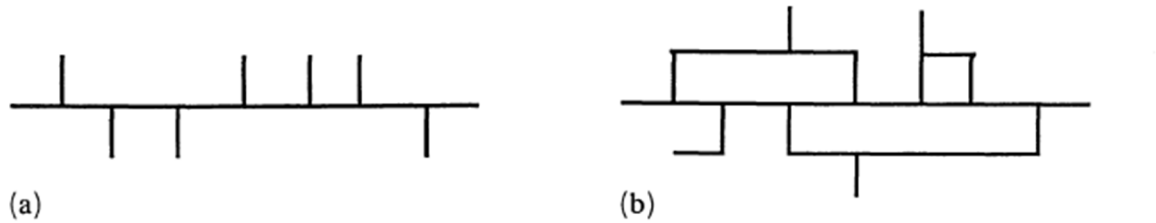

Figure 1: Hypothetical urban networks suggesting different movement patterns. Source: Hillier et al. (1993, p. 29) .

Each configurational pattern corresponds to distinct movement patterns. By concentrating or restricting flow and establishing a hierarchy within an urban system, the configuration prioritizes certain spaces over others in terms of urban mobility. This influences route decisions and either encourages or discourages the use of specific pathways (Hillier et al., 1993; Medeiros, 2006).

Movement attractors, such as commercial areas, function as movement multipliers; however, configuration can also impact movement in ways that are independent of these attractors, indicating that people's flow is not solely determined by land use.

Access is another key aspect, alongside movement, in urban environments influenced by spatial configurations. In this paper, access refers to the ease with which different parts of a spatial layout can be reached from a given point. It also contains an attribute of urban space, balancing the attractiveness of a location with the challenges of access, thereby representing "urban opportunities" for individuals based on their location (Silveira, 2004; Serpa, 2007). In other words, urban opportunities are the possibilities for accessing various locations where individuals can enjoy goods and services, serving as a measure of social inclusion (Castro et al., 2016).

In Space Syntax, access is analyzed through various synthetic measures, including integration, connectivity, choice, depth, control, and step depth, among others. Integration measures how easily a space can be reached from all other spaces within the layout. High integration values indicate spaces that are centrally located and easily accessible, often serving as focal points for movement and activity (Hillier, Yang, & Turner, 2012). On the other hand, connectivity measures the number of directly connected spaces associated with a given space. Higher connectivity typically indicates better access (Klarqvist, 1993).

Choice, also known as "betweenness," quantifies the frequency with which a space serves as a route between other spaces. High choice values indicate that these spaces are likely to be significant for facilitating movement (Hillier, Yang, & Turner, 2012). Depth measures the number of steps or transitions required to reach a specific space from a designated starting point, with lower depth values signifying greater accessibility (Klarqvist, 1993). Control assesses the extent to which a space controls access in relation to its immediate surroundings, taking into account the number of alternative connections available nearby (Klarqvist, 1993). Finally, step depth analyzes the relationship of a specific point within the system to the entirety of the network, following the shortest path from the selected line to all other lines within the system (Turner, 2004). The step depth technique enhances our understanding of the complexity of an urban grid from a human scale perspective.

Space syntax, like any other theoretical framework, has its limitations. It does not fully account for the role of space in the production and reproduction of society, overlooks informational and communicative exchanges, and neglects crucial metrics such as building sizes (Ratti, 2004). Furthermore, factors such as topography, road width, visual fields, and the diverse ways in which people appropriate urban space are not effectively captured by its analyses. Nevertheless, it is essential to recognize these limitations while also appreciating what distinguishes space syntax: its relational scope. The theory aligns with design intuition and opens up new possibilities for exploration (Hillier and Hanson, 1997). Although it does not fully explain urban reality, it significantly enhances our perception of the city.

METHOD

The methodology prioritizes the examination of the urban area of Juiz de Fora, with a specific focus on public squares and urban configuration, while correlating these elements with socioeconomic data derived from the IBGE demographic census sectors. It is important to note that the city features a

variety of public open spaces; however, this study exclusively includes public squares designated for leisure and recreation. Space Syntax was utilized as the primary methodological tool for configurational analyses. The study is limited to the routes within the urban perimeter.

The physical accessibility of the city's squares was calculated using the step depth measure. This technique enabled the analysis of the segments that provided immediate access to the public squares and their relationship to the entire urban system. The measure can be calculated using metric, angular, and topological radii. For this study, only the metric radius was considered, as comfortable walking distances indicated by various authors and urban indicators, are expressed in meters.

DepthmapX software version 0.50 was utilized to process the measurements, as this calculation can only be performed using this software. The values were subsequently imported into QGIS software version 3.16.10 to make the necessary adjustments for mapping. The results of the step depth measurements can be interpreted according to the following parameters:

Table 1. Parameters for interpreting the syntactic results of Step Depth. Source: Adapted from Turner (2004).

Measure		Chromatic Scale
Step Depth	Warm colors indicate the smallest distance from the analyzed segments. Cold colors indicate a greater distance from the analyzed segments. Therefore, the greater the number of lines in warm colors, the shorter the distance to the studied point, favoring accessibility. Axes in cold colors indicate greater distance, corresponding to more difficulty in access.	

The socioeconomic data associated with spatial information focused on population distribution by race or color and average nominal income. Census data were collected from the online database of the Brazilian Institute of Geography and Statistics (IBGE). The objective was to translate social information to a spatial level by creating thematic maps and integrating census data with distribution and spatial syntax analyses. The variables utilized in this study included the average nominal monthly income of individuals aged ten years or older (both with and without income) and the resident population categorized

RESULTS AND DISCUSSIONS

In this study, a total of 80 squares were selected as the sample for analysis, considered as public leisure spaces. The selection of this sample size was based on the Master Plan of Juiz de Fora and the Cadastral Map, and are all located in the urban area. The distribution of the squares is concentrated in Juiz de Fora’s downtown and its surroundings mostly, showing a lack of public leisure spaces in further

neighbourhoods. The configurational access of the squares is best in the central area, justified by the number of spaces and the proximity of one and other.

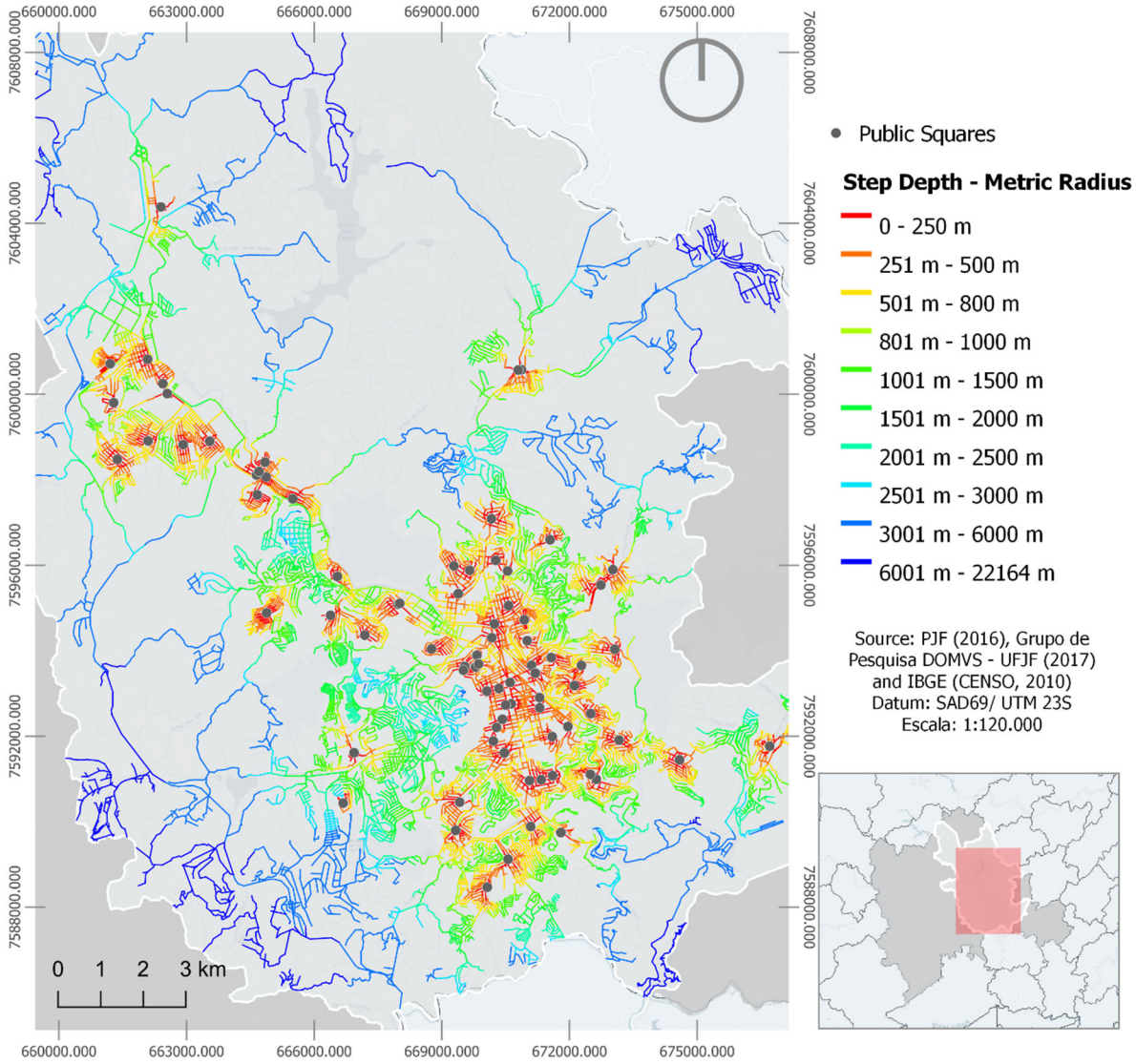

Figure 2: Step Depth measure in metric radius

The step depth measure showed that the squares in the downtown area are either in a radius of 250 metres or 500 metres which means between 3 and 6 minutes walking. If we look at the regions far from the centre we can see, especially in the west and northeast of the city, greater distances to access a public leisure space, indicated by colder tons, making them dependent on public leisure spaces in the closest surroundings. Those regions are also the ones with one of the highest altitudes, which adds another obstacle for the access.

The correlation between the Step Depth data and the income factor showed a moderate negative correlation due to the decrease of income as the step depth increases. When observing the concentration of the points further to the left of the graph, it is clear that almost all income ranges are correlated to some extent with greater proximity to the squares. However, when following the direction of the graphs' trend line, it is possible to say that the census sectors with the greatest

distances to the squares tend to be those with the lowest income. In this way, it can be said that the lower the income, the greater the distance to the squares.

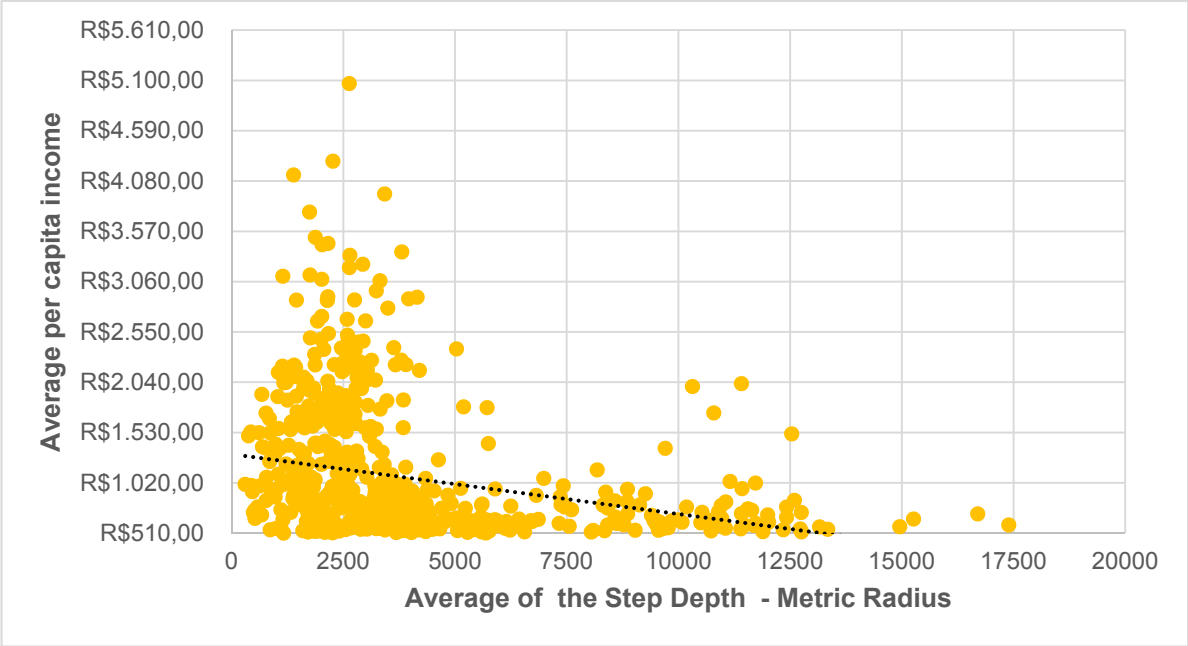

Figure 3: Average per capita income x Step Depth relationship in metric radius

Focusing on the racial composition of Juiz de Fora, 56.96% of the population identifies as white people, while 42.25% identify as black and brown people, according to Fundação João Pinheiro. The white population is mainly concentrated in the central area of the city, extending into adjacent portions, especially towards the west. In contrast, the black and brown populations are primarily located in the eastern part of the city, particularly on the right side of the Paraibuna River, as well as in the southern and north-western urban areas. The watercourse notably serves as a territorial boundary, demarcating the residential areas of different racial groups and highlighting the segregation by race. This pattern of settlement dates back to the beginning of the city's occupation, where the initial urban layout was established on the river's right side.

The comparison between step depth and the resident population by color or race (Figure 4) reveals that mostly white people have access to public leisure spaces, as illustrated in the map overlay. However, this overlay alone does not provide conclusive evidence that black and brown individuals have reduced access to these spaces. Further investigation is needed to obtain a more comprehensive understanding of access disparities. Regardless of color or income, the limited number of public squares in Juiz de Fora affects the entire population. Nonetheless, it is safe to say that low-income residents face greater challenges in accessing these spaces, due to mobility factors. On the other hand, high-income individuals benefit from better urban amenities and have greater access to private leisure facilities. They are also able to reach locations that are more distant without relying on public transportation, expanding even further the disparity in access to public leisure spaces.

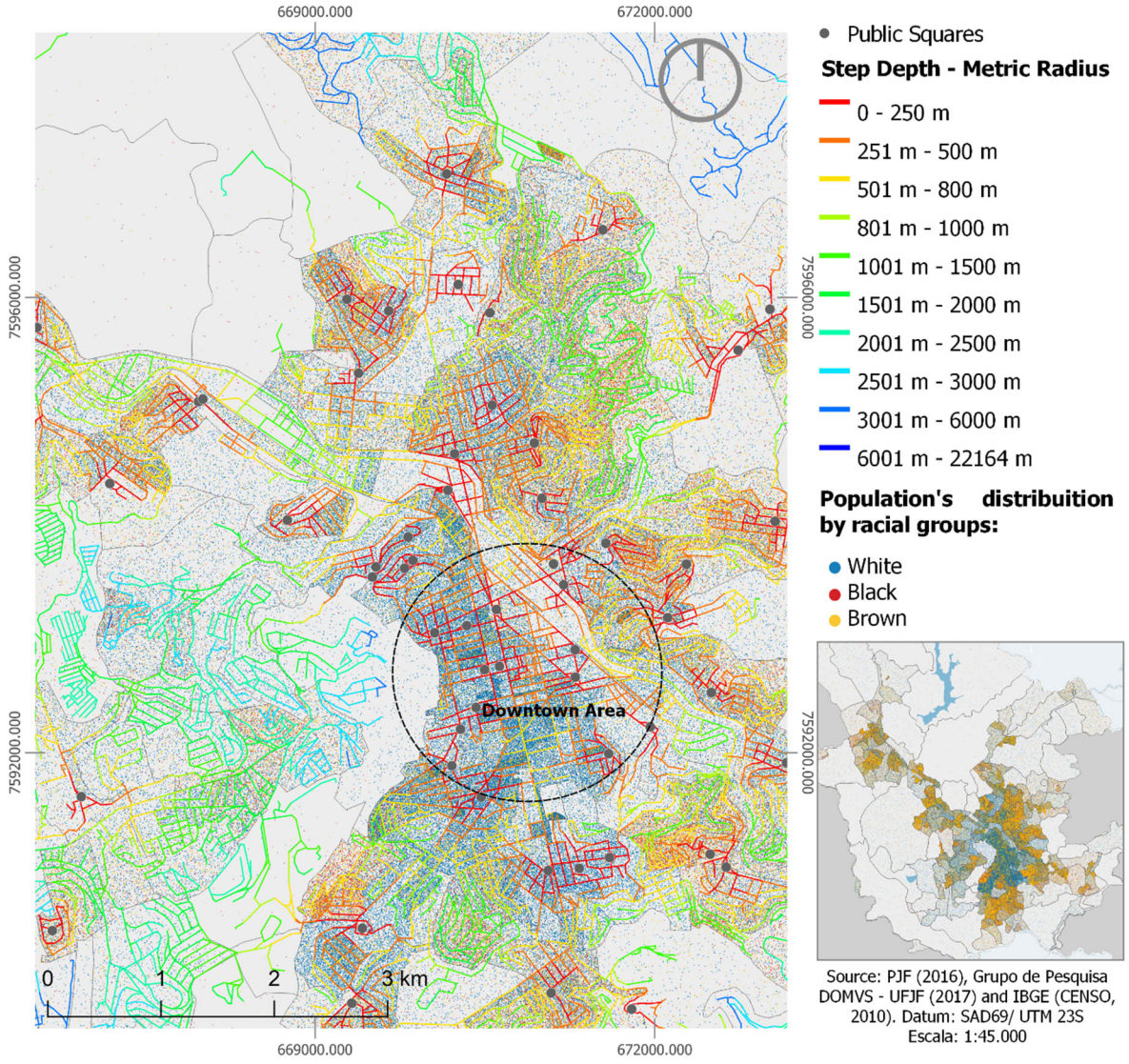

Figure 4 : Step Depth measure in metric radius overlapped with resident population by color or race

The city's topography is another factor that can be added to the socioeconomic and configurational access considerations. Although topography is not directly incorporated into syntactic analysis, it is indirectly captured, as areas with steep relief presented configurational patterns that differ from flatter locations, leading to different syntactic outcomes as well. Places with more difficulty to access public leisure spaces (according to the scale range on figure 2), matched most of the time with steep topography places. In this manner, people who live in regions with more rugged terrain suffer a significant impact on access to public leisure spaces, affecting how easily residents can reach these areas, and also how often they choose to go to those places. Steep slopes and elevated terrains can make it physically demanding for people to access public spaces. This is particularly problematic for individuals with mobility issues, such as the elderly, and those with young children. Additionally, topography can affect the efficiency and availability of public transportation. Steep roads can lead to longer travel times and reduced service frequency. Not to mention that, residents in areas with

difficult topography may face social and economic disadvantages due to limited access to leisure public spaces. This can contribute to social exclusion and reduced quality of life. Communities in hilly areas might have fewer opportunities for recreational activities or social engagement compared to those in more accessible locations.

CONCLUSIONS

Leisure is essential for a high quality of life, and the availability of public spaces for everyone, regardless of race or income, is crucial for fostering social connections. Although public leisure spaces are not always prioritized by governments, they play a vital role in society. These spaces can enhance both physical and mental well-being by promoting physical activity and providing a calming environment that alleviates stress. Furthermore, they offer significant environmental benefits, including improved air quality and the creation of wildlife habitats, while also raising awareness about conservation efforts.

This study examined the accessibility of public leisure spaces based on configuration patterns and sought to determine whether neighborhoods with middle-to-high income white residents have greater access to these spaces. The application of Space Syntax Theory revealed a correlation between configurational patterns and socioeconomic data, particularly income.

According to the syntactic analysis, low-income populations encounter significant challenges in accessing public squares. This issue is further emphasized by the map overlay that compares the distribution of the population by race with the step depth results. White residents generally have greater access to leisure spaces, indicating a disparity in access to public amenities based on race and income level. Nevertheless, it is clear that the number of public squares impacts the entire city.

Access is a continuum and is contingent upon political and economic decisions. The level of access observed in this study is a result of prior decisions and serves as a mechanism that can exacerbate spatial and social inequalities. The findings of this study reveal certain correlations; however, further research is necessary to broaden the scope of the issue and incorporate additional social factors.

Acknowledgements

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Exploring the relationship between the psychological response of pedestrians and urban form

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ABSTRACT

The accelerating trend of global urbanization presents considerable environmental and social challenges, making a shift toward more sustainable and resilient urban habitats imperative. In this context, it is essential to explore the extent to which urban spaces can serve as supportive environments, capable of enhancing the psychophysical well-being and resilience of their inhabitants. A promising transdisciplinary approach in this regard is the concept of restoration, which is linked to the potential of environments to alleviate mental fatigue and foster cognitive clarity and overall mental well-being. However, despite its relevance and broad application in environmental psychology, no studies have systematically examined its connection to urban morphology and morphometry. This paper addresses this research gap by: i. undertaking a web-based survey across three UK cities (i.e., Glasgow, London, Winchester) of different sizes and socio-economic profiles through a methodology specifically designed to assess the stress restoration potential of different urban environments; ii. using a comprehensive set of morphometric indicators to achieve a rich morphological description of the three cities under examination; and iii. investigating the relationship between survey outputs and the set of morphometric indicators through correlation analysis. Findings across the three cities combined suggest that more ordered and Euclidean urban layouts with buildings and plots aligned with their respective streets, simple building shapes, and rectilinear streets, tend to be associated with more stress restoration. Correlations at the city level generally align with this finding but also show locally specific trends. The contribution of this paper is two-fold. It provides one of the first studies of the relationship between aspects of urban form and the psychological response of pedestrians to the urban environment. Second, findings can inform the development of new tools that assess walkability from a more people-centered perspective.

Keywords: Urban MorphoMetrics, walkability, sustainability, people-centered design, environmental psychology

INTRODUCTION

The world is rapidly urbanizing, with official reports projecting that 68% of the global population will reside in cities by 2050 (UN-DESA, 2019). This trend can be seen as positive, as urbanization often leads to improved living standards due to the concentration of economic activities and the provision of cheaper and better public services, including more efficient transport systems (Overseas Development Institute, 2008). However, large-scale urbanization also presents significant challenges, such as heightened socio-economic inequalities (UN-Habitat, 2008; Zhao, 2013) and environmental degradation (Wilson & Chakraborty, 2013), particularly in developing countries. Addressing these challenges requires pursuing more sustainable development forms and retrofitting existing urban areas to ensure safer, more livable, and equitable cities while minimizing urbanization's environmental impact on both local and global scales. Achieving these goals demands contributions from various disciplines, including environmental science, civil engineering, economics, transportation planning, and disaster management, among others. Urban design and environmental psychology also play crucial roles as the structure and perception of places influence a wide array of aspects, including livability and resource consumption patterns. Although there are well-supported theories in both fields regarding which types of urban environments are preferable and what features are conducive to more well-being, the literature on the intersection between morphological and psychological aspects remains underdeveloped.

A promising, yet largely unexplored, bridging concept is represented by the idea of restoration. According to the Attention Restoration Theory (ART) (R. Kaplan & Kaplan, 1989; S. Kaplan, 1995), the interaction between a person and a place can produce cognitive regeneration effects based on four key factors: i. fascination (the environment's 'ability' to attract involuntary attention); ii. extent (the perceived spatial extent); iii. being away (the sensation of being in a different place from usual); iv. compatibility (the compatibility between personal mental maps and the place being experienced/observed). The combination of these factors can result in different levels of restorative potential attributed to a specific place. Typically, such values are the highest in 'designed' green spaces (parks, gardens) and built environments of high historical-cultural value (Fornara & Troffa, 2009; Staats et al., 2016). Furthermore, restoration effects are typically linked to the perception of environmental preference and subjectively perceived well-being, suggesting that high restorative potential generally corresponds to a positive subjective experience (Pasanen et al., 2018). Moreover, some scholars (Gillis & Gatersleben, 2015) highlighted connections between the physical characteristics of a space and its associated restorative qualities. Key elements include materials such as wood and water, the presence of natural light, and views of the sky. The availability of fractal architectural forms has also been shown to enhance restorative qualities, as these patterns mimic the complexity found in nature. Additionally, biomimicry, the imitation of natural environments, plays a role in fostering a restorative experience (Gillis & Gatersleben, 2015). Another important factor is the ability of a space to provide both prospect and refuge (Appleton, 1975) – offering a sense of control over the surroundings without being easily seen. While these studies provide qualitative insights into what kind of urban environments tend to be associated with more restorative potential, systematic and numerical descriptions of the morphological structure of these environments are largely missing. The analysis presented in this paper is therefore one of the first attempts to systematically study the relationship between a comprehensive set of 74 morphometric indicators (primary characters) derived from Urban MorphoMetrics (UMM), an established approach to measure urban form

characteristics and identify morphological regions in cities (Fleischmann et al., 2022), and stress restoration responses, obtained through a survey focusing on three UK cities (Glasgow, London and Winchester).

METHOD

The methodology presented in this paper relies on the UMM approach for identifying distinctive morphological regions or urban types (UTs) from where to extract survey images in the case studies under examination and for obtaining a comprehensive set of morphometric indicators to study in relation to the survey outputs.

Urban MorphoMetrics (UMM)

UMM is a quantitative approach to measure the morphological structure of human settlements at the level of the main components of urban form, that is the building, the plot and the street segment (i.e., the line connecting two sequential intersections in the street network) (Fleischmann et al., 2022). Since plots are ontologically ambiguous (Kropf, 2018), UMM automatically generates plot proxies called morphological cells (or simply cells) from building footprints and streets through a Voronoi-based partitioning of space. The workflow consists of two main steps: i. computation of a comprehensive set of morphometric characters for each cell; ii. clustering such characters to identify distinctive UTs.

UMM operates using minimal information, specifically georeferenced polygons representing building footprints (with heights attached) and georeferenced lines representing street segments. The urban form is described based on 74 primary characters, which account for six key morphological properties (dimension, shape, spatial distribution, intensity, connectivity, and diversity) of buildings, plots (cells) and streets, across three scales (small, medium, and large) (Fleischmann et al., 2022). Four measures are then calculated for each primary character, resulting in a total of 296 contextual characters:

- Interquartile mean: the average of the values between the first and third quartiles of the distribution.
- Interquartile range: the range of values within the central 50% of the distribution.
- Inter-decile Theil index: a measure of local diversity.
- Simpson diversity index: a measure of the heterogeneity of values.

The contextual characters are computed up to the three topological steps from each cell and reflect the local tendency of the primary characters. Agglomerative hierarchical clustering (AHC) with a KNN = 3 spatial constraint is then applied to these contextual characters to identify UTs. As described by Venerandi et al. (2021), this clustering technique is preferred because it tends to output UTs with fewer misclassified cells. The silhouette score, a heuristic technique to assess the quality of the clustering (Rousseeuw, 1987), is used to identify the optimal number of UTs in each case study.

Psychological survey of the urban environment

The psychological dimensions of the urban environment were assessed using the exp-EIA© (Experiential Environmental Impact Assessment) method (Piga et al., 2023). This method was designed to address the crucial need for collecting data that capture collective experiences within urban spaces.

The final aim is to promote collaborative urban design processes through an evidence-based approach. The exp-EIA© method, grounded in environmental psychology and design sciences, enables the measurement of urban experiences across three main dimensions: emotional, cognitive and community/identity. By integrating these dimensions, it provides a comprehensive understanding of how urban environments impact human experiences. It also offers the capability to spatialize data in real-time and collect it through photographic stimuli (panoramas) and digital means (AR and VR), as well as through direct interaction with the environment. To the purpose of this research a digital platform employing spherical panoramas as stimuli was utilized as main tool. The following variables have been investigated:

- Sociodemographic variables: age, gender, residence, level of education, perceived national identity.

- Level of familiarity with the cities.

- Emotional dimension: measured through an affective slider referring to two orthogonal axes (pleasure and arousal), derived from the circumplex model of emotions (Russell & Lanius, 1984).

- Cognitive dimension: environmental preference was measured through four items addressing four main factors (coherence, legibility, complexity, and mystery), according to the Preference Matrix model (S. Kaplan, 1987).

- Restorative effects: according to the Attention Restoration Theory (ART) (R. Kaplan & Kaplan, 1989; S. Kaplan, 1995), the perceived restorative potential of every place was measured addressing four variables (extent, being away, fascination, compatibility).

In this paper, only data related to restorative effects (point 5) were analysed.

Selection of panoramic street views for the survey

UMM was separately applied to the case studies under examination to obtain UTs. The number of panoramic street views for each case study and UTs was decided based on their size, geographic position, and general socio-economic information in order to capture a relevant cross-section of the country where the case studies are located. The choice of how many panoramic street views to include in the survey accounted for the fact that each street view must be evaluated multiple times to hold statistical relevance, survey length, and modality (whether online or offline or a mix of both). The next step requires extracting centroids from each street segment of the case studies under examination, randomly selecting a number of these centroids in each UT based on the rationale illustrated above and downloading the panoramic street views for the centroids' coordinates from online services, such as Google Street View, Mapillary and KartaView. The selected panoramic street views were visually checked to ensure there are no distortions, flares, or other visual issues. If any issues were present, a different street view from the same street segment was selected as replacement. The selected panoramic street views were then uploaded to the survey platform.

Data aggregation and correlation analysis

UMM's 74 primary characters were computed for all the cells in the case studies under examination. However, to analyze the relationship between these characters and the survey outputs, the analysis was restricted to the areas around the panoramic street views, and the characters within these areas,

originally computed for single cells, were aggregated using the median value (a measure of central tendency). To achieve this, only the cells within a 200-metre radius of the selected survey points were retained for the analysis. To account for skewed distributions in the data of both survey outputs and the 74 primary characters, the Spearman correlation was implemented to analyze the relationship between the two. Spearman correlation evaluates a monotonic relationship based on ranks rather than continuous values, making it more robust in the face of skewed distributions. This correlation test produces two results: a coefficient (r_s), which ranges from -1 (indicating a perfect negative relationship) to 1 (indicating a perfect positive relationship), and a p-value, which indicates the statistical significance of the test.

APPLICATION

The morphometric taxonomies of Glasgow, London and Winchester

The analysis presented in this paper focuses on three UK cities: Glasgow, London, and Winchester, which differ in size (city, metropolis, town), geographic location (Scotland and England), and socio-economic profiles (relatively deprived, mixed and well-off). Building footprints (with heights) and street segments for these three cities are obtained from Ordnance Survey's MasterMap Building Height Attribute[57] and the OS Open Roads[58]. Following the UMM approach presented in the Methodology section, 74 primary characters are computed in each city from this data. Contextual characters were then computed and AHC was applied to explore possible clustering solutions. Silhouette scores were used to guide the selection of the optimal number of UTs for each case study, resulting in 14 UTs for Glasgow (Figure 1), 15 for London (Figure 2), and 10 for Winchester (Figure 3). General overviews of these cities, along with brief accounts of the correspondence between main historical-morphological phases and UTs, are presented next.

[57] *https://www.ordnancesurvey.co.uk/products/os-mastermap-building-height-attribute*

[58] *https://www.ordnancesurvey.co.uk/products/os-open-roads*

Glasgow

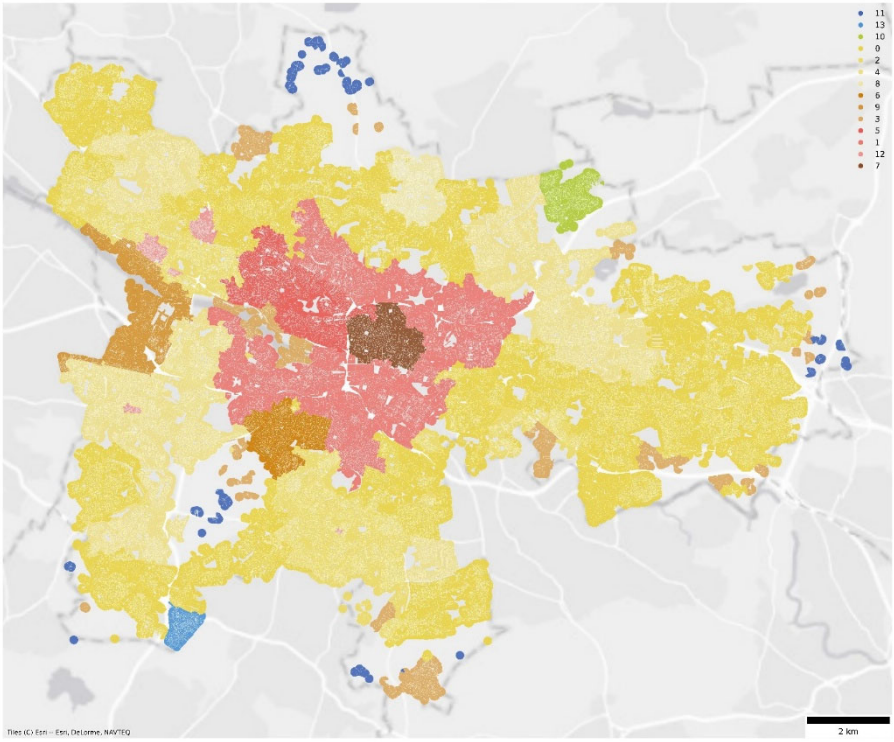

Figure 1. Morphometric taxonomy of Glasgow. The more similar the colors, the more similar the urban form of the UTs. Source: the authors, Esri, DeLorme, NAVTEQ.

Glasgow's historic core developed around the cathedral and High Street in the 12th century but shifted overtime. This shift, driven by economic growth—first through trade and later by various industries, occurred from the 18th to the late 19th century. The city expanded first westward (UT5), then to the southeast and north. The Merchant City (UT7), established during the 18th-century commercial boom, is characterized by its rigid orthogonal grid and now-repurposed warehouses. Glasgow's industrial surge in the 19th century dramatically expanded the city's population, reaching over 1 million residents by the 1930s. Residential areas from this period are marked by tenements, which maintained a consistent typology across the city but varied in character depending on the social classes they housed. Sandstone villas (UT6) were prominent in wealthier areas, and this typology persisted with more modest forms in later developments (UT2 and 4). Lush green spaces and significant architectural landmarks were also established during this time. By the early 20th century, overcrowding in tenements, coupled with the impact of two World Wars, led to a rapid decline in Glasgow’s housing stock. This decline spurred comprehensive redevelopment in large portions of the inner city, with modernist principles implemented in peripheral estates (UT0, 4, and partly UT2) and inner-city estates. The city's population decreased to 630,000, and many industrial and transport infrastructure areas, including the River Clyde, were repurposed for smaller-scale industry and depots (UT9 and 3). Redevelopment efforts in the 1950s and '60s, such as the controversial M8 motorway and the more recent M74, disrupted urban cohesion but also encouraged private development towards the city's fiscal boundaries (mostly UT2, with variations like UT6 and UT13). Today, Glasgow continues to focus on retaining its traditional areas and creating new ones based on placemaking principles, prioritizing safe, efficient transport alternatives and more walkable environments.

London

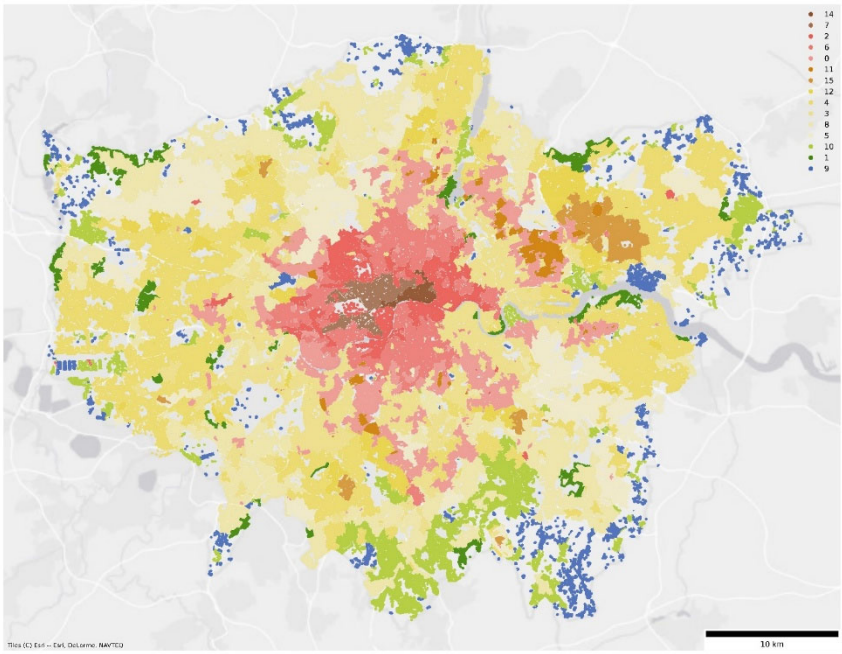

Figure 2. Morphometric taxonomy of London. The more similar the colors, the more similar the urban form of the UTs. Source: the authors, Esri, DeLorme, NAVTEQ.

Following the establishment of Londinium – now commonly referred to as the Square Mile – on the River Thames by the Romans in 47AD, the city has experienced remarkable levels of growth which have led to it becoming one of just two Alpha ++ cities globally along with New York.[59] These two places are the most integrated with the global economy across the world. London's growth was limited through the medieval, Tudor and Stuart Era's, which involved some expansion beyond the Roman city walls, the construction of the Tower of London, and the establishment of Westminster as a seat of government. Driven by the industrial revolution, between the start of the Georgian period and the end of the Victorian, the population of London increased over ten-fold from 630,000 to 6.5 million and the physical growth of the city followed suit. In the form of dense streets and terraces the city extended to Alexandra Palace to the north and Tooting Common to the south. There is a loose but perceptible relationship between the taxonomy presented in this paper (Figure 2) and growth periods within London. The Square Mile (UT14) is picked out clearly by the analysis, but there is little distinction between development within the Georgian and Victorian periods of expansion, which are defined within UT2 and UT6, indicating that the form of development in these periods was quite similar, even if there may have existed architectural deviations. Notably, the Georgian expansion of the Square Mile immediately west, through the vehicle of the great estates, is highlighted clearly by the analysis (UT7). The great estates represent a collection of large areas within central London that have been owned and managed by aristocratic families for centuries. Development within the great estates is unique and characterized by formal street patterns, terraces of townhouses or mansion blocks, and the incorporation of communal greens with strong boundary treatments. Over the 20th century, population growth and the growth of the city became decoupled, and the land area of the city increased significantly despite a fractional increase in its population. This resulted from efforts in

[59] *https://gawc.lboro.ac.uk/gawc-worlds/the-world-according-to-gawc/world-cities-2022/*

the inter- and post-war periods to improve housing conditions for the poor by demolishing dense inner-city neighbourhoods in need of modernization and rehousing their residents in lower density suburbs (UT 5, 8, 3, 4, 12). Supplementing the Victorian suburban development that came before it, this period of construction led to the position we are in today whereby most of the land within the M25, the city's ring road, has been urbanized.

Winchester

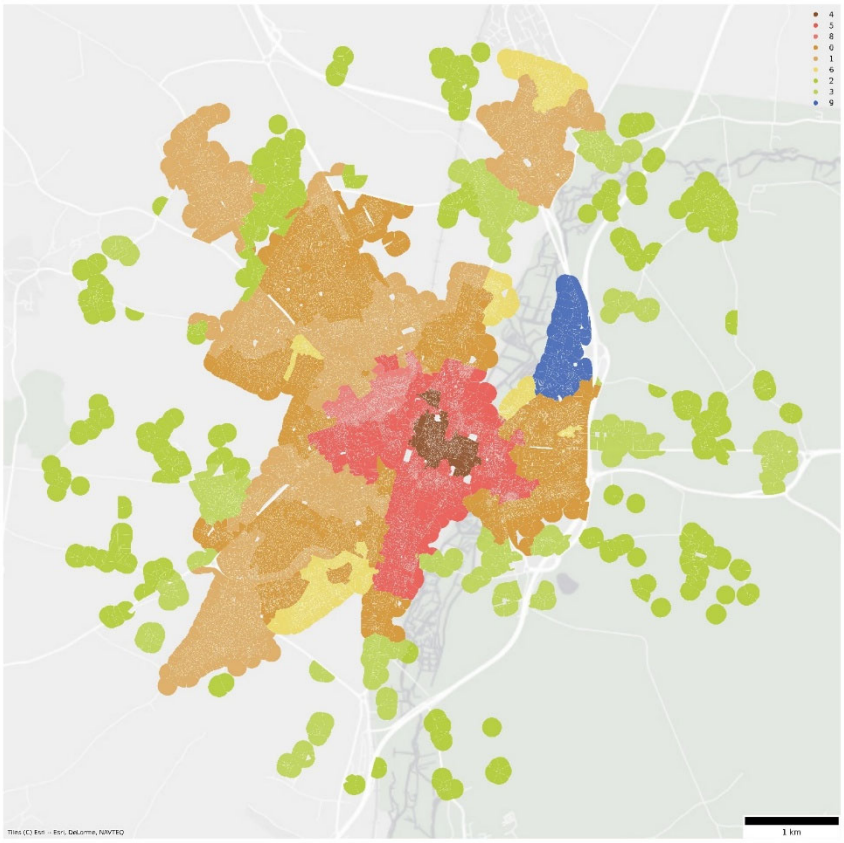

Figure 3. Morphometric taxonomy of Winchester. The more similar the colors, the more similar the urban form of the UTs. Source: the authors, Esri, DeLorme, NAVTEQ.

Winchester represents one of the most established settlements in the UK, with origins in the iron age before it was established as the Roman town of Venta Belgarum. The historic core of the city (UT4) follows the street grid that was imposed by the Romans after diverting the River Itchen. Outside of the historic core of the city, two phases are highlighted clearly by the morphometric taxonomy (Figure 3), first with UT2 and UT8 and later with UT0, UT1, and UT6. All the streets within UT2 and UT8 had been formed before the end of the Victorian period. The remaining development occurred after the Second World War in a period where car ownership became the norm, allowing less dense development forms which were designed to cater for vehicles. There exists a unique character area (UT9) to the north-east of the city which is highlighted in blue in Figure 3. This industrial centre emerged in the second half of the 20th century when it became possible to move goods in enormous quantities by road. It is strategically located adjacent to the M3, and its form is heavily influenced by its function, which is of a vastly different nature to other more residential development forms throughout Winchester.

Selection of survey points in Glasgow, London and Winchester

As described in the Methodology the number panoramic street view for each case study and UT were decided based on their size, geographic position, and socioeconomic status. The total numbers of survey points included 70 points for Glasgow, 105 for London and 27 for Winchester. To select the locations of the survey points in each city, the following steps were performed: firstly, each street's centroid was assigned to the UT of the closest cell; secondly, to determine how many points should be selected in each UT, the total number of survey points was divided by the total number of UTs in each city (resulting in 5 points per UT in Glasgow, 8 in London, and 4 in Winchester); thirdly, street segments centroids were randomly selected in each UT. Panoramic street views were gathered using the geographic coordinates of the selected street centroids and uploaded to the survey platform. Samples of these panoramic street views for Glasgow, London, and Winchester are provided in Figure 4. After selecting the survey points, 200-metre buffers were created around each point, and the values of the primary characters were aggregated by calculating their medians.



Figure 4. Samples of raw panoramic street views for Glasgow (Charles St, G21 2QA, top), London (Marne Rd, RM9 4BU, middle), and Winchester (Jewry St, SO23 8SA, bottom). Source: Google Street View.

Survey outcomes

182 people responded to the survey who evaluated 201 scenes from the three cities under examination. This resulted in 2,206 evaluations, with an average of about 11 evaluations per scene. The gender distribution of the respondents was evenly split, with 48.3% identifying as male and 48.3% as female, while 3.4% as non-binary. The average age of the respondents was 44.6 years. Regarding educational background, 3.3% of the respondents declared a lower secondary education level, 19.8% an upper secondary education level, 29.1% held a bachelor's degree, 35.2% had a master's degree,

and 12.6% had post-master's education. Most of the respondents were from the United Kingdom (68.7%), with the remaining 31.3% coming from other nationalities, including 4.9% from India and Italy. The average self-reported knowledge of the cities was 3.35 for London, 2.42 for Winchester, and 2.23 for Glasgow.

The results on regenerative potential divided by city show a moderate variability in average values, with slightly higher scores for Glasgow (m = 2.78), followed by London (m = 2.68) and Winchester (m = 2.58). However, there is a wide value variability within the three cities. In London, the highest score is achieved by survey point 102 (m = 4.11, the highest value among all evaluated images and the only one to exceed 4) (Figure 5, middle left). Six other points showed relatively high scores greater than 3.5. On the opposite end of the ranking, four points scored equal to or less than 1.8, with point 112 scoring 1.68 (Figure 5, middle right). In Glasgow, three points show an average restorative potential of 3.5 or higher, with survey point 62 showing the greatest value (m = 3.72) (Figure 5, top left). On the opposite end, only survey point 51 scores below 1.8 (m = 1.75) (Figure 5, top right), while two other points have scores equal to or lower than 2. Finally, Winchester generally shows lower scores compared to the other two cities. Survey point No. 2 has the highest score (m = 3.5) (Figure 5, bottom left) and three other points exceed the value of 3. On the opposite side, the lowest score in Winchester (and across the set of cities under examination) is recorded at survey point 27 (m = 1.55) (Figure 5, bottom right), while two other points do not exceed the threshold of 2.



Figure 5. Extracts of panoramic street views with the highest (left column) and lowest (right column) restoration scores in Glasgow (top row), London (middle row) and Winchester (bottom row). Source: Google Street View.

Analyzing the relationship between survey outcomes and urban form

Spearman's correlation was applied to all pairwise combinations of primary characters and the stress restoration metric, both across the three cities combined (Table 1) and for each city individually (Table 2). In general, only a few (8 on 74) correlations were statistically valid (p-value <= 0.05) and correlations were weak (r = 0.14) to moderate (r = -0.6). These results were, to some extent, expected, as single morphometric indicators alone can hardly describe complex phenomena like those considered in this study.

Table 1. Spearman's correlations between primary characters and stress restoration across the three cities combined. Only statistically significant correlations are shown (p-value <= 0.05).

Primary character	Corr.	p-value
Proportion of 3-way intersections	-0.2189	0.001796
Street misalignment of a building footprint	-0.1912	0.006564
Shape regularity of a building footprint	0.1590	0.024163
Street misalignment of a cell	-0.1535	0.029562
Linearity of a street segment	0.1446	0.040493

The results of the analysis across the three cities suggest that greater stress restoration is associated with smaller proportions of 3-way intersections (r = -0.21), smaller angles between the axes of buildings and nearby streets (r = -0.19), as well as between cells and nearby streets (r = -0.15), buildings with simpler shapes (few or no recesses or protruding elements) (r = 0.16), and more rectilinear streets (r = 0.14). In summary, stress restoration tends to be linked to more regular urban fabrics, likely characterized by greater proportions of 4 (or more)-way intersections, buildings and plots aligned with their respective streets, compact/simple building shapes, and rectilinear streets.

Table 2. Spearman's correlations between primary characters and stress restoration in Glasgow, London and Winchester. Only statistically significant correlations are shown (p-value <= 0.05).

City	Primary character	Corr.	p-value
Glasgow	*Coverage area ratio of a cell*	0.2805	0.018682
	Corner irregularity of a building footprint	0.2575	0.031395
London	*Squareness of a building footprint*	-0.2166	0.026496
	Street misalignment of a building footprint	-0.2061	0.034886
	Volumetric complexity of a building	-0.2060	0.03496
Winchester	*Proportion of 3-way intersections*	-0.5955	0.001331

The patterns observed across the three cities combined only partially hold when analyzing relationships for each city individually. More specifically, like in the former, stress restoration tends to be associated with more regular urban fabrics, typified by smaller proportions of 3-way intersections, in Winchester, smaller angles between the axes of buildings and nearby streets and less volumetric complexity, in London. However, different patterns also emerge. In London, more elongated buildings, which are likely the result of densification processes related to the burgage cycle (Conzen, 1960), are associated with higher levels of stress recovery, suggesting a connection with denser and more historic city parts. Similarly, in Glasgow, density, measured in terms of plot coverage, and buildings with more irregular corners are associated with higher levels of stress recovery.

DISCUSSION, LIMITATIONS AND FUTURE WORK

The preliminary results presented in this study align with several insights from the literature on environmental cognition (S. Kaplan, 1987), suggesting that higher environmental preference and restoration scores stem from a perceived balance between understanding (ease of reading and mapping a space) and exploration (formal variability of the buildings). In terms of regular layouts, the "Gestalt laws" (Wertheimer, 1938) indicate that the perceptual system naturally tends to recognise regular and closed shapes in space. Similarly, other scholars (Yusli et al., 2021) emphasised the importance of perceived compatibility between individual cognitive schemas and the environment as a key factor in experiencing well-being within it, particularly due to its relationship with perceived safety (Stragà et al., 2023). Given the previously mentioned correlation between environmental preference and perceived restorative qualities, it is also possible to hypothesise that the high scores obtained from high-density environments and buildings with irregular footprints may be linked to the historical value of a place, which is a key factor in environmental preference (Stamps & Nasar, 1997). Additionally, Stamps (1999) has noted that the complexity of a building's facade is a significant predictor of preference, particularly in relation to its implied historical value. The analysis presented in this paper provides insights into the correlations between stress restoration and individual metrics of urban form. However, urban environments are multifaceted entities composed of multiple, interconnected features rather than single, isolated ones. Future work may thus consider summarising the metrics of urban form, for example, through clustering techniques, to obtain categories of urban fabrics that describe the morphometric complexity of different urban environments in a more comprehensive manner and test the correlation between stress restoration and these categories.

Further limitations concern the survey methodology. Weather conditions can influence responses. For example, it is possible that cloudy street views score less due to overcast conditions. Similarly, street views with greenery may receive higher scores because humans tend to find restoration in natural elements. A further limitation concerns the fact that the survey was not carried out in the real world. Respondents did not directly experience the streets they evaluated, which may have affected the scores they assigned. Similarly, the place where they took the survey (e.g., their own living room, office, coffee shop) and on what device (e.g., phone, laptop, PC) may have impacted the scores. The correlations found in this study do not imply causation, meaning that changing the configuration of streets according to the findings of this study may not improve stress restoration. More robust techniques of data analysis should be implemented to account for the cofounding factors mentioned above and investigate causal links. Although the analysis in this paper focuses on a cross-section of representative British cities, the findings are not universally applicable but may still inform broader discussions. Psychological surveys, morphometric assessments and correlation analysis should be carried out in other geographic contexts to extend the generalisability of the findings.

CONCLUSIONS

Both urban morphology and environmental psychology can contribute to achieving more sustainable forms of urban development. However, while both disciplines investigate and identify the features of the urban environment which tend to be better for pedestrians and residents, systematic approaches which harmonize both disciplines seem to be lacking. In this paper, we propose a methodology to reach this aim by: i. conducting a survey in Winchester, London, and Glasgow, using a method to evaluate the stress restoration potential of different urban settings; ii. employing a range of

morphometric indicators to provide a detailed morphological analysis of the cities studied; and iii. using correlation analysis to examine the relationship between the survey results and the morphometric indicators. The outputs of this analysis across the three cities combined show that more geometrically regular spaces, characterized by buildings with regular footprints, rectilinear streets, building footprints and plots aligned with their respective streets, are associated with more stress restoration potential. The patterns observed across all three cities apply only partially when examining the relationships within each city separately. The main differences are that higher density in Glasgow and more irregular building shapes in both Glasgow and London are associated with higher levels of stress restoration. Previous findings in environmental psychology seem to corroborate these preliminary results. The ease of reading a space (and perceiving it as more aligned with personal mental schemas), along with the formal variability of buildings, was found to be associated with better restoration scores. Furthermore, humans' perceptual system tends to more easily recognize regular and closed shapes in space. While this study has several limitations, primarily related to the lack of control variables (e.g., socioeconomic information on survey respondents, weather conditions in panoramic views), it paves the way for further research at the intersection of quantitative analysis in urban morphology and environmental psychology, potentially shedding more light on what forms of urban development better align with positive psychological responses of city dwellers.

Credits

Dr Alessandro Venerandi: Conceptualization, Supervision, Methodology, Data Curation, Investigation, Formal Analysis, Software, Writing, Visualization; Dr Barbara Piga: Conceptualization, Methodology, Formal Analysis, Investigation, Writing, Supervision, Project administration, Funding acquisition; Dr Marco Boffi: Conceptualization, Methodology, Formal Analysis, Investigation, Writing, Supervision, Project administration, Funding acquisition; Dr Gabriele Stancato: Data Curation, Formal Analysis, Investigation, Software, Writing; Dr Nicola Rainisio: Conceptualization, Methodology, Formal Analysis, Investigation, Writing; Hal Mellen: Funding acquisition, Formal Analysis, Writing; Dr Ombretta Romice: Formal Analysis, Writing; Prof Sergio Porta: Funding acquisition, Writing.

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Morphological patterns as condition to climate change urban adaptation

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ABSTRACT

Climate change is currently discussed as one of the greatest challenges for humanity. Its effects on the configuration of cities are evident, as they arouse the need for interventions to adapt them. However, the cities are very heterogeneous, so that depending on the morphology of the occupation, availability of free areas, topography, density and built typology, associated with the specific climatic issues of each location, indicate the need of different strategies. In this sense, the main objective of this study is to indicate possible urban intervention guidelines for adaptation on different urban fabrics at Metropolitan Area of São Paulo, concerning Urban Heat Island (UHI), based on the urbanistic studies that our research group has been developing in areas which suffer with extreme phenomena such as Paraisopolis, Lapa, Franco da Rocha, among others; combined with the Local Climate Zones System. The methodology adopted relates concepts and methods of climate sciences with morphology and urban design. The work steps include: literature review; production and analysis of maps and georeferenced aerial photos from official databases on watersheds, flood areas, land use and occupation, transport systems, surface temperatures, vegetation, topography, social vulnerability; classification of the studied areas according to the Local Climate Zones - LCZ; consultation of sustainable urban systems manuals; data analysis and development of guidelines based on urban design and nature-based solutions criteria and focused on the surfaces temperature. The findings of this research indicate that interventions for climate change cities adaptation may include the increase of vegetation cover, the implementation of Sustainable Drainage Systems and Green-Blue Infrastructure for the different typologies of urban fabrics, respecting their morphological specificities and climatic conditions, which can guide future public policies. Conclusions suggest that the urbanization model of Brazilian cities aggravates the effects of climate change demanding urgent revision.

Keywords: local climate zones (LCZ); urban heat island (UHI); surface temperature

INTRODUCTION

Climate change stands as one of the most pressing challenges of our time, impacting various aspects of human life and the environment, where the configuration and resilience of cities are put to the test. Over the past decade, the frequency and intensity of extreme events such as Urban Heat Island (UHI), floods, landslides, and potable water shortages, have intensified. Architecture and urbanism play crucial roles in this urgent and necessary process of city adaptation. However, despite the imminent risks, the agenda of mitigation and resilience of cities in the face of climate change has struggled to be implemented through public policies and urban intervention projects (Alvim, 2019). For this reason, it is necessary to develop studies that strengthen this agenda to technically and politically empower society to face these challenges. In this sense, this article discusses the urban-environmental patterns and their potential for transformation in the face of addressing the warning that the urbanization model of Brazilian cities exacerbates the effects of global climate change.

One of the major modifications caused by the urban environment is the drastic replacement of vegetation and permeable soils with buildings and impermeable surfaces, both in urban areas and in areas surrounding cities, which exert enormous influence on local, regional, and global climate. The removal of vegetation cover decreases soil infiltration and evapotranspiration rates. This factor, combined with impermeabilization, air, water, and soil pollution, alters the microclimatic and hydric conditions in cities, exacerbating urban socio-environmental problems (Stewart and Oke, 2012; Ferreira, 2019), and lead to varying energy balances, contributing to the formation of Urban Heat Island (Amorim, 2021).

Surface Urban Heat Islands, or inverse oasis, occur when urban surface temperatures are higher than those of their surroundings and are a significant concern for urban planning because it can have severe repercussions across all aspects of human life (Stewart and Oke, 2012). The morphology of urban fabrics influences temperatures because the construction materials in cities are often dark and, therefore, absorb and store more solar energy. For instance, the temperature of dark and dry surfaces in cities can reach up to 88°C during the day, while surfaces with vegetation and moist soil under the same conditions can reach only 18°C (Gartland, 2010).

The effect commonly leads to various implications, including alterations in the local microclimate, thermal discomfort, effects on public health, and changes in hydrological behavior, such as water mass displacement (Marengo, 2020; Almeida et al., 2021). Especially in cities with hot weather, the extra warmth can increase discomfort and potentially raise the threat of heat stress and mortality, and heighten the cost of air conditioning and the demand for energy (Stewart and Oke, 2012). It exposes vulnerable populations to extreme weather events, disrupts disease patterns, and endangers food security, access to clean water, and breathable air. Moreover, rising temperatures exacerbate drought conditions in typically arid regions, creating a fertile environment for forest fires and heatwaves (Marengo, 2018).

Urban centers are hotspots for major disasters but, on the other hand, also offer opportunities for action through the implementation of green buildings, the provision of potable water and renewable energy, the supply of sustainable transport systems capable of connecting urban and rural areas, and the potential to contribute to the organization of a more inclusive and just society (IPCC, 2022). Anelli (2020) suggests that evaluating the relation between climate change and cities requires two paths.

The first one is understanding urbanization as a strong agent that promotes climate warming and the second is understanding the effects of climate change on cities marked by social inequality of their settlements. Ferreira (2012) and Amorim et al., (2021) emphasize the need for specific approaches based on urban morphology and local climatic conditions.

The territorial mosaic of cities, characterized by diverse city fabrics patterns and their features (such as the morphology of occupation, availability of open spaces, and typology of surfaces), requires a nuanced understanding of how different areas respond to climate change. For this reason, the hypothesis discussed in this paper is that considering the extreme events that directly impact urban areas, adaptation strategies must consider urban pattern diversity to effectively mitigate and manage climate risks.

In the Metropolitan Area of São Paulo (MASP), there has been an increase in the frequency and intensity of extreme events over the last decade. Unfortunately, it is ill-prepared for extreme events, and the impacts are worse in peripheral areas where they affect socially vulnerable groups living in exposed areas (Marengo, 2020). This trend is closely related to the area's urbanization pattern, which includes a mobility model heavily reliant on automotive vehicles for daily commutes (Anelli, 2020). Additionally, the prevalence of reflective surfaces interferes with the natural rainfall regime and contributes to the formation of Urban Heat Islands (UHIs) (ibidem). For this reason, it is important to highlight that the heterogeneous physical and social characteristics of the MASP, along with the geomorphological layout of the area, directly contribute to these impacts (Jacobi et al., 2013).

Implementing Nature-based Solutions (NBS) at different scales and strategies emerges as a promising methodological path in helping cities manage stormwater, reduce heat, and improve air quality (Lima et al., 2023). NBS encompasses strategies inspired, supported, or copied from nature, aiming to address environmental, social, and economic challenges while simultaneously promoting human well-being and biodiversity benefits. These solutions are tailored to the specific characteristics of each location and involve actions used to sustainably protect, restore, and manage natural or modified ecosystems. By harnessing existing natural features, systems, and materials through systemic interventions, NBS minimizes the impact of human actions on the landscape and fosters resilient environments, and can be widely applied in cities (European Commission, 2021).

In this context, this research aims to identify, characterize, and classify distinct urban morphological and climatic patterns in both consolidated and expanding areas within MASP, focused on land use and occupation changes and Heat Island phenomena, and to provide urban planning and design guidelines for intervention, tailoring specific solutions to each type of urban fabric regarding the use of Nature Based Solutions. While each case responds differently to these factors, they all share vulnerability to extreme climate events. The paper is organized into five main sections: Materials and Methodologies, Results, Final Discussion and Recommendations, Conclusion and Acknowledgements. Additionally, it concludes with a list of references supporting the research.

METHOD

Seeking solutions to adapt the cities to climate changes, this study analyzes three specific situations in MASP. Specifically, the study examines a garden neighborhood (Vila Ipojuca), a densely populated favela (Paraisópolis) in São Paulo, and an urbanized zone of single-family homes (Villa Verde) in Franco

da Rocha. The three chosen regions are vertically aligned in a metropolitan scale territorial section that cuts through areas with different thermal and morphological characteristics, but which suffer from the effects of extreme events such as floods and heat islands (figure 1).



Figure 1: Location of the studied areas. Source: Imagem Google Earth, 2024 (modified).

The research process encompasses steps including: a comprehensive literature review that explores topics related to climate change, urban adaptation, resilience, vulnerability, and the formation of urban heat islands, relating occupancy patterns to urban fabric characteristics. Next, field visits are conducted to the study areas, providing firsthand insights and data collection opportunities regarding morphological and ecological aspects and surface temperature in the microscale, by using pictures captured in August 2024 by a thermal camera, FLIR E5 Pro model. For urban fabric patterns characterization, it investigated street layouts, block sizes, setbacks, vegetation cover, topography, land use and building typologies heights, and surface material on three specific cases using field visits collected data and geo-reference official data. Additionally, for macroscale analysis, georeferenced maps were produced using official databases, including surface temperatures images from June 20th 2023 using Landsat 8 data, by Nasa Satellite data by Landsat 8 Operational Land Imager/Thermal Infrared Sensor (OLI/TIRS), provided by the United States Geological Survey and generated from thermal infrared bands (USGS, 2024).

Furthermore, micro-scale climate classification relies on the Local Climate Zone System (LCZ): As stated by Oke (1987), the urban climate system is formed between the Urban Boundary Layer (UBL) - mesoscale, and the Urban Canopy Layer (UCL) - microscale, that follows the height and roofs of buildings and trees. Between UBL and UCL it is the Surface Layer, or local scale of urban climate, and it is where the phenomenon of Surface Urban Heat Islands takes place and is influenced by what occurs above in the UBL and below in the UCL (figure 2). This idea was used to define the LCZ theory.

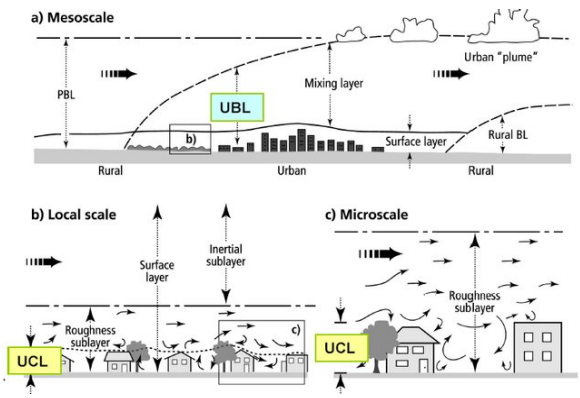

Figure 2: Key spatial scales in the urban atmosphere (adapted from Oke 1987). Source: Grimmond et al. (2016).

The LCZ (Local Climate Zones) theory posits that urban climate results from modifications due to urbanization and its impact on local atmospheric conditions. To assess urban occupancy models and their role in forming urban heat islands (UHI), the theory considers urban morphology, land use, activities, surface structure, and climatic data. The method categorizes the urban landscape into 17 types based on urban morphology and temperature data, establishing a direct link between urbanization and thermal impacts. This framework aids in documenting and comparing field sites and temperature data, benefiting UHI researchers, city planners, landscape ecologists, and global climate change studies. Qualitative and quantitative analyses explore urban-environmental patterns, with a specific focus on identifying heat islands within the study areas. Finally, the study examines the possibilities of application of NBS within established urban environments focusing on the construction of sustainable cities.

RESULTS AND DISCUSSIONS

The Metropolitan Area of São Paulo

The Metropolitan Area of São Paulo (MASP), located in the state of São Paulo, Brazil, is the largest metropolitan region in the country, housing approximately 20.7 million inhabitants. It ranks among the ten most populous metropolitan areas globally. Encompassing 39 municipalities, this area is undergoing rapid urbanization. São Paulo faces daily challenges such as high air pollutant concentrations, floods, cold waves, and heat islands. These issues are exacerbated by a large population with significant socioeconomic and environmental vulnerability. Notably, the relationship between air temperature and mortality in the municipality, according to McMichael *et al.*, (2008) reveals that, a 1°C increase in average temperature corresponds to a 3.46% rise in overall mortality and a 3.26% increase in cardiovascular and respiratory mortality (Barros and Lombardo, 2022).

Regarding the analysis of urban heat islands and surface temperatures using Landsat 8 images from the MASP, on a macro scale, the entire Metropolitan Area functions as an urban heat island (figure 03). It reveals that elevated surface temperatures are predominantly concentrated in urban regions, particularly those with high population density, such as São Paulo county. These elevated temperatures are primarily found in areas with impermeable surfaces. At the periphery of these urban zones, a noticeable decrease in temperature is observed, especially in rural and vegetated areas, which typically exhibit lower temperatures due to their green cover. That happens because in the urban area, vegetation has been replaced by impermeable surfaces that retain more heat, such as asphalt and other heat-absorbing materials.

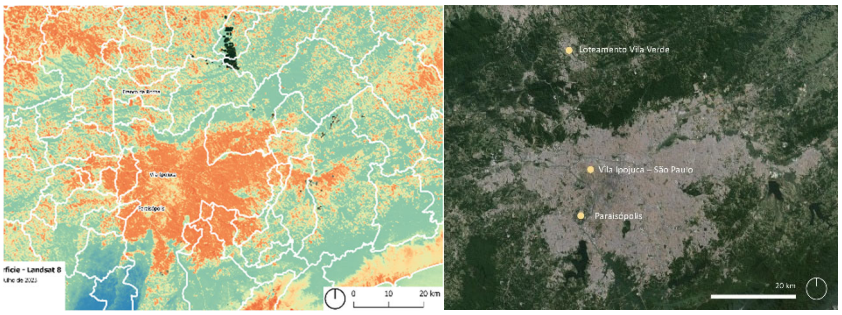

Figure 03. Surface temperature map of Metropolitan Area of São Paulo. Source: developed by the authors based on the United States Geological Survey (USGS) Landsat 8 data (2024).

This finding aligns with established knowledge that green and permeable areas tend to have cooler surface temperatures and that the difference between maximum and minimum temperatures observed in São Paulo during the daytime in the dry season was 10°C according to Lombardo (1985), 10.4°C according to Flores *et al*. (2016), and 12.8°C according to Ferreira (2019), which have been increasing due to the climate changes effects. Furthermore, this study has identified isolated pockets of higher surface temperatures dispersed throughout the city. Therefore, the analysis of surface temperatures in the area reveals significant temperature variations among different urban fabrics in São Paulo when conducted at a micro scale.

As stated by Marengo (2020), the prospect of recurring extreme events in the Metropolitan Area of São Paulo, such as prolonged droughts alternating with floods, necessitates a comprehensive planning approach regarding alterations in land use. It is important to mention the three cases of study. Moreover, it is likely that the urban heat island phenomenon will be intensified by deforestation, urban patterns and air pollution within the MASP, influencing the patterns of rainfall. Model experiments indicate that urbanizing areas originally covered by natural vegetation may lead to temperature increases of approximately 3.5 °C or more. The models predict fewer cold nights and more hot days, which can influence convective rainfall, intensifying its frequency and magnitude.

Paraisópolis Settlement, São Paulo - SP

Paraisópolis is located in the Southwest Zone of São Paulo. The area is located approximately 15 km from the city center, and it's known as one of the largest informal and unplanned settlements of the city, being characterized by dense urbanization and a lack of green spaces. It consists of a consolidated informal occupation that was originally projected to be an upper-class neighborhood with regular and orthogonal lots. However, around the 1950s, the uninhabited land began to be occupied, becoming an irregular dense occupation.

Paraisópolis is characterized by social vulnerability in the form of overlapping self-build houses, the use of materials that increase the warming and the topography formed by curves and slopes, which are integrated into the current occupation that allows access to the settlement. The blocks are rectangular and dense, most of them reaching up to 200 m x 100 m. There are very small or non-existent sidewalks, making it difficult to identify the limits of the street. The outline of the lots and the setbacks are almost non-existent, most of the buildings occupy the sidewalk or the street. The houses are built in materials like brick, concrete and fiber cement tiles, with two to six stores. The height of the buildings points out that there is a lack of space to build new homes, making verticalization the best alternative for residents. The closeness of the constructions due to the lack of space also

contribute to the heat island effect, making clear the association of land occupation, concentration of vulnerable areas and the formation of heat islands (Lima *et al*., 2023).

Land use in Paraisópolis is mostly residential and commercial, characterized by mixed-use buildings, with the ground floor being used for commerce or services and the upper floors for residences. The area suffers from flooding on rainy days with a high volume of precipitation, invading the homes built on Antonico stream banks. Observing the Landsat 8 it is possible to notice how surface temperatures manifest inside the perimeter study area of Paraisópolis. The map presents a high temperature surface, which can be related to the high impermeable and dense area, with lots of irregular occupations and no available green surfaces. The important fact to highlight about this case is that in the surrounding neighborhood, Morumbi, which presents a difference when it comes to density and green cover areas, the surface temperature is lower.

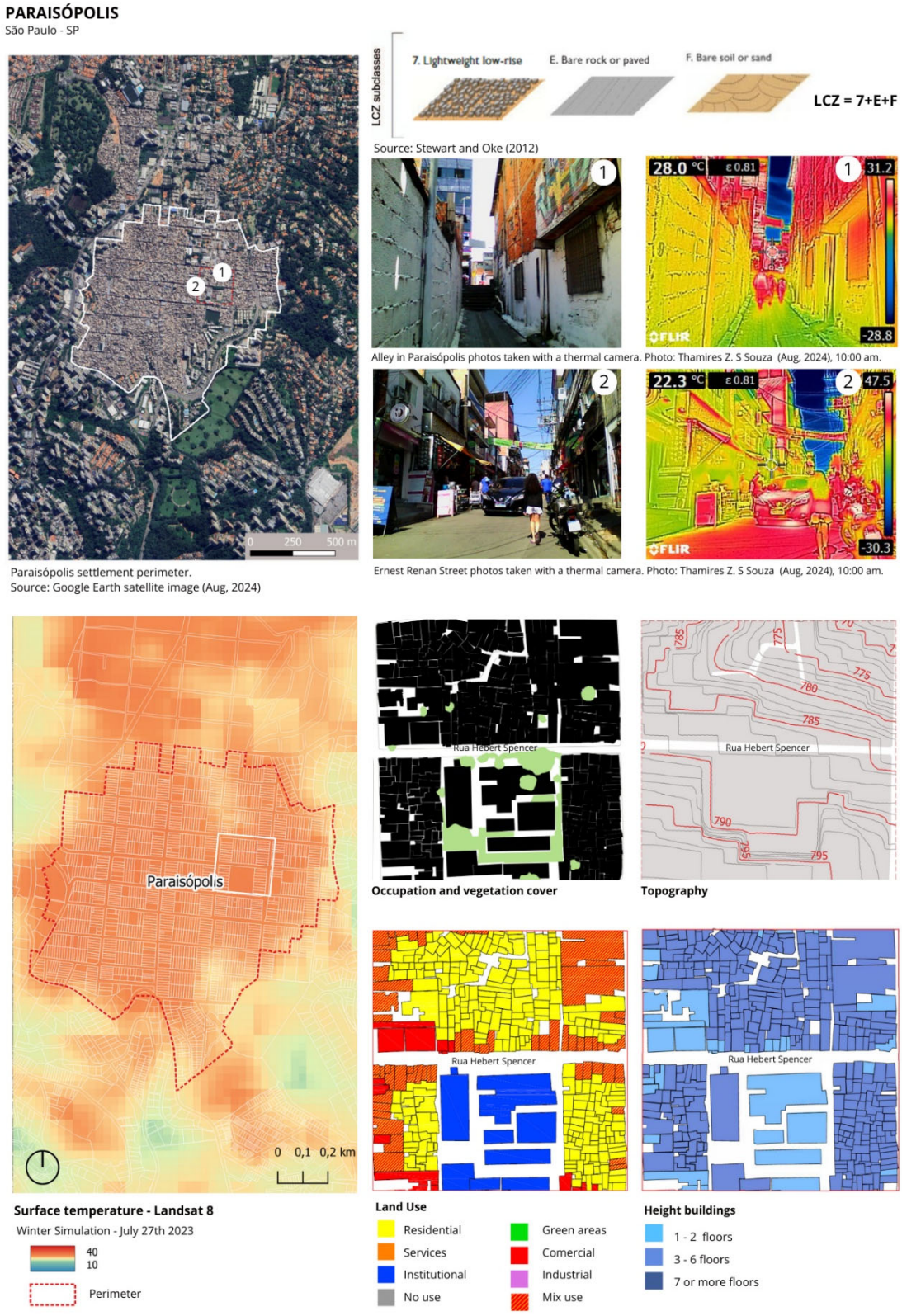

Figure 04. Characterization and analysis sheet for Paraisópolis. Source: developed by the authors based on the United States Geological Survey (USGS) Landsat 8 data (2024), GeoSampa (2024) and data collected by the authors.

Paraisópolis can be defined as a lightweight low-rise area (LCZ 7), it is described as a dense mix of single-story buildings, few or no trees, land cover mostly hard-packed and lightweight construction materials. Observing the thermal camera analysis, it is possible to notice that in the alley (1) where there is a channeled stream and drainage system, the surface temperature tends to be milder, presenting shadows, while on the Ernest Renan Street (2), a very dense commercial street, the temperature is much higher, especially on the street pavement. The lack of shade and low wind speeds further contribute to the formation of heat islands, posing risks to public health and mortality. Therefore, considering the type of coating and paving is crucial in addressing these matters.

To change this scenario in Paraisópolis it is necessary to focus on the expansion of areas with vegetation and trees as a way of reducing the intensity of heat island, improving the thermal comfort and health conditions of the inhabitants, as well as avoiding the risk of flooding caused by extreme rainfall, which can be developed in the form of green-blue infrastructure or other NBS. Some NBSs, such as green roofs and walls, flowerbeds and rain gardens, can be used in precarious settlements, but they present difficulties in the supply of free areas for their implementation, availability of financing for the project and construction, maintenance and forms of irrigation, which must be done with reused water and not with water from the treated water network.

Vila Ipojuca, São Paulo - SP

Vila Ipojuca is situated in the highest topographical region of the Lapa neighborhood, in the Western Zone of São Paulo. The area is approximately 10 km from the city center, positioned in an intermediate ring between the central area and the periphery. It comprises a well-established occupation area and an equally well-established surrounding area. Its occupation began in the 1920s, covering an area of hills and valley bottoms. The area's topography is rugged and organically integrated into the street layout, following the contour lines to provide gentle slopes. As a result, some blocks are very long, extending up to 1 km, and can only be crossed via pedestrian passages. The lot sizes vary, with most averaging around 300 m². The setbacks are not very wide, averaging 4 meters at the front and 1 meter on the sides. The rear setbacks are not consistent, with many occupied by outbuildings. Some side setbacks are non-existent (Figure 05).

Regarding the height of the buildings, the neighborhood of Vila Ipojuca is predominantly horizontal, with two-story buildings, and a few tall buildings. Land use is predominantly residential, although along the main roads, there are local services and commerce. Its generous green areas and tree-lined squares stand out, including São Crispim Square, which was threatened with deforestation but was preserved through civil society actions. However, there are streets without trees, such as a large part of Ricardo Medina Avenue. There is a stream that cuts the area, the Tiburtino Stream that has been identified under streets, alleys and squares. With the subsequent high impermeabilization of the soil, the speed of rainwater runoff increased, exacerbating flooding near the Lapa Market, where the stream is intercepted by the railway. At this point, floods are recurrent.

Observing the Landsat 8 image (figure 05), it is possible to notice that the lighter areas (which correspond to areas of lower surface heat) correlate to green areas and areas where the tallest buildings are concentrated (in the center of the image). According to the LCZ typology, it consists of a mix of zones 3, meaning dense mix of low-rise buildings (1-3 stories), few or no trees, mixed with type 4, that correspond to open arrangement of tall buildings to tens of stories, paved with stone, brick,

tile, and concrete construction materials. Concerning the thermal camera analysis, it is noted that in the region of Praça São Crispim (1), the shading from the trees significantly reduces the pavement temperature, while on Ricardo Medina Avenue (2) the street temperature is much higher due to the lack of shading.

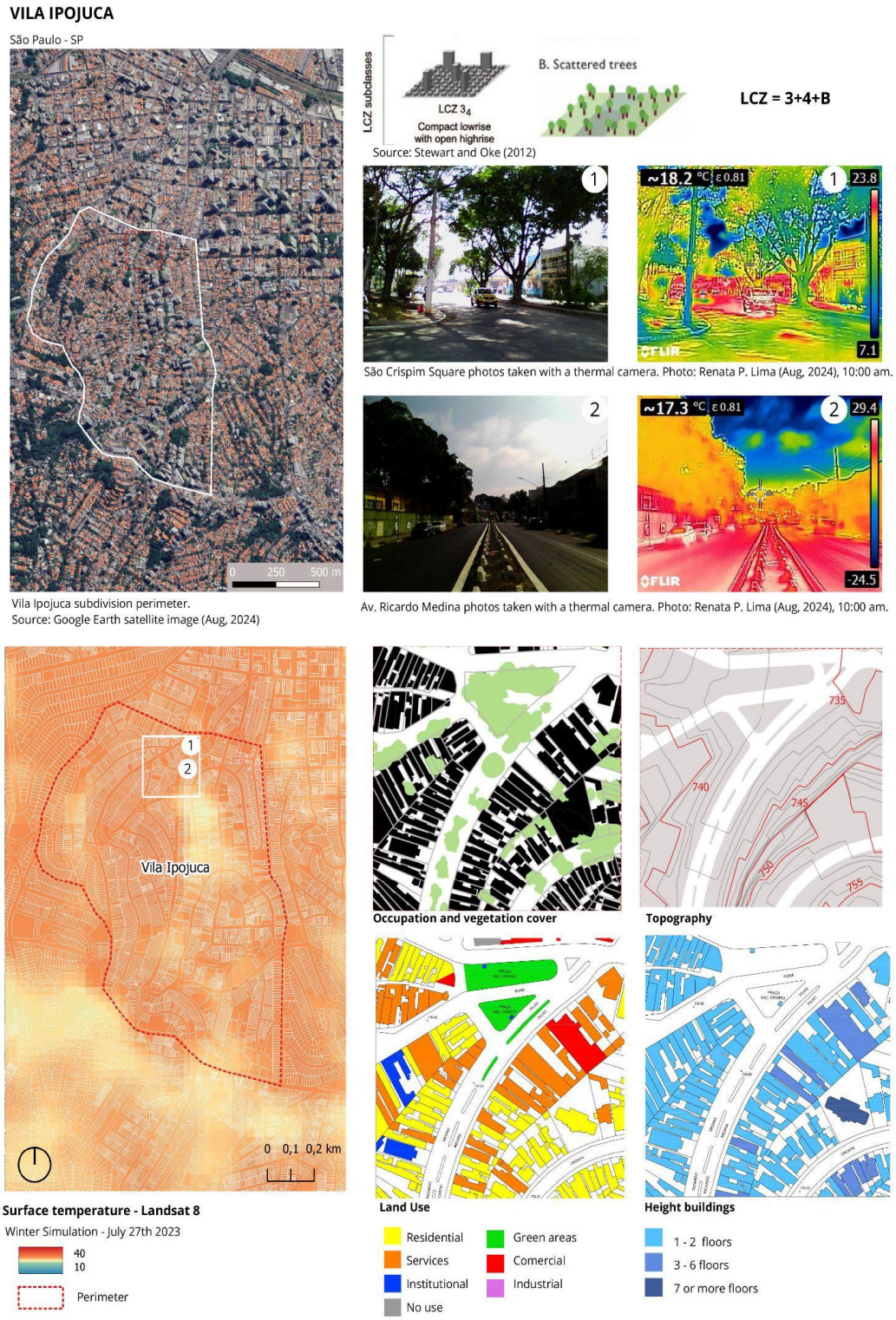

Figure 05. Characterization and analysis sheet for Vila Ipojuca. Source: developed by the authors based on the United States Geological Survey (USGS) Landsat 8 data (2024), GeoSampa (2024) and data collected by the authors.

In an effort to reduce heat in the area and mitigate the effects of urban heat islands in the area, which is predominantly paved and impermeable except for some green squares, replacing this pavement with cooler and permeable surfaces would be a viable solution. Additionally, a linear park could be established between São Crispim Square and Olavo de Peres Velasco Square, along the sanitary alley

where the river is channeled. This route could feature lakes, cisterns, rain gardens, and bioswales to collect clean water. Enhancing vegetation cover over the streets, green areas and lot through functional landscaping and protecting the existing ones would also be crucial. The use of bioclimatic architecture techniques in constructions could also bring very interesting results in this regard.

Villa Verde Neighborhood, City of Franco da Rocha - SP

Villa Verde is a Real Estate project located in Franco da Rocha municipality, situated 5,6 km away from its city center and about 43 km from São Paulo downtown. Villa Verde is characterized as a gated community surrounded by a still not urbanized area that preserves some vegetation. The access to the area is through a high-speed road (Presidente Tancredo de Almeida Neves Highway) that connects the city of Franco da Rocha to São Paulo and other centralities as Campinas and Jundiaí.

While the surroundings of the city center occupy a low-level region (725 meter from sea level) which is the cause of several drainage problems in the densest area of the city, Villa Verde is located in a high-level sector (approx. 100 meters higher) which makes this neighborhood less affected by flood events and, consequently, more costly in terms of land value. Moreover, while 62% of the city terrain is classified as strong hills (UFABC et al., 2021), Villa Verde presents a softer one direction inclined terrain. The topography also reflects on its social-economical standards: while Franco da Rocha is generally characterized by a prevalence of low-income settlements, Villa Verde neighborhood presents large and medium-high quality houses, which can often cost more than R$ 1 million.

Considering the urban pattern, Villa Verde presents similar features to the North American suburban neighborhoods: a monofunctional residential area, accessed exclusively by car, with coverage characterized most entirely by impermeable material in common areas, such as concrete on the sidewalks and asphalt on the inside roads. The few green areas in the neighborhood are in the form of lawns in front of the houses, with few trees. This gated community is occupied by 1 to 3 store houses, mostly made in reinforced concrete and concrete blocks, covered in metal or clay tiles.

Observing the Landsat 8 image (figure 06), it is possible to notice that the surrounding green areas correspond to a much lower surface heat in shades of dark and light green, while the inside of the neighborhood perimeter presents higher surface heat, represented by shades of red and orange, which match with paved and impermeable areas inside the gated community. Concerning the thermal camera analysis, it is noted that there is a strong difference in surface temperature of the impermeable pavement when compared to the green lawn in front of the houses, as well as to the shaded spots next to the few trees in the neighborhood. According to the LCZ typology, Villa Verde neighborhood consists of type 3 - Compact Low Rise, which is defined by a dense mix of low-rise buildings, few trees, most paved land cover and concrete as mainly construction material. In terms of land cover, it is possible to relate Villa Verde to type E - bare rock or paved, defined as a landscape of paved cover, with few or no trees. This type of cover is common in urban areas, increasing thermal inertia.

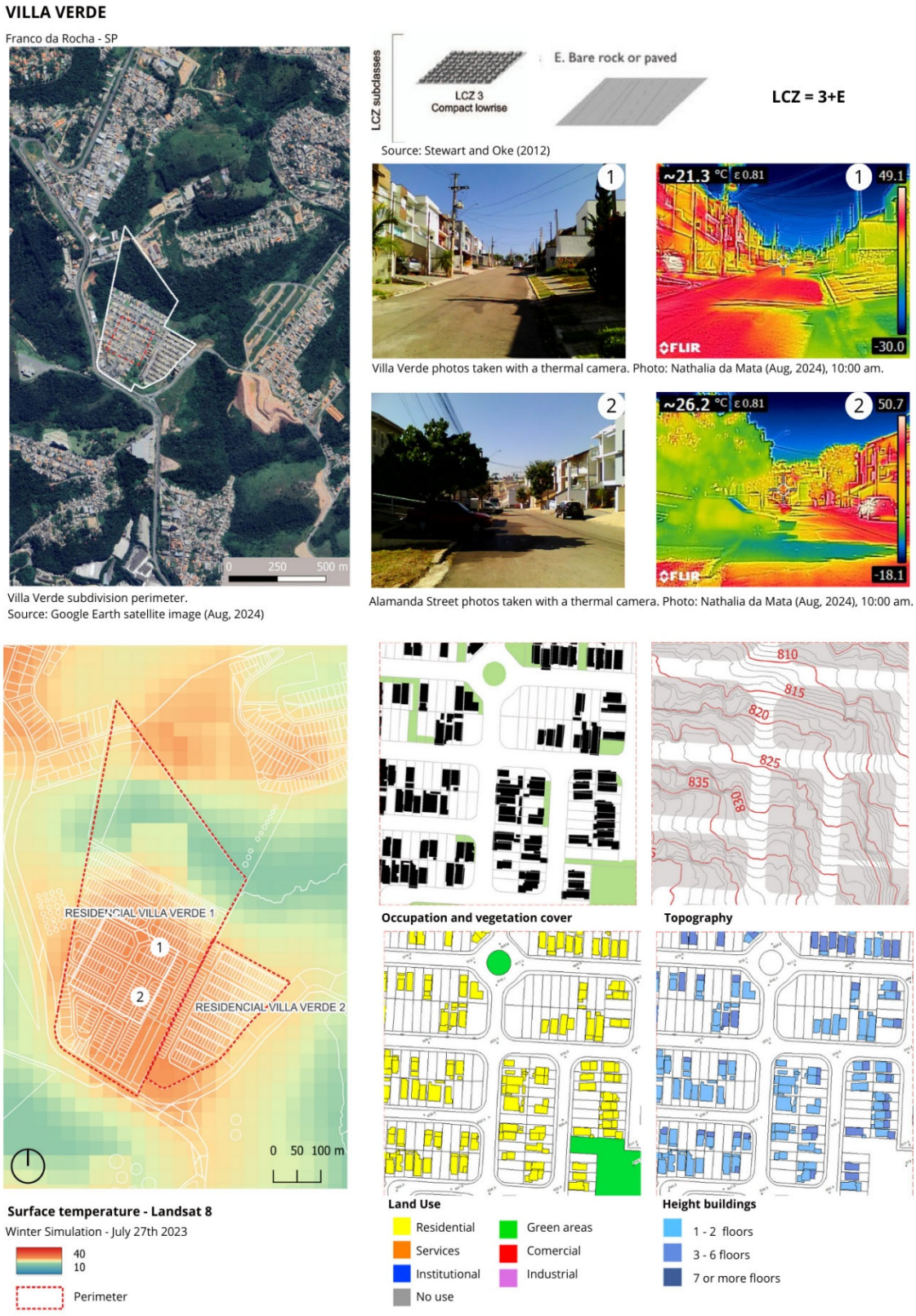

Figure 06. Characterization and analysis sheet for Villa Verde. Source: developed by the authors based on the United States Geological Survey (USGS) Landsat 8 data (2024), Inmap (2024) and data collected by the authors.

Aiming the reduction of the effects of urban heat islands analyzed, it could be recommended the increase of green cover on the common areas of Villa Verde, as well as increment in the number of larger vegetation such as trees to expand the shading in the neighborhood. The substitution of asphalt

by other covering materials is also recommended, due to its high thermal inertia, such as concrete and, in the best case, greenery.

The analysis of three MASP case studies shows that the morphological pattern of urban fabrics classified according to LCZ aligns with temperature differences observed in Landsat satellite images. It showed that heat tends to accumulate in regions with sparse vegetation and impermeable surface, indicating that urban development significantly alters local climate. These issues, along with the types of surfaces, are directly linked to architectural and urban planning decisions, revising the morphological pattern is a reliable means of mitigating UHI and should be urgently adopted as an urban planning central tool. So, the use of Local Climate Zones (LCZ) as a parameter could be beneficial for urban planning studies. But it is important to note that LCZ analysis needs to be supplemented with detailed investigation to recognize small squares and trees as it was done in this study with the thermal camera.

When comparing the three cases and the Landsat images simultaneously, it also becomes evident that not only the typology of the urban fabric and the surface materials matters in terms of urban climate and UHI configuration but also the positioning of the sample within the urban context. In Franco da Rocha, the Villa Verde subdivision lacks vegetation, resulting in higher surface temperatures compared to cooler surroundings. In Paraisópolis, densely packed areas exhibit higher temperatures, while more spaced-out areas like Morumbi are cooler. On average, these temperature differences amount to 3°C, but they can be even higher on extremely hot days. Interestingly, in Vila Ipojuca, the Landsat image does not show significant contrast between this neighborhood and its surroundings. This lack of contrast is likely due to the similar morphological typology of the surrounding areas. Building dense areas also seem hotter and spaced-out areas cooler if analyzing Landsat images. But with the thermal camera, it was noticed that alleys and spaces without light as it was found in Paraisópolis can bring humidity that reduces the temperature. However, in very warm situations, they tend to become stuffy and lack air circulation, which can greatly increase the discomfort of the inhabitants.

In the sense of providing tailoring specific solutions to each type of urban fabric, Nature-Based Solutions (NBS) offer a promising approach. In this way, vegetation acts as a microclimatic regulator, reducing solar radiation and modifying air temperature and humidity through shading. In large quantities, vegetation can also influence rainfall frequency and reduce air pollution through photosynthesis and respiration. Additionally, integrating water and greenery through Green and Blue Infrastructures (GBI) and Sustainable Drainage Systems (SuDS) enhances their benefits. Local and microscale strategies include rain gardens, planting small trees and palm trees. On individual lots and at the building scale green roofs, green facades, bio-swales, light cover materials, flower boxes and rain gardens reduce stormwater overflow, filter water and air, and contribute to local microclimates. Key actions include increasing tree planting and expanding and protecting green areas. Connecting parks, squares, linear parks, boulevards, gardens, and green roofs is also crucial for maximizing their cumulative effects. However, solutions for improving temperature conditions extend beyond increasing vegetation cover and drainage systems. It is recommended that climatic aspects be considered when specifying materials for pavements and coatings of public spaces decreasing the use of asphalt. Mitigation actions should also include controlling land use and improving the comfort

technology of buildings. exploring sustainable certifications for neighborhoods, and developing more assertive legislation regarding environmental and sustainable issues would be very beneficial.

CONCLUSIONS

This study endeavored to correlate the morphological patterns of three distinct areas in São Paulo with urban climate characteristics, utilizing the Local Climate Zones (LCZ) framework. The findings elucidate that anthropogenic activities markedly alter surface temperatures and impact the urban climate, engendering or exacerbating urban heat islands, as evidenced in the studied areas. This underscores the imperative to expedite adaptation processes. Methodologically, the study advocates for urban analyses to be interdisciplinary and multiscale, with a strong emphasis on incorporating surface temperature data in all urban studies. The LCZ framework offers invaluable insights into micro-scale characteristics, yet the unique features of each region necessitate bespoke analysis and design. This highlights the critical importance of urban planning and morphology studies and the necessity for developing bioclimatic micro-scale urban projects. Such projects should embrace a holistic approach, integrating heat island mitigation with green spaces, drainage, transportation, and other infrastructure systems. The incorporation of Nature-Based Solutions (NBS), such as augmenting vegetation cover, implementing Sustainable Drainage Systems, and developing Green-Blue Infrastructure, is essential. These solutions should be embedded into future public policies at MASP to bolster resilience and advance climate justice.

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Navigating microclimatic challenges in urban morphology: integration of knowledge into practice in Brisbane, Australia

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ABSTRACT

Amidst its changing urban form, Brisbane, Australia, is grappling with complex microclimatic challenges. The city's increasing densification and growing population are contributing to a noticeable decline in thermal and wind comfort. Although there is significant scientific evidence on microclimatic effects, and both city and state governments have issued multiple guidelines and visions for addressing them, the challenges in this area continue to worsen. This points to an unaddressed concern: the effective integration of microclimatic design principles into contemporary urban development practices. Analysis and evaluation of existing urban planning and design paradigm through semi-structure reviews with built environment professional reveals a series of challenges: the ambiguous nature of current urban planning codes, a pervasive knowledge gap about microclimate implications, short-sighted political and economic considerations, and an absence of robust technical method during initial design phases. Future strategies should focus on continual professional development, increasing public awareness, and incorporating microclimate-sensitive practices into the city's urban planning and design frameworks.

Keywords: Microclimate-sensitive urban design; urban densification; thermal comfort.

INTRODUCTION

The recognition of urban sprawl's unsustainable nature has led to a growing shift towards higher-density urban development in contemporary cities (OECD, 2012). However, the compactness of such cities introduces significant environmental challenges, particularly concerning the urban climate. The dense concentration of buildings and infrastructure alters the microclimate, intensifying heat retention and reducing airflow, thereby exacerbating the urban heat island (UHI) effect (Oke et al., 2017). Consequently, there is an increasing emphasis on incorporating urban climate considerations into urban planning and design. This approach is viewed as vital for mitigating climate change impacts and enhancing the resilience and well-being of urban populations (Masson et al., 2020).

Despite the growing importance of this issue, the integration of urban climate knowledge into professional urban planning and design practices remains limited. Scholars have pointed there are limited examples of effectively translating urban climate insights into real planning and design

outcomes (Hebbert and Mackillop, 2013). Thus, the primary aim of this paper is to investigate the challenges of integrating urban climate considerations into planning and design practices in Brisbane, Australia. It is also important to recognise that urban morphology is shaped by various factors, including economic, political, and social dynamics. At the same time, professional planners and designers often have firsthand experience in navigating these influences. Therefore, this study primarily focuses on the experiences and insights of built environment professionals.

The study is structured in two parts: the first examines the evolution of Brisbane's urban morphology, providing essential context and its relationship with urban climate; the second offers a qualitative analysis of interviews, which uncovers the key barriers to effective implementation and presents recommendations for enhancing the incorporation of climate-responsive strategies into urban form.

BACKGROUND

Urban morphology plays a crucial role in shaping the microclimate within a city. The urban climate is influenced by various characteristics of the built environment, and numerous studies have explored a range of quantifiable urban morphological parameters and indices (Yang et al., 2023). At its core, this relationship is often defined by the three fundamental elements of urban form: streets, blocks, and buildings.

In vernacular cities, streets were often oriented to channel natural ventilation, enhancing airflow and cooling (Aynsley, 1999). However, in contemporary cities, tall buildings frequently create deep street canyons. While these canyons can reduce solar exposure and lower surface temperatures during the day, they also tend to trap heat and pollutants by hindering natural ventilation (Qaid & Ossen, 2015). Additionally, the compact blocks and reduced open spaces, a consequence of the larger functional areas of tall buildings, further obstruct wind flow, exacerbating heat retention and air quality issues (Sanaieian et al., 2014). Therefore, a well-considered urban design that balances building heights, street widths, and block configurations is essential for fostering a more favourable microclimate.

In Brisbane, the typologies of inner-city streets, blocks, and buildings have undergone significant transformation over the past two decades. Figure 1 presents a satellite imagery comparison of inner-city Brisbane. This transformation is part of a broader trend observed in many cities across the Anglosphere, where government initiatives promoting compact city development have led to increased densification within the central business district (CBD) and surrounding areas. These efforts reflect a growing political agenda aiming to reduce urban sprawl by concentrating development and enhancing the vibrancy of the city centre (Raynor et al., 2018).



(Figure 1 Comparison of Brisbane's inner city land scape, Left. 2004, Right 2024)

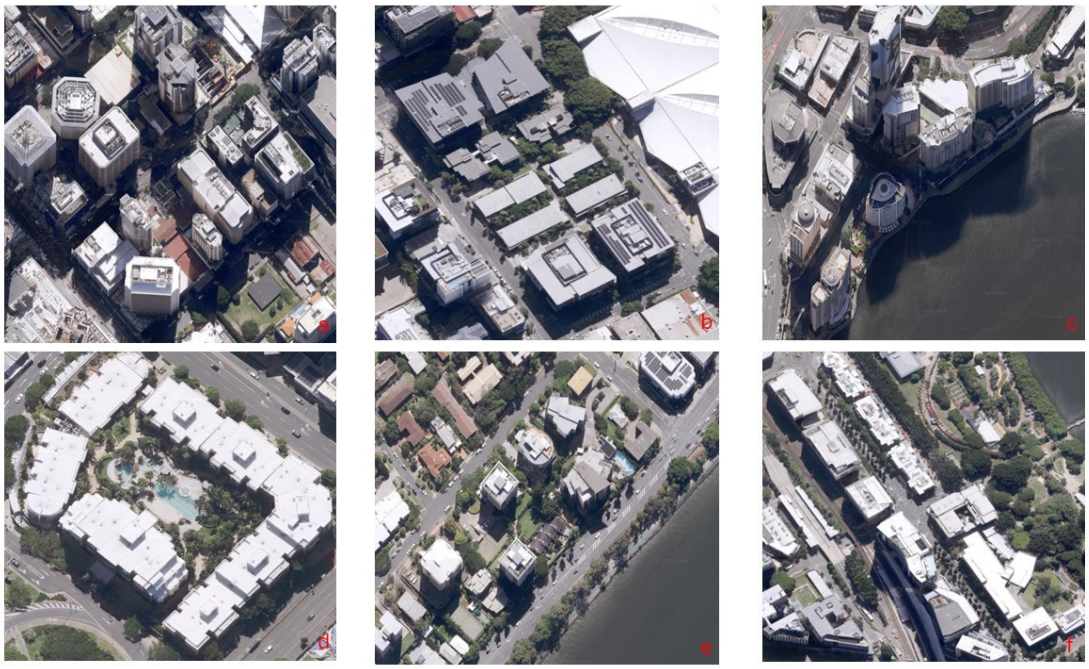
Historical street and parcel layouts significantly influence urban form. Previous research by Siksna (1998) illustrates how city blocks affect the configuration of the parcels within them. In the context of Brisbane, the city was established both as an urban centre and as a fortress in a hostile environment. Unlike cities such as Adelaide or Canberra, where specific design strategies were implemented, Brisbane's inner-city parcels was primarily driven by surveyors, leading to the adoption of a grid pattern with minimal design consideration. The initial settlement pattern consisted of 200 x 90 m rectangular street blocks, arranged in a street mesh spacing of 221 x 111 m, with each block divided into twenty equal back-to-back plots (Sanders and Schroder, 2008). Over the course of two centuries, parcels were amalgamated to accommodate the demand for taller buildings with larger footprints. This trend indicates that the city blocks experienced subdivision from its inception, driven by landowners seeking the profits that such development opportunities offered (Figure 2).



(Figure 2. Building Footprint and Subdivision, Brisbane City Centre 1910, 1930,1960 and 2005, Sanders and Schroder, 2008).

The changing urban form of inner Brisbane is influenced not only by socio-economic and historical factors but also by regulatory frameworks. As argued by Gu (2014), form-based codes embedded within planning schemes are inherently morphological, extending beyond land use to control elements such as building height, setbacks, and site coverage. Since the early 2000s, Brisbane has undergone significant densification efforts, driven by changing planning codes. As a result, under various state-level statutory instruments, most new dwellings must be developed within existing

urban areas (Fig 3). To facilitate densification, amendments to the planning scheme have included reducing parcel sizes and removing building height restrictions (Gallagher et al., 2023).



(Figure. 3 Typical Block Typology, Inner Brisbane)

Developers typically work within existing property boundaries, which contributes to the development of local architectural characteristics (Stell & Tait, 2016). The extent to which this pattern persists varies according to factors such as planning codes and market demands. For example, the transition from low-rise office spaces and row shops to high-rise residential towers in the Brisbane CBD can be attributed to several factors. Firstly, the increasing urban population and growing demand for housing in proximity to employment centres have driven the need for more residential spaces within the city. Secondly, the economic benefits of high-rise residential projects, such as higher rental yields and property values, have attracted developers to shift their focus from office to residential developments. Thirdly, changes in lifestyle preferences, with more people seeking the convenience of living close to work, amenities, and public transport, have further fuelled the demand for residential towers. The transition is also supported by policy changes encouraging urban densification and the repurposing of land for mixed-use developments.

However, compact development has leads to more and more empirical evidence regarding the detrimental affects of urban heat island effects. Brisbane has experienced a steady increase in temperature in recent decades, with more frequent and longer heatwaves. Extreme urban heat island phenomenon has been detected in many infill development areas. (Deilami & Kamruzzaman, 2017). In addition, residents have been organising to oppose ongoing high-rise developments, arguing that these projects could exacerbate urban heat island effects and create potential wind comfort issues (Mongard, 2023).

Interview results

A series of qualitative semi-structured interviews were conducted between October 2023 and January 2024 with 19 professionals from five disciplines—urban planning, architecture, landscape architecture, urban design, and building engineering—based in Brisbane. The objective was to explore these professionals' experiences with the utilisation of urban climate knowledge in urban development projects (Liu et al., 2024)

The study on urban climate design implementation in Brisbane brings both relational and functional challenges faced by professionals in the built environment sector. Through in-depth interviews and thematic analysis, five primary areas of challenge emerged: awareness, policy and planning regulation, resources and capability, data and modelling, and future development (Table 1).

Table 1: Challenges and Recommendations from the Interviews

Challenges	Description	Recommendations
Awareness Disparity	Significant gap in understanding urban climate issues between professionals and clients, particularly between large developers and smaller projects.	Increase public and professional understanding of urban climate issues through education, outreach, and showcasing exemplar projects.
Weak Policy and Regulation	Existing frameworks are primarily advisory, lacking enforceability, which makes climate-responsive design negotiable rather than mandatory.	Develop more robust, enforceable policy frameworks that mandate the inclusion of urban climate considerations in all stages of planning and design.
Economic Viability Concerns	Short-term financial considerations often lead developers to resist incorporating climate-sensitive practices due to perceived cost increases.	Foster a culture in the market that prioritizes long-term sustainability alongside economic viability, encouraging developers to integrate climate-sensitive practices through monetary incentives
Resource Constraints	Restrictive project timelines and budget limitations make it difficult to align climate strategies with practical development realities.	Encourage more time and budget to planning and developers to ensure that climate-responsive strategies can be effectively implemented.
Limited Technical Capabilities	A lack of specialized knowledge and skills, particularly in CFD modelling and data analysis, hampers the effective implementation of climate strategies.	Enhance the technical skills of professionals through training and provide access to advanced tools and resources for better climate modelling.
Inadequate Data and Modelling	Insufficient access to accurate, site-specific data and the inadequacy of current modelling tools hinders detailed microclimate assessments.	Invest in the development of more sophisticated, publicly available, accurate, and user-friendly data and modelling tools that provide detailed, site-specific climate assessment

Relational challenges primarily concern the dynamics and interactions among various stakeholders involved in urban development. A significant issue highlighted is the dominance of political and economic factors that shape urban planning priorities. The study reveals that economic development agendas, often driven by market forces, overshadow sustainable and climate-resilient objectives. This market-led approach results in urban growth patterns that frequently neglect or inadequately address urban climate issues. Additionally, the study identifies a significant knowledge gap among stakeholders, with varying levels of awareness and understanding of urban microclimate issues. While professionals in the field are generally aware of these issues, there is a marked disparity in awareness among clients, particularly smaller developers, which hinders the broader adoption of climate-sensitive design practices.

Functional challenges relate to the technical aspects of implementing climate-responsive design strategies. The study highlights the limitations of existing policy frameworks, which, while

acknowledging the importance of climate-responsive design, are often advisory rather than mandatory. This lack of regulatory enforcement reduces the motivation among developers and planners to integrate microclimate considerations into their projects. Additionally, the technical complexity associated with urban microclimate modelling and simulation tools poses a barrier to their widespread use. These tools, although powerful, require specialized knowledge and skills, which are often lacking among urban planners and designers. The study also points to the challenges in data availability and accuracy, which are critical for effective microclimate assessment but are often inadequate, leading to reliance on less precise, rule-of-thumb strategies.

DISCUSSION AND CONCLUSION

Urban climate poses a complex challenge, requiring innovative design solutions across various spatial scales. The research identifies three key recommendations to improve the integration of urban climate knowledge into planning and design practices.

First, raising awareness of urban climate issues is crucial. Without recognition of these challenges, stakeholders, including politicians and the public, are unlikely to act proactively. The study highlights that responses often occur only after extreme events, such as floods or heatwaves. Demonstrating best practices through exemplar projects could be an effective way to increase awareness. Second, the research underscores the need for robust, flexible, and balanced regulations to guide market-driven planning. While the regulatory environment varies depending on economic, political, and cultural contexts, better communication of urban climate knowledge is universally necessary. Third, the study calls for more interactive approaches and accessible tools to engage stakeholders effectively. Practitioners need user-friendly modelling tools that provide clear, interpretable information for non-experts. GIS platforms and CFD modelling tools, such as EnviMet, are identified as valuable resources for detailed microclimate analysis.

The study also emphasizes that relational challenges, particularly political-economic factors, are more critical than technical issues in urban climate design. Future research should focus on how professionals navigate institutional barriers and power dynamics among stakeholders to achieve optimal design outcomes, offering insights into improving urban climate resilience.

In conclusion, this paper underscores the critical relationship between urban morphology and microclimate in Brisbane's planning and design practices. The research reveals that the city's evolving urban form, driven by densification, has significant implications for thermal comfort and natural ventilation. Addressing these microclimatic challenges requires a deeper integration of climate-responsive strategies within the existing urban morphology framework. Enhancing awareness, strengthening regulatory approaches, and advancing technical tools are essential to better align urban morphology with the need for sustainable and resilient microclimates.

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Peripheral expansion of the Minha Casa, Minha Vida Program and their impacts on the fragmentation and functioning of landscapes, the case of the metropolis of Brasilia

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ABSTRACT

The article aims to analyze the impacts on the fragmentation of the regional cerrado landscape and the loss of groundwater recharge resulting from the peripheral expansion of contiguous developments of the Minha Casa, Minha Vida Program (PMCMV) in Valparaíso de Goiás/GO, municipality belonging to the metropolitan area of Brasília. Were used satellite images taken from the Landsat 5 and 8, for these the atmospheric correction was made and the normalized difference for vegetation index (NDVI) was determined; this indicator makes it possible to compare changes in the types and densities of vegetation and land use between time periods, which allowed to contrast the urban form and vegetation before (July 02, 2009) and after (July 06, 2022) of the expansion of housing developments in the region. The result showed an increase of 39.63% in the urban fabric and from 27.19% to 35.68% in the impervious areas, which was particularly critical on the banks of the Santa Maria and Saia Velha Rivers. To analyze the consequences of the changes of form in functioning of the landscape, the Analytic Hierarchy Process (AHP) was used; thus, according to the literature and previous work by the authors, were processed in QGIS® the relative weight that each variable exerts on groundwater recharge, resulting in 50% for NDVI (as a proxy for land cover), 18% for paedology and 32% for geomorphology; and, at the level of each variable, scores from 0 to 4 were specified to determine the influence of every situation on recharge. The results showed the sensitivity of fragmentation to the loss of recharge and recommendations for the proper insertion of the housing developments on the metropolitan periphery, considering the importance and return of the PMCMV, as well as the need for measures to ensure water security through the preservation and connectivity of remnants vegetation.

Keywords: Landscape fragmentation, loss of groundwater recharge, Minha Casa Minha Vida Program, urban sprawl, metropolis of Brasília.

INTRODUCTION

The Minha Casa, Minha Vida (My House, My Life) Program is designing an important part of the urban fabric of Brazilian cities; launched in 2009, between 2009 and 2020 it produced 5,1 million units and, relaunched in 2023, the prospect is that these numbers will continue to increase.

In fact, alongside the first signs of the scale it would take on, there was already criticism in the literature about the urban, architectural, social and environmental impacts it would have. After all, a Program designed under the expectation of the market, which is in charge of selecting the land and building the units, meant choosing homogeneous and peripheral mega complexes, in order to gain land scale, without necessarily corresponding to the expectation of a better location in the city, in terms of community equipaments and mobility. It also meant little variation in building typologies that could meet the needs of different families; the adoption of standardized architectural solutions, without much adaptation to the climatic and landscape singularities of each site, and simplified, with the aesthetic impoverishment of the fabrics. As well as causing sociological impoverishment, with the segregation of the low-income population on the outskirts, sometimes in enclosed spaces, reproducing the paradigm of carceral cities, and without a sense of community, since it is common for residents to access the units where they can afford or where they have been granted by the government, without necessarily having emotional ties.

Furthermore, the implementation of huge contiguous complexes on the outskirts, usually through the physical extension of fabrics, has resulted in serious impacts on the connectivity of landscapes, through the reduction and fragmentation of habitats, and on water recharge; however, few studies have analyzed these cumulative effects on the sites that have received many complexes.

Likewise, the metropolis of Brasília was strongly impacted by the Program, receiving around 2664 developments (Brasil, 2024). In particular, the outskirts of Goiás, due to their large supply of cheap land, permissive municipal administrations when it comes to approving these developments and the great metropolitan demand for homes, have become the ideal location for attracting huge, contiguous and homogeneous Program developments. Furthermore, analysis of the impacts that this recent urban-metropolitan expansion has had on the reduction and fragmentation of habitats and on the water recharge patterns of the cerrado is still scarce.

The Cerrado is Brazil's second largest biome; it is the most biodiverse savannah in the world, with around 12,000 species, 5,000 of them endemic, and it is the place where the waters that feed the main basins of the South American subcontinent are stored and distributed. Despite this importance, it has been severely impacted; data from MapBiomas (2024) shows that the cerrado has already lost 50% of its vegetation cover and is losing its surface and underground water flow, mainly due to the advance of the agricultural frontier, but also due to urban expansion. However, there are few studies dedicated to understanding the role of urban expansion in the impacts on the cerrado. The report shows that deforestation in the Cerrado in 2022 represented 31.2% of the total deforested areas in Brazil (MapBiomas, 2024).

The aim of this study is to analyze the impacts on the fragmentation of the regional cerrado landscape and the loss of groundwater recharge resulting from the peripheral expansion of contiguous developments under the Minha Casa, Minha Vida (My House, My Life) Program in Valparaíso de Goiás/GO, municipality belonging to the metropolitan area of Brasília. The municipality has attracted 470 PMCMV developments with strong consequences for the sub-basins of the Saia Velha and Santa Maria streams, which cut through the city.

Thus, items 1 and 2 present the theoretical approach to the subject - the PMCMV in the fabric of the urban fabric; urban expansion and its effects on landscape connectivity and water recharge - while

items 3 and 4 present the method and empirical results, respectively. Finally, the conclusion consolidates the theoretical and empirical contributions of the research.

THE PMCMV IN THE WEAVING OF THE URBAN FABRIC

The Minha Casa Minha Vida (My House My Life) Program (PMCMV) was launched in 2009 by Federal Law nº 11.977, and extinguished in 2020 by Federal Law nº 14.118, which established the Green and Yellow House Program. However, with the return of the Lula government, the program was relaunched through Federal Law nº 14.620, so that over 11 uninterrupted years and one more re-launch, it has concentrated an action that results in important impacts on the urban fabric of Brazilian cities, something that needs to be brought into the debate as a way of improving housing policy.

Launched as a counter-cyclical measure in the face of the neoliberal crisis of 2008, the Program would represent an eclipse in the policy of the National Social Housing System, which had been set up since 2005, based on the idea of meeting the various municipal housing needs, based on bringing together the actors and instruments that would ensure well-located housing in the urban fabric. Thus, the executive bodies – national, state and municipal – would draw up the Social Interest Housing Plans as a way of sizing up the lines of action and budgets needed to solve the various local housing problems; be it in terms of upgrading the stock, through full land regularization, housing improvements, social rent, or increasing the stock, through the production of new units, while the financial bodies and funds would make the resources available in accordance with the Plans.

Contradictorily, the PMCMV is based on the promotion of new housing, in a *modus operandi* in which the construction companies are in charge of choosing the land and building the units, which are then passed on to the municipalities, to be distributed according to the municipal inscription in the housing deficit, in the case of Line 1 of the Program, or are sold directly with financing from CAIXA Bank, in the case of Lines 1.5, 2 and 3. The Program was launched with the manifest aim of alleviating the Brazilian housing deficit (FJP, 2023), concentrating its actions in the contexts where it is most significant – on the outskirts of cities, in the case of the population with an income up to tree minimum wages, and in the poorest states.

Thus, the Program is divided into four tracks – 1, for families in urban areas with a monthly income of up to R$ 1,800; 1.5 extinguished in the 2023 version; 2, for families with a monthly income of up to R$ 4,700 and 3 for families with a monthly income of up to R$ 8,000 – and the resources, budgetary (FAR, Public Offer, Entities and Rural) and onerous (FGTS), are distributed according to these. Thus, line 1 has a 90% subsidy, initially using resources from the General Budget of the Union (OGU), but currently from the FGTS, and a discount on financing with the use of the FGTS; lines 1.5 and 2 have a subsidy of up to R$55,000 and a discount on financing with the use of the FGTS; and line 3 does not have a down payment subsidy, but only financing with lower interest rates from the FGTS. The programmatic lines absorb the demands of the sectors, with the Residential Leasing Fund (*Fundo de Arrendamento Residencial – FAR*) modality serving the housing production contracted with companies; the Entities modality is intended for families organized in an associative manner, according to the Government's qualification and the Public Offering to serve municipalities with a population of up to 50 thousand inhabitants, according to the presentation of proposals by municipal governments or state

governments. It is worth remembering that this last modality is currently discontinued. Whereas subsidized financing serves higher-income families, mostly with FGTS resources (Brazil, 2020).

Based on this operational design, the Program has accumulated 6,075,704 contracted units and 5,162,407 completed units (table 1), and the significance of these numbers in cushioning the quantitative deficit should be considered, given that, in 2009, it was 5,703,003 units and, currently, it stands at 6,215,313 units (2022), as well as in the historical performance with the income line of up to 3 MW. Until then, this social group had not been effectively reached by a preventive housing policy for the production of new housing (Cardoso et al., 2017), but only with specific action, with the use of government resources – such as the Fundação Casa Popular (applying revenues from the Ministry of Labor) and the Residential Leasing Program (applying a mix of FGTS-OGU revenues) – or onerous resources from the FGTS – such as the popular programs of the BNH and the Housing Finance System of the Sarney and Collor governments (Popular Housing Program) (Gomes, 2018).

Table 1. Modalities of MCMV. Source: Brasil, 2020.

Modalities	**Line 1 (OGU)**	**Line 1,5 (OGU + FGTS)**	**Line 2 (OGU + FGTS)**	**Line 3 (FGTS)**
FAR	1.449.264	0	0	0
Entities	78.847	0	0	0
Public Offer	166.886	0	0	0
Financing (or FGTS)	215.749	150.127	3.108.378	363.349
Total	1.910.546	150.127	3.108.378	363.349

Nevertheless, the option for new housing has resulted in a series of urban, architectural, social and environmental impacts covered in important post-occupational research (Rolnik et al., 2015; Cardoso et al., 2017) and in the government's own self-criticism (Brasil, 2020). Thus, in urban terms, the Program has difficulty reconciling housing policy with urban policy, since the selection of land is the responsibility of construction companies, which has meant, as a rule, the choice of mega-projects on the outskirts of large cities and in projects outside the urban fabric, in small cities. Furthermore, many Programs were not accompanied by the qualitative and quantitative supply of equipment, green areas and mobility, promoting the paradigm of housing without a city, leading the government itself to recognize the failure and determine, based on Ordinance nº 660 of 2018, that the complexes could be equipped with equipment. Furthermore, as land prices were defined by supply and demand, the launch of the Program generated an initial increase in land values, further driven by the major events of the World Cup and the Olympics. However, with the economic crisis and the Covid-19 pandemic itself, there was, subsequently, a retraction in the real estate market and, with it, the tendency for land prices to stabilize. While the trend towards cost simplification meant, in architectural terms, the choice of homogeneous typologies, generally multi-family buildings of up to 4 floors, to dispense with elevators, with living room, kitchen, bathroom and two bedrooms, or single-family houses of 42,00 m² or semi-detached; without a greater typological variation, to meet the needs of each type of family. As a rule, there were no adaptations of bioclimatic comfort, which could adapt to the climatic needs of each part of the country, nor innovations, in the sense of introducing more environmentally sustainable materials and technologies for the rational use of resources.

This led the government itself to recognize the failure and require, through Ordinance nº 660 of 2018, that the size of each project be limited to a maximum of 300 homes in the case of developments

implemented under a condominium regime, and 500 units in cities with more than 500,000 inhabitants. However, there was no limit on contiguous developments, up to a limit of 2,000 units. Furthermore, the Ordinance indicated, but did not require, that projects promote typological variation; adapt environmental comfort measures that are more appropriate for each bioclimatic zone in the country, especially shading and cross ventilation in long-stay environments, with bedrooms and living rooms, and the choice of light-colored finishing materials for facades.

The condition of popular housing enclaves has led to these places being stigmatized in social terms as strongholds of violence, drug trafficking, marginalization, and lack of community ties. In addition to the paradox of families having to pay condominium fees, which are incompatible with the value of the monthly financing payments (Brasil, 2020).

The environmental consequences of the urban and architectural choices of these developments have mainly resulted in the extension of urban fabrics, the lack of landscaping and afforestation of collective spaces, and the little use of sustainable infrastructures. This was precisely incorporated into the measures to improve the policy by Ordinance nº 660 of 2018, which attempts to relegate developments located in urban expansion areas, established after April 10, 2012, to being subject to proof of the existence of a specific project that justifies such expansion, established by municipal law and with minimum planning requirements; as well as indicating that the developments adopt landscaping measures, with lighting, afforestation and collective leisure spaces; and environmental technologies, such as rational use of water, solar energy, among others.

However, the Ordinance does not provide more detailed indications about significant cumulative impacts on the reduction of habitats and water recharge, caused in regions that tended to receive many complexes, which may even reflect the lack of guidance derived from scientific research on the subject.

Ultimately, the adaptations of the Ordinance, although they have resulted in improvements to the new complexes, without, however, changing their *status quo*, signal the importance of improving public policy, especially based on the contributions of scientific research. However, the policy is still weak in addressing the causes of the problem, which is the induction of housing in better structured central areas and the use of the existing fabric itself, something less attractive to the market, the protagonist of the policy.

Isolating the case of the metropolis of Brasília, as an example, 21.36% of the developments were concentrated in the Federal District, none of them in the most central Administrative Region of the Pilot Plan, and 78.64% in the outskirts of Goiás (as shown in Table 2). Certainly, this condition can be extended to other Brazilian metropolises.

Table 2. MCMV in the AMB. Source: Brasil, 2024.

	FAR, Poblic Ofer, Rural, Entities		**FGTS**	
Municipalities	**Total Developments**	**Total Units**	**Total Developments**	**Total Units**
Brasília	9	8177	560	569
Águas Lindas de Goiás	2	303	932	934
Alexânia	1	49	8	9

Cidade Ocidental	0	0	174	174
Cocalzinho de Goiás	1	40	19	20
Cristalina	0	0	7	7
Formosa	1	101	61	62
Luziânia	1	499	174	175
Novo Gama	2	300	46	48
Padre Bernardo	1	50	12	13
Planaltina	1	298	123	124
Santo Antônio do Descoberto	1	149	58	59
Valparaíso de Goiás	0	0	470	470
Total	20	9966	2644	2664

THE URGENCY OF AN URBAN MODEL THAT IS PARSIMONIOUS TO THE ECOLOGICAL FABRIC

The search for an urban model that is more parsimonious to the natural environment has historically been the subject of important reflections and proposals, such as the Boston Emerald Necklace (1878 and 1895), Broadacre City (1932) and the Copenhagen Finger Plan (1948), to name just a few examples. Perhaps Thoreau's authentic thinking was a pioneer in defending a transcendental relationship between man and nature.

The classic authors of environmental planning from the 1960s, such as Anne Spring, Michel Houhg, and especially McHarg, can be exemplified as seminal for the approximation of the themes, due to their contribution of the considered and combined reading of thematic overlayers, for the generation of a summary map of restrictions on site occupation.

However, there has traditionally been a tendency for these agendas to be segmented on the political agenda, with environmental issues being addressed only through sanitation and the protection of conservation units/water sources, within the comprehensive master plans of the 1970s, and the urban model, with only one chapter on the environmental issue, as can be seen in the Brundtland Report, where the topic is addressed in Chapter 9 of Part III (Costa, 2008).

More recently, criticism of the impacts brought about by modernist urban sprawl, producing dormitory suburbs around the world, has been addressed in theoretical and propositional reflections, based on models such as the compact city (Dantzig; Saaty, 1973) and Smart Growth (Duany; Speck, 2004). In these studies, the treatment of issues such as controlling the optimal size of each urban area, varying typologies to optimize density and diversity of uses, the presence of common spaces for local food production and the activation of community life, leads to them being touted as examples of so-called “sustainable cities”, although environmental reflection is not the core of these reflections. In the field of ecology, at the same time, important theoretical contributions were made with studies on modeling carrying capacity and ecological footprint, which have been included in the urban planning literature as methodological references for measuring natural and built carrying capacity.

Furthermore, on the political agenda, the worsening of the environmental crisis resulting from human activities has resulted in the approach to climate change as a harmful synthesis of imbalances in biogeochemical cycles, with the 61 IPCC Panels produced to date and the Climate Conventions/Agreements, such as the Paris Agreement in 2015, currently in force, being the main spheres of reflection and consultation.

It is considered that these studies advance in the direction of a deep ecology (Naess, 1984), understanding a dense network of causes and effects of natural cycles and humans as just one of the beings to be respected in the web of life, although the proposals do not yet change the status quo. At the same time, the UN's sustainable development goals (Agenda 2030) also currently represent a platform for the articulation of multiple actors and actions around the planetary environmental crisis, despite the ambiguities of their linkage and the search for social equity by the mainstream.

Data already show that between 2011-2020 the average temperature of the planet was 1.1ºC higher than in the period 1850-1900, that the global mean sea level rose by 0.20 m between 1901-2018; that hundreds of local species losses were caused by increases in the magnitude of heat extremes (high confidence) with mass mortality events recorded on land and in the ocean (very high confidence). Particularly for cities, they show that between 2010-2020 human mortality caused by floods, droughts and storms was 15 times higher in highly vulnerable regions, compared to regions of very low vulnerability (high confidence); in addition to causing greater damage to water and food security (high confidence) (IPPC, 2023). For the Cerrado, data show that the average temperature of the biome rose between 2.2°C and 4.0°C between 1961 and 2019, while precipitation fell by 15% in the same period (Hofmann et al., 2021).

One of the main consequences of urban expansion (due to changes in land use) for the natural environment is the loss and fragmentation of habitats and the reduction of water recharge.

To this end, it is believed that zoning is a key element in achieving an urban model that is more parsimonious to the natural environment, since it affects the entire municipal territory – urban, rural, natural – and is responsible for promoting the fair distribution of the different types of uses and occupation gradients throughout the territory. Thus, supply and demand balance methodologies for measuring natural and built support capacity and/or multicriteria analysis – combined and weighted – for generating a summary map of restrictions would be important instruments for this desired parsimony. Likewise, the importance of bottom-up reading and conservation of traditional and community actors and practices in zoning is defended.

The result would be the protection of environmental areas – conservation units, water sources, traditional management – for the provision of ecosystem services; conservation of family farming areas for supply close to the consumer market and control over mechanized farming areas to minimize impacts; creation of buffer zones between the urban and environmental areas; control over the urban perimeter for the compactness of the urban area; promotion of density and diversity of building typologies to minimize displacements and optimize occupation; promotion of environmental strategies from the lot, in terms of setbacks, templates, adoption of compensatory urban drainage measures.

Zoning would also be effective in promoting ecological coordination at the supra-municipal scale. Thus, the Ecological Economic Zoning (ZEEs), drawn up by the states as required by the Forest Code (Federal Law nº 12.651 of 2012), would be key to this, while the national ZEEs would promote coordination between biomes, crossing the ecological fabric between the different states. Even the Statute of the Metropolis (Federal Law nº 13.089 of 2015) advocates the need for supra-municipal zoning in the contexts of urban agglomerations and metropolitan regions. Ultimately, there is a

preservation zone, which provides ecosystem services, a transition/buffer zone, for the grading of natural and human uses, and a zone of concentration of anthropic activities. However, in practice, what we have in several Brazilian municipalities is a fragile zoning, proposed without a more restrictive reading of the natural environment, valuing the urban area more than the rural-environmental totality of the territory, without the effective bottom-up participation of traditional and community actors. This adds to the fragility of supra-municipal articulation of state ZEEs by river basin and of national ZEEs by biomes. Valparaíso, as we will see, is the sum of these deficiencies. Landscape ecology provides an important theoretical understanding of the structure, function and alteration of natural remnants with a view to constituting an ecological continuum that promotes biodiversity and various ecosystem services. Thus, according to Forman (2008), the structure constitutes the two-dimensional arrangement of the landscape through three elements – patches, corridors and matrices (Forman, 2008). Patches are the units of a landscape, which, according to Forman (2008), vary in terms of type, heterogeneity, size, shape and edge characteristics. The type refers to the prevailing land uses – urban, agricultural, environmental –; the heterogeneity to the density and distribution of these uses; the size – small, large –, in turn, to the environmental validity of the unit; the shape – circular, rectangular – to the area necessary for the survival of each animal; and the edge thickness to the limit necessary to ensure the integrity of the remnants and avoid the abrupt clash between natural/anthropic uses (Forman, 2008).

Corridors, according to the theory of island biogeography (MacArthur; Wilson, 1967), are connections between patterns of habitats dispersed in fragments, seeking to form a continuous network for the movement and genetic exchange between animals and plants. Thus, the passages existing in this continuum favor exchanges, while barriers inhibit them. Among the characteristics of corridors that interfere with their biological integrity are width – wide, narrow –; shape – straight, winding –; connectivity – continuous, discontinuous –; presence/absence of rivers, parkways, transmission lines; length – long, short –; connection or not by patches along the length and ends and, finally, the complexity of the use of the adjacent land. Stepping stones, on the other hand, are ways of creating small discontinuous connection points when there is no possibility of forming a continuous corridor (Forman, 2008).

The matrix is the surrounding area where the patches are embedded; constituting the most extensive and connected element and therefore playing a preponderant role in the functioning of the landscape (Forman, 2008).

While the function, or interaction between spatial elements, represents the flows of energy, materials and species between the ecosystems present (Forman, 2008).

While the alteration refers to changes in the structure and function of the ecological mosaic over time, articulating consolidated or transforming landscapes (Forman; Gordon, 1986). The authors thus classify five phases of land use change – perforation (when there is the creation of holes in the landscape), dissection (when there is a relative slicing of the landscape), fragmentation (when there is a break-up into pieces), shrinkage (when there is a reduction in size) and disappearance (when there is elimination).

The groundwater recharge process can be explained by an intrinsic interrelation between natural and anthropogenic factors (Gomes et al., 2022). Among the main anthropogenic characteristics are: i)

effectively impermeable surfaces – known as sealed – such as sidewalks, roads, parking lots, backyards, buildings, swimming pools, sports courts, etc., where infiltration is close to zero; ii) changes in soil cover, such as in the case of agricultural crops, pastures, orchards, gardens, exposed soil, compacted soil, reduction of native cover, especially trees, unpaved roads, etc. which, although they do not result in zero infiltration, alter the natural recharge pattern. The main natural characteristics that interfere with infiltration include: i) spatial variations in geomorphology, especially in terms of relative altitude and slope; ii) vertical percolation of water between surface layers, in the soil-vegetation relationship, and underground layers, towards underground aquifers. In geomorphological terms, regional highs are responsible for deep recharges and regional lows for discharges into surface water bodies (Silveira; Usunoff, 2009). In terms of percolation, the initial influence is vertical, due to the presence of vegetation (Gomes et al., 2022), and the subsequent influence is horizontal, due to the action of gravity and the materials that make up the soil (GOMES et al, 2022). Porosity (which is the relationship between pore volume and total volume), permeability (which is the soil's ability to allow water flow through its pores based on their size and connection) and soil thickness (holding capacity) all play a role in this process; the first two characteristics act initially and in combination, and the last one secondarily.

The main consequences of reduced infiltration are the reduction not only in the supply of underground aquifers, but also in the supply of springs during the dry season, in addition to increased surface runoff, which can contribute to increasing peak flow in the beds of watercourses, which can result in floods, inundations and flooding points; in addition to erosion and silting (GOMES et al, 2022).

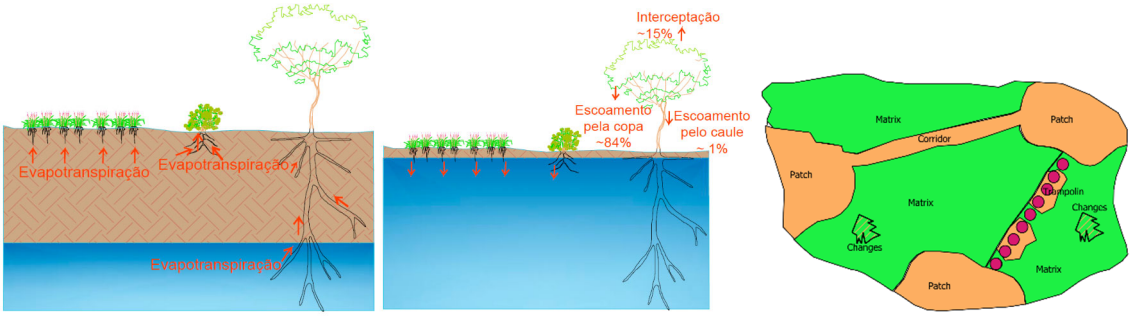


Figure 1. Interaction vegetation-soil in the groundwater recharge process. Source: GOMES et al., 2022.

Figure 2. Matrix-Patches- Corridors. Source: authors.

This knowledge was applied to the work of comparing satellite images before and after the expansion of the PMCMV sets in the region to understand the changes in the shape/size/edge characteristics of the vegetation. And in the analysis of the impairment of one of the most important functions of the ecological continuum, which is water recharge. Thus, a weight was assigned to each soil type according to its characteristics of allowing water recharge, as will be seen.

Studies have shown the impacts of reduced water recharge in the Cerrado. Among them, Salmona et al. (2023) performed statistical modeling of fluviometric and climate data from 81 Cerrado basins between 1985 and 2022, having identified that 88% of them already show a decrease in flow, mainly due to climate change and land use estimated to contribute 44% and 56% respectively to the impact.

Excerpting the data on the loss of vegetated area and river surface of the rivers in the municipality of Valparaíso de Goiás- GO, there is a loss of 33,46% of areas between 1985-2023 and a reduction in the maximum, average and minimum areas from 4-2-1 ha to 2-1-1 ha between 1985-2023.

Table 3. Cerrado loss and recharging in Valparaíso de Goiás.. Source: Mapbiomes, 2024.

	1985	2009	2023
Vegetation			
Non-vegeted area	33,46	48,47	57,06
Forest	55,09	36,67	30,78
Natural formation not forested	2,61	2,27	2,32
Agriculture	8,81	12,57	9,83
Basin			
	4ha | 2ha | 1ha	4ha | 2ha | 1ha	2ha | 1ha | 1ha

METHOD

In order to analyze the impact of habitat loss and fragmentation due to urban sprawl in the municipality of Valparaíso de Goiás, the working method used satellite images taken from the Landsat 5 and 8, Instrument TM, spatial resolution 30 by 30 m, obtained from the NASA website https://earthexplorer.usgs.gov/ (2022), for orbit 221/point 71, for which the normalized difference for vegetation index (NDVI). This indicator makes it possible to compare changes in the types and densities of vegetation and land use between time periods, which allowed to contrast the urban form and vegetation before (July 02, 2009) and after (July 06, 2022) of the expansion of housing developments in the region. For this reason, we tried to use images taken from the same season (mid-drought) for greater data consistency.

The images were processed using the QGIS geoprocessing software, starting with atmospheric correction of the images, applying equation 1 for converting radiance to planetary reflectance at the top of the atmosphere, for the red (band 3 in Landsat 5 and band 4 in Landsat 8) and infrared (band 4 in Landsat 5 and band 5 in Landsat 8) bands, according to NASA (2022):

$1\rho' \lambda = ((Mp \times Qcal) + Ap)/ \theta SE.$ (Equation 1)

In which, $\rho' \lambda$ is the reflectance of the top of the atmosphere; Mp is the REFLECTANCE_MULT_BAND_X metadata parameter, where x is the band number; Qcal is the digital number value of each pixel; Ap is the REFLECTANCE_ADD_BAND_X metadata parameter, where x is the band number; θSE is the elevation angle of the sun. The NDVI was then calculated using equation 2:

$2NDVI = (NIR – RED) / (NIR + RED)$. (Equation 2)

Where NIR is the near infrared band and RED is the red band. To analyze the impact on water recharge, the method used the Analytic Hierarchy Process (AHP) to combine and weight the most influential anthropogenic and natural variables in the scenario before (2009) and after (2022) the launch of the PCMV in the municipality. Thus, according to the literature and previous work by the authors, were processed in QGIS® the relative weight that each variable exerts on groundwater recharge, resulting in 50% for NDVI (as a proxy for land cover), 18% for pedology and 32% for geomorphology and, at the level of each variable, scores from 0 to 4 were specified to determine the influence of every situation on recharge (table 4).

Table 4. Weight of variables used in AHP. Source: authors.

Ground Cover (50%)	Pedology (18%)	Geomorphology (32%)
High density Building (magenta) – 4	High density Building – 0	Medium dissection planes, cotas between 900 and 1100 m (good groundwater recharge) – 2
Low density Building (pink) – 3	Neossolo (low groundwater recharge: 10-7 e 10-8 m/s) – 3	Low dissection planes, cotas between 900 a 1100 m (good groundwater recharge) – 1
Lower density vegetation (dark blue) – 2,5	Aluviais (low groundwater recharge) – 3	
Medium density vegetation (light blue) – 2	Cambissolo (very low groundwater recharge: 10-7 e 10-8 m/s) – 4	
Hight density vegetation (green) – 1	Latossolo (good groundwater recharge: 10^{-4} m/s a 10^{-7} m/s) – 1	

THE PMCMV EXPERIENCE IN THE MUNICIPALITY OF VALPARAÍSO DE GOIÁS

Valparaiso de Goiás has been suffering the effects of its proximity to Brasília since the first years of the capital's inauguration in 1960. The municipality, which had 6,000 inhabitants in 1980, grew by 157.51% between 1980 and 1985, by 89.55% between 1987 and 1990, and by 43.58% between 1991 and 1996, reaching a population of 75,380 inhabitants. Before the PMCMV, in 2009, the population of the municipality was 123,444 people, jumping to the current 198.861 inhabitants (2022). The municipality, located approximately 33 km from Brasília, has approximately 42% of the population economically active working in Brasília. Furthermore, 4,109 make use of the public education system and 26,858 of the capital's hospitals and health centers (PMAD, 2018) (figure 3).

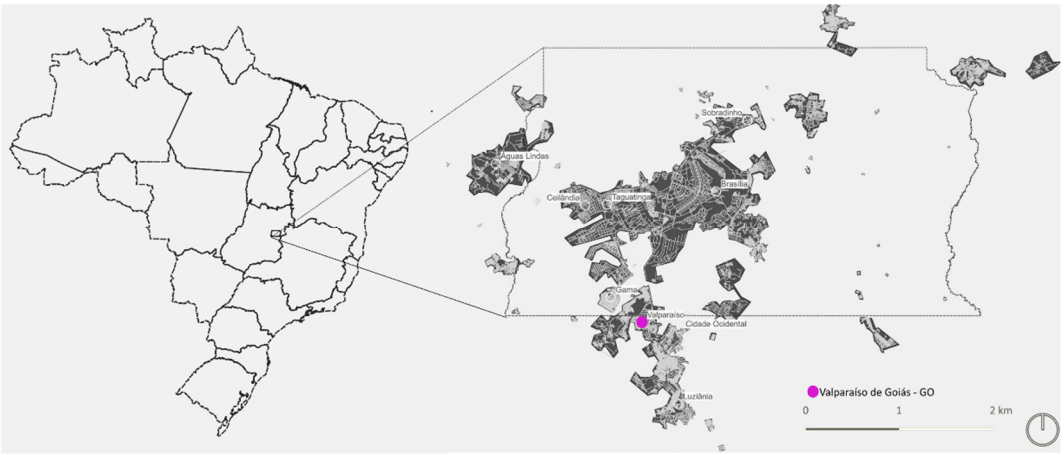


Figure 3. The location of the municipality. Source: authors.

The high metropolitan demand for housing, the existence of a large supply of cheap land for urban expansion and permissive municipal legislation, meant that the outskirts of the metropolis in Goiás received many PMCMV projects, it is worth noting that 470 are located in the municipality.

The NDVI data obtained for the municipality, before and after the attraction of these projects, show that the location had an increase of 39.63% in urban expansion in the 2009-2022 relationship; the impermeable areas increased from 27.19% in 2009 to 35.68% in 2022 (figures 4 and 5). This expansion occurred mainly in the Anhanguera, Ypringa, and Pacaembu sectors, in addition to a recent occupation around the only urban park in the municipality, by the new neighborhoods: Florais do Planalto, Rio

das Pedras, and Reserva Paraíso. There was also a significant increase in red spots near the northern edge of the municipality, which borders the Federal District, and also in relation to its extremes.

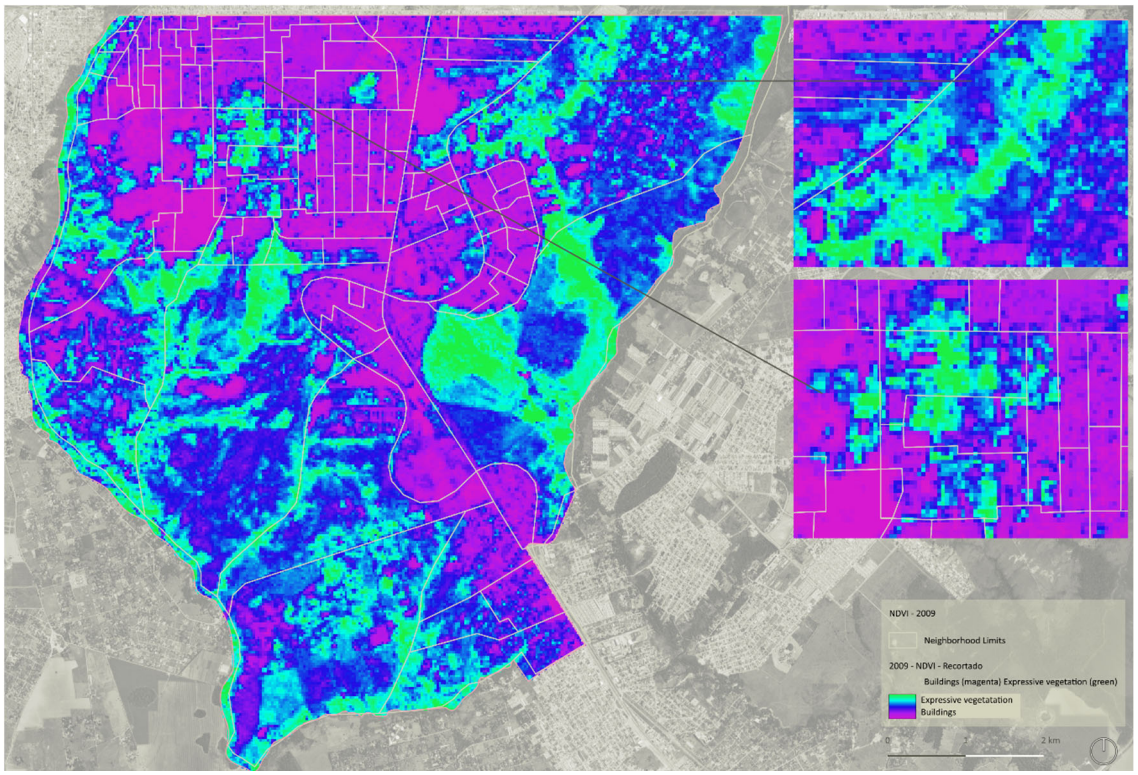


Figure 4. NDVI 2009. Source: authors.

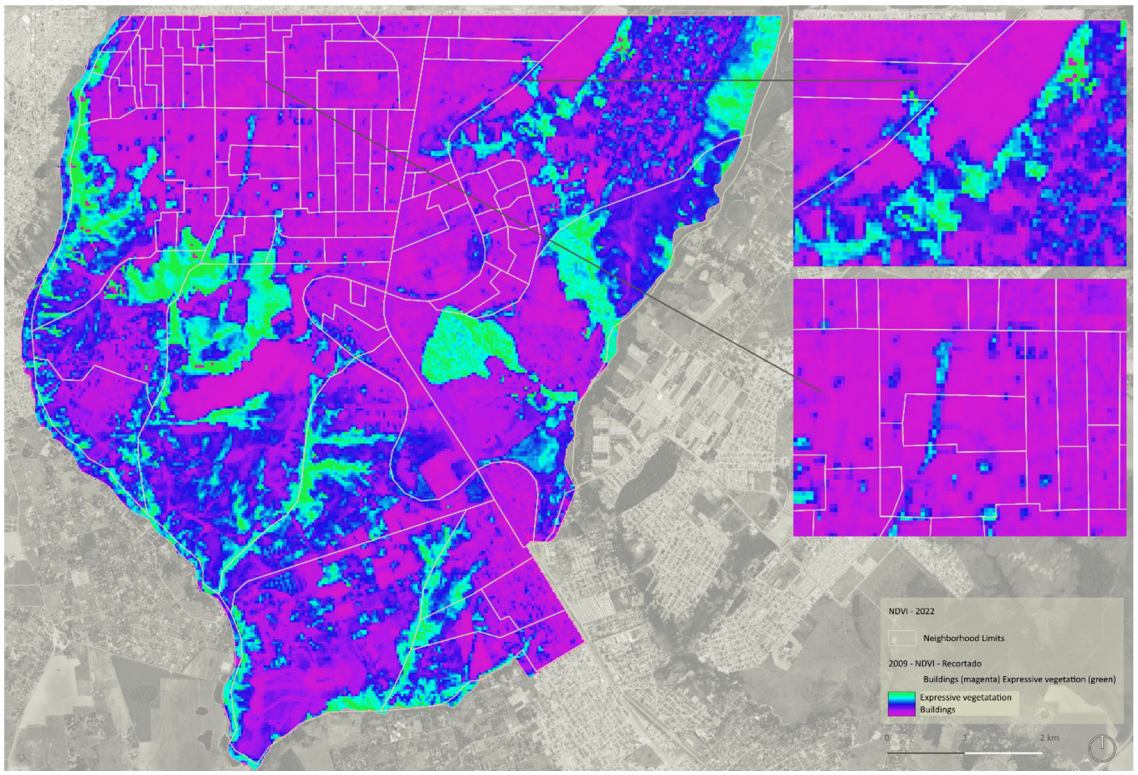


Figure 5. NDVI 2022. Source: authors.

It can be seen that zoning was the main factor responsible for this increase (figure 6), considering that most of the typologies responsible for urban expansion are residential in nature, mostly multi-family buildings and single-family condominiums. It is important to note that the Anhanguera and Ypiranga farms are located, respectively, in the Corumbá and São Bartolomeu basins, sensitive areas from the point of view of the water recharge potential of the cerrado. Superimposing zoning on this shape, we can see that it was responsible for this rapid expansion.

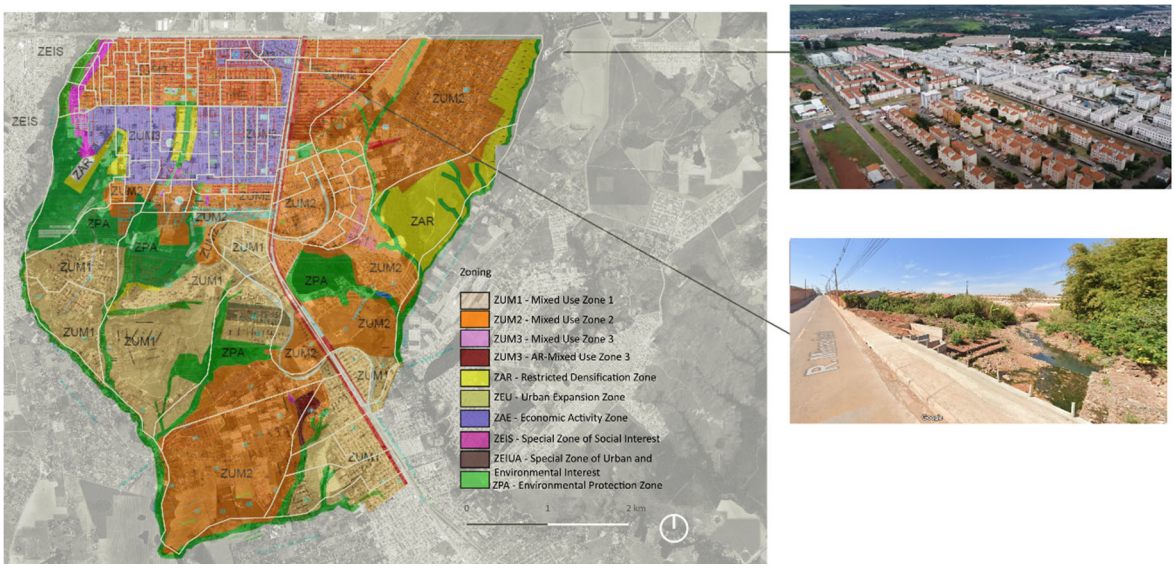
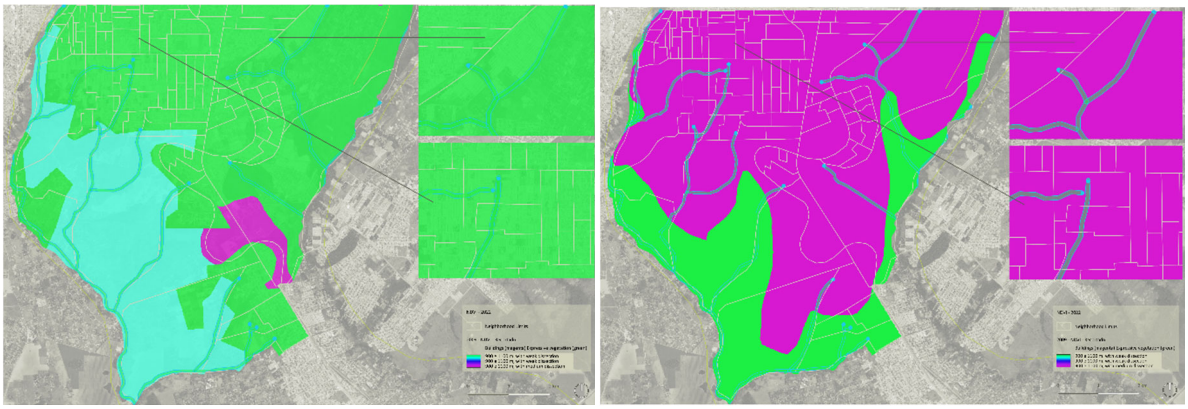


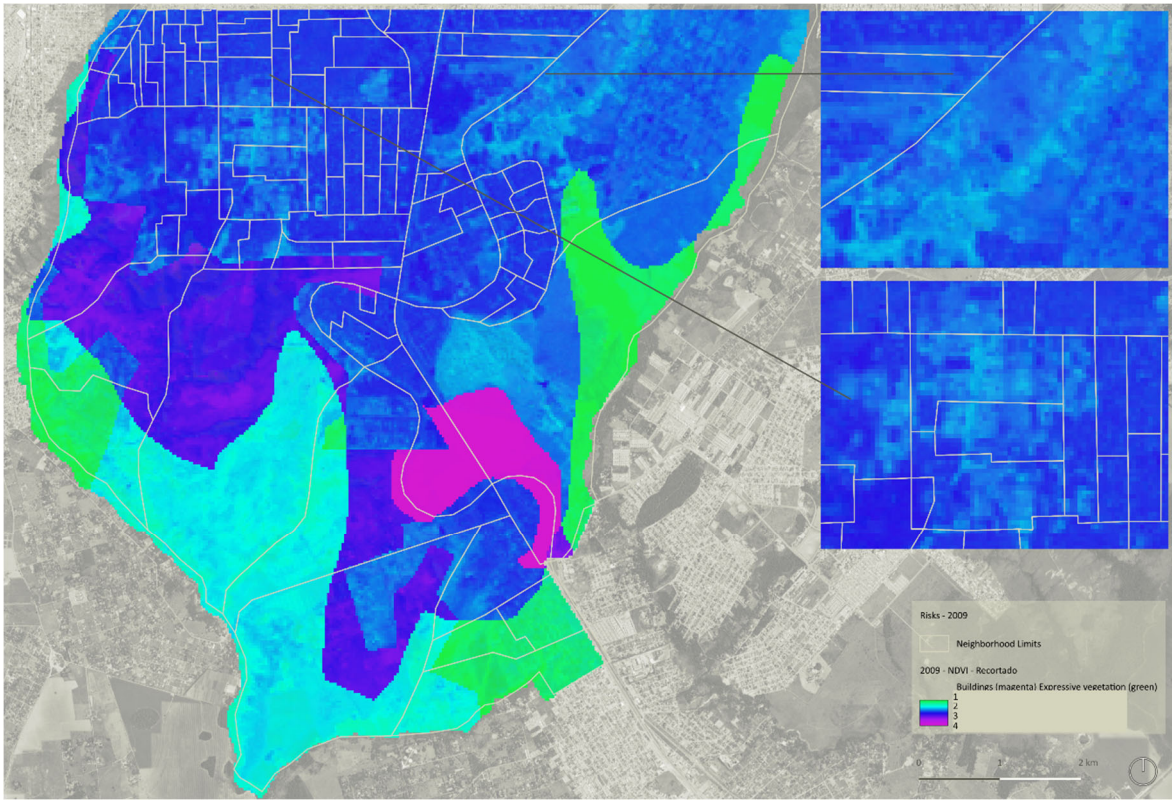
Figure 6. Zonning. Typologies (a) and river situation (b). Source: authors.

Below are the geomorphology and pedology maps that served as the basis for the AHP (figures 7 and 8).

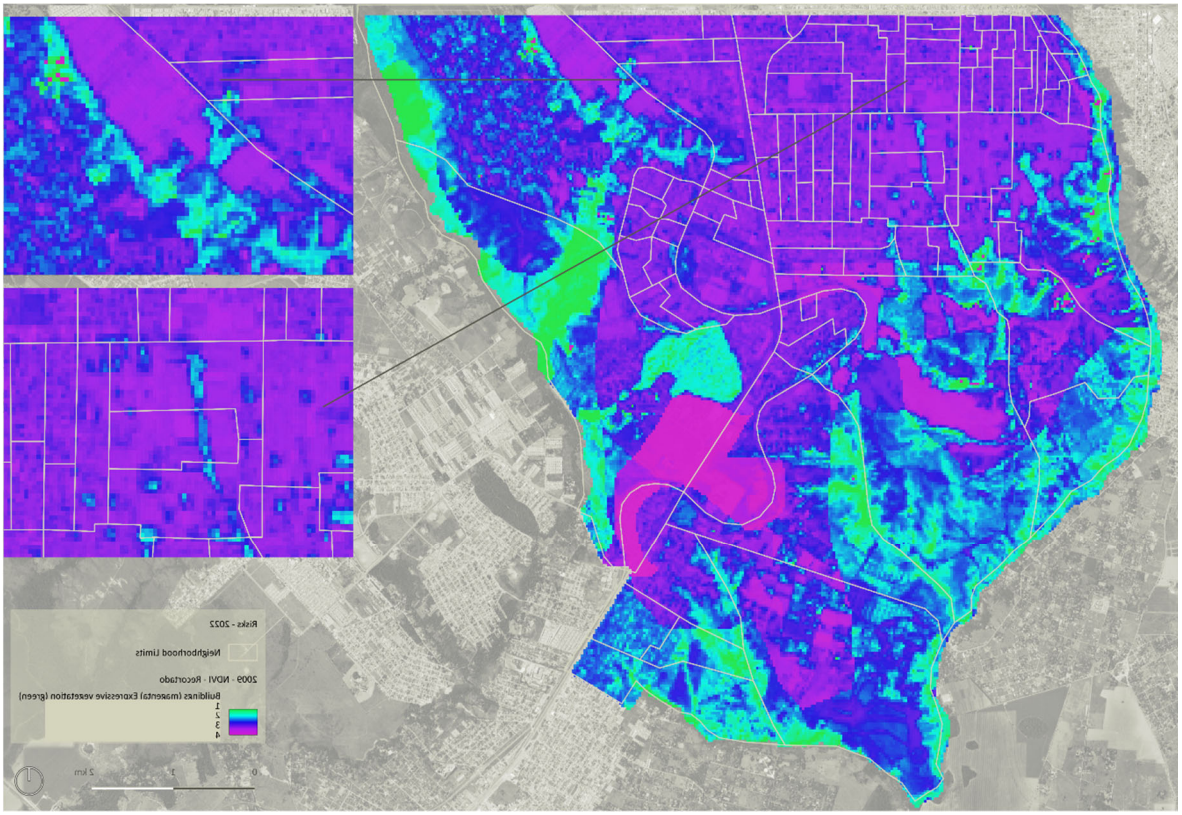


Figures 7 and 8. Pedology and Geomorfology. Source: authors.

The results of these processes show the areas most critical to recharge in the 2022 scenario, compared to 2009; resulting in an increase of 35% in critical recharge risk areas (Figures 9 and 10). The map shows new critical areas precisely in the places that received the most ensembles (Anhanguera, Ypringa, and Pacaembu).



Figures 9. Risks for recharging. Source: authors.



Figures 10. Risks for recharging. Source: authors.

CONCLUSIONS

The work showed the impact of urban sprawl on the reduction and fragmentation of vegetation and the reduction of groundwater recharge. The study's theoretical approach thus fills an important gap, given the scarcity of studies analyzing the impacts of urban sprawl on habitat fragmentation and groundwater recharge. As a result, the article's recommendations point to the urgent need to reconcile housing policy, the production of new housing, and urban policy, through strict zoning of the territory. The provision of risk analyses helps urban planning and public policy, by seeking to restrict the expansion of the urban fabric of Brazilian cities, a subject that is not only dear to the urban and social impacts it produces, but also the environmental impacts brought up in this work.

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(Re)thinking green infrastructure: a morphological perspective

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ABSTRACT

Green infrastructure received significant attention over the past few decades. Literature on the topic emphasizes the relevance of natural environments for both human and non-human populations. Natural and semi-natural green spaces are also seen as highly beneficial for transforming urban landscapes in response to sustainability imperatives, either with the aim of improving the quality of the physical environment and people's lives, preserving biodiversity and natural processes, or adapting human settlements to the uncertainties of climate change. While research on green infrastructure is mainly based on environmental and ecological concerns, the relative absence of a morphological viewpoint on the topic is rather surprising. Against this backdrop, this paper aims to provide some answers to a simple but fundamental question in understanding and (re)designing built environments: how can green infrastructure be defined from an morphology perspective? The main objective of this paper is to illustrates what is meant by green infrastructure when examined on the basis of the conceptual framework and methodological tools specific to the study of urban form. The study draws from a typo-morphological analysis of parks and urban green spaces in Montreal (Quebec, Canada). The analysis focuses on their shapes and relationships towards geomorphological and anthropogenic systems at multiple scales. It also investigates their (trans)formation process. Findings underline that parks and urban green spaces generate a complex system of sites of varying shapes and relationships evolving over space and time at all scales of the built environment. They also reveal that their evolution is not always fully planned, but rather the result of territorial systems (trans)formation and the unstructured growth of urban fabrics. These insights contribute to the knowledge-building about green infrastructure morphologies and to debates regarding the quality of past, present, and future urban landscapes.

Keywords: green infrastructure, parks and green spaces, sites, morphology, definition.

INTRODUCTION

This paper is based on my research and teaching activities linked to my doctoral thesis on the topic of infrastructure landscapes, which specifically addresses the (trans)formation processes of green infrastructure. More specifically, it is grounded on the difficulty of capturing green infrastructure from a morphological viewpoint, and the relative absence of research tackling this cognitive gap.

Over the last few decades, green infrastructure has received significant attention, primarily aimed at meeting the imperatives of sustainability, and drawing on the many roles of natural and semi-natural features and areas to support the (trans)formation of built environments (Benedict and McMahon, 2006; Steiner, 2014; Bolleter and Ramalho, 2020). As an operative concept, green infrastructure is thus based on some definitions, including that of the European Commission (2013: 3), which is widely disseminated in the literature:*''a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services''*. A review by Matsler et al (2021) suggests, however, that such a definition is not consensual. It is rather extended by disciplinary and geographical conceptualizations which translate green infrastructure, notably, as a green space planning concept, urban ecology concept or water/stormwater management concept.

However, the ecological perspective among definitions fuelling the literature on green infrastructure poses a cognitive and normative imbalance on a morphological level. In fact, literature is rather dominated by concepts, principles, methods and typologies related to the field of ecology, which orient the study of green infrastructure and drive many planning and design approaches (Bartesaghi Koc *et al.,* 2017; Monteiro *et al.*, 2020; Reed and Lister, 2020). Given the disinterest of urban morphologists in the study of parks, green spaces and natural environments (Whitehand, 2017; Whitehand, 2019), those fundamental to the study of and intervention on urban form are thus relatively absent within the literature and, thus, evacuated from the morphological perspective and debates on the topic of green infrastructure.

(Re)thinking green infrastructure: an imperative

Against this backdrop, this paper aims to provide some answers to a simple but fundamental question in understanding and (re)designing built environments: how can green infrastructure be defined from an urban morphology perspective? Its aim is to illustrate *what is meant* by green infrastructure when examined from the conceptual framework and methodological tools specific to the study of urban form. The study draws from a typo-morphological analysis of parks and green spaces in Montreal (Quebec, Canada). Three operative questions are thus put forward regarding their morphologies: 1) what are their shapes?; 2) what are their relationships with urban and territorial systems?; 3) how do these shapes and relationships originate?

This paper is divided into three parts. The first part presents Montreal as a case study and describes the methods. The second part presents the main research findings. Building on these results, the following discussion rethinks green infrastructure from a morphological perspective and puts forward a (re)definition. Finally, the conclusion describes the main limitations of the study and suggests avenues for future research on the topic.

MONTREAL AS CASE STUDY

Industrial, commercial, intellectual, and cultural hub, Montreal is located in the province of Quebec, Canada. It is Quebec's metropolis and the country's second most populous city, with 1,762,949 inhabitants. The Greater Montreal Area, comprising 82 municipalities, is the second largest after Toronto's in terms of population (4,104,074 inhabitants), accounting for 11% of the national population and 48% of the provincial one (Statistics Canada, 2021).

Montreal is located in the St. Lawrence lowlands, amidst an archipelago of over 300 islands and a complex hydrographic crossroads. This singular geography was one of the decisive factors in the city's foundation in 1642 on the Island of Montreal (Figure 1). It also contributed to its gradual development from a fortified village (and later a fortified town) supporting the missionary, social and commercial objectives of the French Regime into an industrial metropolis fostering the growth of the British Empire, the rise of the Canadian nation, and the ongoing development of Quebec (Marsan, 2016; Linteau, 2022).

Moreover, the administrative boundaries of Montreal now encompass nearly 70% of the Island of Montreal, as well as extending onto several neighbouring islands (Statistics Canada, 2021). This growth over almost 400 years was influenced by the inertia of the two colonial projects in both their physical and intangible structures (Marsan, 2016; Racine *et al.*, 2022). It is also a result of the progressive evolution of neighbouring towns and villages, and their gradual annexation to the City of Montreal from 1883 to 2002—first in response to bankruptcies, and lastly as part of the provincial government's plan to reorganize municipal administration in Quebec (Marsan, 2016; Beaudet, 2021).



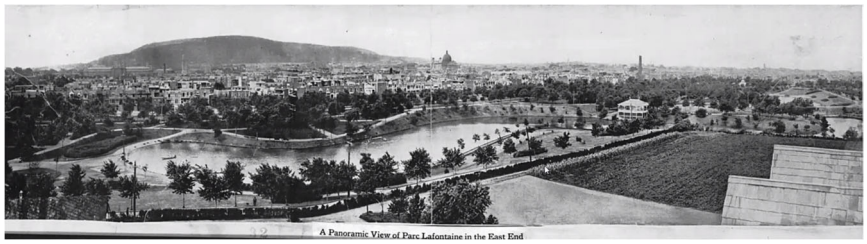

Figure 1. Montreal from St-Helen's Island. Credit: James Duncan, 1852-1853. Source: McCord Stewart Museum.
Figure 2. A Panoramic View of Parc Lafontaine in the East End. Credit: Unknown photographer, circa 1910. Source: McCord Stewart Museum.

The interest in studying Montreal is manifold. Firstly, Montreal's parks and green spaces are highly diverse. Such diversity is mainly due to their piecemeal development as the city evolved. Examples include convent and ornamental gardens from the pre-industrial era, squares and urban parks from the 19th century (Figure 2), and neighborhood parks from the first part of the 20th century. This corpus also presents a variety of parks developed during the post-World War II expansion (neighbourhood parks, amenity parks, green networks, etc.) and several examples of infrastructure retrofiting for park purposes (canal, dam, dike, seaway, rail network, highway network, etc.).

Secondly, Montreal has been characterized by the growing synergy of numerous stakeholders in favour of the development and transformation of parks and green spaces since the end of the 20th century. This synergy is part of a shared vision for the sustainable development of the metropolitan territory, with the aim of increasing urban biodiversity and ecological connectivity, and ensuring the protection and enhancement of natural environments (CMM, 2013; Dupras *et al.*, 2015; Bissonnette *et al.*, 2018; Ville de Montréal, 2021). The development of nature parks initiated this approach in the 1970s. The development of green alleys followed, on a finer scale, in the 1990s. Jointly supported by the insights of landscape ecology and sustainability, green and blue grids, large ecological parks, biodiversity and ecological corridors, urban park redevelopment, sponge parks, green alleys, mini-forests and planted sidewalk buffers are among the solutions currently being planned and developed in the Greater Montreal area.

Thirdly, Montreal's park and green space network (Figure 3) is a complex historical object to define, given its continuous development since the 19th century and the variety of principles that have since guided its (trans)formation. It provides an excellent case for our morphological exploration.

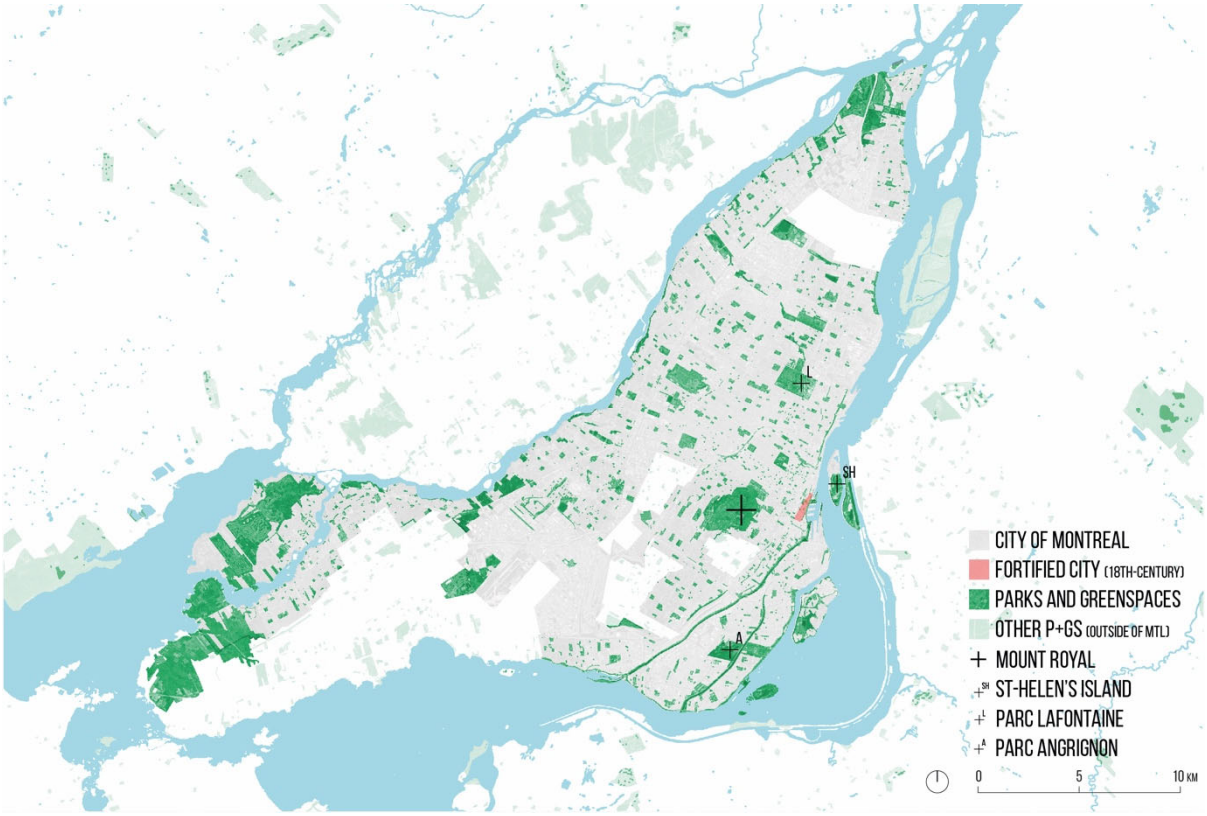

Figure 3. Parks and greenspaces in Montreal. Image by the author, 2024. Adapted from multiple sources.

METHODS

This study investigates the morphologies of Montreal's parks and green spaces from the viewpoint of their sites. This approach simplifies their physical reality, leaving aside their layout and uses, in order to facilitate our understanding of their formal and relational properties.

The study was developed in two parts. The first, a preparatory phase, included 1) gathering open geographic and historical data on Montreal's parks and green spaces, as well as data documenting Montreal's urban form (hydrography, topography, infrastructure networks, fabrics, etc.), 2) creating

a project file with these data (on QGIS, Lima 3.32), 3) validating their relevance and the need for additional data collection, and 4) screening the data, in particular that of parks and green spaces (eliminating invalid entries, grouping entries by sites, etc.). These steps were followed by 5) the initial analysis of quantitative and qualitative data for parks and green spaces, 6) the exploration of certain hypotheses (small and large sites, sites in relation to the hydrographic network and infrastructure networks) and, 7) the validation of the variables and methods to be used.

Table 1 summarizes data used in this study. The initial analysis of data on parks and green spaces reveals that there are nearly 1,700 in Montreal. These sites are mainly public spaces. Their total surface area covers almost 70 square kilometres, mostly administered by the Montreal Agglomeration (all the municipalities on the Island of Montreal) or the City of Montreal. They are also divided into

three functional types: parks, green spaces and roadway spaces (Figure 4). Hypotheses were explored in collaboration with 22 graduate students at Université Laval's School of Architecture in winter 2024 *(ARC-7032 : Morphologie et syntaxe des milieux bâtis)*.

Table 1. Table showing type, description, and source of data.

Type of Data	Subcategory	Type of Documents/Data	Description / Example	Source	Year
Geographic Data	Georeferenced open data	Data on parks, greenspaces, and public places	GIS data with precise coordinates, and quantitative and qualitive data (i.e. area, ownership, management type, functiononal type)	Ville de Montréal	2020
		Data on parks and greenspaces	GIS data with precise coordinates	Communauté Métropolitaine de Montréal (CMM)	2022
		Data on parks and sports fields	GIS data with precise coordinates	Statistics Canada	2023
		Data on hydrography, coutour lines, networks, roads and streets, land subdivision, buildings, landuse, etc.	GIS data with precise coordinates	Statistics Canada, Données Québec, CMM, Géoindex	2016-2023
		Maps of the Island of Montreal	Georeferenced raster image	Géoindex	1890-1929
Archival Documents	Maps and plans	Topographical maps, city maps, urban plans, land-use plans	Maps showing the land division, urbanization, urban layout, and land-use of the Montreal archipelago and the City of Montreal	Bibliothèque et Archives Canada, Bibliothèque et Archives nationales du Québec (BAnQ), Ville de Montréal	1831-1949
	Photographs	Aerial photos	Images depicting the City of Montreal and part of the Montreal Island	Ville de Montréal	1925-1935, 1947-1949
		Historical photographs, aerial photos	Images depicting Montreal urban landscape	Ville de Montréal, Bibliothèque et Archives nationales du Québec, Musée McCord Stewart	1880-2000
Other	Photographs	Photos of Montreal parks and greenspaces	Photos depicting parks and green spaces interfaces	Fieldwork	2020-2024

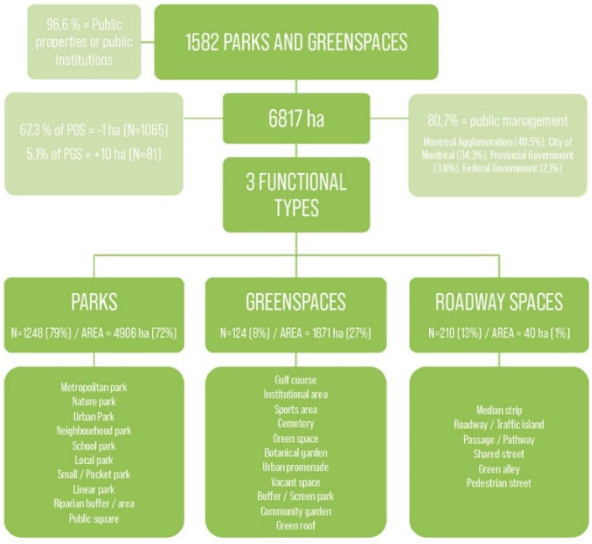

Figure 4. Initial observations on parks and green spaces in Montreal. Adapted from Ville de Montréal, 2020.

The second phase of the study covers the main analysis which was developed in three iterative steps (Figure 5). The first step consisted in analyzing the sites' shapes through manual classification (on Adobe Illustrator, for parks and green spaces of over 1 ha) and visual classification (on QGIS, for those of 1 ha or less). It focused on identifying their shapes (the common ones and their variations, the exceptional ones) and defining typologies. These typologies were then cross-referenced with data on the size and functional type of each site, with the aim of extending their understanding.

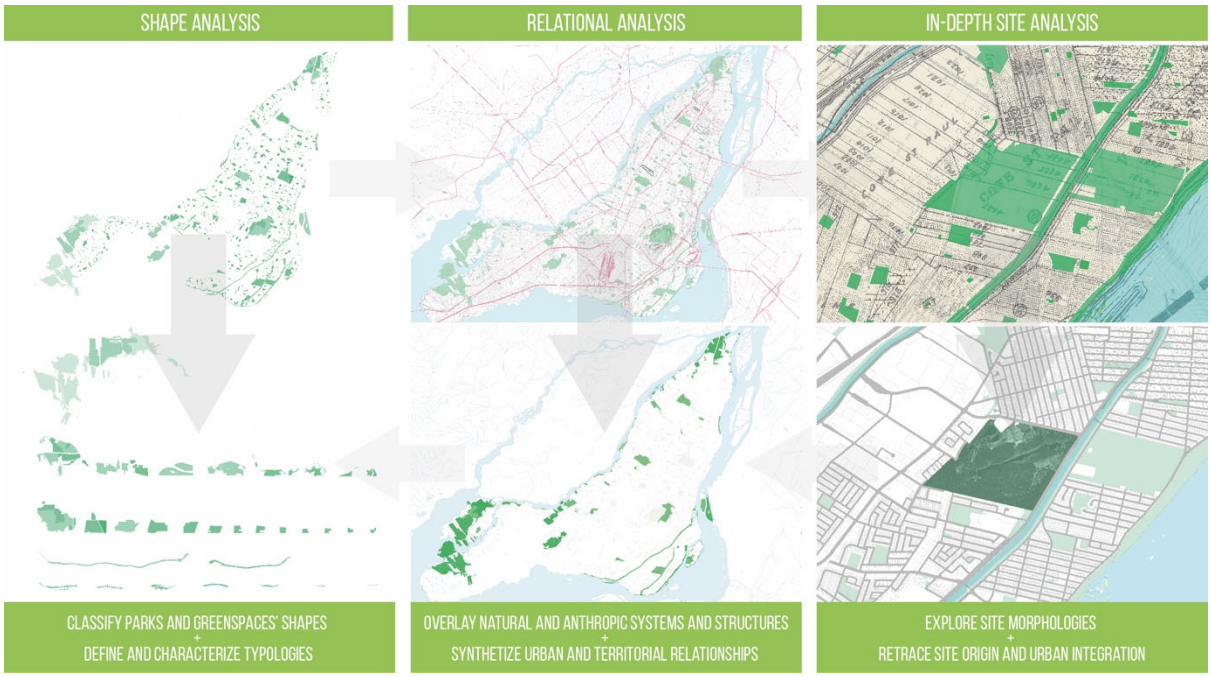

Figure 5. Exploring parks and green spaces morphologies. Types of analysis and overall methodological process. Image by the author, 2024.

During the second step, a relational analysis of the sites was carried out to better understand their relationships with urban form's systems and elements. This analysis was based on the typo-morphological approach, which recognizes that urban forms have different levels of complexity depending on the scale of analysis and the type of components examined (Table 2). It was also inspired by the work of Paola Viganò on analyzing urban systems (see Secchi and Viganò, 2009; Viganò, 2013; Viganò, 2023). The approach consisted in cross-referencing, in QGIS, the map layer for parks and green spaces with those for territorial systems (hydrography, topography, agricultural fabric, networks), agglomerations (basic and specialized fabrics) and fabrics (roads, parcels, buildings). This led to a series of maps showing the relationships between the various systems. These relationships were then compiled, classified within levels of complexity, and finally synthesized.

Table 2. Levels of complexity of built environments. Translated from Racine et al., 2022.

Organisms	Systems of structures	Structures of elements	Elements
Buildings	Building systems	Building envelope Framework	Exterior walls Roofs Roof frames Beams and columns

Urban fabrics	Street pattern Lots / plot pattern Building pattern	Pertinent strip of a street	Streets Lots / plots Buildings
Agglomerations (villages, town, cities, metropolitan areas)	Infrastructures (roads, acqueduct, etc.) Neighbourhoods (tissus and amenities)	Public/collective domain	Tissus (basic and specialised) Parks and public spaces
Territories	Networks (highway, railway, transmission lines, maritime routes)	Aglomerations and pertinent areas Agricultural fabric Productive areas	Agglomerations Infrastructures Routes Farms

The final step further explored park and green space shapes and relationships by examining the origins and the integration of certain sites. Their evolution was analyzed by superimposing current geographical data and historical maps, as well as by examining historical and iconographic sources. Integration was also examined through fabric analysis and a photographic survey. The case of Angrignon Park is presented in this paper.

PARK AND GREEN SPACE MORPHOLOGIES

This section synthesizes our main findings, in order to better understand the morphologies of parks and green spaces, and to support, through discussion, the redefinition of green infrastructure.

On shapes

Analysis reveals two main categories: punctual and linear. Thus, punctual sites assume the appearance of a point of more or less size on a map, whereas linear sites are more like a line of varying length and thickness. Based on typical examples identified for these two categories of sites, Figure 6 illustrates their essential characteristics and main variations. We notice that sites, both punctual and linear, can be regular in shape (square, rectangle, triangle, strip, etc.) or irregular when the complexity of their boundaries affects their intelligibility. Furthermore, sites tend to be continuous or discontinuous. In other words, each site may correspond to a single space—which is the case for the majority of sites—or be divided into more than one space. The discontinuities mainly refer to a site's fragmentation by the street or road network. They can also denote the dispersal of a site divided by waterways, urban or agricultural fabrics. Such cases are uncommon and limited to large-scale sites (metropolitan parks or nature parks).

Otherwise, the analysis highlights an interesting variation corresponding to the agglomeration of several contiguous sites. Mount Royal is an example of a punctual agglomeration, combining, for example, Mount Royal Park, large cemeteries and the Université de Montréal grounds. As another example, in the southern part of the Island of Montréal, a series of parks (urban, neighbourhood, local, etc.) organizes a linear agglomeration along the St. Lawrence River and Lachine Rapids.

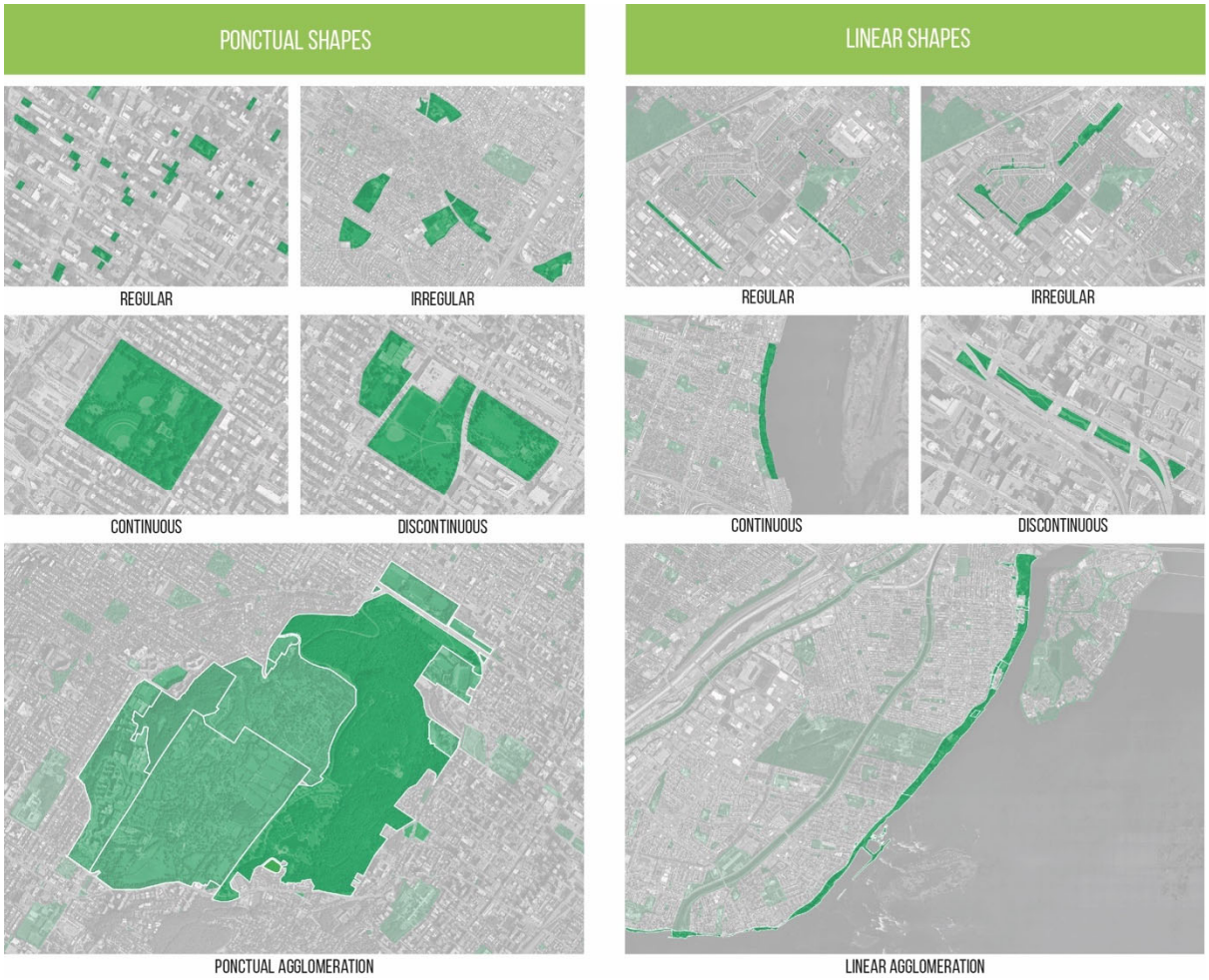

Figure 6. Basic typologies and sub-categories of park and green space shapes. Image by the author, 2024.

A closer look at the correlations between site shape, size and functional type reveals a number of interesting findings (Table 3). First, as functional types, parks and green spaces can be both punctual or linear, while roadway spaces are mostly linear. We also note that roadway spaces are the smallest, green spaces are generally less than 10 ha in size, and parks are distributed across all sizes. It's also interesting to note that certain functional sub-categories (e.g. neighbourhood parks and institutional spaces) are represented by both punctual and linear sites of widely varying sizes.

Table 3. Table illustrating correlations between park and green space shapes, sizes, and functional types.

Functional types	**Type of shapes**	**Less than 1 ha**	**1 - 9,99 ha**	**10 – 100 ha**	**More than 100 ha**
Parks (P)	Ponctual	NBHD park Local park School park Public square Small park	NBHD park Local park School park Public square Riparian area*	NBHD park Urban Park Nature park Metropolitan park* School park*	Metropolitan park
	Linear	Riparian area Linear park Public square* Local park * Small park*	Riparian area NBHD park Linear park Public square* Local park*	Riparian area NBHD park Urban Park Nature park	

	Other			Nature park	Metropolitan park
Greenspaces (GS)	Ponctual	Institutional area Sports area Green space Cemetery Vacant space Community garden Green roof	Institutional area Sports area Cemetery Vacant space	Golf course Institutional area* Sports area* Green space* Botanical garden	Golf course Cemetery
	Linear	Green space Buffer park Urban promenade Institutional area*	Institutional area Green space* Buffer park* Urban promenade*	Green space* Urban promenade*	Institutional area
Roadway Spaces (RS)	Ponctual	Traffic island	Traffic island*		
	Linear	Median strip Traffic island Passage / Pathway Shared street Pedestrian street Green alley	Median strip Shared street		

Note: All sub-categories of functional types shown in grey and marked with an (*) correspond to exceptions within a sub-category. Others in grey illustrate under-represented sub-categories in the sample (N<5).

On relationships

The relational analysis of parks and green spaces extends our understanding of their position in the complex arrangement of urban forms. Of course, parks are elements of the spatial structure of the collective public realm as table 2 illustrated. Nevertheless, the results reveal five key ideas that extend this scope (Figure 7). Firstly, parks and green spaces are building elements. There is only one green roof in our sample. However, given the importance attached to green roofs in green infrastructure and sustainability literature, this is sufficient to extrapolate. Secondly, parks and green spaces are elements of the urban fabric. They correspond to spaces within the street system and to smaller plots. They also refer to the pertinent area of the built system (open spaces), notably that of public buildings.

Thirdly, parks and green spaces constitute specialized fabrics. This character is determined by their size and/or the agglomeration of multiple sites. They tend to develop on the periphery, becoming places of destination and impacting fabric growth. They refer above all to large parks, often those linked to the main territorial systems (waterways, wetlands or forests, agricultural fabric).

Fourthly, parks and green spaces are thresholds between systems. This idea is closely related to linear sites/agglomerations positioned between fabrics or between fabrics and a territorial or urban systems. These sites are particularly common on the perimeter of the Island (riparian area or waterfront park), juxtaposing infrastructure networks, or highlighting the mismatch between a particular fabric and the road or street system.

Finally, parks and green spaces become transformative agents of territorial systems. In this way, sites play a part in retrofiting infrastructure networks, or enclosing natural systems or remnants of the agricultural fabric. The former generally play a part in re-articulating fabrics. The latter, in defining specialized urban fabrics, are more likely to act as barriers to development. This phenomenon follows in the footsteps of urban park development since the 19th century.

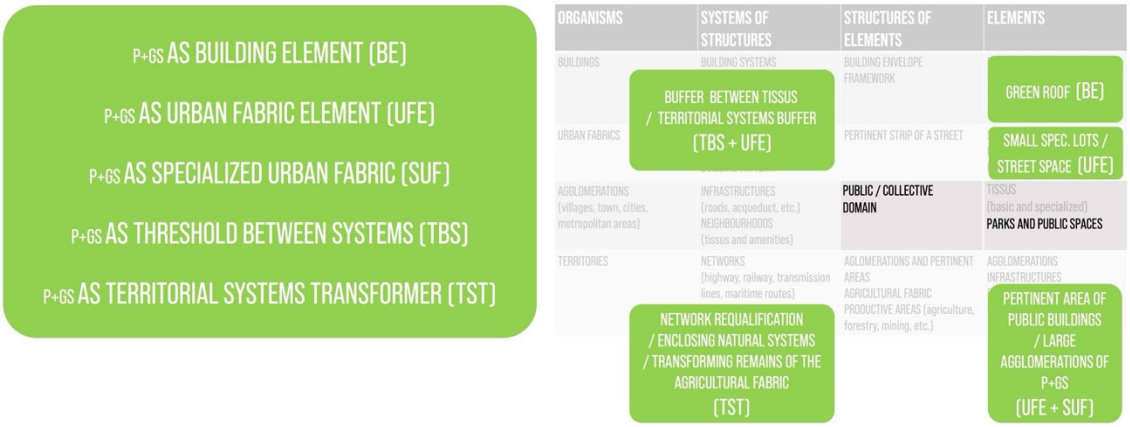

Figure 7. Five key ideas on park and green space positions within built environments. Image by the author, 2024. Adapted from Racine et al., 2022.

On origins and integration: Lessons from Park Angrignon

Angrignon Park is located in the southwestern part of Montreal. This urban park constitutes a specialized urban fabric of almost 100 hectares. It belongs to punctual sites and has a mostly regular and continuous configuration.

Figure 8 shows the key stages in the evolution of Angrignon Park. We notice that the site is a remnant of the agricultural fabric which was gradually transformed, over more than a century, by the impact of infrastructure networks and changes in land tenure.

Indeed, this process was initiated by the construction of the Aqueduct Canal in 1866, which resulted in the fragmentation of the agricultural fabric. Rendered inaccessible by this division, the back part of the lands was left uncultivated and, over several decades, became the dense woodland characterizing the site today. The construction of the railroad in the 1920s confined a part of this woodland, which was only recently reintegrated into the park.

Moreover, this process was heavily influenced by the reorganization of Montreal's administrative boundaries during the annexations of neighbouring villages and towns in the first part of the 20th century. The site thus became its western periphery. Until the 1950s, the City of Montreal leased the lands for park purposes and gradually acquired them.

Since then, the site's municipal jurisdiction has guided its main transformations. This led to the planning and gradual formalization of Angrignon Park - with its central lake, paths, parkway and complement to the existing urban fabric. In the 1970s, the park became the site of the metro extension terminus. The parkway was extended into a connecting road to accommodate the increase in traffic. In the 1980s, public housing buildings—managed by the City of Montreal—were built on the site, as part of the complement to the existing urban fabric.

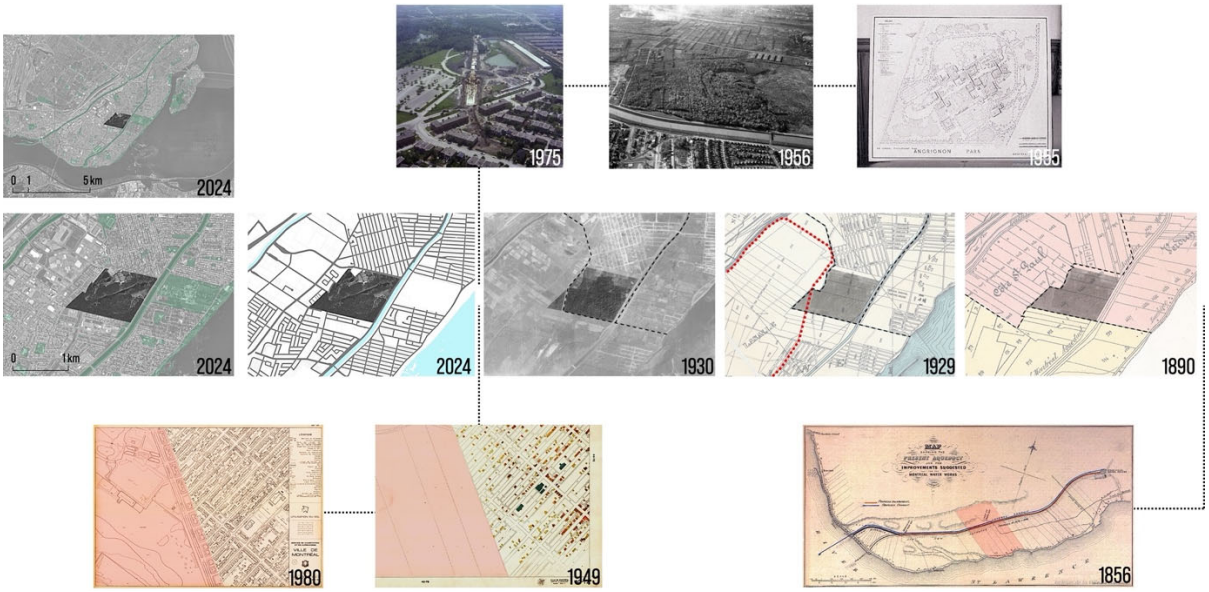

Figure 8. Angrignon Park evolution process. Image by the author, 2024. Adapted from multiple sources.

Thanks to this chronology, we can understand the roots of Angrignon Park's unbalanced relationship with its surrounding urban fabrics. Their interfaces are the main evidence (Figure 9). Indeed, the northern interface is the most coherent. It demonstrates the desire to integrate the site and the adjacent fabric from the planning phase onwards, thus accentuating the permeability between one and the other, and defining a built front which structures the collective public realm.

Rather, the interface defined by the Aqueduct Canal is a clear rupture between the two systems, and also amplifies the fragmentation of the urban fabric at a larger scale. The canal's barrier effect has even intensified over time, as other infrastructure networks have subsequently been built alongside (major road, power transmission lines).

The western and northern interfaces, meanwhile, are evidence of the enduring nature of administrative, cadastral, and infrastructural boundaries. Such permanences accentuate the separation of the park from the fabric that later developed within the neighbouring municipality. The park's entrances (those formal, informal and in the process of being formalized) are illustrative of the difficult integration of these systems, which rather turn their backs on each other. Important though they are, these entrances do little to alleviate the malaise.



Figure 9. Angrignon Park integration. Park interfaces, entrances, and permeability. Image from author, 2024.

DISCUSSION

Our findings offer a fresh look at parks and green spaces. Their transposition provides a better understanding of *what is meant* by green infrastructure, and helps (re)define their meaning beyond interpretations based on an ecological stance.

Therefore, it is crucial to recognize that parks and green spaces constitute the base layer on which green infrastructure elements are structured within urban settings. Thus, it is on and from this base layer that biodiversity can be increased, habitats and ecosystems preserved, cohabitation between human and non-human populations supported, and environmental benefits spread beyond individual sites.

Results show that sites are numerous, do not constitute a continuous network, are characterized by different forms and different relationships with and within urban and territorial systems. We note that they can be grouped into two more encompassing categories (punctual sites and linear sites), which synthesize the basic shape of several sites whose dimensions and functions are nevertheless very different.

This first set of observations resonates with the insights of landscape ecology and mainstream green infrastructure research. It is here, however, that our observations support another morphological perspective. In fact, the study of morphology in the field of landscape ecology is primarily concerned with the division between “green” systems and those relating to urban form. The urban morphology

perspective, on the other hand, is more interested in the relationships between the various systems, stressing the importance of their integration.

As such, our results reveal a number of tensions. The difficulty of extending formal categories and their correlations first highlights the exceptional nature of many sites and, by extension, their context-specific integration. The case of Angrignon Park is instrumental here, which poses integration issues that are common to many large parks. It exemplifies the historical depth of spatial structures which define a site's shape and relationships. It also demonstrates two opposing trends: 1) the benefits of jointly planning and designing the layout of a site and its adjoining fabric, and 2) the morphological consequences of laying out two systems independently, as two land-uses ignoring one another.

Urban integration of parks and green spaces is a genuine problem. Overemphasizing their ecological value will only amplify it. And since this issue is not being given much consideration in the literature on green infrastructure, it is necessary to bring it up for debate. Here, then, is a definition of green infrastructure based on our findings, and modelled on that of the European Commission (see introduction), from which to pursue our collective thinking on this matter: Green infrastructure is a relatively planned network of sites, including parks and green spaces, supporting natural, semi-natural, urban and collective spaces, and which should be designed and managed to deliver a wide integration of urban form systems.

CONCLUSIONS

The objective of this paper was to better understand green infrastructure from a morphological viewpoint. The study of the Montreal case proved highly informative. It raised a number of observations about the morphologies of their sites, shed light on the integration issues that characterize them and, ultimately, enabled us to reformulate their definition.

However, there are a number of limitations to our study. To begin with, the study does not cover all green infrastructure sites. We examined parks and green spaces, and based our definition on their findings. Therefore, our study does not take into account private sites contributing to green infrastructure (forest estate, farmland, specialized plots, front lawn, etc.). Examining them would further refine our findings and orientations. Secondly, the morphological perspective advocated in this study is primarily structural. The functional perspective has not been addressed. This omission does, however, raise a fundamental question: When researching green infrastructure, what should urban morphologists study from a functional perspective: the human, the non-human, both? Such limitations pave the way for very promising new research.

Otherwise, and since research on green infrastructure (or on parks and green spaces) is fairly poor in urban morphology, it is imperative to build up new knowledge on the topic. Integration issues must be tackled head-on. Other theoretical, conceptual or methodological principles specific to the field should be tested, and case studies compared and contrasted. As a result, urban morphology lessons can be brought to the forefront of debates and solutions on green infrastructure and, more broadly, on the accompanying processes of urban landscape (trans)formation.

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Sustainable urban morphology: examining the relationship between urban form, design strategies, and building energy consumption

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ABSTRACT

Exploring sustainable urban form has been a crucial aspect in advancing sustainable urban development, particularly in the context of climate change and limited resources worldwide. Low-energy-oriented urban design strategies for new district development and existing district renewal are paid more and more attention among both researchers and designers. Commonly discussed urban form elements often revolve around building morphology, layout, and characteristics such as building height, floor area ratio, building density, orientation and so on. However, when considering energy performance at the neighbourhood block scale, urban design elements also encompass non-building spaces such as streets and open spaces, which are essential considerations in urban design for their impact on energy consumption. To furtherly discuss the relationship between urban form, urban design strategies and building energy, the study introduce several new indicators to describe the outer space form of urban neighbourhood blocks. Using Shanghai, China as a case study, typical urban block form types are chosen and extracted for comparation experiment. The energy consumption simulations are conducted by Ladybug Tools with the EnergyPlus engine. Based on the simulation results, an investigation and correlation analysis are conducted to examine the relationship between urban form elements, particularly urban design features such as effective streetwall length, effective street space and street space density, and neighbourhood building energy consumption. The results provide valuable insights for sustainable urban district design and renovation, aiming for low-energy performance, and stimulate further attention to the impact of urban block design elements on urban sustainability.

Keywords: urban form, neighbourhood building energy consumption, urban design.

INTRODUCTION

According to UN Habitat (UN Habitat, 2012), urban areas account for 75% of global primary energy consumption and are, therefore, the primary contributors to carbon emissions driving climate change. A significant portion of urban energy demand arises from the heating and cooling needs of buildings. In response to the challenges posed by rapid urbanization and the pursuit of sustainable urban development, researchers have increasingly focused on strategies to reduce energy consumption in

urban buildings. In recent years, with the gradual deepening and expansion of research on the relationship between urban form and building energy consumption, the main object of study has begun to shift from the macro scale of cities and urban districts to the meso and micro scale of blocks, and from merely focusing on the energy consumption of buildings themselves to paying attention to the influence of the surrounding environment on them. Many studies have highlighted the influence of the urban environment, particularly at the neighborhood scale, on building energy performance.

Ratti et al. (Ratti et al., 2005) identified four key factors affecting energy performance: user behavior, energy system efficiency, architectural design, and urban form. Subsequent research has established a clear correlation between urban form and building energy consumption. For example, Delmastro et al. (Delmastro et al.,2015) found that variations in urban form could lead to an 11% difference in heating energy consumption, with the difference increasing to 16% when solar gain is considered. Similarly, Silva et al. (Silva et al.,2017), using the city of Porto in Portugal as a case study, demonstrated that urban form could explain 78% of the variance in energy use, including heating, cooling, and mobility. These studies commonly examine urban form indicators such as density, street aspect ratio, and sky view factor.

However, a common issue in existing studies on the impact of urban morphology on building energy consumption is the lack of definitive conclusions regarding the morphological factors that influence energy consumption and the extent of their impact. This uncertainty stems from various reasons. On one hand, cities, as complex systems, are influenced by numerous factors; on the other hand, findings in existing research are often constrained by climatic characteristics, scale, and other contextual factors. Broadly speaking, there are two common research approaches: the first involves conducting simulation experiments under given morphological conditions to measure corresponding energy performance and then analyzing the relationships and the degree of influence; the second approach entails correlating actual energy consumption data with morphological indicators to identify significant factors and their impact.

Regardless of the approach, the research is closely related to the description of urban form. As summarized by Quan (Quan and Li, 2021), the methods used in existing studies can be broadly classified into four categories: density measures, geometric measures, land use and land cover measures, and typologies. These classifications are based on the identification and categorization of morphological factors found in previous studies. However, when attempting to synthesize findings on energy consumption changes for each specific factor, it becomes clear that most studies do not allow for direct comparison of results under a single morphological factor.

Therefore, a classification based on the sources of the studies is presented here. By reviewing recent research on urban morphology and energy consumption, the morphological indicators and their corresponding energy impacts are summarized below (Table 1), focusing primarily on studies at the block scale that employ energy consumption simulation as the primary research method.

Table 1. Some morphological indicators and their corresponding energy impacts.

Researchers	Year	Location	Indicators	Influence

Liu *et al*.	2023	Jianhu,China	Building density (BD), open space ratio(OSR), shape coefficient (SC), average perimeter-area(PAR)	+BD, +OSR, +SC, +PAR
Zhang and Gao	2021	Nanjing, China	Floor area ratio (FAR), surface area ratio (SAR), sky view factor (SVF)	-FAR,-SAR,+SVF
Ahmadian *et al*.	2021	London, UK	Plan depth (PD), number of storeys (NS), building density (BD)	-PD,-NS,+BD
Lima *et al*.	2019	Maceio, Brazil	Building shape factor (BSF), building height (BH), building density (BD), building orientation (BO)	-BSF, +BH, -BD, BO
Javanroodi *et al*.	2018	Tehran, Iran	Building density (BD), height to width ratio (H/W)	-BD, +H/W
Quan *et al*.	2016	Shanghai, China	Building density (BD), building height (BH), floor area ratio (FAR)	-BH,+BD,+FAR

Common morphological indicators include Floor Area Ratio (FAR), Building Density (BD), and Building Coverage Ratio (BCR). These indicators mainly describe the relationship between buildings and the surrounding space, representing a building- or solid-dominated perspective. Another set of indicators focuses on describing the "void" aspects of morphology, such as Open Space Ratio (OCR), obstruction angle, and the Sky View Factor (SVF).

It is worth noting that although many studies focus on the impact of urban morphology on energy consumption at the neighborhood scale, the indicators used to describe urban morphology often tend to focus more on building form, lacking relevant indicators from an urban design perspective. For example, when describing urban morphology using only density and floor area ratio (FAR), vastly different situations can arise due to variations in building form and layout. These differences not only affect the morphology of the buildings themselves but also have implications for the form of public spaces influenced by building morphology. Using the open space ratio as a sole indicator may fail to comprehensively represent the real urban morphology, while also lacking consideration from the perspective of pedestrian use within urban design.

Current morphological indicators often overlook the form of public spaces, despite their critical importance in practical urban design. Given this context, it becomes particularly important to address how public space morphology indicators influence building energy consumption, especially when the design goal is to create more sustainable urban forms. Achieving this goal requires not only low-energy solutions but also the creation of public spaces that are more conducive to human activity.

This study selects several indicators that describe public space morphology from different perspectives within the broader context of urban morphology. By combining these indicators with building form types and analyzing energy consumption under simulated urban morphologies, the study aims to identify correlations between these indicators and building energy consumption. Furthermore, it seeks to highlight the impact of common urban design strategies related to urban morphology on energy performance, thereby offering some guidance for designing more sustainable and livable urban forms in the future.

METHOD

To investigate the relationship between energy performance of different form prototypes and urban design indicators, this study follows a three-stage process (Figure1): parametric modeling, energy consumption simulation, and correlation analysis. The focus is on simulating the energy consumption

of a designed set of comparative experimental forms. By comparing simulation results with urban form types and urban design indicators, the study aims to elucidate the relationship between urban forms, building energy performance, and the characteristics of urban public spaces.

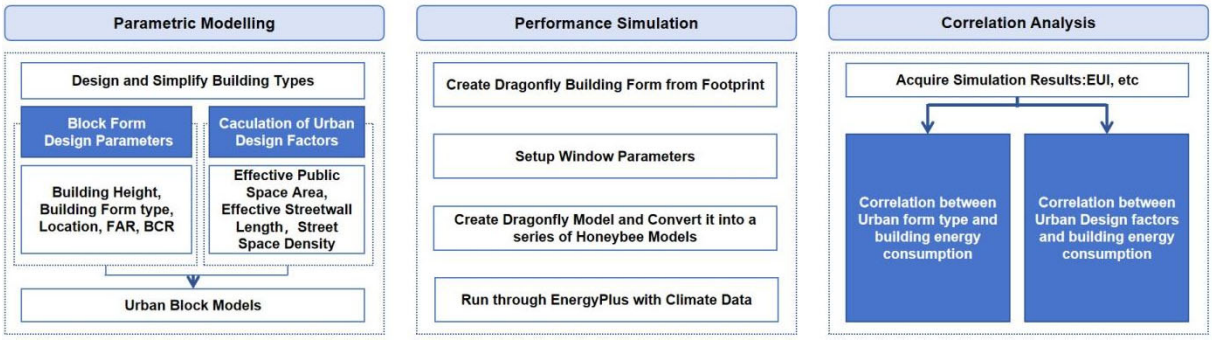


Figure 1. Three-stage research process. diagram credit: author.

The first stage focuses primarily on establishing a reasonable and effective parametric model. This phase consists of two main steps. First, a standard residential unit needs to be selected to facilitate morphological combinations and calculations. Then, by extracting and abstracting the real residential block morphology, a 3D morphological model is built, while controlling key variables and determining other block morphology indicators. Following this, the urban design-related indicators and their corresponding values are calculated and recorded based on these models, laying the groundwork for the subsequent building energy simulation.

To explore the questions mentiond, an experiment is designed with these six urban block form types using the same residential unit (Figure 2) so that it may conviently make sure that they share the same total building area. These are different urban form with the same FAR. The table below (Table 2) shows the basic form situation and block design parameters. The six hypothetical block types are selected and generated based on the real residential neighbourhood in Shanghai. The size of each block is defined as 120m * 120m, which is usually seen as small and middle scale block.

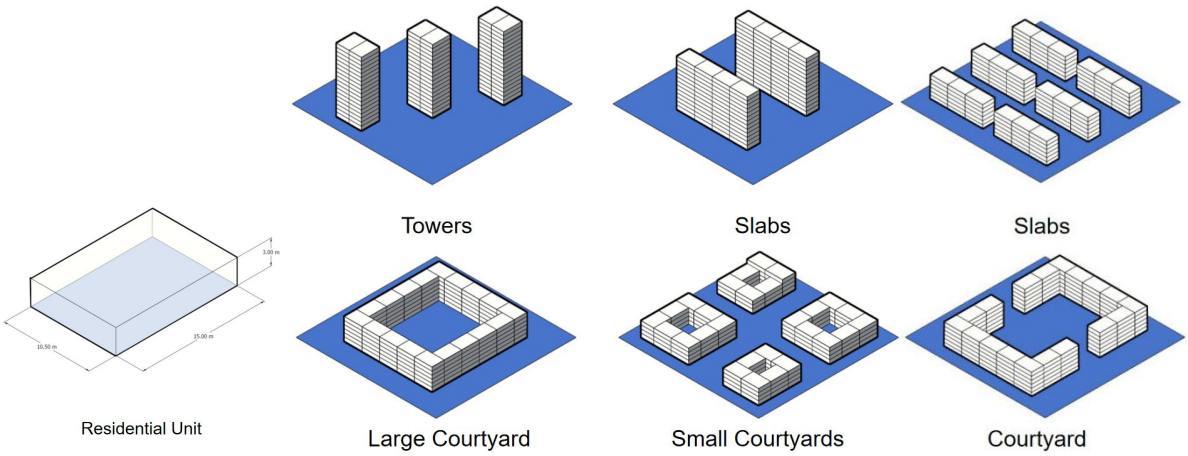


Figure 2. Residential unit and six urban block form types. diagram credit: author.

As research on urban building energy consumption advances, the use of computer models to simulate building energy performance under specific conditions has become a leading quantitative method.

Various energy simulation tools and software have significantly contributed to researchers' ability to understand and optimize urban design from a city performance perspective. One example is CityBES, a web-based open tool that facilitates city-scale building energy planning (Chen, 2017). However, for smaller-scale block energy simulations, the applicability of city-scale platforms and software diminishes. Consequently, building energy simulations frequently rely on the EnergyPlus engine, developed by the U.S. Department of Energy. EnergyPlus offers comprehensive simulations of a building's thermal performance, humidity levels, airflow, and lighting, accounting for factors such as thermal conduction, air infiltration, solar radiation, lighting, and HVAC systems. To enhance practicality and ease of use, platforms like OpenStudio, DesignBuilder, and Ladybug Tools have integrated the EnergyPlus engine into their interfaces.

In the second stage, this study uses the parametric design plugins Dragonfly, Ladybug, and Honeybee within the Ladybug Tools suite, based on the EnergyPlus simulation engine, to simulate building energy consumption. This simulation provides data on EUI and annual heating and cooling loads (Figure 3).

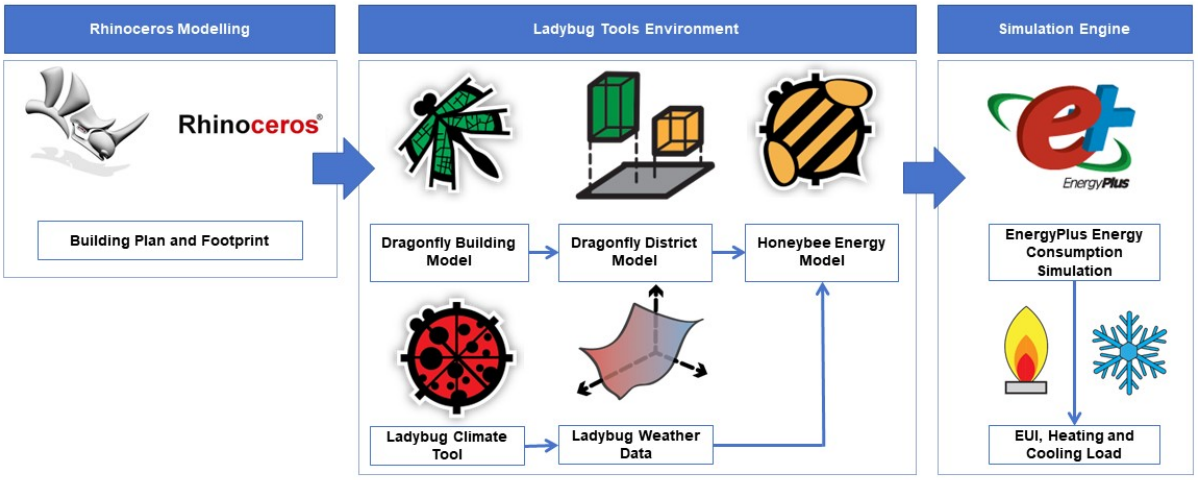
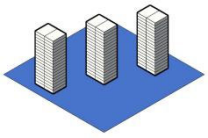
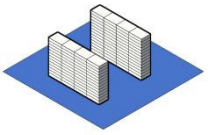
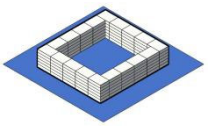
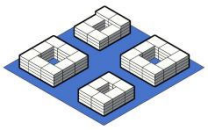
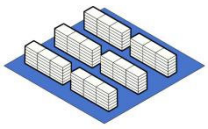
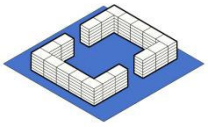


Figure 3. Performance simulation method and process. diagram credit: author.

This simulation provides data on EUI and annual heating and cooling loads. The selection of simulation software prioritizes the reliability of results, process consistency, and parametric manipulation of forms. The simulation workflow involves using the Grasshopper parametric design platform within Rhino to select and recognize pre-set building site plans, set building volumes by floor height and number of floors, and configure daylighting parameters by window-to-wall ratio. The Dragonfly model is then created and converted into a series of Honeybee models for energy simulation, with a window-to-wall ratio limit of 0.35 for residential buildings.

Environmental settings place all the blocks in the same urban context to exclude interference from other factors. For this study, focusing on heating and cooling loads and EUI, Shanghai is chosen as the experimental background city due to its typical hot summer and cold winter climate, classified in ASHARE standards as 3A (temperature: warm, moisture: humid; Köppen Classification: Humid Subtropical - Warm Summer). The EnergyPlus simulations, based on Shanghai's climate parameters, generate annual EUI and monthly heating and cooling load data.

Table 2. Block form design parameters of six experiment types.

No.	Block Form Type	Geometric Model	Site Area	Total Building Area	Building Footprint Area	Number of Floors
P-1	Point		14400㎡	17010㎡	945㎡	18
S-1	Slab		14400㎡	17010㎡	1260㎡	14,13
C-1	Courtyard		14400㎡	17010㎡	2835㎡	6
C-2	Courtyard		14400㎡	17010㎡	4410㎡	4,5
S-2	Slab		14400㎡	17010㎡	2835㎡	6
C-3	Courtyard		14400㎡	17010㎡	2835㎡	6

Furtherly, more proposed form indcators which could show street and open sapce differences concerning on pedestrians are introduced in. As urban designers care more about urban spaces formed by buildings and the quality of urban public spaces, the new indicators represent these concerns.

Firstly, the effective streetwall length plays a crucial role. Streetwall buildings help define the shape of the street, creating a cohesive spatial experience while bringing ground-floor activities closer to urban pedestrians. This indicator highlights the contrast between object-in-space blocks, such as tower and slab types, and streetwall blocks, including courtyard-based designs.

Secondly, the effective street space area which refers to the street spaces that could provide usage possibility to all pedestrians. It depends on the streetwall space formed by buildings. As shown in the table (Table 3), the towers type is hardly capable of creating effective street space area as it lacks the supporting of streetwall.

Thirdly,the new indicator Street Space Density need to be further explained. street space density is defined as the percentage of non-urban space occupied by buildings in relation to the total site area (Figure 4). It mainly shows the urban space situation formed by buildings, as the higher street density represents more compact and pedestrain-friendly block.

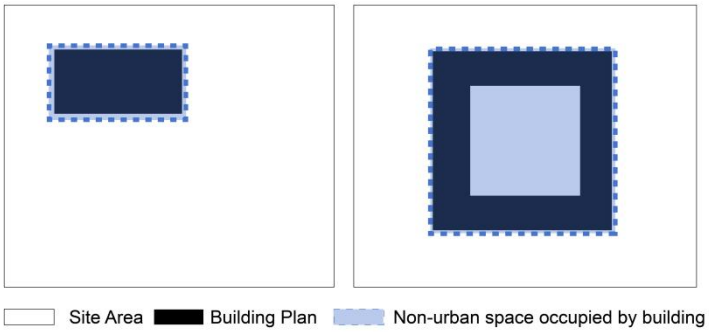


Figure 4. Diagram of definition of street space density . diagram credit: author.

In table 3 it also shows the commonly use indicator Open Space Area for reference. It represents the typical choice for former research.However, from the view of urban design, the indicator open space area is not capable of fully describing the real street and public space situation of a blcok. For instance, the courtyard types have less open space area but share more effective street space and higher street space density. This situation indicates that more indicators about outer urban space are quite necessary.

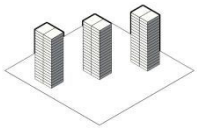
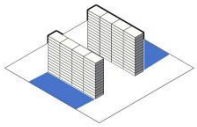
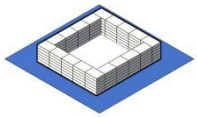
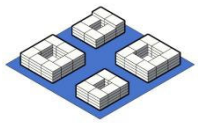
The calculation methods of urban design factors for block forms are as follows:

$$ESL = \sum EffectiveStreetwallBuildingSurfaceLength$$ (ESL: Effective Streetwall Length)

$$ESSA = \sum EffectiveStreetwallBuildingSurfaceLength * PedestrianSpaceWidth$$ (ESSA: Effective Street Sapace Area)

$$SSD = \frac{\sum Non\text{-}urban\ Space\ Occupied\ by\ Buildings\ Area}{Site\ Area}$$ (SSD: Street Space Density)

Table 3. Urban design factors of six experiment types .

No.	Block Form Type	Effective Street Space	Effective Streetwall Length	Open Space Area	Effective Street Space Area	Street Space Density
P-1	Point		-	13455㎡	-	-
S-1	Slab		120m	13140㎡	1200㎡	-
C-1	Courtyard		291m	11565㎡	8325㎡	42%
C-2	Courtyard		462m	9990㎡	8959.5㎡	37%
S-2	Slab		180m	11565㎡	2700㎡	-
C-3	Courtyard		291m	11565㎡	6045㎡	52%

RESULTS AND DISCUSSIONS

The simulation results of each form type are gathered and showed below(Table 4 and Figure5).The C-1 courtyard type perform the lowest EUI while the S-2 slab type shows the highest. The three courtyard types and one long slab type exhibit relatively equal and lower building energy performance. When considering the balance between cooling and heating loads, the C-2 courtyard type demonstrates the best balance.

Table 4. Simulation results of six block form types.

No.	Block Form Type	EUI	Cooling Load	Heating Load
P-1	Point	175.174 KW/㎡	58.175 KW/㎡	45.356 KW/㎡
S-1	Slab	171.992 KW/㎡	55.728 KW/㎡	43.960 KW/㎡
C-1	Courtyard	167.41 KW/㎡	52.310 KW/㎡	43.434 KW/㎡
C-2	Courtyard	170.308 KW/㎡	49.207 KW/㎡	49.343 KW/㎡
S-2	Slab	178.845 KW/㎡	53.171 KW/㎡	54.283 KW/㎡
C-3	Courtyard	171.858 KW/㎡	53.512 KW/㎡	46.462 KW/㎡

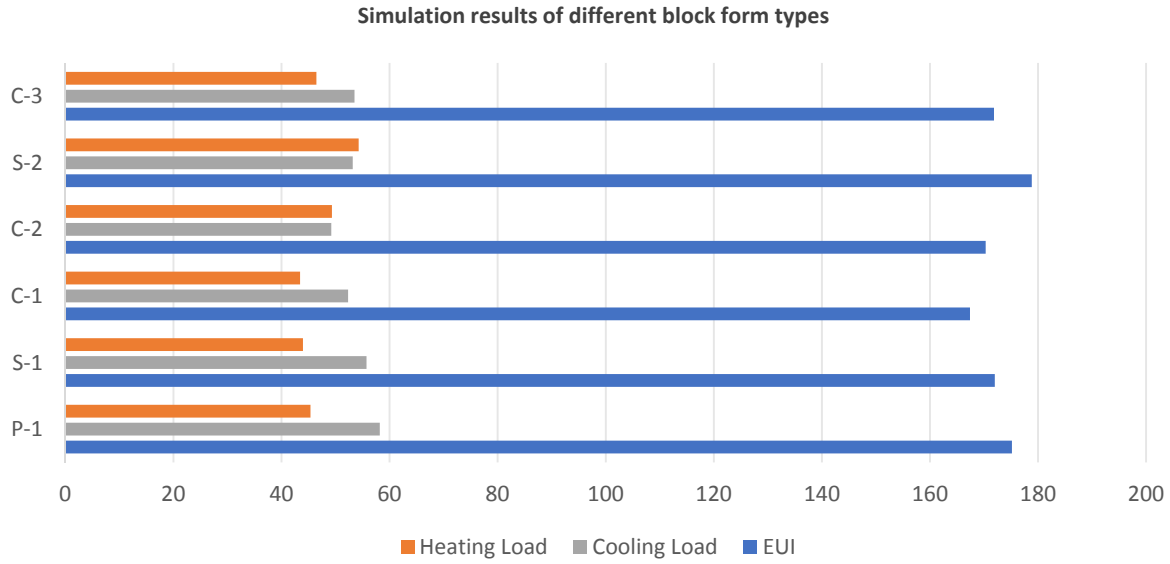


Figure 5. Simulation results of different block form types. Diagram credit: author.

Across all six morphological prototypes, the difference between the highest and lowest Energy Use Intensity (EUI) is approximately 6.8%, indicating that under the simulation conditions, the energy performance of the different types is generally similar.

he relatively small differences in the building energy simulation results may be due to all types being tested under idealized environmental conditions, excluding other influencing factors. Some of the variation in cooling and heating loads could be attributed to differences in building orientation among the various morphological types, particularly under Shanghai's climate conditions.

However, when the urban design morphology indicators mentioned earlier are factored in, it becomes apparent that the C-1 and C-3 block types not only maintain relatively low building energy consumption but also have higher ESL (Effective Streetwall Length), ESSA (Effective Street Space Area), and SSD (Street Space Density) values. This indicates that while achieving a sustainable level of building energy consumption, these types provide greater value for urban public spaces and pedestrians compared to the other types. This result suggests that, given the same Floor Area Ratio (FAR) requirements, it is possible to select urban block types that both meet low building energy consumption standards and offer better public space environments and walking experiences.

In contrast, the P-1, S-1, and S-2 types, which perform relatively poorly in terms of urban design morphology indicators, do not demonstrate particularly outstanding energy performance. When comparing the results, it is clear that the block types with better performance in urban design indicators hold a competitive edge. By ranking the data from best to worst (6-1) and summarizing the results, the table and the figure (Table 5, Figure 6) below reveal the more advantageous and balanced morphological types.

Table 5. Simulation results comparation rank with urban design indicators.

No.	EUI	Effective Streetwall Length	Effective Street Space Area	Street Space Density
P-1	2	1	1	1
S-1	3	2	2	1
C-1	6	4	5	5
C-2	5	6	6	4
S-2	1	3	3	1
C-3	4	4	4	6

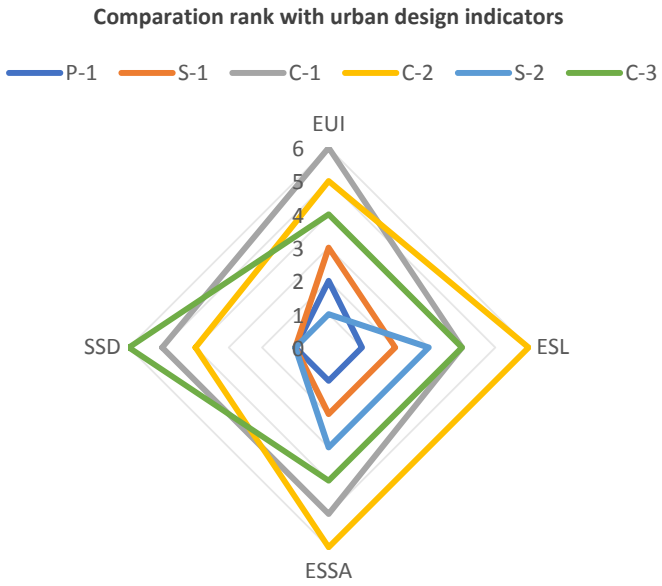


Figure 6. Comparation rank with urban design indicators. Diagram credit: author.

This study also have some limitations. First of all, the morphological characteristics in the experiment are limited, and although these types are designed based on the neighbourhood blocks in reality, some of the form details are simplified. Besides, the types have more possibilities when considering on a larger block scale and other programmes.

Secondly, urban design strategies need to be considered more during the first stage of experiment to emphasize the starting point, which is the importance of urban design view.

CONCLUSIONS

This paper introduces several morphological indicators from an urban design perspective when discussing the correlation between urban form elements and building energy consumption. Through energy simulation and comparative experiments under consistent conditions, it verifies the existence of morphological types that achieve a balanced performance in multiple aspects. The findings suggest that urban and architectural designers can, from the early stages of planning, focus on block morphology to create designs that not only meet sustainable building energy performance standards but also provide walkable and high-quality urban street spaces through effective urban form. Balance between energy efficiency and proper public urban spaces can be achieved through early-staged urban form design.

This research seeks to provide new insights into the relationship between urban form and building energy consumption, with a particular focus on the urban design perspective. It aims to encourage a reevaluation of design approaches when initiating new urban projects, emphasizing the importance of creating urban forms that are not only energy-efficient but also walkable and sustainable. The study aspires to contribute to the ongoing pursuit of urban environments that balance energy performance with broader sustainability goals.

In future research, more standardized and normalized indicators will be needed to describe and evaluate urban form, particularly the characteristics of public spaces. This will enhance the accuracy of early design guidelines and allow for a deeper exploration of how these indicators specifically influence changes in block energy performance. Additionally, future studies should address the issue of over-reliance on simplified prototypes when describing urban form in related research. This challenge could potentially be resolved through the development of a new system for morphological description.

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Symbiotic design in urban form and river landscape dynamics: A case study of early modern castle towns, Tone River basin in Japan

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ABSTRACT

In the early modern period, Tone River basin, the largest in Japan, developed an environmentally symbiotic watershed structure by integrating castle towns with the river landscape. This study explores what lessons can be drawn from this landscape-based urban morphology in early modern Japan, to promote a harmonious relationship between water environment and urban form in the face of climate change. The aim is to identify how the urban form responded to the river basin landscape in early modern Japan, Tone River basin as a case study. A morphological analysis of the river landscape and castle towns in the early modern period was conducted by using GIS (Geographic Information System). The results show that the 12 castle towns are arranged in a balanced manner on the plateaus and plains of the basin with three different landscape characteristics: upstream, midstream and downstream. These castle towns can be classified into four typologies in relation to the dynamics of river landscape: water flow utilisation type, water environment adaptation type, topography-defined type and flood defence type. Each urban typology had a distinct approach to adapting to the surrounding water landscape, and these differences were reflected in their urban forms. Analysis of the relationship between these urban typologies and the three regions - upstream, midstream, and downstream - reveals that they do not necessarily correspond directly to these three regions. Instead of a general model of urban form for each region, urban typologies were shaped by individual adaptations to the specific river landscape dynamics of each location. Forming such a harmonious relationship between urban form and the basin-wide river landscape is also being addressed in contemporary advanced flood control measures. These historical towns, with their integration of natural landscapes provide important lessons for contemporary urban and landscape design, particularly in the context of creating climate-adaptive cities.

Keywords: Landscape-based urban morphology, Japanese early modern castle town, Adaptive approach, River basin, River landscape.

INTRODUCTION

Background and purpose of this study

In early 17th-century Japan, castle towns were constructed simultaneously across the country, resulting in diverse urban forms tailored to the unique landscapes of different regions. The environmental symbiosis formed the foundation of the design of these towns, taking into account

factors such as topography, geology, and water systems. In Tone River basin, which flows through multiple prefectures including Tokyo, Saitama, Chiba, Gunma, Ibaraki, and Tochigi, making it the largest water basin in the country, approximately one-tenth of Japan's castle towns were concentrated. This development coincided with large-scale river improvement efforts, leading to the creation of urban forms in balance with the river landscape, effectively supporting flood control and water utilisation.

The question addressed in this study is what can be learned from the landscape-based urban morphology in early modern Japan to consider the harmonious relationship between river landscape and urban form in response to climate change. This study uses Tone River basin as a case study to identify the urban forms that responded to the river basin landscape in early modern Japan, and discusses its contemporary significance.

Extensive research on the morphology of cities and settlements in response to landscape dynamics, particularly those shaped by rivers and coastal forces, has provided valuable insights into how urban areas have adapted to water-related challenges. Studies on historical urban structures and landscape systems underscore the significance of landscape-based spatial planning, which emphasises fostering a symbiotic relationship between landscape dynamics and urban development to promote sustainability, ecological resilience, and effective water management (Nijhuis, 2022). Case studies of historical settlements in low-lying areas, such as the early settlements in Zeeland in the Netherlands, illustrate how communities have navigated these challenges through innovative spatial transformations, reflecting the water management and demands of their time (Rutte, 2023).

As for research on early modern castle towns in Japan, some have systematically analysed castle towns across Japan in terms of urban form and urban design (Yamori, 1970; Satoh, 2015), while others have discussed the flood control and water utilisation methods and landscape design methods of castle towns in relation to the surrounding rivers (Niitani, 1987; Yoshida and Niitani, 1998; Mizuta, 2012a; Mizuta, 2012b; Tanaka *et al.*, 2016).

However, there have been no studies that consider multiple castle towns connected to the same river as a network and systematically discuss urban form in relation to the river landscape of the entire basin.

Therefore, using Tone River basin as a case study, this study aims to categorise the urban form of early modern castle towns located in the basin, focusing on the surrounding river landscape, and to clarify their relationship with the landscape of the entire basin. The contemporary significance of this river basin environment established in early modern times is also examined, based on comparisons with an example of advanced flood control measures in the Netherlands and a discussion of the challenges caused by the changes in Tone River basin due to modernisation.

Overview of the case study (See Fig.1)

This study focuses on Tone River basin in Japan. During the Edo period (early 17th century to late 19th century), large-scale river improvements occurred alongside multiple urban developments, highlighting the diverse and interdependent relationships between river landscape and urban form.

The basin area is the largest in Japan at 16,840 km^2, with mountains, hills and volcanic areas accounting for about 49% of the total area, plateaus for about 27% and alluvial plains for about 24%. While most river basins in Japan are largely mountainous, Tone River basin is characterised by a large proportion of plateaus and plains, allowing many castle towns to be built in the basin of a single river.

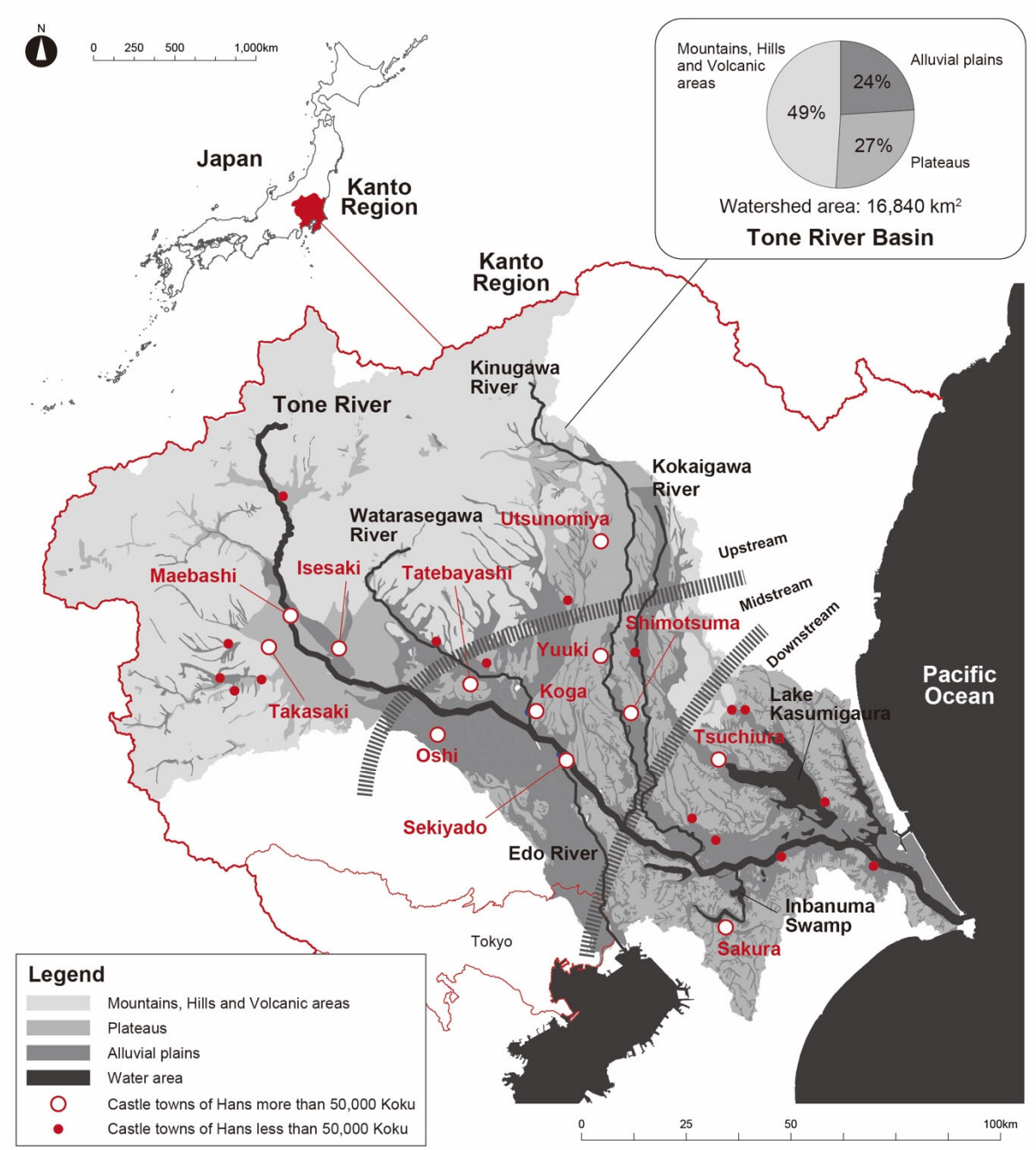

Figure 1. Basin environment of Tone River.

In Japan, the construction of early modern castle towns occurred nationwide in the early 17th century. In Tone River basin, this urban development was accompanied by a large-scale river improvement project known as Tone River Diversion (Tone Gawa Tohsen in Japanese). The primary objectives of Tone River Diversion were to secure agricultural irrigation water for new paddy fields, establish a shorter and more reliable shipping route to Edo (political and economic centre of the Edo period and

the predecessor of Tokyo), and protect Edo from flooding. Tone River Diversion indicates that the stream channel of Tone River was shifted to the east, and Tone River, which had been flowing in a north-south direction towards Edo, was replaced in its midstream by an east-west channel that drains into the Pacific Ocean. As a result, several rivers were connected and irrigation channels were developed, and especially in the midstream, rivers began to divide and merge in complex ways. In addition, water from Tone River began to flow into the low marshy areas downstream, where several large swamps were located and flooding due to backwaters became frequent.

After Tone River Diversion, Tone River consists of three rivers confluence to the main river from the north and one river distributing to the south, connecting to two large swamps downstream. The three rivers that confluence are Watarasegawa River, Kinugawa River and Kokaigawa River. Kinugawa and Kokaigawa Rivers were not originally included in Tone River basin, but were merged into Tone River in Tone River Diversion. The diverging river is Edo River. After Tone River Diversion, water from Tone River began to flow into this river. The two large swamps downstream are Lake Kasumigaura and Inbanuma Swamp. These were connected to Tone River by Tone River Diversion and backwaters flowed into them.

Around 30 early modern castle towns were built in Tone River basin at the same time as Tone River Diversion. There is no other place in Japan where so many early modern castle towns were built in the basin of a single river at the same time as large-scale river improvement, making it suitable for the purpose of this study to understand the diverse patterns of urban form in response to the river landscape.

In Tone River basin during the Edo period, Edo was located at the southern end and several feudal domains, called “Han” in Japanese and their castle towns were dispersed throughout the river basin. A total of 28 Hans survived from the early to the end of the Edo period and formed the basis for urban and regional development in modernisation. There were approximately 300 Hans in Japan at the end of the Edo period, indicating that about one-tenth of all Hans in the country were located in Tone River basin. The scale of Hans ranges from 10,000 to 170,000 Koku. “Koku” is a unit of land productivity in early modern Japan and indicates the scale of a territory. Eight Hans had more than 50,000 Koku at the end of the Edo period and four had more than 50,000 Koku during a certain period of time in the Edo period, making a total of 12 Hans, which can be positioned as large Hans with a central position in this area. Of the approximately 300 Hans in the country, only the top one-third were larger than 50,000 Koku. In this research, 50,000 Koku or more was considered to be large in scale. (Table 1)

Table 1. Scale of early modern castle towns in Tone River basin.

Scale	Name of Hans and their castle towns
Over 100,000 Koku	Maebashi(17), Sakura(11), Oshi(10)
50,000-100,000 Koku	Tsuchiura(9.5), Takasaki(8.2), Koga(8), Utsunomiya(7), Tatebayashi(6)
Less than 50,000 Koku	Sekiyado(4.8), Numata(3.5), Annaka(3), Mibu(3), Isesaki(2), Obata(2), Ishioka(2), Shimodate(2), Yuuki(1.8), Sano(1.6), Ashikaga(1.1), Shimotsuma(1), Nanokaichi(1), Yoshii(1), Omigawa(1), Takaoka(1), Asoh(1), Ushiku(1), Shizuku(Unknown), Ryugasaki(Unknown)

*Parentheses indicate the number of Koku (Unit: 10,000) at the end of the Edo period.
*Underbars indicate Hans that had 50,000-100,000 koku during a certain period of time during the Edo period, although the amount was below 50,000 koku at the end of the Edo period.

*For Shizuku and Ryugasaki, the number of Koku at the end of Edo period is unknown, but as no record can be verified that they had more than 50,000 Koku during the Edo period, it was taken to be less than 50,000 Koku.

Structure of this paper

The structure of this paper is organised into four chapters:

Chapter 1 (INTRODUCTION) presents the background and purpose of the study, providing an overview of Tone River basin's landscape composition. It also examines the river improvement efforts of Tone River, which occurred concurrently with urban development during the early modern period, offering a comprehensive picture of the basin's transformation following these improvements.

Chapter 2 (METHOD) outlines the methodology used in the study.

Chapter 3 (RESULTS AND DISCUSSIONS) details the results and discussions, organised into four sections. The first section identifies the castle towns within Tone River Basin, analysing their locational characteristics. The second section categorises the urban forms of the larger castle towns at the core of the basin in relation to the surrounding river landscape. The third section explores the relationship between the typology of these urban forms and the broader basin landscape. Finally, the fourth section highlights the contemporary significance of the river basin environment established in early modern times, based on comparisons with an example of advanced flood control measures in the Netherlands and a discussion of the challenges caused by the changes in Tone River basin due to modernisation.

Chapter 4 (CONCLUSIONS) concludes the paper, synthesising the findings from the previous chapters.

METHOD

In this study, a morphological analysis of the river landscape and castle towns in the early modern period was conducted using GIS. The following three maps were overlaid and analysed on Arc GIS Pro by Esri.

First is the "Original 1:20,000 rapid survey map of the First Military District (hereafter referred to as the rapid survey map)", which was produced by the Army's General Staff between 1880 and 1886. This map is used to display the river landscapes and the urban forms of the late 19th century on the GIS. The late 19th century in Japan was the end of the early modern period and the time of gradual urban development due to modernisation. The 1880s, when this map was produced, was a period shortly after the start of modernisation, and the environment of the river basin at the Edo period was not considered to have changed significantly. In this study, the basin environment shown in the rapid survey map is regarded as of the end of the early modern period. This map has been produced for most of Tone River basin, but some are missing. The urban forms of the castle towns located in the missing areas were identified using castle town drawings in the Edo period.

Second is the "Land Classification Map at 1:500,000", which was produced by the Economic Planning Agency in 1968. This map is used to display the topographic classification into three categories: mountains, hills and volcanic areas, plateaus and alluvial plains, to show the landscape structure on the GIS.

The third is the “Basic Map Information” published by the Geospatial Information Authority of Japan. In particular, the Digital Elevation Model (DEM) is used to analyse the cross-sectional configuration of the landscape with the 3D analyst tools in Arc GIS Pro.

RESULTS AND DISCUSSIONS

Layout configuration of early modern castle towns in Tone River basin

Figure 1 shows the location of the castle towns that served as bases for each of the 28 Hans. Five castle towns are located in mountainous areas, while the other 23 towns are located on plateaus and plains below 120m above sea level, out of the mountainous areas. Focusing on the castle towns of the 12 larger Hans, all of these are located on plateaus and plains, and are well balanced on the upstream, midstream and downstream of Tone River and midstream and downstream of Kinugawa River. Their locations can be divided into three based on landscape characteristics.

Upstream: Upstream of Tone River and midstream of Kinugawa River

This region is located at the foot of the mountains that are the source of Tone and Kinugawa Rivers, with water flowing down gently sloping open plateaus. Maebashi, Takasaki, Isesaki and Utsunomiya are located in this region.

Midstream: Midstream of Tone River and downstream of Kinugawa River

This region is located around an area where rivers were replaced and irrigation channels were built during Tone River Diversion, and where rivers converge from many directions, creating diversity in the landscape due to the complex diversions and mergers. The six towns of Oshi, Tatebayashi, Koga, Sekiyado, Shimotsuma and Yuuki are located in this region.

Downstream: Downstream of Tone River

It is a low marshy area where several large swamps are located, and where flood damage due to backwaters has increased as water from Tone River began to flow into the swamps as a result of Tone River Diversion. Two towns, Sakura and Tsuchiura, are located in this region.

The layout configuration of castle towns in Tone River basin is a balanced arrangement of 12 larger castle towns on the plateaus and plains of three different regions - upstream, midstream and downstream - with smaller castle towns scattered around them.

Four types of urban form in relation to the river landscape

The 12 core castle towns were categorised by focusing on the planar and cross-sectional relationship between the urban form and the river landscape. Focusing on four urban and regional elements - surrounding water landscape around the castle town, water moats in the castle town, the castle and the street of the castle town - the relationship between their layout, forms and water flows are analysed. Where necessary, the shape of the topography and river embankments were also included in the analysis. As a result, they could be classified into four types: water flow utilisation type, water environment adaptation type, topography-defined type and flood defence type.

Water flow utilisation type: Maebashi, Takasaki, Isesaki, Utsunomiya (see Fig. 2)

This type of town draws water from the surrounding area into the town by using water flows along a gentle topographical slope from the surrounding water landscape to the castle and the castle town.

Maebashi, Takasaki, Isesaki and Utsunomiya belong to this typology. The castle and the castle town are located on highlands, with the castle facing a river flowing through the lowlands. In many towns, the large part of the water moat is formed in a rectangular shape, which follows the street pattern of the castle town. In Takasaki, for example, the castle is located facing east of Karasugawa River, a tributary of Tone River, and the castle town is formed to enclose the northeast of the castle. The streets of the castle town are arranged in a north-south and east-west direction, and the water moat surrounding the castle and the castle town is formed in a rectangular shape to match the street pattern. Water for the water moat is drawn from Naganozeki irrigation canal from Haruna Shirakawa River, which confluences with Karasugawa River upstream from the castle town.

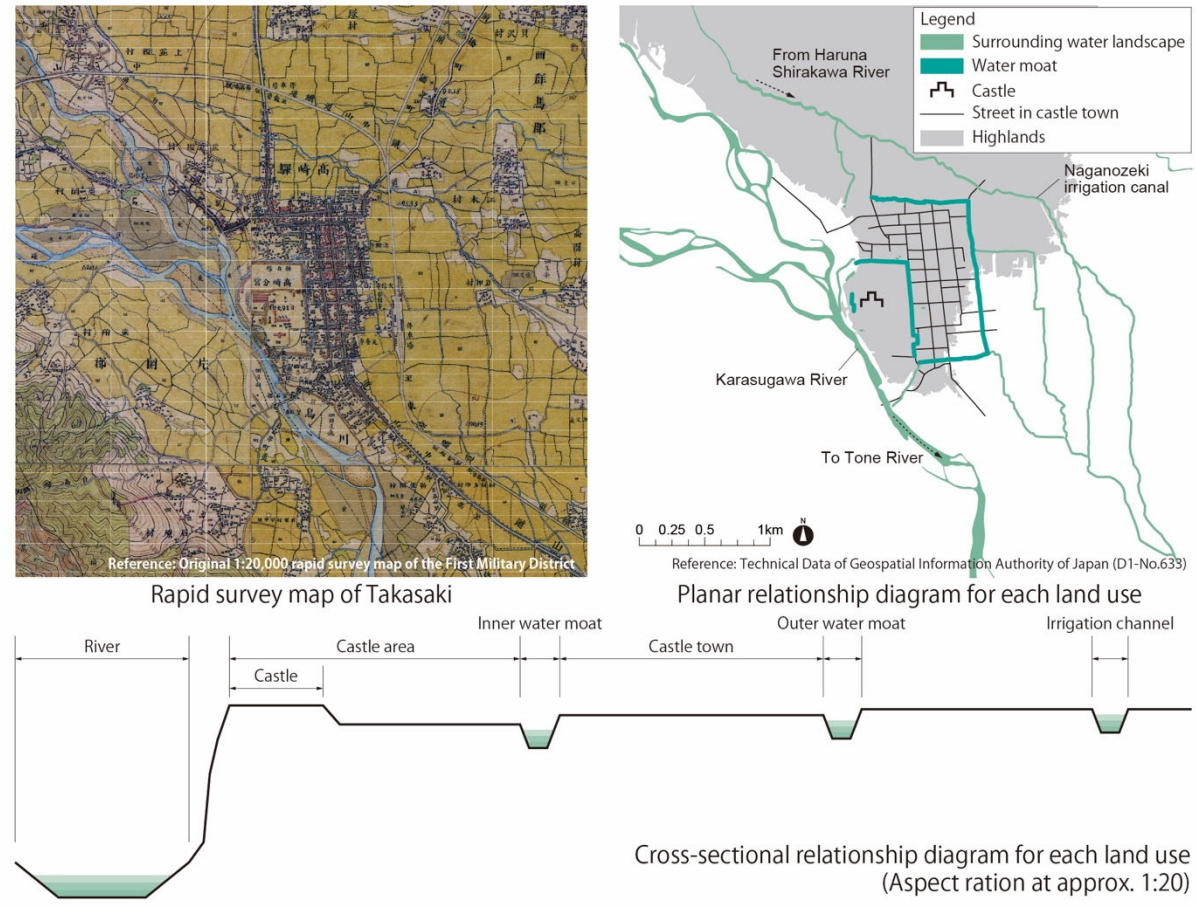

Figure 2. Urban form of Takasaki.

Water environment adaptation type: Tsuchiura, Koga, Oshi, Shimotsuma (see Fig. 3)

This type of town has an adaptable form that encompasses extensive water moats and flexibly receives water flowing in from surrounding water landscape. Tsuchiura, Koga, Oshi and Shimotsuma belong to this typology. What these towns have in common is that they are located in areas where water collects from several directions. In Tsuchiura and Koga, which are located at the confluence of rivers, both water flowing in from upstream and backwaters from downstream enter the castle town area. Oshi is located in the middle of an open lowland area of paddy fields, with drainage from the surrounding paddy fields flowing into the castle town. Shimotsuma is located at the tip of a tongue-shaped plateau, with adjacent wetlands forming a water moat and water flowing from the plateau. Koga, for example, has a castle located on the eastern side of Watarasegawa River, with extensive water moats surrounding the castle. Water moats have an organic form that is adapted to the

microtopography and allows flexibly to accommodate rising water levels. To the south of the water moat is the confluence of Watarasegawa and Tone Rivers, with hinterland wetlands integrated with the water moat. The castle town is formed on a slight elevation on the north-eastern side of the castle, reducing the risk of flooding in the living environment.

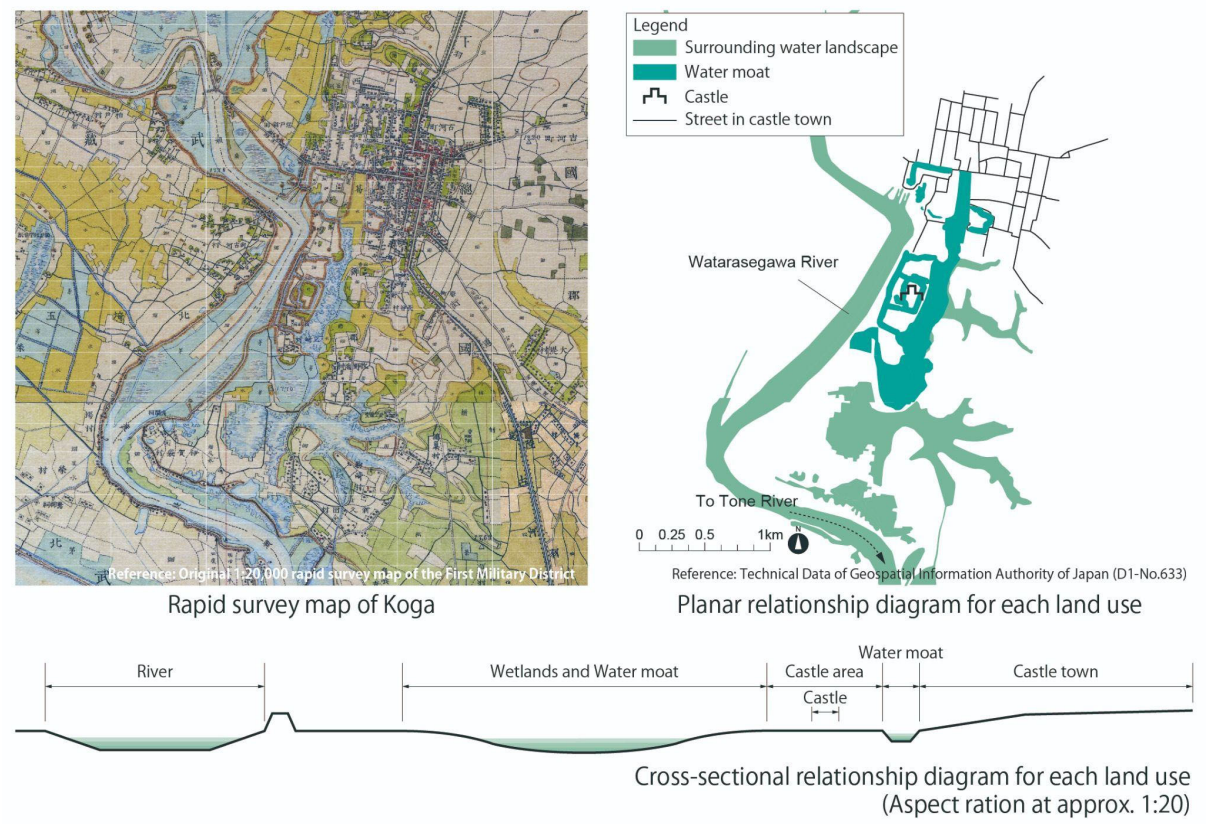

Figure 3. Urban form of Koga.

Topography-defined type: Yuuki, Tatebayashi, Sakura (see Fig. 4)

This type of town has urban areas compactly located on a plateau surrounded by water landscape, with the natural topography defining the urban form. Yuuki, Tatebayashi and Sakura belong to this typology. For example, Sakura has a castle and castle town on the plateau facing Inbanuma Swamp. After Tone River Diversion, the backwaters of Tone River began to enter Inbanuma Swamp, and various facilities located below the plateau were relocated and consolidated on the plateau. The castle is located at the tip of the plateau, while the main street, which forms the backbone of the castle town, is located on the ridge line, following the topographical shape. The water moat is located at the foot of the plateau and its shape follows the topography, taking in water from the surrounding water landscape.

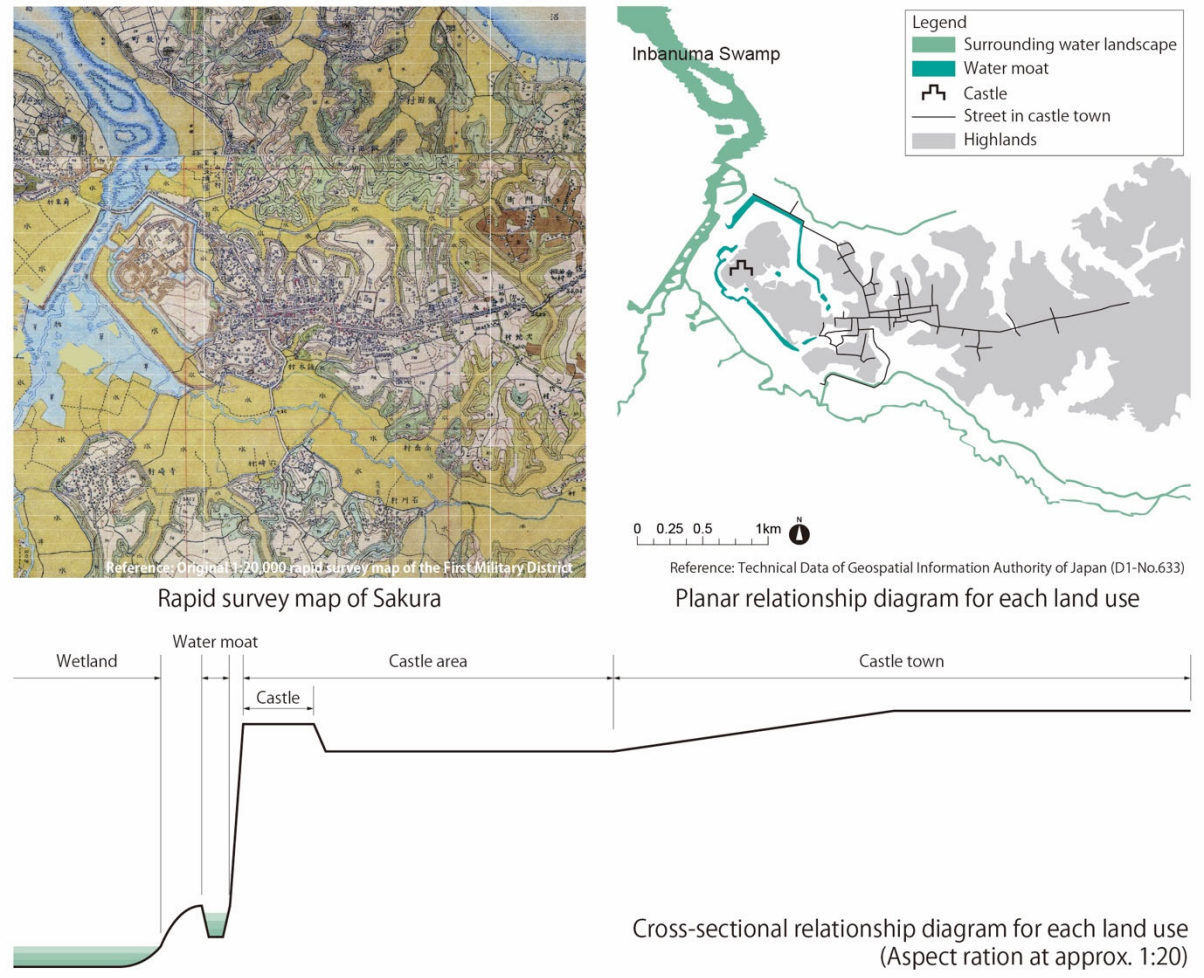

Figure 4. Urban form of Sakura.

Flood defence type: Sekiyado (see Fig. 5)

This type of town is integrated with embankments along the river and provides flood defence by enclosing the whole urban area with embankments. Only Sekiyado belongs to this typology. Sekiyado is located at the divergence of Edo and Tone Rivers and is surrounded on three sides to the north, east and west by river embankments. The castle is adjacent to the diversion point and is surrounded by a ring-shaped water moat. This water moat takes water from the river beyond the embankment and is also connected to the irrigation canal downstream. The main street of the castle town, located outside the water moat, is formed on a slight elevation and is continuous with the river embankment. On the extension of the main street, a jetty called “Bodashi” is located on Edo River. The Bodashi gently channel water from Tone River into Edo River, stabilising the navigation channel and protecting Edo, which is located at the bottom of Edo River from flood. As it is located at a key transport point, functions as a checkpoint are also integrated in the castle town.

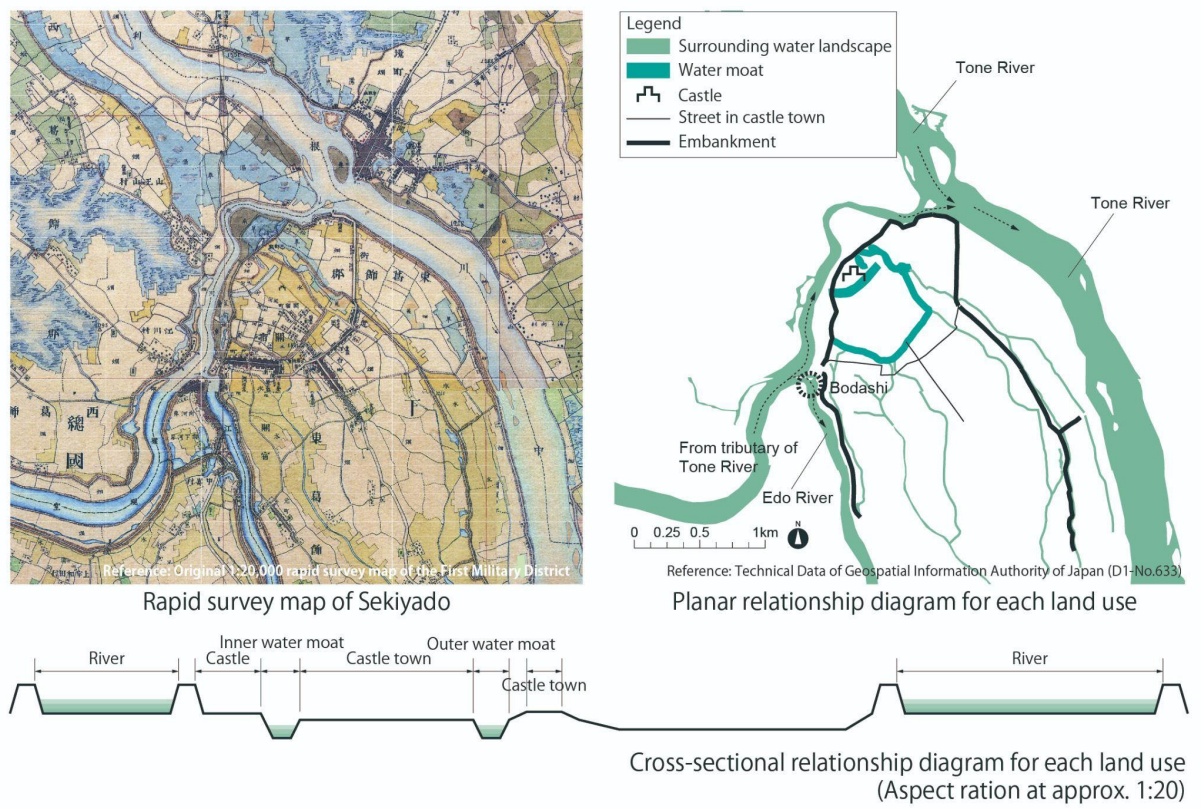

Figure 5. Urban form of Sekiyado.

In summary, it is possible to interpret each type as having a different approach to adapting to the surrounding water landscape. The water flow utilisation type is an approach that draws on relatively stable water flows into the urban area. The water environment adaptation type, on the other hand, is a more flexible approach that receives water flowing in from multiple directions. In contrast to these two types, the topography-defined type and flood defence type attempt to separate from, but partly relate to, the surrounding water landscape. The topography-defined type makes use of differences in elevation with water landscape as a method of separation, while the flood defence type creates a clear boundary with the water landscape by incorporating embankments into the urban area. These differences in the creation of relationships with the surrounding water landscape are reflected in the differences in urban form.

Relationship between the location and the urban typologies

In terms of the relationship between the location and the urban typologies, the following three features can be identified.

First, the four towns located on the upstream (Maebashi, Takasaki, Isesaki and Utsunomiya) all share the same principle of the water flow utilisation type. The wide plateaus and gentle slope of the topography in this region made it relatively easy to incorporate natural water flows into the urban areas. This made it possible to control the flow of water and form the water moat in line with the street pattern of the castle town. These towns also share the common feature of the castle being located on a plateau alongside the river. The river, and the difference in elevation, is thought to have been effective in protecting the castle from warfare. On the other hand, there are examples where

open views of the river and surrounding mountains from the castle were incorporated into the garden design. At Obata, which is also located on the upstream, the castle area was designed with a Chisen Kaiyu style garden (a style of Japanese garden with a path around a central pond and spring) called Rakusan-en, where the river and surrounding mountains were incorporated as a borrowing landscape. The layout of the castle adjacent to the river was probably designed as an integral part of the landscape experience as well as for defensive purposes in warfare.

Second, in the six towns located in the midstream (Oshi, Tatebayashi, Koga, Sekiyado, Shimotsuma and Yuuki), the surrounding river landscape is different in each town and the urban form is also diverse, with no unified typology. The diversity of the landscape in this region is influenced by the confluence of rivers from many directions and by river diversions. Various urban forms were constructed in response to the different landscape conditions in each town. The area is also at high risk of flooding, and three different approaches to flood prevention were adopted: internalising flood-adaptable water landscape within the town (Water environment adaptation type), consolidating the town on safe higher ground (Topography-defined type), and integrating river embankments for flood protection (Flood defence type).

Third, the two towns downstream of Tone River (Tsuchiura and Sakura) have in common that their towns are located facing large swamps, but they do not share the urban typologies. After Tone River Diversion, the swamps in the downstream region experienced more frequent flooding. The towns adjacent to these swamps were forced to respond to this change of river dynamics, but their approaches differ. In Tsuchiura, where the main factor of flooding was by the high-tide from the sea, the adaptive urban structure was strengthened (Water environment adaptation type). While in Sakura, which was directly impacted from the rainfall upstream, urban functions that were located around the swamp were relocated and consolidated in a town that was built on a plateau (Topography-defined type). These varying responses to changes in the landscape dynamics and water flow have resulted in the development of different urban forms.

The above shows that the division of areas into upstream, midstream and downstream and typologies of urban form does not accurately describe the relationship between river landscape and urban morphology or Tone River Basin. It is reasonable to assume the impact of the river landscape on urban morphology in the midstream and downstream regions is greater than that of the upstream with narrow and high velocity watercourse. Consequently, various urban forms have emerged in order to accommodate these dynamics in the castle town plan. The principle of spatial composition is the establishment of a living environment that is adaptable to water flow in relation to the topography of the context.

Reviving early modern water management for modern climate adaptation

In early modern castle towns, there was an inherent relationship between the built environment and the natural landscape. These castle towns were not only designed to respond individually to the river landscape but also functioned as comprehensive flood mitigation systems. Similar to the "Room for the River" project in the Netherlands (2006-2015), where 30 projects were integrated to work as a unified system - these towns collectively managed water flow and flood risks. They were interconnected, ensuring flood mitigation efforts were across the entire region rather than just within isolated areas.

However, as modernisation and industrialisation progressed, particularly after the Meiji era (1868-1912) and during the postwar economic boom, this integrated approach began to weaken. The space allocated for water management such as embankment in the upper stream was abandoned and the crucial connection between rivers and spatial development was replaced by strengthening the dikes and widening the river beds. As a result, increased discharge to low-lying areas intensified flood risks, highlighting the effectiveness of river watershed system wide water management practices (Okuma, 1991).

Revisiting these lost connections offers valuable insights for addressing flood risks and creating healthier, more sustainable urban environments. By integrating green infrastructure that aligns with natural landscape systems, we can develop adaptive typologies, especially in flood-prone areas. Grounding urban development in river dynamics, as seen in historical planning, can better inform modern climate resilience strategies and enhance the sustainability of urban landscapes.

CONCLUSIONS

This study reveals the urban form of early modern castle towns in balance with the landscape in Tone River basin in Japan. Each of the urban form typologies found in this study has a different approach to adapting to the river landscape. It can be said that the differences in urban forms are, in other words, differences in the approach to how the living environment is constructed in finding the balance with the river landscape.

A key finding of this study is that urban form typologies do not necessarily align with the regional divisions of upstream, midstream, and downstream, but are instead specific to the river dynamics of each site. It is more appropriate to interpret that urban typologies were established through individual adaptations to the river landscape dynamics interacting in the cross-regional relationship of the entire basin, instead of a general model of urban form for each region. The spatial composition was significantly shaped by water dynamics, geological conditions, and topography of the site, which made a sustainable relationship.

Forming such a harmonious relationship between urban form and the basin-wide river landscape is also being addressed in flood mitigation systems adapted to contemporary climate change. The principles derived from this study offer valuable insights for spatial design and basin-wide flood management planning.

In addition, the urban form of early modern castle towns in Tone River basin can be seen as a representation of the human effort to explore and establish a living environment that could co-exist with the river landscape. This attitude of working with landscape dynamics and striving to find a way of living with these dynamics provides important insights for contemporary urban and landscape design in the era of climate change.

Acknowledgements

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The contribution of open circulation spaces to the socio-environmental quality of the city: infrastructure and connections in Campos dos Goytacazes/RJ

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ABSTRACT

Among the important structures that make up urban form, the Open Space System is the result of the formation and production of urban spaces. These systems are related to subdivision norms and land use, geo-biophysical support, the society that lives in them and their economic and sociocultural demands, whilst also maintain links with built spaces. Within this system, open spaces for circulation, such as streets, sidewalks, and cycle paths, stand out, as they connect the other open spaces. Facing climate change, Open Space System plays an important role in urban areas, because in addition to being spaces for leisure and social interaction, they perform functions such as preservation and conservation and can improve the quality of the urban environment. For these spaces to work properly, it is necessary to ensure that everyone can access them, reinforcing the role of open circulation spaces. These can contribute to the quality of the environment by connecting other spaces and by incorporating features that contribute to the environment, such as urban trees and urban drainage systems. In this context, healthier, non-motorized, forms of travel, such as walking and cycling – known as active mobility - are also considered. This research, therefore, focuses on circulation spaces, aiming to analyse, in Campos dos Goytacazes/RJ, their capacity to connect other open spaces, understanding whether this structure contributes to equal access and healthier commutes. To this end, in addition to reviewing the literature on open spaces and active mobility, this research prepares and carries out critical cartography and field surveys. Even with its hot climate the city has potential for promoting active mobility as it is flat and has short commutes. What the research will show, however, is that open circulation spaces reproduce the following logic: narrow sidewalks, without standardization, without trees or other elements that mitigate temperatures and disconnection between elements, deprivileging active mobility.

Keywords: open circulation spaces, active mobility, urban socio-environmental quality

INTRODUCTION

The following paper is fruit of both the results of the author's PhD, that was about the Open Space System of Campos dos Goytacazes, a city in the state of Rio de Janeiro, Brazil, and subsequent studies that focused on an important category in the same system: open spaces of circulation. Studies that make use of surveys, mapping and debates about urban mobility to examine active mobility and the

structure of the city, or in other words, the street, and evaluate characteristics that can contribute to a better quality of commuting around the city.

As a component of urban form, the Open Space System evolves in conjunction with a city's growth and development, adapting to changes in functionality and characteristics. Urban form refers to the different spatial patterns and arrangements that cities can adopt. These forms are influenced and molded by diverse factors, such as physical, historical, cultural and technological aspects, and urban planning. They are made up of open and built, public and private, legal and illegal spaces. Urban form is a social product, but at the same time a prerequisite for social processes (Lefebvre, 2001). It encompasses the interrelationship between the physical structure and the processes of formation and transformation achieved by the various actions that shape the spatial configuration of a city. Urban form is susceptible to the influences of different factors that act upon the urban territory, whether physical or otherwise, and ultimately leave their mark on the shape of a city.

The physical aspect is composed of elements of relief, soil, water, and vegetation, which are superimposed upon the productive and occupational structures, representing the initial basis for the formation of any settlement. These structures have been built or modified by human action. In this context, living beings, especially human beings – who are particularly responsible for the processing of elements of the city (Macedo, 2012b) - group together, organize themselves and move around. In urban settlements, one of the main actions of the processing and modification of the landscape occurs through urban planning and the division of land use. These actions define the relationship between public and private spaces, built or non-built areas, generating morphological structures that make up the urban form, these very structures shaped by social and legislative standards (Aliprandi, 2017).

Within the set of morphological structures generated by land division it is the spaces free of buildings that stand out. Open Space has been defined by Miranda Magnoli, since the decade of 1970, as: “all of the space that is not occupied by a built volume (soil-space, water-space, light-space around buildings that people can access)”[60] (Magnoli, 2006b, p.179). An open space is one that is uncovered and may or may not include natural elements such as vegetation. It may be designated as public or private, and may be utilized by pedestrians, vehicles, or for the purposes of environmental conservation. Moreover, according to the same author, in the urban context, open spaces should always be understood in their relationship with built volumes, because: “[...] each one explains itself through the other, through its interdependence”[61] (Magnoli, 2006a, p. 152).

Open spaces form, according to Lima (1996), a pervasive fabric that permeates all the urban space. They are more susceptible to transformation over time, because within the urban context, as Macedo (1999) affirms, they are subordinated to forms of property and land division, they suffer the pressures of the formal and informal real estate market, and are transformed by urban infrastructure investment (Macedo, 1999; Tângari, 2013). Open spaces cannot be analyzed or proposed in isolation. It is necessary to recognize the inter-relations between them and, moreover, their relationship with biophysical aspects and with living beings, whether human or non-human, which consequently

60 The original: “O espaço livre é todo espaço não ocupado por um volume edificado (espaço-solo, espaço-água, espaço-luz ao redor das edificações a que as pessoas têm acesso)”.
61 The original: “[...] cada um se explica na medida do outro, na interdependência”.

enforces the idea of system (Bertalanffy, 1995 apud Uhlmann, 2002), forming in this way the Open Space System.

The Open Space System has important functions in the urban landscape. This includes the constitution of the image of the city, the exercise of leisure activities, and the implementation of the public sphere, which refers to all of public life, including debate and communicative action, which means that the general public sphere can be, in a strict sense, the political public sphere (QUEIROGA, 2014). This is due to the freedom that open spaces, especially public open spaces, can offer, providing access, use and appropriation for different groups of society. Furthermore, it can help improve the quality of the environment, because open spaces whether public or private, can provide the opportunity to produce food for domestic or commercial consumption, through the planting of vegetables, which can improve the air, the microclimate and the physical health of living beings, whilst also providing leisure and relaxation activities that can bring mental health benefits. With this said, facing the current climate change situation and the role that the Open Space System can have in this context, urban planning must recognize it as an important infrastructure of the city.

The Urban Open Space System include different categories of spaces that maintain this systemic interrelationship between them: spaces geared towards permanence (squares, parks, lakes, gardens, clubs etc.), areas geared towards circulation (sidewalks, streets and avenues, roundabouts, railways etc.), areas related to infrastructure (gas pipelines, water pipelines, electricity cables etc.), residual spaces (empty lots, expropriated land, slope stabilization etc.) and open spaces of environmental character (which are subject to environmental legislation and not authorized to be urbanized) (Aliprandi, 2017).

The open spaces of circulation are fundamental to connect the other open spaces of the Open Space System, whether public or private, and the built areas. It is by way of the street that we get to work, to school, to nurseries, hospitals, parks, squares, and to a number of different important spaces of our everyday lives. The street, in particular, is a fundamental element in the structure of a system and can be considered the most important public open space of the city (Macedo, 2012a; Macedo et al., 2015).

The street, including its sidewalks, is an important public open space, because beyond its role to provide a place for circulation and articulation between places and other types of other open spaces, whether public or private, it can accommodate other activities, as Jacobs affirms (1961, p. 29):

> Streets in cities serve many purposes besides carrying vehicles, and city sidewalks—the pedestrian parts of the streets—serve many purposes besides carrying pedestrians. These uses are bound up with circulation but are not identical with it and in their own right they are at least as basic as circulation to the proper workings of cities.

For the Open Space System to work and the aforementioned functions (constitution of the image of the city, the exercise of leisure activities, the implementation of the public sphere in general and the improvement of environmental quality) to perform well, it is necessary to guarantee that everyone has access to diverse elements, reinforcing the fundamental role of the open spaces of circulation. By connecting these other spaces, they can contribute to the quality of the environment.

Moreover, they can incorporate characteristics that contribute to the environment, such as urban trees, for example, and can serve as a platform for the development of healthier forms of commuting, by less motorized means, like walking and cycling, now known as active mobility.

Urban mobility can be understood as the ability to move around a territory (Vasconcellos, 2001). It involves the circulation of individual vehicles, collective transport, freight vehicles, bicycles, pedestrians and animals. All these types of circulation should work in a systematic way, or in other words, through a certain degree of interdependence on one another. Daily commuting involves different modes of transport, which should operate in an integrated way, but more active mobility represents the weakest type of circulation within this system.

In Brazil, since the 1980s, we have seen the prioritization of individual motorized transport in urban planning. This context has created more space for cars, broadening roads, allowing for faster speeds, and consequently, amid these transformations, sidewalks and cycle paths began to lose space, making the roads more dangerous, warding people off. Since the introduction of motorized vehicles in the city, roads have been broadened in detriment to the surroundings and to the existence of vegetation, making the sidewalks narrower and interspersed with different elements, like posts and signs (Macedo et al., 2018).

The possibility of circulating around the urban environment enables individuals to establish a relationship with their surroundings, and, therefore, experience the city. For this movement to happen in a healthy way, the urban environment must have an adequate infrastructure, guaranteeing security and comfort for those who move around it every day. According to Andrade and Lonke (2017, p.60): "The healthiest alternative is to promote active transport, which includes walking and using non-motorized transport – a bicycle, for example -, and linking it to public transport"[62]. It is important to emphasize that no mode of transport should be considered unsuitable or as an option to be abolished, but it is necessary to rethink the priorities of current planning, especially when facing climate change, an urgent reality to be addressed.

Considering this discussion, now we will direct our observation to the city being studied, Campos dos Goytacazes, in the north of the state of Rio de Janeiro. Situated 290km from the capital, it is the state's biggest municipality, extending 4,037.7km², with a population of 463,731, 90.30% of which live in the urban area (IBGE, 2010). It stands out in the region's economy due to the activities connected to the extraction of oil and gas from the Campos Basin.

During a long period, the economy of the region was based on sugar cane production, from the town's foundation in the XVII century until the industry's decline in the 1970s and 80s. The municipal resources have increased significantly due to the oil royalties received since the discovery of the oil in Campos Basin, in the 1970s.

As a result of the economic changes, the urban area began to spread over the countryside, causing a significant rural exodus and consequent problems with housing, service provision and urban infrastructure. Among these problems the shortcomings concerning urban mobility stand out,

62 The original: "A alternativa mais saudável é o incentivo do transporte ativo, que inclui caminhada e uso de transporte não motorizado - bicicleta, por exemplo -, somado ao transporte público."

exacerbated by the extensive way the expansion took place over the territory, comprising of vast plains which are irrigated by the Paraíba do Sul River, and the prioritization of the use of cars.

The city has a humid tropical climate, with high temperatures during most of the year, presenting a flat topography throughout its urban extension. The distance from one end of its urban area to another is no further than 15km, a characteristic that, considering that it is a plain, could contribute to active mobility in the city, but also represents a challenge for a city with a hotter climate, which is Campos' case. Previous studies have shown that the open spaces of circulation in Campos dos Goytacazes are lacking in physical characteristics and connectivity, but also present potential regarding use and appropriation and for the effectivity of urban connections, as we shall show.

Consequently, there has been an increase in interest in understanding if the city in question, considering the mentioned characteristics, presents the infrastructure that could contribute to this type of commuting. Questioning, moreover, if the current structures contribute to equal access to the different elements of the city's Open Space System. Thus, this research focuses on the spaces of circulation in the city of Campos e Goytacazes, evaluating its capacity to connect with other open spaces, understanding whether this structure contributes to the equal access to them and whether it contributes to healthier commuting.

The following section will present the steps taken and the potential avenues for discussion. It will also present the methodology and its stages, the results of the surveys conducted thus far, and some cartographies. Finally, the conclusions reached so far will be presented.

METHOD

There were three main stages to the methodology used in this study: revision of the literature about open spaces and active mobility, as presented in the previous section; a field survey and the elaboration of critical cartography.

Although the most important part of the street is that used exclusively for motorized vehicle traffic, the infrastructure geared towards active mobility involves the whole street, given the constant interrelationship between the roadway, pedestrians and cyclists, especially by way of street crossings. Despite this, the research focused on the sidewalks and their characteristics, because no other studies about them in the city of Campos were found. Furthermore, from the perspective of the sidewalks and observing their capacity to connect other elements of the structure and other modalities, it showed itself to be a sufficient tool of analysis for this moment of research.

The survey method includes six characteristics that are analyzed during the field visits (Soares e Aliprandi, 2024):

- Technical: aspects like the dimensions of the sidewalks are observed, if they fit into the minimal dimensions required by legislation and allow for the exercise of necessary activities, the existence and conditions of ramps and tactile signs, and the conditions of the preservation of these sidewalks.

- Use and benefits: aspects such as how commerce affects the use of sidewalks are observed, as are the ways in which the front of residential buildings or businesses interfere and whether street furniture, like bins and benches, exist and are efficiently available.

- Environment: here we analyze shadow, whether there are elements that provide shadow, such as trees, and whether they are sufficient to provide comfort to the user. In addition, we observe if there is rubbish in the street and whether it is correctly disposed of in bins and, also whether the noise pollution is at an acceptable level or not.

- Security: we analyze whether there is efficient public lighting, if the street crossings that are normally used are in the correct place, and whether signs are present in a satisfactory way.

- Circulation and mobility: we analyze the flow of pedestrians, whether it is possible to walk without interruptions or if there are obstacles that could be avoided on route, we also analyze the circulation of motorized vehicles, observing whether cars are within the ideal speed, and if the size of the street blocks is adequate.

- Interaction with other modalities: we analyze the interaction of the sidewalks with the cycle paths, if there are cycle paths or routes nearby. Concerning public transport, we analyze whether there are bus stops nearby and, regarding the general interaction between sidewalks, cycle path routes and public transport, we observe whether the three modalities interact well, whether there is the necessary structure for this.

From the forms elaborated in the field, which analyze the stretch of a sidewalk from one corner to another, the characteristics are inserted into maps through the geoprocessing program Arcgis, which permits a visual analysis of the distribution of the infrastructure and an overlaying of the information on the territory, allowing critical reflections about the results. In addition, the trees on the sidewalks are mapped in the same program, which made it possible to analyze their distribution and their influence on mobility. These new maps are read in parallel with the analyses already carried out in the doctoral thesis, confirming or complementing the notes made at that time.

RESULTS AND DISCUSSIONS

The municipality of Campos dos Goytacazes is in the northern region of the State of Rio de Janeiro, Brazil, with eight neighboring municipalities: São João da Barra, Carapebus, Cardoso Moreira, Conceição de Macabu, Quissamã, São Fidélis, São Francisco de Itabapoana and Macaé, as shown by Figure 1. The region has an area of 9.730.443km² and a population of 861,084 inhabitants (IBGE, 2010). The study presented here focuses on the area inside the urban perimeter, demonstrated in Figure 2.

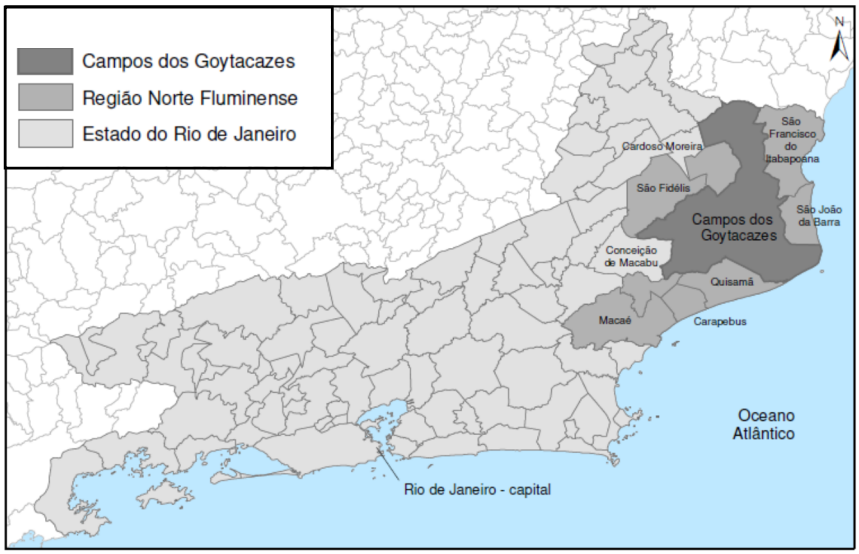

Figure 1: Location of the municipalities of the north of Rio de Janeiro and the state capital. Source: Aliprandi (2017), based on IBGE (2010) data.

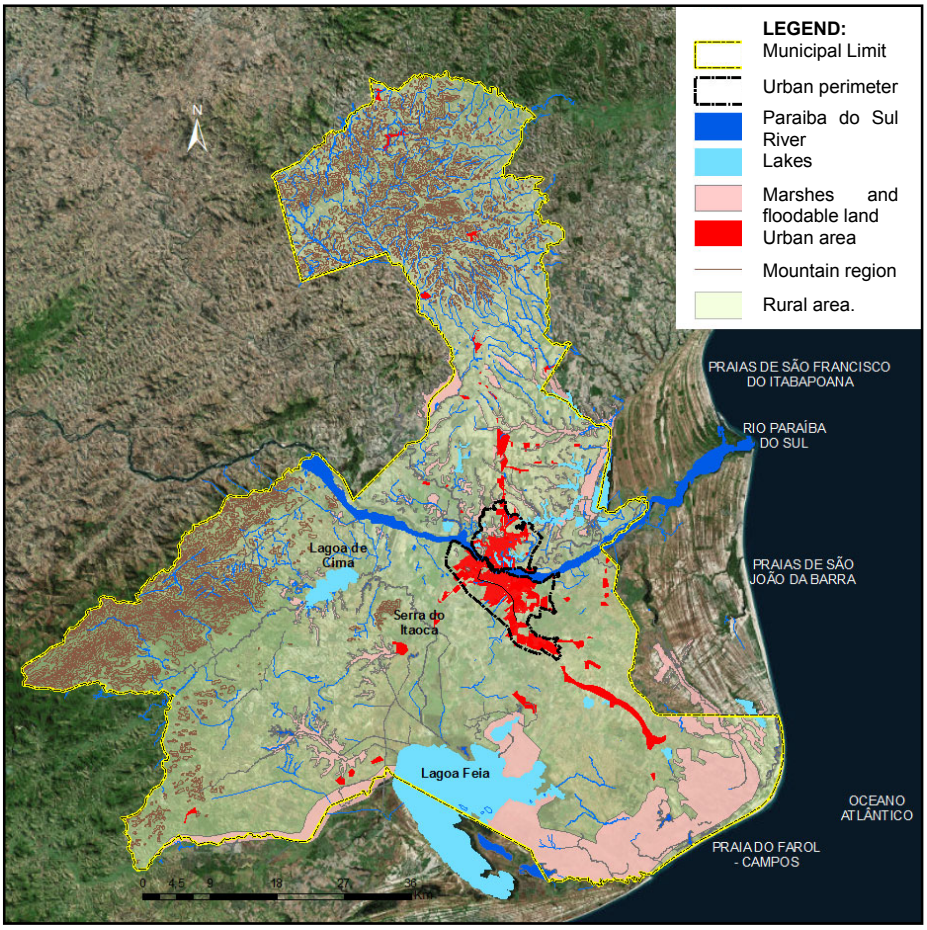

Figure 2: Campos dos Goytacazes Municipality and localisation of the urban area. Source: Aliprandi (2017), based on the IBGE (2010) and PDPCG (2008) maps and the field surveys.

In the author's thesis (Aliprandi, 2017), the Open Space System of the city was evaluated in terms of its qualitative characteristics: environmental, social and aesthetic. Environmental quality is related to

the maintenance of permeable areas that contribute to permeable areas, and to the creation of microclimates, primarily due to the existence of large vegetation. This vegetation increases shadow and the retention of particles of air pollution, whilst also promoting the existence of animal life. Moreover, in the case of urban circulation, it facilitates the movement of pedestrians and cyclists. Social quality is concerned with meeting the social demands of the population, which are heterogenous, consequently the Open Space System must adhere to the principles of access equality and of multifunctionality. This allows for a balanced and diversified distribution of the types of open spaces and functionality. Aesthetic quality is related to the image we create of the city.

To perform this evaluation, field observation was carried out, which was later supplemented with information from Google Earth and Google Street View, filling in Table 1, considering each urban sector defined in the doctorate research (Figure 3):

TYPE	SUBTYPE	Characterisation				Accessibility			Social Practice/ Activity	Landscape characteristics			
		Legislation	Dimension	Title situation	Management	Physical Access físico	Protocol	Visual Access		Conservation	Urban furniture	Paving	Vegetation - Trees
Environmental character	sustainable use												
Urban character	related to permanence												
	related to circulation												

Table 1: Model used in the evaluation of Urban Space System attributes

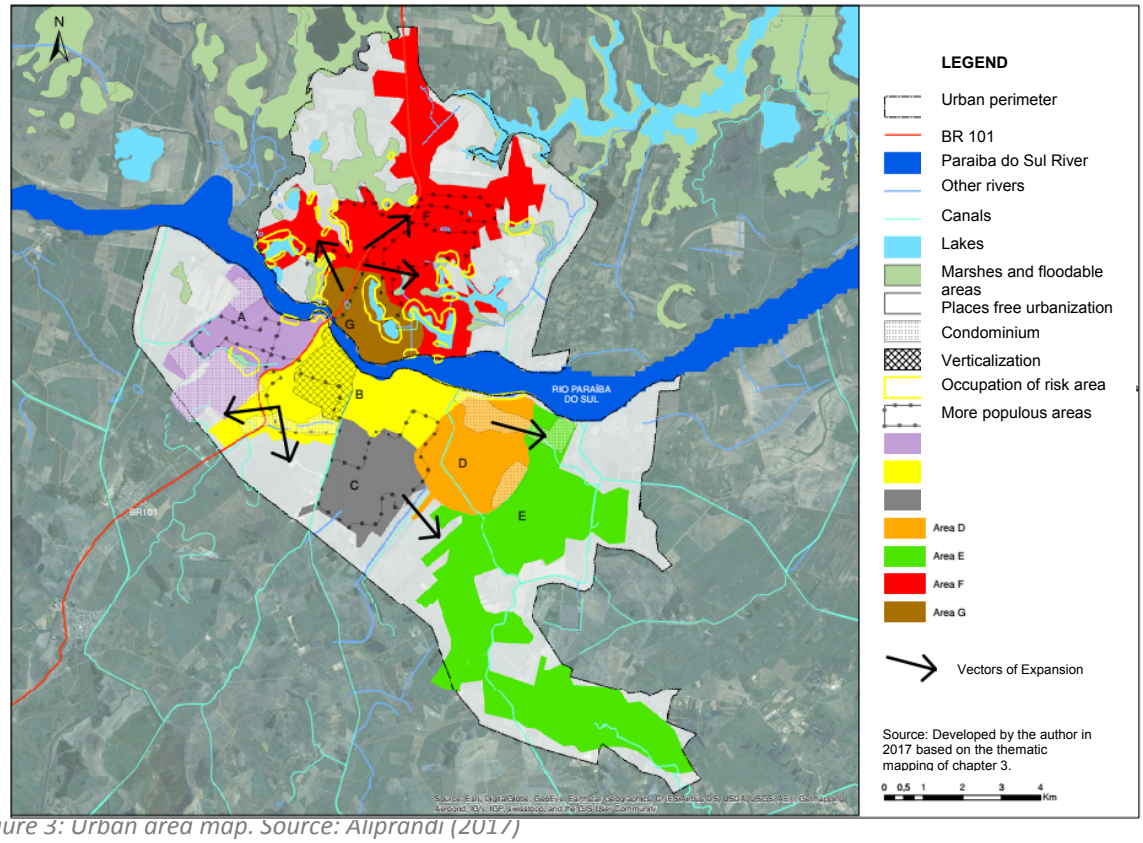

Figure 3: Urban area map. Source: Aliprandi (2017)

The sectors are the result of the overlaying of the mapping of characteristics like private open spaces, the presence and distribution of public open spaces and the distribution of population and income in the city's territory, including the form in which some urban problems are distributed in the city, such as urban fragmentation, spatial segregation, the treatment of water resources, to mention just a few. It is not within the scope of this paper to engage in a deep discussion about these problems and about the division of these areas, as they are a result of an analysis that goes beyond the issues presented here. It is worth highlighting, however, that carrying out area research contributes to the comparative analysis about the behavior of the problem analyzed all over the territory.

As our focus is open spaces of circulation, and considering Table 1, the most relevant issues for this analysis are found in the characteristics "Social practice/activity", identifying whether the streets allow for diverse uses, beyond circulation itself, "Paving", identifying the types of road surface, observing the permeability of the ground, and "Vegetation", with a focus on the existence of trees. About the latter, in current study that also being carried out guided by the author, the urban tree canopy in the city is being mapped, and the findings so far have confirmed the existing data. In addition, the mapping of sidewalks, presented in the methodology, analyses and complements the item "Vegetation", by identifying the areas with shadow, and the item "Urban furniture/buildings", that are elements that are considered in the categories "Uses and benefits", "Security", and "Circulation and Mobility", also explained in the methodology.

What was observed is that the open spaces of circulation in the city are somewhat impermeable, generally paved with tarmac, with a few examples of cobblestone streets, particularly in the limits of

the urban perimeter. The streets have few trees, presenting merely 10 to 30% of urban tree canopy, a situation which worsens in the more central area B, and its neighboring area A. Regarding social practices, with the exception of central areas B and G, it is possible to find different activities, like children playing in the streets or people sat on the sidewalk, a more prevalent phenomenon in the residential neighborhoods.

In relation to the most up-to-date mapping of the characteristics of the sidewalks, seeking to test the method and carry out an initial analysis considering the diverse urban areas of the city, points of analysis scattered around the territory were chosen, shown in Figure 4. The points chosen were crossroads, permitting the analysis of at least four streets in each place. Thirteen stretches were selected considering as criteria, apart from being crossroads, being spots with large facilities such as shopping centers and bus terminals, as they are areas of high pedestrian traffic.

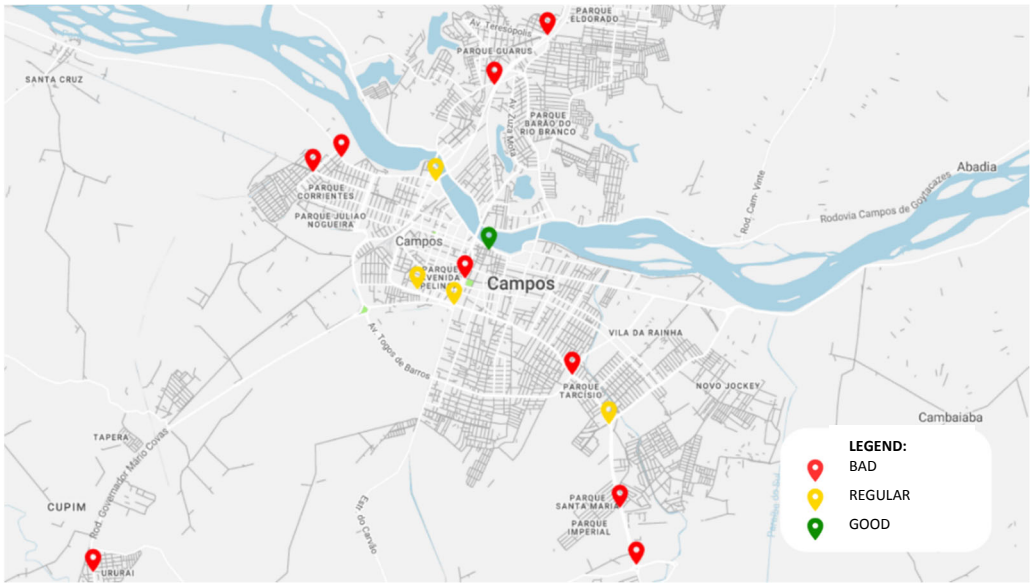

Figure 4: Points mapped in the first cycle of the study. Source: Layla Soares, IC grant student (2024).

The data is collected on site using the survey form and in the laboratory the data is used to fill in a attributes table from Arcgis. With the compilation of this data, the stretches observed receive evaluations as can be seen in Figure 4: red = bad, yellow = regular; and green = good. The result showed here is more general, to illustrate the method. It to present the map of each category and their subcategories goes beyond the scope of this paper, consequently we cannot analyze the issues separately, but we will highlight them below.

Through the survey it was possible to observe that the sidewalks face some common problems, such as the lack of accessibility, where tactile paving, access ramps, signs, satisfactory safety and preservation provisions are not identified, making walking more difficult. Furthermore, we identified high levels of noise pollution due to the significant number of motorized vehicles, a lack of urban furniture and shelter, including trees, exposing the pedestrians to sun and rain.

The spot marked in green on the Figure 4 is in the historical center of the city. It is a place where the roads are well maintained, well-lit and well shaded, but this is mainly due to the shops along the street and the fact that the streets are narrow, bringing the buildings closer together. The sidewalks, however, are very narrow and there are many obstacles, owing to the shops that line the sidewalk.

The occupation of the sidewalks by businesses is a common occurrence in the other spots studied, interrupting the flow of people. The dimensions and quality of the sidewalks, and of the crossings, considering both how they were engineered and how they are maintained, are the points that most interfere in the flow and use of the sidewalks. The situation is more precarious in places in more peripheral areas, where we find most of the red points on the map.

During the survey we perceived and witnessed various challenges to the simple act of walking in the city, from the bad maintenance or incorrect choice of workmanship, narrow or almost inexistant sidewalks, lack of adequate signaling for pedestrians, traffic lights with insufficient time to cross, to the numerous violations of traffic law, mainly disrespecting pedestrians. These observations are best presented in the article by Soares and Aliprandi (2024).

Concerning cycling in the city, there is not a detailed mapping in this study about the characteristics of the structure, like is being carried out about the sidewalks, but it is important to highlight that the city went through a number of reforms in its cycle path network in 2023 and 2024, expanding the possibilities of the circulation of this category, connecting points in the city that were previously excluded from the network, reducing problems of discontinuity that were faced by the cyclists. In the map shown in Figure 5 it is possible to observe the plan of this modification.

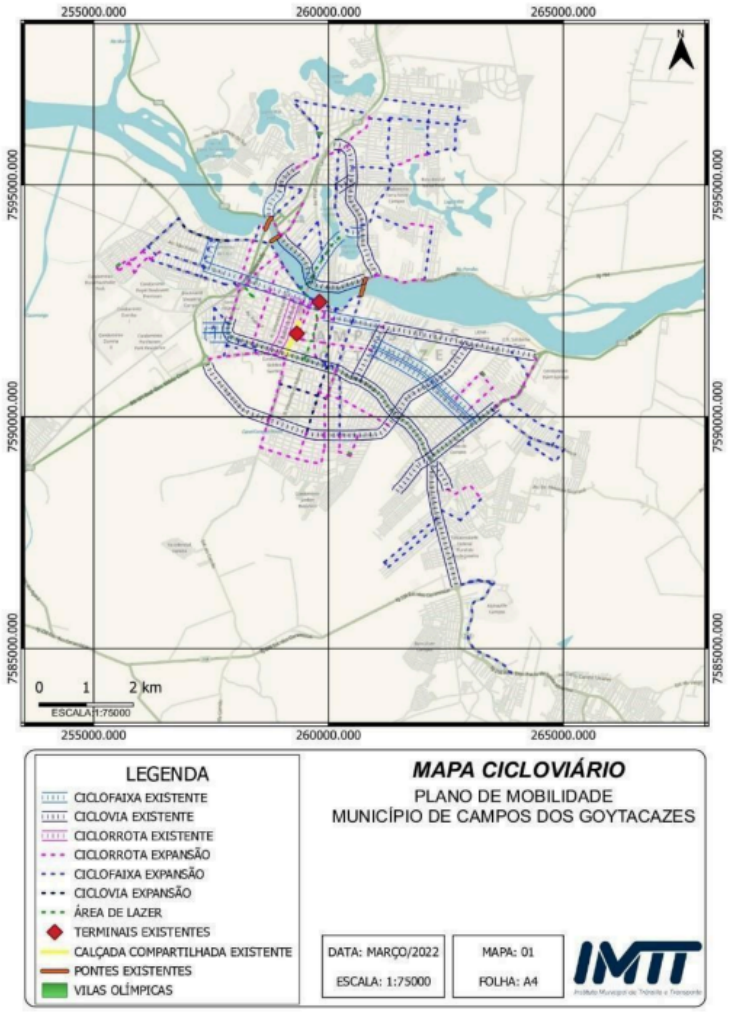

Figure 4: Cycle map of Campos dos Goytacazes proposed by the Mobility Plan. Source: Made available by the Municipal Institute of Traffic and Transport (IMTT) during a meeting (2022).

During some field trips to observe this infrastructure, people were seen walking and running on the cycle paths and lanes in many stretches, a lot of the time because of the surrounding precarious sidewalks, it doesn't existent urban facilities that support cyclists, like bike racks, and also other problems like unevenness in the sidewalks and narrow cycle lanes and dangerous intersections.

CONCLUSIONS

Considering the data shown, the infrastructure for active mobility in the city of Campos dos Goytacazes does not contribute fully to the promotion of this type of commuting, particularly the circulation of pedestrians. The findings indicate that the infrastructure is of a low quality and does not allow for a pleasant or safe pedestrian experience, hindering the access to the city's other open spaces, via this mode of circulation. Whilst in relation to the cycle path network, there is a significant improvement, broadening the possibilities of use and access to several spaces in the city, and therefore the safety of its users.

The integration between the modes was positively evaluated in terms of its potential, as it was identified that public transport routes and some kind of bicycle network could be easily accessed in

the spots analyzed. It is important to stress, however, that even so they lack support facilities, like bus stops and bike racks, other problems in the crossings were also identified, making the integration unsafe. Furthermore, the high impermeableness of the ground and the low number of trees in the open spaces of circulation in the city stood out, which can have a detrimental impact on environmental quality.

The data collected and analyzed thus far reinforces the importance of this study and the need to continue with the surveys, which can provide more precise information, so that future public interventions can be more efficient.

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The green city morphology – Urban form, food production and nutrient circularity

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ABSTRACT

The green city seeks to intertwine greenery, landscapes and agriculture into townscapes to create a sustainable urban form that will support high standard of living with nature, increased biodiversity and circular flow of resources. This paper conceptualizes and discusses visions, scales and elements of the agroecological urbanism and the green city through morphologically informed urban design. Urban designers analyse cities in three dimensions, whereas urban morphologists understand cities as a hierarchy of design elements: streets and their layout, plots and their aggregation in blocks, buildings, and land uses. The green city can be morphologically understood as a set of design elements such as windows farms, roof gardens, vertical farms, greenhouses, community allotments, backyard gardens, etc. that can be composed within the morphological hierarchy of cities. The urban agricultural systems and agritech (a shortening of agricultural technology) can utilize local wastes and employ underutilized space in urban areas for food provisioning to circulate resources. This includes e.g. vacant buildings, parking garages, basements, roofs, storage rooms, shipping containers, etc. Bringing urban morphology, landscape architecture and architecture, urban agriculture, landscape and industrial ecology together opens possibilities to better understand needs and challenges in developing productive green cities.

Keywords: green city, typomorphology, urban agriculture, food production, nutrient circularity

INTRODUCTION [Heading 1]

The future requires bold disruptive visions of future cities to achieve smart sustainability challenges. The green city prioritizes environmental design, greenery, landscapes, agriculture and townscapes that intertwine in a sustainable urban form that supports high standard of living in nature, biodiversity and circular flow of resources. The green city relates to buzzwords such as urban village, eco-village, eco-town, garden city (reviving a concept from the end of the 19th century), sustainable community, sustainable urban extension, etc. (Cowan, 2021). In parallel, smart sustainability emerges as a new transformative approach focusing on development of eco cities and sustainable neighbourhoods, digitisation of urban infrastructure, and collaborative experimentation with low-carbon and digital technologies (Evans & Karvonen, 2014; Evans et al., 2016; Cugurullo, 2021). This paper looks and discusses green architecture and eco city visions from self-sufficient hermit huts to social utopias,

working cities and productive landscapes (Howard, 1898; Le Corbusier, 1987 [1925]; Wright, 1935; Viljoen et al., 2005; Gorgolewski et al., 2011; Viljoen, A. & Bohn, 2014; Davis, 2020), informal urban agriculture (Hardman & Larkham, 2014), landscape architecture and urbanism (McHarg, 1992 [1969]; Turner, 1996; 1998; Waldheim, 2016), to emerging agricultural technologies (abbreviated as agritech) inspiring high-tech smart sustainability experiments (Farhangi et al., 2020), such as urban food labs or indoor, vertical or rooftop farms (Orsini et al., 2017; Martin & Molin, 2019; Martin et al., 2019; 2023; Martin & Orsini, 2023).

To discuss physical prerequisites and opportunities for agroecological urbanism and productive green cities, this paper converges perspectives from urban morphology, agriculture and food systems, and industrial ecology to conceptualize scales and elements for a handbook for morphologically informed urban design. Morphological analysis is defined by a hierarchy of three fundamental elements: streets and their layout, plots and their aggregation in blocks, buildings and land uses as building utilisation (Conzen, 1960; Moudon, 1997; Kropf, 2011; 2014; 2018). Urban designers focus on the experiential qualities of cities in in three dimensions (3D), liveable city and the human scale (Southworth, 2016). They combine imagery, diagrams, and maps to analyse and design cities (Talen, 2009). They develop typologies and they turn typologies into visions, design codes or Form-Based Codes (FBCs) with morphological methods (Duany & Talen, 2002; Carmona et al, 2006; Walters, 2007; Talen, 2013). Urban morphology informs urban design as hierarchy of design elements and sub-elements at various scales conventionally structured in urban design handbooks based on typologies. If urban morphology is about inference and interpretation of type, urban design is about invention of types and intervention using type in a systematic fashion (Marshall & Çalişkan, 2011). The agroecological urbanism of the green city can be morphologically understood as design elements at various scale such as rural and urban farms, community or private urban gardens, vertical farms and fields, windows farms, or roof gardens, etc. that can be integrated in the morphological hierarchy of the city. Many underutilized spaces in urban areas, particularly open spaces between buildings, that characterise the 20th century urbanism (Le Corbusier, 1987 [1925]) can be used for food provisioning and promotion of a circularity. This includes open green spaces, vacant buildings, parking garages, basements, storage rooms, shipping containers, and integrated in-store in commercial locations (Martin & Bustamante, 2021). This paper aims to inspire debates on implementing old and new urban agriculture technologies to produce high quality food and contribute to food security and nutrient circularity locally.

The city, nature and agriculture

The green city intersects cities and nature, integrating urban environments with natural ecosystems and agriculture needed to sustain cities. Figure 1 diagrammatises the relationships between cities, agriculture and nature highlighting aspects of investigation of the relationship where agriculture is cultivated nature typically understood as countryside and the city stands as opposite. The city is within the domain of urban morphology that looks at the formation of urban elements (streets/squares, plots and buildings) and their transformation over time, nature is conceived as landscape, ecology and biology. Landscape architecture, urban design and landscape urbanism have a unique location in this relationship to integrate vegetation and water (green and blue design elements) in cities as landscape ecology (McHarg, 1992 [1969]; Turner & Gardner 2015 [2001]). Landscape architecture is the art, science and technology of composing gardens for private or public use, and green spaces and outdoor environments as public realm with good social, aesthetic and ecological, incorporating landform,

vegetation and water elements with buildings, landmarks, built structures and paving (Turner, 2014). The term landscape ecology was introduced by the German biogeographer Carl Troll (1939) and combines the spatial approach of the geographer with the functional approach of the ecologist (Turner & Gardner, 2015, p.3, see McHarg, 1992 [1969]). It focuses on the spatial relationships among landscape elements, or ecosystems, the flows of energy, nutrients, plants and animals and the ecological dynamics of the landscape mosaic through time (Forman 1983).



Figure 1: Intersection of city and nature conceptualizing relationships between disciplines focused on the green city and urban agriculture

The food systems intersect agriculture and city starting with food production (on farms as cultivated nature or within natural ecosystems as hunting and gathering) through food distribution and trade (that includes global chains of warehouses, ports, transport and logistic infrastructure) to wholesale and retail food distribution (food markets at squares, big box supermarkets and grocers and supermarkets in buildings). Food preparation happens in kitchens and restaurants as sub-elements of buildings. The green city exist is many variations across the city, nature and agriculture fields. Some theoretical frameworks have roots in social utopianism, anarchism and even hermit communities, while others can be located in urban morphology and design, but incorporate biological and ecological narratives (from biomimicry, and biophilia, most radical assume generic engineering of proto cells to create living settlements), ecology and environmentalism (living in/living with nature), landscape architecture, etc. There is also permaculture that seeks to imitate natural ecosystem circularity for agriculture. To structure the literature of green cities and (utopian) visions that highlight agriculture, this paper starts with morphological dissection of scales and elements.

The morphology of the green city

Urban morphology studies the physical elements and structure of cities, the physiognomy and character of their buildings, streets or neighbourhoods. One of the important aspects is the resolution of analyses or the scale (Moudon, 1997). Figure 2 shows the theoretical framework for morphological resolution based on environmental perception of urban space and the public-private spaces morphological structure of cities from a private building and plot to a public street/square (Figure 2E). The environmental perception of urban space is shaped by anthropometrics in architecture (armreach) and personal and social distances in anthropology (Hall, 1959; 1966; Gehl, 1986 [1971]) (Figure 2A). The visual world is like a sphere around a person and is clear everywhere while the visual field is the area within the field of view of both eyes (Figure 2B). The field of view is clear in the centre (foveal vision) and vague in the periphery (defined by Gibson, 1986) and the visual acuity is within a

radius of 100-200 m. Visual perception is enhanced when supported by related auditory cues and vice versa. Sounds provide an important link to reality, are enriching and protective (Southworth, 1967; 2020). Sounds come from any directions. They are aural and turn the head around (Stojanovski & Axelsson, 2018; Axelsson, 2020). The operational environment defines the space where people move and work. It is a movement space and can extend up to 100 kilometres. The perceptual environment is the space where people are directly conscious and to which they give symbolic meaning (it can extend up to 1 kilometre). In the behavioural environment, people are not only aware but also perform behavioural response (Rapoport, 1977). Figure 2C show the nested structure of operational and perceptual hierarchy of environments, whereas Figure 2D shows the amoebic shapes that are created by the urban morphology and the physical and social factors that shape the inner behavioural environment, as well as the operational environment shaped by walking.

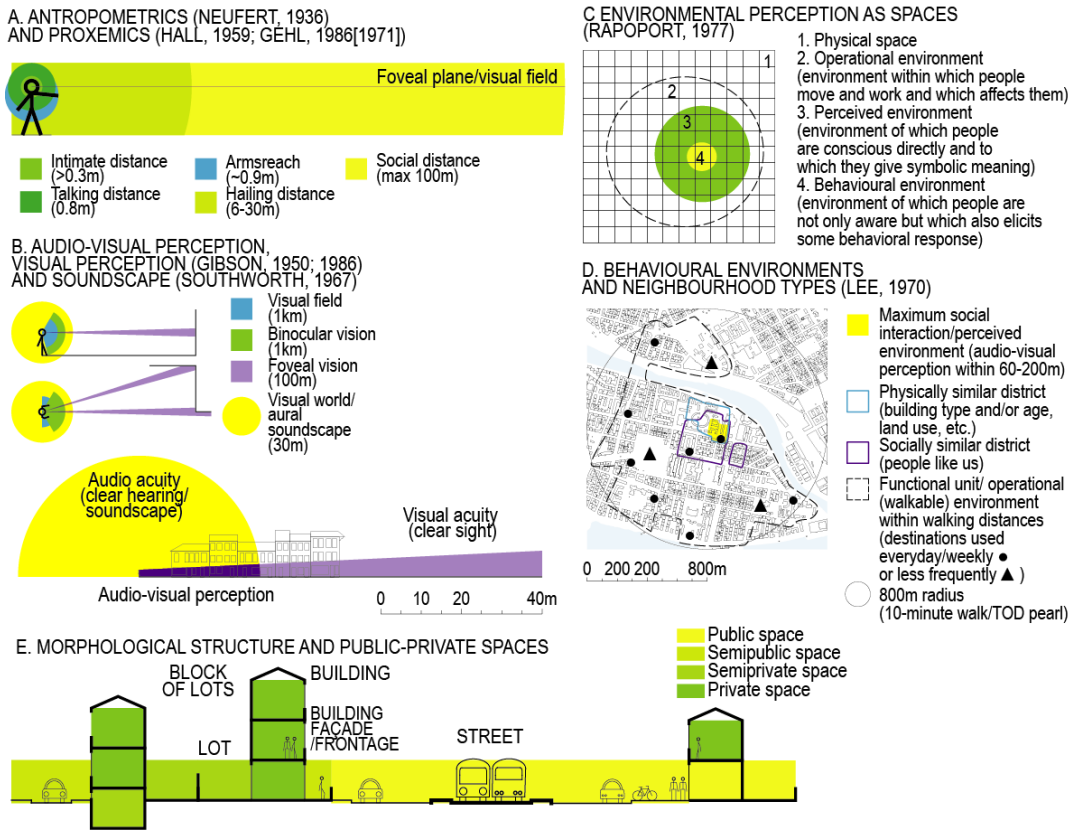

Figure 2: Theoretical framework for morphological structure of scales based on environmental perception

This paper furthermore explores the literature of green cities and (utopian) visions that highlight agriculture. It classifies concepts, projects, technologies, etc. by discipline, scale and agricultural technology level, by expert approaches and by regulations. To structure the literature review it uses a genealogical approach (Stojanovski & Samuels, 2023). Urban designers eclectically combine imagery, diagrams, and maps in urban design handbook urban design manuals (Bentley et al, 1985; 2024; Talen 2009) and for advocacy for design guidelines (Duany & Talen, 2002; Carmona, et al., 2006; Walters, 2007; Talen 2013) as urban design can be defined as the art of making and shaping cities by creating compositions of morphological elements in physical space (Taylor, 1999; Marshall 2016). Figure 3 shows a diagram of urban agriculture, mapping important events, models, references, actors, etc. in respect to morphological schools and approaches (see Stojanovski, 2022) highlighting disciplines such as economy/geography, architecture and landscape architecture that worked with agricultural

models. There is a dominance of architects who worked with green architecture, self-sufficient communities and urban agriculture who developed visions from entire cities such as Le Corbusier and Frank Lloyd Wright, to biospheres and neighbourhoods as CPUL (Continuous Productive Urban Landscapes) to green buildings, indoor farming, guerilla gardening and foodscaping of urban spaces (Hardman & Larkham, 2014; Elmlund & Haas, 2019).

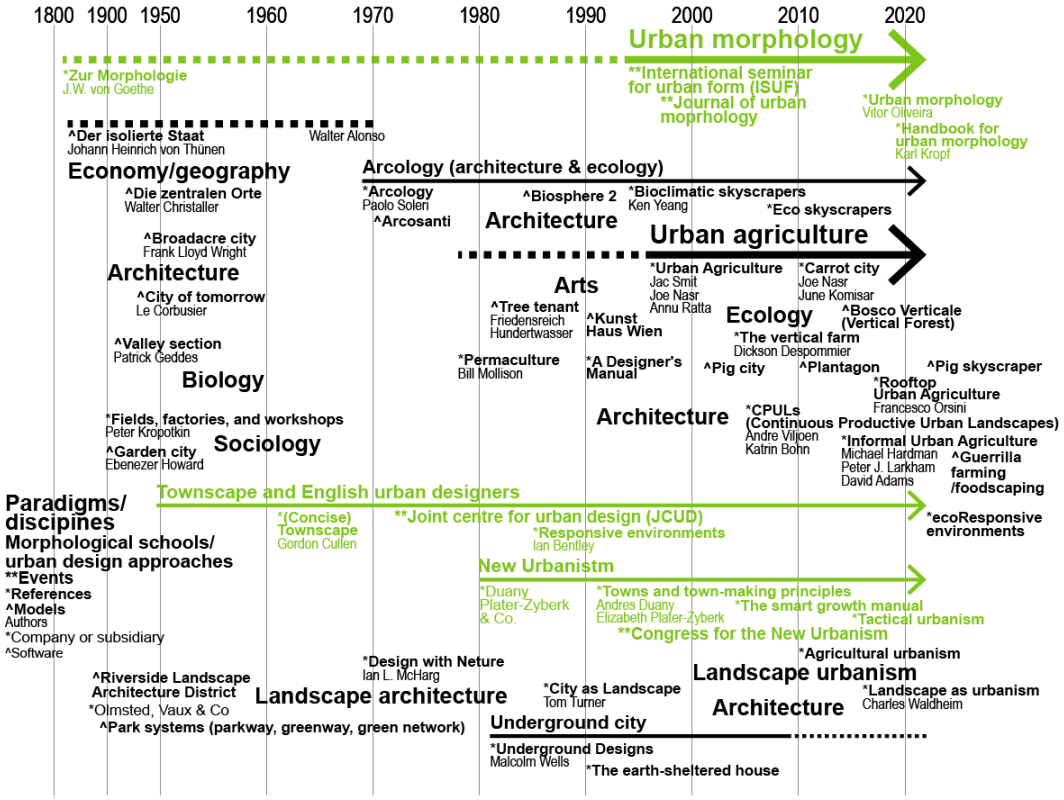

Figure 3: A genealogical diagram of urban agriculture, mapping important events, models, references, actors, etc. in respect to morphological schools and approaches (see Stojanovski, 2022, for the entire genealogical diagram of urban morphology)

Green city visions

There are various green city visions. Historically, the towns were a mix of city and agriculture located at transport foci surrounded by arable land and/or abundant fisheries. These historical towns/cities created a hierarchy of centres (smaller towns and villages) along transportation axes at a scale of an urban region. Johann Heinrich Von Thünen (1966 [1826]) proposed a theory of cities developing as concentric rings (Der isolirte Staat, or the Isolated City) based on transportation costs that was further developed in a theory of central places (Die zentralen Orte) by Walter Christaller's (1966, [1933]). With the industrialisation of agriculture and transport emerged models for self-sufficient communities and social utopia by thinkers as Henri de Saint-Simon, Charles Fourier and Robert Owen. A phalanstère (or phalanstery) was a type of building proposed by Charles Fourier in the early 19th century by Charles Fourier and designed for self-contained and self-sufficient community consisting of thousands people working together. Fourier combined the French word phalange (phalanx, an emblematic military unit) with the word monastère (monastery) to describe the social ethic of the utopian community. Peter Kropotkin created the most detailed model for social utopian community surveying food production in England in the 19th century. The community consisted of 200 families with five members, living on

1000 acres. 340 acres were to be used for growing the cereals like wheat, oats, barley, 400 acres used for all the green crops and fodder required to keep 30 or 40 cows for milk and butter and 300 heads of cattle for supply of meat. 20 acres were to be used for growing vegetables and fruits from which 2 acres under glass. Half an acre is attached to each house for hobbies and amusement, like poultry keeping, or any fancy culture, flowers, and in the end, there are remaining 140 acres for all sorts of purposes, like public gardens, squares, manufactures. Landscape architecture also emerged in the 19th century to address the need of green spaces in cities. Frederick Law Olmsted was pivotal in designing parks, parkways, greenways as green networks in cities that with green belts and wedges remain as a landscape planning and architecture typology for green spaces in cities (Turner, 1995; 2006). Ebenezer Howard (1898) summarised the industrialization dream of mixing city and countryside by proposing a polycentric city of tomorrow consists of railway suburbs that reside in the green tranquillity of the landscape and have a speedy connection to the diverse and exciting industrial, but polluted city. Le Corbusier's (1987 [1925]) city of tomorrow and Frank Lloyd Wright's (1935) Broadacre city created also visions of green and self-sufficient cities. Ebenezer Howard estimated roughly six times smaller agricultural area than Peter Kropotkin (6000-acre garden town assumes 5000 acres under agriculture to fulfil the needs for a city of 32000 people vs. 1000-acre community for 200 households or 1000 people), whereas Frank Lloyd Wright (1935) planned 1400 small farm units (8000 residents) on four square miles (2560 acres) in the Broadacre city. Paolo Soleri, a student of Frank Lloyd Wright planned the Arcosanti community of 5000 residents on a 4060-acre land preserve property, being one of the last agricultural utopias planned in that tradition.

A new revolution with urban agriculture, green architecture and landscape urbanism came with the environmental movement in the 1970s. Concepts such as permaculture (permanent + agriculture) by Bill Mollison, tree tenant by Friedensreich Hundertwasser, underground and earth-sheltered houses Malcolm Wells, etc. in the 1980s preceded a revolution in urban agriculture since the 1990s supported by development of new agritech (hydroponics, aeroponics, etc.). Some systems like aeroponics came out from trials to grow food on space stations in zero gravity (Stojanovski, 2023; Stojanovski & Adams, 2024). Furthermore, there is a new generation of entrepreneurs and enthusiasts as actors advocating for agroecological urbanism such as "artisan farmers", who are local businesses running farms that specialize in a specific crop (e.g. mushroom farms, salads, etc.) and supply local food with high quality and cost, typically to the local community and restaurants, "agrotechnologists" entrepreneurs developing new innovative agritech for global impact and markets, guerilla farmers or gardeners who grow food predominantly for recreation, and "agritects", typically architects who as professionals advocate for urban agriculture and green architecture, etc. This has created development of indoor and rooftop agritech, visions and experiments with vertical farming including pig skyscrapers (see Despommier, 2010; Gorgolewski et al., 2011). Food growing, farmer markets and food festivals also play important role in placemaking as guerilla gardening and city farming (Adams & Hardman, 2014; Hardman & Larkham, 2014; Hardman, et al, 2022).

Figure 4 classify the visions, concepts, models, projects, technologies, etc. by scale and agricultural technology level. Figure 5 shows them by expert approaches (professional farmers and agronomists vs. recreational agriculturists) and by regulations (formal permits for agricultural land uses or farming activities vs. informal placemaking acts such as guerilla farming/gardening). Most of the models and elements from landscape agriculture are summarised by Tom Turner (1995; 1996; 1998; 2006), whereas in architecture by Joe Nasr and June Komisar (as "carrot city" advocacy, see Gorgolewski et

al, 2011, Nasr & Potteiger, 2023, as depositories of urban agriculture concepts, models, projects, typologies, etc.). Additional resources are agritects such as Andre Viljoen and Katrin Bohn (2005; 2014), Janine de la Salle & Mark Holland (2010), Craig Verzone and Christina Woods (2021), and their books on productive landscapes, agricultural and food urbanism.

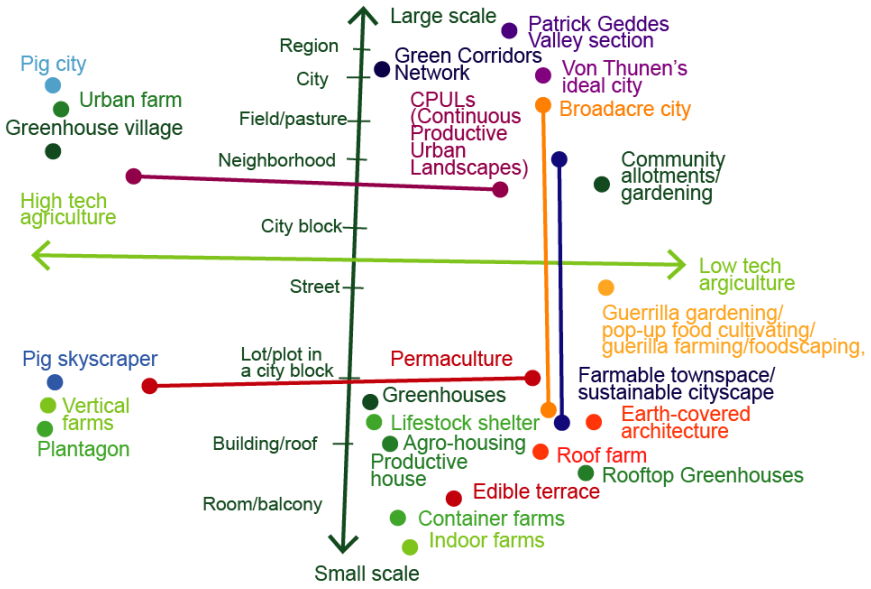

Figure 4: Urban agriculture and agroecological urbanisms by scale and agricultural technology level

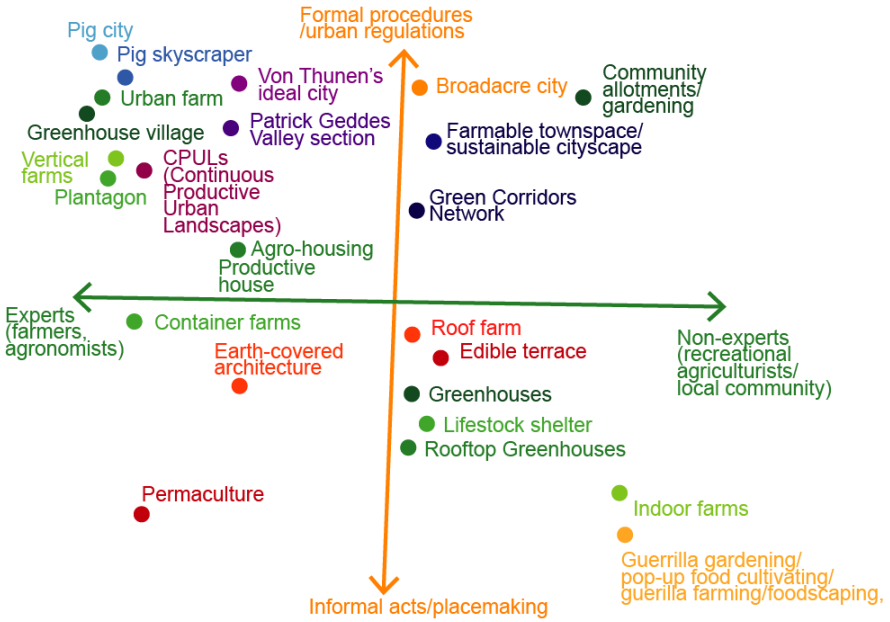

Figure 5: Urban agriculture and agroecological urbanisms by expertise and regulations

The figures above show visions, concepts, models, projects, technologies, etc. of urban agriculture and agroecological urbanisms at various scales with intention to map and classify morphology, scales and elements within a framework of perceptual morphology and inspire debate on integrating them in typologies of neighbourhoods, streets and buildings in various international contexts. The aim is to develop green city urban design handbooks considering local morphological context and perceptual constraints. Table 1 summarizes the visions for agroecological urbanisms, urban agriculture projects and agricultural technologies at morphological scales from a room to a city and it also juxtaposes

agricultural technologies and landscape elements in a respect to direct sun or shade, public and public spaces and accessibility.

Table 1: Morphological scales transposed with agricultural technologies and landscape elements

Morphological scales	Agricultural technologies and landscape elements	Insolation	Public space and accessibility
Room (windows, doors)	Pots, indoor farming systems (plant pods, indoor gardens), window farms	Partially in sun/shade	Private space (within an arm's reach)
Balcony/terrace (door, windshield)	Planting walls/hanging planters		
Building story	Composters	Shade	Private space (within an arm's reach)
Ground floor (entrances, doors)	Raised beds/containers/soft planters		Private space or public space (within a VIEWSHED)
Roof	Row of plants	Direct sun/ possibly shaded from buildings	Private, semi-private or semi-public (within an arm's reach)
BUILDING	Row of trees		
Building façades (windows, doors, balconies)	Arbor/pergola		Private space or public space (within a VIEWSHED)
PLOT/PARCEL	Greenhouses		Private or semi-public space (within an arm's reach and a VIEWSHED)
Backyards/open spaces	Livestock shelters/sheds		
Front yards/open spaces	Hydroponic/aquaponic systems		
City block front	Green façades		Public and semi-public spaces within a VIEWSHED/aural space of audio-visual perception (30-200m)
CITY BLOCKS	Parks, pocket parks, garden lots, community gardens, allotments	Direct sun	
Plot division			
STREET/STREETSCAPE	Strips of greenery/tree alleys		
Sidewalks	Street landscaping		
STREETS/ROUTES (as a neighbourhood pattern/hierarchy)	Boulevards		
	Parkways		
NEIGHBORHOODS/DISTRICTS (urban tissue)	Park belts		**Typically, public spaces in WALKABLE/ CICLYING RADIUS (15MIN CITY), 1.2km/5km**
	Green trails		
City (urban tissue)	Park system		
	Green belt		
	Greenway system		
Open space/agricultural land	Fields/pastures		Private spaces within VISUAL EXTEND (1km)
	Woodlands/rockcrops		
	Stables/stalls/corrals/pens/styes		
	Silos, barns, storages		
	Drainage systems and water treatment		
	Waste treatment and composting landfills		
	Irrigation/fertilization systems/fertigation		
	Pest management		
Region	Farms (urban, peri-urban and rural)		Private spaces within MOTORIZED ACCESS

Table 1 differentiate scales by colour. There is agritech that can be placed in a room or a balcony as sub-element of an apartment/house or building story. The roof and the open spaces on a plot (front and back yards) can use a range of technologies from pots and raised beds, greenhouses, livestock shelters/sheds, hydroponic/aquaponic/aeroponic systems as well as green walls. At a scale of city

block there are parks, pocket parks, garden lots, community gardens, allotments and the street space can include also agritech besides street landscaping. At a scale of neighbourhood and city there are parkways, park belts, green trails, park systems, green belts and wedges, greenway systems, etc. There are various elements of farms on agricultural land such as fields, pastures, woodlands, rock crops, stables, stalls, corrals, pens, styes, silos, barns, storages, drainage systems and water treatments, waste treatments and composting landfills, irrigation and fertilization systems (including fertigation tech) and pest management facilities and systems.

DISCUSSIONS AND CONCLUSION

This paper maps visions, concepts, models, projects, agricultural and urban technologies, etc. of urban agriculture and agroecological urbanisms arguing that green city can be morphologically understood as elements. This knowledge can be used to develop urban design handbooks and guidelines for green city considering local morphological context. The paper starts with a diagram of the interactions of the disciplines that tangle city, nature and agriculture and it defines scales of perceptual and cognitive morphology to analyse urban agriculture. It creates a tentative genealogy of the visions, concepts, models, projects, technologies, etc. and maps representative examples of visions, projects and elements firstly by scale and agricultural technology level, and secondly by agricultural expertise and by urban regulations. In the end, it presents a list of agricultural technologies and landscape elements in respect to the morphological elements at various scales, the need of insolation for the vegetation, considering the duality of public and private space in cities and accessibility. This paper sets a framework for writing an urban design handbook for green cities based on eclectic urban morphology.

There are various green city visions, some deriving from social utopianism, anarchism, environmental recluses and hermit communities, etc. Other come from wishes to integrate nature, living with nature, love of nature, biomimicry, and biophilia. There are many agritects' visions that seek to create green architecture and productive landscape, some can get radical forms as Malcolm Wells who promotes underground living (additional underground city scenario can be found in Stojanovski, 2007). There is another stream of green city concepts that seeks to integrate landscape in cities, starting from Frederick Law Olmsted, Le Corbusier and new proponents of landscape urbanism. Furthermore, there is a new generation of entrepreneurs and agricultural enthusiasts as such as "agrotechnologists" developing new innovative agritech, "artisan farmers" that innovate and animate local communities and business, as professionals and as recreational guerilla farmers and placemaking gardeners who plant and grow food predominantly for fun and relaxation. Food growing, farmer markets and food festivals also play important role for social cohesion and economic revival of many neighbourhoods and communities. The discussions in this paper we focus on agriculture, not as recreational activity, but as (circular) food systems that seek to eliminate wastes and produce high quality locally grown food that complements industrial production. Industrial production is crucial for grain and meats, but local production can supply high quality vegetables and fruits, as well as small scale animal husbandry. There is a great potential to integrate various agritech across the morphological elements at various scales and it needs coordination between the various disciplines. Architects and landscape architects can create visions and prototypes. Agronomists and industrial ecologists can create circular food systems. The urban agricultural systems can utilize local wastes and employ underutilized space in urban areas for food provisioning to circulate resources. This includes e.g. vacant buildings, parking garages, basements, roofs, storage rooms, shipping containers, and agritech integrated in-store in

commercial locations. Bringing together urban morphology with architecture, landscape agriculture, agronomy, landscape and industrial ecology in dissecting the morphology and elements of the green city can contribute to better possibilities for developing productive green cities and reaching the goals of the smart sustainability paradigm in development of eco cities and sustainable neighbourhoods.

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The verticalization impact on the living environment in the city of Sobral in Ceará, Brazil

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ABSTRACT

The process of verticalization in urban areas triggers significant changes in urban morphology, directly influencing environmental comfort. This process, characterised by the construction of high-rise buildings, impacts the urban landscape and modifies the city's profile and spatial dynamics. These alterations in urban spaces in semi-arid climate regions, such as Sobral (located in the interior of Ceará), can intensify the formation of heat islands and create situations of significant thermal discomfort. In this context, the present work presents a case study of sections of the municipality of Sobral, where the transformations foreseen in the recently revised and approved Municipal Master Plan, if executed as such, may drastically affect the local urban microclimate. Sobral has a population of around 200,000 inhabitants and is characterised by urban sprawl. The urban morphology is predominantly horizontal across most of its territory. The city has a hot semi-arid tropical climate with an average temperature of 26 to 28 degrees Celsius, reaching high temperatures above 36 degrees in the last months of the year. High-rise buildings can create urban canyons, restricting air flow and contributing to heat islands. This, in turn, has implications for air quality and the well-being of the inhabitants. This work aims to show scenario studies through in loco studies using temperature measuring equipment in geographically close locations and to analyse how this revision of the Master Plan and zoning can impact the spatial configuration and microclimate of the city, affecting the comfort and health of the inhabitants. We hope that, with this work, more careful studies will be conducted before laws that disregard the quality of life of citizens are approved, as they are formulated solely to meet the needs of a real estate market concerned only with its own interests.

Keywords: verticalization; local microclimate; heat islands

INTRODUCTION

Located in the interior of Ceará, northeastern Brazil, Sobral is considered a medium-sized city due to its size of inhabitants as well as its intermediary role in the region. According to França (2007, p. 51-52):

[...] for the Brazilian Institute of Geography and Statistics – IBGE -, the average city is one with a population between 100,000 and 500,000 inhabitants. According to the United Nations - UN -,

medium-sized cities are those with agglomerations between 100,000 and 1,000,000 inhabitants [...] Andrade and Serra (2001) also work with this same definition of medium-sized city presented by IBGE. While Amorim Filho and Bueno e Abreu (1982) established a minimum size of 10 thousand in the municipality's headquarters [...].

However, according to Sposito (2010), when we refer to the city considering only its demographic character, we are considering “medium-sized” cities, that is, those that have between 50 thousand and 500 thousand inhabitants, but it cannot be conceptualised these cities as average only employing the demographic element. In other words, a “medium-sized” city is not the same thing as a “medium-sized city”, medium-sized cities are those that play intermediary roles in their urban networks, differentiating them from “medium-sized” cities, which are those that are defined exclusively in function of their demographic size

Sobral is a city characterised by its horizontal morphology, made up mostly of houses and low-rise buildings. The city has a semi-arid climate with an average temperature between 26 and 28 degrees Celsius, reaching high temperatures, above 36 degrees, in the last months of the year.

In 2018, with the amendment of the Land Use and Occupation Law, in the amendment of templates, this scenario began to change. The maximum height of certain areas went from 12 metres to 48 metres or 72 metres, causing a change that we will only be able to perceive the effects of in the long term.

Verticalization is a common phenomenon in growing cities, characterised by the construction of tall buildings that transform the urban landscape. In regions with a semi-arid climate, such as Sobral, in Ceará, this process can exacerbate environmental problems, including the formation of heat islands and increased thermal discomfort.

This study aims to analyse the consequences of verticalization on urban environmental comfort, focusing on microclimate changes resulting from the implementation of the revised Municipal Master Plan.

Considering cities as arenas of conflict over urban space, the appropriation of urban land and the establishment of private property have become central issues in this conflict. For some, land represents use value, while for others, it represents exchange value (Kowarick, 1983; Harvey, 2011; Maricato, 2015). This conflict is highly disproportionate: while some use land, or urban soil, for speculation, others are deprived of everything, being excluded from the constitutional right to build the city and often lacking access to leisure spaces, public services and infrastructure, adequate housing, among other things.

The problem of urbanization and verticalization in Sobral

The urban form is decisive for the biodiversity and ecological footprint of Sobral that we aim for. It is possible to identify a dichotomy in the spatial patterns resulting from the proposed models for the city (Andrade, 2014). One model is based on landscape architecture, interfacing landscape ecology and urban ecology, aiming for greener cities according to sustainable planning standards. Verticalization must respect a limit appropriate to the human scale, as already pointed out by Alexander et al. (2013). Its occurrence in certain areas without prior studies, as is happening in Sobral,

is concerning. In front of Sobral Shopping, where there is a Priority Occupation Zone (ZOP), the allowed construction height is 72 meters, and in the Priority Densification Zone (ZAP), constructions up to 48 meters high are permitted.

In 2022, in another article, was alerted that

> On the number of floors, Christopher Alexander puts it that "To have small scale, for human reasons and to keep costs low, buildings must have the lowest height possible." (Alexander, 2013: 474). The consequences of verticalizing the city are already known by the example of other larger cities that have suffered from this process previously, such as the increase in temperature, for example. Verticalization can create or accentuate heat islands. The increase in roughness lines and surface wind turbulance can also destructure the city's air circulation system. We have the climate change factor, which today already affects cities (Okretic et al., 2022)

This effect of heat islands is already something "natural" of the city's urbanization process, as we can see in the images below.

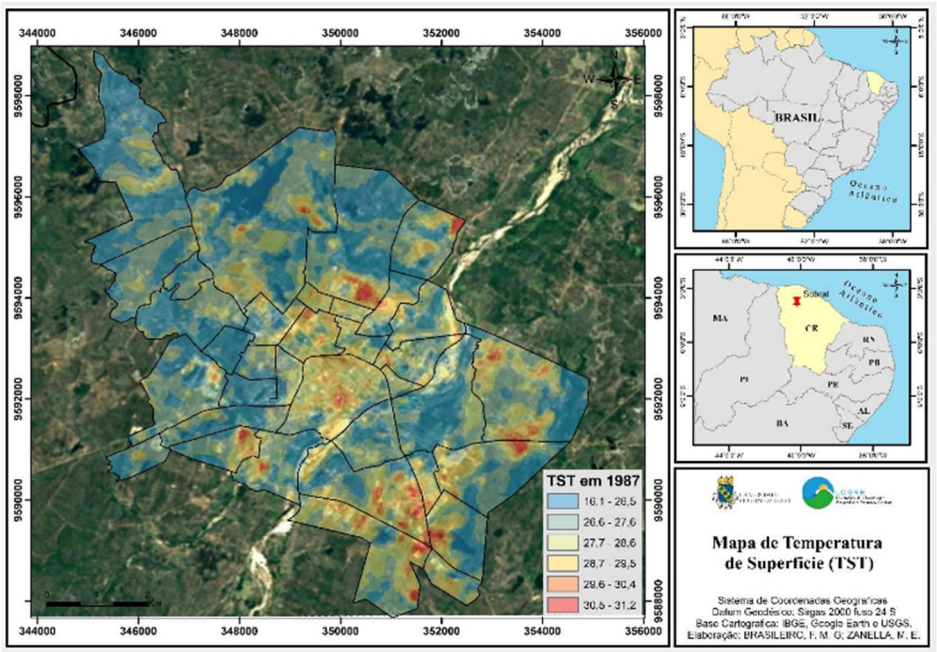

Figure 1. Surface Temperature (ST) of Sobral in 1987. Credit: Prepared by Brasileiro; Zanella (2020).

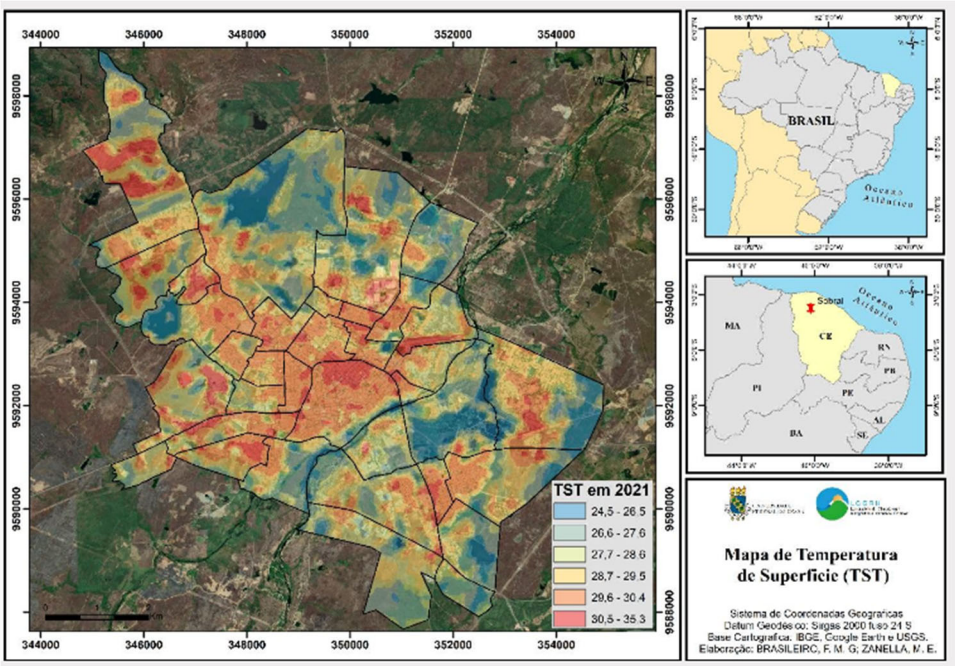

Figure 2. Surface Temperature (ST) of Sobral in 2020. Credit: Prepared by Brasileiro; Zanella (2020).

Heat islands – effects on the city

The formation of urban heat islands is a complex and multifactorial phenomenon, resulting from the interaction of several anthropogenic and natural processes. The intensification of urbanisation, described by the sealing of the soil, the reduction of vegetation cover and the concentration of materials with high thermal capacity, contributes significantly to the increase in temperatures in urban areas (Bias et al, 2023). These factors show that "albedo patterns", that is, the ability to reflect solar radiation, play a crucial role in the spatial distribution of temperatures in urban areas, with high temperatures in the centres and lower temperatures in suburbs and rural areas. Buildings also reduce average wind speeds, delaying the transfer of heat from surfaces to the air and intensifying the thermal sensation. According to Gartland (2010; p.10):

> [...] The combination of dark building materials and pavements with a canyon-like configuration absorbs and stores more solar energy. The temperature of these dark, dry surfaces can reach 88•C during the day, while vegetated surfaces and moist soil under the same conditions only reach 18•C. Anthropogenic, man-made heat, lower wind speeds and air pollution in urban areas also contribute to the formation of heat islands.

Sobral's spatial configuration, wind dynamics and soil sealing intensify the effects of heat islands in the city, compromising the population's quality of life, increasing urban vulnerability and the action of extreme events associated with the climate crisis. In addition to the greenhouse effect, heat islands have been reducing housing conditions in many urban areas, and considering that more than 75% of the world's population lives in these areas (United Nations, 2002), the impacts of heat islands have many consequences that , to mitigate them it is necessary to first understand their causes. Gartland (2010) lists the main urban characteristics that contribute to the formation of heat islands (Table 1).

Thus, these characteristics can be highlighted in five main causes for the formation of heat islands: reduced evaporation; greater heat storage; increases in radiation balance; reduced convection and

increased anthropogenic heat. In urban areas, the tendency to have lower wind speeds is greater than in rural areas, as buildings act as barriers against the wind, reducing wind speeds by up to 60% (Landsberg, 1981).

Due to the breadth of the area, it is true that with the advancement of geotechnologies and the use of resources such as remote sensing, it will be adopted as a way of identifying heat islands within the polygon referring to the urban perimeter of the headquarters district.

Characteristics that contribute to heat islands formation	
lack of vegetation	effect on energy balance
widespread use of impermeable surface	reduces evaporation
greater thermal diffusion of urban materials	increases the heat storage
low solar reflectance of urban materials	increases radiation balance
urban geometries that trap heat	increases radiation balance
urban geometries that reduce wind speed	reducess convection
increase in pollution levels	increases radiation balance
increased energy use	increases anthropogenic heat

Figure 3. Table with Urban and suburban characteristics important for the formation of heat islands and their effects on the energy balance on the Earth's surface. Credit: Gartland, 2010.

Thus, these characteristics can be highlighted in five main causes for the formation of heat islands: reduced evaporation; increased heat storage; increases in radiation balance; reduced convection; and increased anthropogenic heat. In urban areas, the tendency to have lower wind speeds is greater than in rural areas because buildings act as barriers against the wind, reducing wind speeds by up to 60% (Landsberg, 1981).

Due to the vast area, it is factual that with the advancement of geotechnologies and the use of resources such as remote sensing, it is adopted as a means of identifying heat islands within the polygon corresponding to the urban perimeter of the district seat.

The formation of urban heat islands is a complex and multifactorial phenomenon resulting from the interaction of various anthropogenic and natural processes. The intensification of urbanization, characterized by soil sealing, reduction of vegetation cover, and the concentration of materials with high thermal capacity, significantly contributes to the increase in temperatures in urban areas. Bias et al. (2003) highlight that albedo patterns, i.e., the ability to reflect solar radiation, play a crucial role in the spatial distribution of temperatures in urban areas, with higher temperatures in the centers and lower ones in the suburbs. The spatial configuration of Sobral, the dynamics of the winds, and soil sealing intensify the effects of heat islands in the city, compromising the quality of life of the population and increasing urban vulnerability to extreme events associated with climate change. Due to the vast area, it is factual that with the advancement of geotechnologies, the use of resources such as remote sensing is adopted as a means of identifying heat islands within the polygon corresponding to the urban perimeter of the district seat.

METHOD

To investigate the impacts of verticalization in Sobral, two zones were selected that will possibly be most affected by the release of the new templates, the ZOP (Priority Occupation Zone) and the ZAP (Preferential Density Zone). Thus, an approach was adopted to analyze the changes in land occupation laws from 2000, comparing with the drastic changes that have occurred in recent years, especially from 2018 to today, combining on-site temperature measurements with analyzes of future scenarios based on the guidelines of the Municipal Master Plan. Data collection was carried out with the aid of software to collect temperature data at different points in the city, representing areas with different construction densities. The data was analyzed to evaluate possible changes in the microclimate.

In the present analysis, the Landsat-9/TIRS satellite image was obtained for free through the Earth Explorer platform, provided by the United States Geological Survey (USGS, 2022), with a reference date of July 14, 2024. The data was processed using the open-source software QGIS 3.30. The extracted information corresponds to the thermal infrared channel (band 10) of the satellite, which has a spatial resolution of 30 meters and shows low cloud cover.

The processing of the thermal infrared band was conducted according to the procedures established by Coelho and Correa (2013) and Avdan and Jovanovska (2016). In this context, the TIRS band data were converted from spectral radiance to brightness temperature using the Semi-Automatic Classification plugin of QGIS 3.30.

Using the Raster Calculator tool of QGIS 3.30, the land surface temperature, corrected for emissivity, was calculated according to Equation 1. For the conversion of temperature from Kelvin to Celsius, the results were adjusted by subtracting the value of absolute zero, approximately −273.15°C.

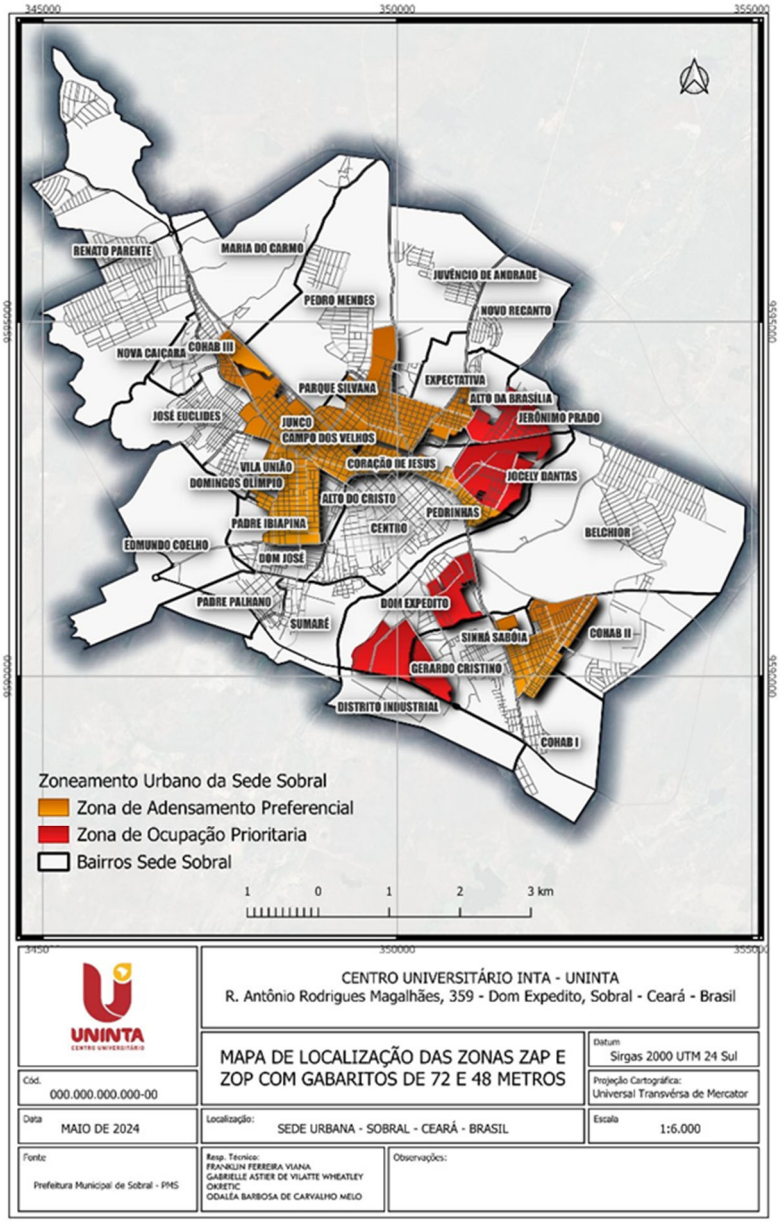

Figure 4. Map with the Priority Occupation Zones and Priority Density Zones. Credit. Own elaboration based on data from Sobral City Hall (2023).

Sobral yesterday, today and tomorrow – scenario analysis

The historical analysis reveals that Sobral had predominant horizontal urban growth, characterized by the expansion of peripheral neighbourhoods and the maintenance of a low population density. The city developed basic infrastructure to support its growth, but faced challenges related to rapid and disorderly urbanization.

Sobral and changes in Laws

LAW OF ALLOCATION, USE AND OCCUPATION OF LAND, URBAN INDICATORS OF LAND OCCUPATION

ZONAS	USO	TAXA DE PERMEABILIDADE (%)	TAXA DE OCUPAÇÃO (%)	ÍNDICE DE APROVEITAMENTO (IA)	ALTURA MÁXIMA DA EDIFICAÇÃO (m)	RECUOS			ÁREA DO LOTE (m²)	OBSERVAÇÕES
						FRENTE	FUNDO	LATERAL		
ZR1	Residencial unifamiliar.	35	50	1,0	9	5	3	3	800	
	Escola de 1° Grau e Creche.	35	50	1,0	9	5	3	3	800	
ZR2	Residencial unifamiliar.	30	50	1,0	9	3	1,5	1,5	250	
	Comércio e serviço de pequeno porte com caráter local.	30	50	1,0	9	3	1,5	1,5	250	As edificações poderão ter, no máximo, 04 (quatro) pavimentos, incluindo o pavimento térreo.
	Misto (residência associada a comércio varejista e/ou serviços em geral).	30	50	1,0	9	3	1,5	1,5	250	As edificações poderão ter, no máximo, 04 (quatro) pavimentos, incluindo o pavimento térreo. O uso não residencial não deve ocupar mais de 50% da edificação.
	Indústria leve e semi-artesanal.	30	50	1,0	9	3	1,5	1,5	250	
	Escola de 1° Grau e assemelhados e Creche e assemelhados.	30	50	1,0	9	3	1,5	1,5	250	
ZR3	Residencial unifamiliar.	25	50	1,0	9	0	3	0	125	
	Comércio e serviço de pequeno porte com caráter local.	25	50	1,0	9	0	3	0	125	As edificações poderão ter, no máximo, 04 (quatro) pavimentos, incluindo o pavimento térreo.
	Misto (residência associada a comércio varejista e/ou serviços em geral e/ou indústrias de pequeno porte, não poluentes, ou usos não residenciais associados entre si).	25	50	1,0	9	0	3	0	125	As edificações poderão ter, no máximo, 04 (quatro) pavimentos, incluindo o pavimento térreo. O uso não residencial não deve ocupar mais de 50% da edificação.
	Indústria leve e semi-artesanal.	25	50	1,0	9	0	3	0	125	
	Escola de 1° Grau e assemelhados e Creche e assemelhados.	25	50	1,0	9	3	3	0	125	
ZR4	Residencial multifamiliar.	20	50	1,5	18	0	3	1,5	300	
	Comércio varejista, serviços em geral , equipamentos e indústrias de pequeno e médio porte não poluentes.	20	50	1,5	18	0	3	1,5	300	As edificações poderão ter, no máximo, 04 (quatro) pavimentos, incluindo o pavimento térreo.
	Misto (residência associada a comércio varejista e/ou serviços em geral e/ou indústrias de pequeno porte, não poluentes, ou usos não residenciais associados entre si).	20	50	1,75	18	0	3	1,5	300	As edificações poderão ter, no máximo, 04 (quatro) pavimentos, incluindo o pavimento térreo. Os usos não residenciais podem ser associados entre si em uma mesma edificação.

continua

Figure 5. Table with urban indexes from 2000, photo credit: Sobral City Hall (2000).

ANEXO IV DA LEI COMPLEMENTAR Nº 91 DE 17 DE NOVEMBRO DE 2023
PARÂMETROS DE OCUPAÇÃO DO SOLO

ANEXO IV - PARÂMETROS DE OCUPAÇÃO DO SOLO

ZONAS		T.P (%)	T.O (%)	T.O SUBSOLO (%)	IA	R. FRENTE (m)	R. FUNDOS (m)	R. LATERAIS (m)	ALTURA MÁX. (m)	ÁREA MÍN. (m²)	ÁREA MÁX. (m²)	TESTADA MÍN. (m)	TESTADA MÁX. (m)
ZEIP	SETOR 1	10	85	60	Consultar Lei do Plano Diretor	Não permitido	1,5	Não permitido	10*	125	100	5	10
	SETOR 2	10	85	60		Não permitido	1,5	Máximo 1,5	10*	125	100	5	10
	SETOR 3	15	70	60		0	1,5	0	10*	125	100	5	10
	SETOR 4	15	70	60		Não permitido	1,5	Não Permitido	10*	125	100	5	10
	SETOR 5	15	70	60		0	1,5	0	12*	125	40.000	5	200
	SETOR 6	15	70	60		0	1,5	0	12*	125	225	5	15
	SETOR 7	15	70	60		0	1,5	0	15*	125	40.000	5	200
	SETOR 8	15	70	60		0	1,5	0	8*	125	100	5	10
	SETOR 9	15	70	60		0	1,5	0	12*	Não são permitidas alteraçõesnas configurações dos lotes existentes.			
ZCR		20	70	60		0	3	0	15	125	40.000	5	200
ZOP		30	60	60		3	3	1,5	72	250	62.500	10 - Meio da Quadra 12 - Esquina	250
ZAP		25	65	60		3	1,5	1,5	48	125	62.500	5 - Meio da Quadra 7 - Esquina	250
ZAM		30	60	60		3	1,5	1,5	15	150	62.500	6	250
ZEPE	ZEPE 1	30	60	20		5	3	3 - Uso Industrial / 1,5 - Outros Usos	25	250	40.000	10	500
	ZEPE 2	30	60						25				
ZEIS	ZEIS 1	15	80			1,5	1,5	0	9	90	22.500	5	150
	ZEIS 2	25	70	Não permitido		1,5	2	1,5	15				
	ZEIS 3	25	65			2,5	2	1,5	15				
ZPP	ZPP 1	20	70			0	1,5	0	9	125	40.000	5	200
	ZPP 2	30	60	Não permitido		0	3	1,5	9				
	ZPP 3	30	60			3	3	1,5	15				
ZEIA	ZEIA - APP	**	**	**		**	**	**	**	**	**	**	**
	ZEIA - 1	80	15			Não se aplica	Não se aplica	Não se aplica	5	**	**	**	**
	ZEIA - 2	70	25	Não permitido					8				
	ZEIA - 3	80	15						**				
ZOD		20	70	Não permitido		0	3	1,5	12	125	40.000	5	200
ZRO		80	15	Não permitido		Não se aplica	Não se aplica	Não se aplica	**	**	40.000	**	200
ZEIT		20	70	Não permitido		0	3	1,5	12	125	40.000	5	200
ZEIC		15	70	Não permitido		0	3	Não permitido	8	125	40.000	5	200

Observações:
* Mediante aprovação do Instituto do Patrimônio Histórico e Artístico Nacional (IPHAN).
** Projeto Especial, observados os casos de Utilidade Pública, de Interesse Social ou de Baixo Impacto Ambiental fixados na Lei Federal nº 12.651, de 15 de maio de 2012, e suas alterações.
- Os parâmetros definidos para a ZRO só poderão ser aplicados após elaboração de Plano de Recuperação de Áreas Degradadas (PRAD), incluindo Plano de Reassentamento de áreas de risco.

Figure 6. Table with current urban indices. Credit: Sobral City Hall (2023).

Currently, Sobral is a city of approximately 200,000 inhabitants, with an urban landscape in transformation. The introduction of tall buildings and the verticalization of central areas indicate a significant change in urban morphology. However, this transformation brings challenges such as the formation of heat islands and the impact on environmental comfort.

The projected future scenarios suggest that if the guidelines of the Municipal Master Plan are implemented without adaptations, Sobral may face significant environmental challenges. Verticalization may intensify the formation of heat islands, restrict air flow, and increase thermal

discomfort, affecting the quality of life of the inhabitants. In the following map, it is possible to see the zones that have suffered and will suffer medium- and long-term changes due to the approval of urban indices, which are the ZAP and the ZOP, as mentioned. We crossed these maps with the heat islands.

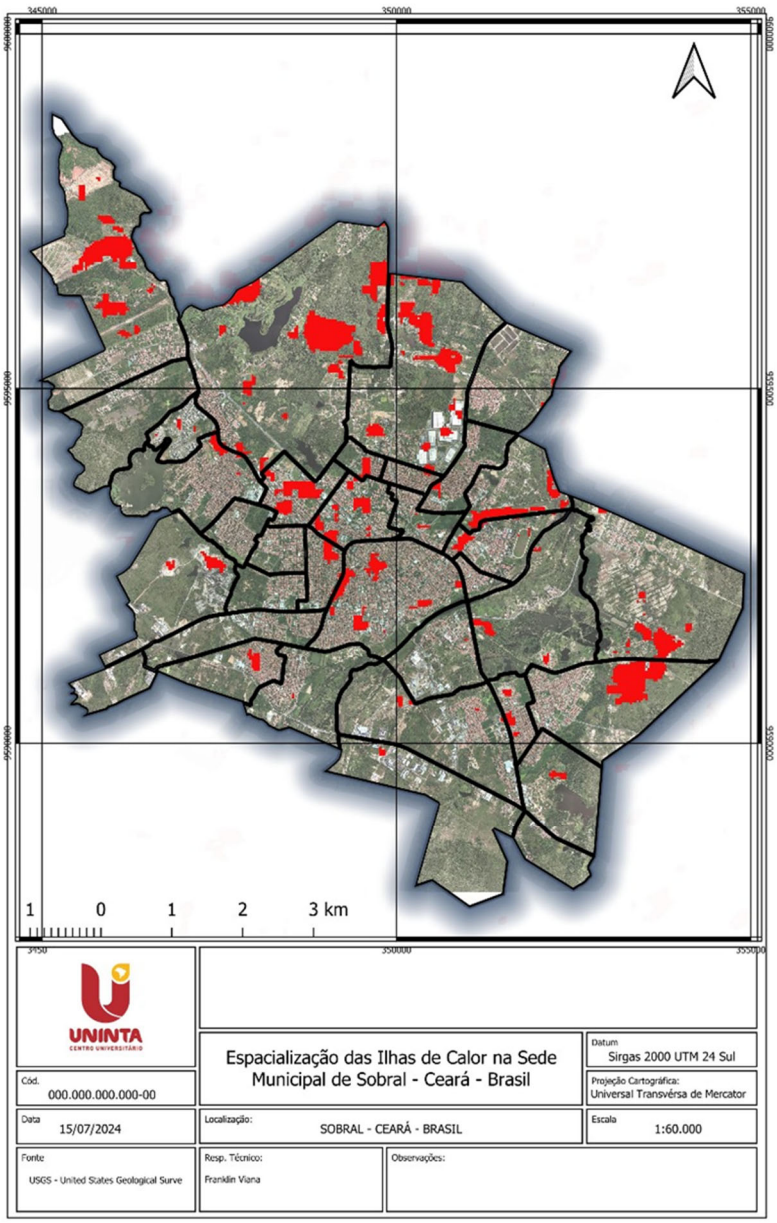

Figure 7. Map with the Heat islands Priority in Sobral. Credit: Own elaboration based on data from Sobral City Hall (2023).

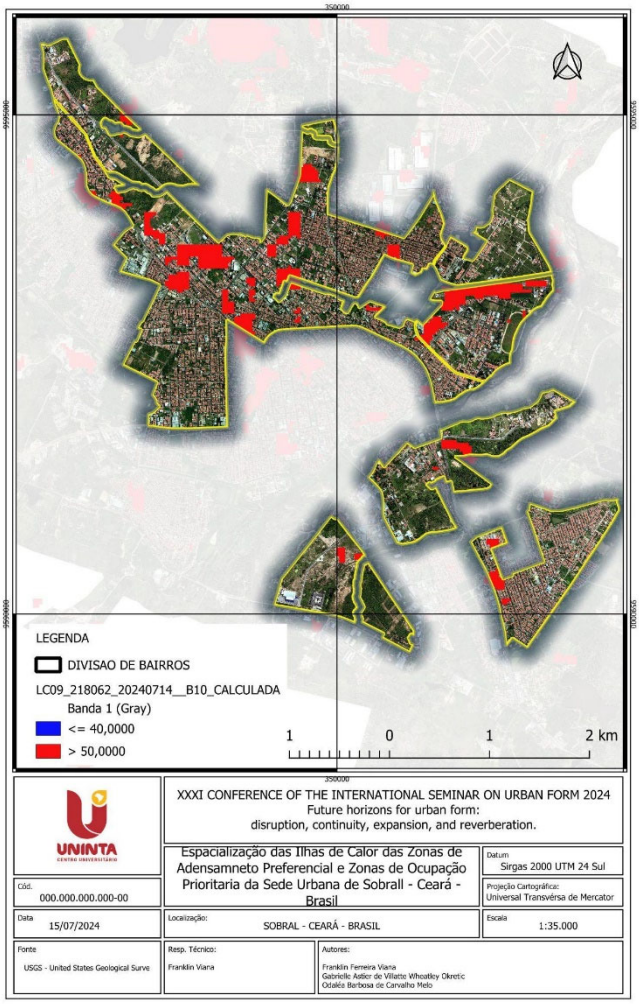

Figure 8. Map with the Heat islands located in Priority Occupation Zones (ZOP) and Priority Density Zones (ZAP). Credit. Own elaboration based on data from Sobral City Hall (2023).

RESULTS AND DISCUSSIONS

The results indicate that the construction of tall buildings in Sobral can create "urban canyons," which restrict air flow and contribute to the formation of heat islands. Temperature measurements revealed significant differences between areas with different building densities, with verticalized regions exhibiting higher temperatures. The analysis of scenarios outlined in the Municipal Master Plan suggests that if implemented without adaptations, the new guidelines may exacerbate thermal comfort issues in the city.

The discussion of the results emphasizes the importance of considering environmental impacts in urban policy formulation. While verticalization can be a solution for urban densification, it must be carefully planned to avoid deteriorating the quality of life for inhabitants. In Sobral, the revision of the Municipal Master Plan offers an opportunity to implement mitigation strategies, such as incorporating green areas and adopting construction materials that minimize heat absorption.

CONCLUSIONS

This study highlights the need for a balanced approach to urban verticalization, especially in semi-arid regions like Sobral. The construction of tall buildings can bring benefits in terms of densification and efficient use of urban space, but also poses significant challenges for environmental comfort. Urban policies that consider these factors are essential to ensure sustainability and quality of life in growing cities.

Acknowledgements

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Towards a sustainable urbanization: assessing the distribution of urban trees in the city of Rio de Janeiro, Brazil

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ABSTRACT

Over the past decades, unprecedented urban growth has brought about a convergence of challenges that pose significant risks to the environment and human well-being. This situation underscores the critical need for integrated urban development approaches that prioritize the preservation of natural resources and the promotion of resilient, equitable cities. In this context, several studies have highlighted the benefits of urban forests as a nature-based solution to climate change adaptation, biodiversity conservation, and the enhancement of human well-being. While much of the research has focused on green infrastructure within large protected areas, such as national and provincial parks, there has been limited exploration of how accelerated urban sprawl and changes in land use have affected tree populations in ordinary urban spaces. This research addresses this gap by (i) recognizing the need for a systemic approach in assessing open spaces and green areas, and (ii) acknowledging that the impact on urban trees is influenced by management decisions at various levels, from institutions and municipalities to individual landowners. Our study aimed to assess the distribution of trees across public and private open spaces in the city of Rio de Janeiro, Brazil, by developing a methodology that uses the normalized difference vegetation index (NDVI) and geo-processing techniques to map, categorize, and quantify tree clusters based on the type of open space they occur. The resulting database represents a pioneering effort to support comparative analyses and cross-references with existing urban infrastructure and socio-spatial indicators. Our findings reveal, for instance, that in high-density neighborhoods, private open spaces play a crucial role in preserving tree fragments, thereby contributing to the improvement of local social and environmental conditions. We hope this work will serve as a valuable resource for public agencies, scholars, urban planners, and other stakeholders interested in aligning sustainable urban planning policies with climate adaptation efforts in Brazil.

Keywords: Sustainable Urbanization; Urban Trees; NDVI, Urban Forestry; Rio de Janeiro

INTRODUCTION

Urbanization has emerged as one of the most transformative processes of the 21st century, reshaping landscapes, economies, and the lives of millions worldwide. As cities expand at unprecedented rates, they bring forth a range of complex challenges, including environmental degradation, loss of

biodiversity, and increased risks to human health and well-being (Davis, 2006; Brenner and Schmid, 2015). These challenges have made it imperative to adopt integrated urban development strategies that not only accommodate population growth but also prioritize environmental sustainability and resilience (UN-Habitat, 2022).

Among the various proposed strategies, nature-based solutions have gained significant attention for their potential to address urban environmental issues while simultaneously enhancing the quality of life for city dwellers (Raymond et al. 2017; Fastenrath et al. 2020; Longato et al. 2023). Urban forests, in particular, have been recognized for their critical role in climate change adaptation, biodiversity conservation, and the improvement of human well-being (Nowak and Dwyer, 2007; Baur et al. 2013; Nowak et al. 2016). Despite this recognition, much of the existing research has focused on trees within protected areas, such as national or state parks, leaving a gap in our understanding of how urban sprawl and changing land use patterns affect tree populations in more ordinary, everyday urban spaces.

This work aims to address this gap by first, recognizing the need for a systemic approach in assessing open spaces and green areas, and second, by acknowledging that the impact on urban trees is influenced by management decisions at various levels, from institutions and municipalities to individual landowners. Our findings not only provide a comprehensive overview of the current state of urban forestry in Rio de Janeiro but also uncover the complex relationship between green spaces and the concentration of wealth within the city. This contributes to the ongoing discourse on how socioeconomic disparities are spatially manifested and how they affect the quality of life for city dwellers, particularly in the most vulnerable communities.

Cade study

This study focuses on Rio de Janeiro as a case study. As Brazil's second-largest metropolis, following São Paulo, the city is home to approximately 6.212 million people. For administrative purposes, Rio is organized into five planning areas (APs), defined by the 1992 Decennial Master Plan, and further divided into 33 Administrative Regions (RAs). These regions bring together neighbourhoods grouped by their shared morphological and socio-environmental characteristics (Figure 1).

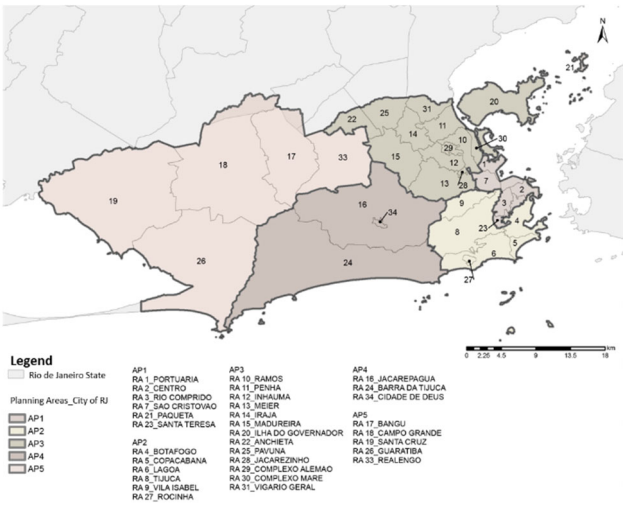

Figure 1. City of Rio de Janeiro and its administrative boundaries. Source: Data.Rio Portal, 2022.

To begin with, it seems important to outline some foundational concepts adopted in this work to support further discussions regarding the object of study:

Open areas, open spaces, and green areas

In the urban environment, open areas correspond to the set of undeveloped, unbuilt spaces within the urban fabric. This concept was initially established at the University of São Paulo by Miranda Magnoli (1982), and was adopted by several Brazilian researchers (Macedo et al. 2018). When analysed at the neighbourhood scale, open areas can differ from open spaces and green areas as follows: open spaces serve a social function and present practices as attributed to them, such as leisure, recreation, contemplation, parking, circulation, etc. They may serve for public uses – including parks, squares, plazas, and public gardens – or restricted to private use, such as clubs, governmental facilities, or residences. Green areas, on the other hand, are undeveloped areas with a significant presence of vegetation, but they do not have a specific social function. Their presence in the urban fabric represents an important environmental component, due to the maintenance and diversification of natural flora, in addition to contributing to higher rates of soil permeability, percolation, and climate balance.

A systemic approach for assessing open spaces and green areas

By recognizing open spaces and green areas as integral components of a dynamic and complex urban infrastructure system, we can achieve a more holistic understanding of how these spaces interact with one another and the broader urban environment. A systemic approach considers the spatial distribution, connectivity, and accessibility of these areas, alongside their ecological, social, and economic functions. This perspective is crucial for identifying interrelationships within the urban landscape, and uncovering patterns and dynamics that might be overlooked in more isolated analyses. In this context, concepts from landscape ecology are particularly valuable, as they highlight how patterns of occupation—such as patches, fragments, and corridors—can guide interventions aimed at landscape or environmental restoration in specific territorial segments (Forman, 1995]

METHOD

The mapping, categorization, and quantification of urban tree clusters were carried out using a combination of remote sensing techniques and spatial analysis tools, specifically employing the software ArcGIS/ESRI©. This process relied on a series of orthophotos of the city territory, generated from low-resolution satellite images (Sentinel-2 - ESA) and Landsat-8 - NASA/USGS), provided by the Pereira Passos Institute (IPP/PCRJ) in 2015. In total, 265 orthophotos were utilized to ensure comprehensive coverage of the city's entire area, distributed per Planning Area (AP) as follows: AP1 – 19 orthophotos, AP2 – 30 orthophotos, AP3 – 48 orthophotos, AP4 – 48 orthophotos, and AP5 – 107 orthophotos. To ensure accuracy and consistency in data collection and analysis, we established two key criteria in order to guide our approach, providing a structured framework for the methodology.

a) The urban forest fragments within protected areas were excluded from the inventory:

The City of Rio de Janeiro preserves significant fragments of the Atlantic Forest biome, along with associated ecosystems such as restingas and mangroves. To protect these areas, they are recognized as Conservation Units (UCs) , regulated by the National System of Nature Conservation Units (SNUC). The SNUC system sets out the criteria and regulations for the establishment and management of

conservation units. The UCs are divided into two main categories: (a) Full Protection Units; and (b) Sustainable Use Units. The primary purpose of Full Protection Units is to preserve nature, allowing only indirect use of natural resources. They are strictly reserved for environmental conservation, prohibiting any other uses, including urban, industrial, or agricultural activities. Sustainable Use Units focus on conserving nature by preserving biomes and living organisms while permitting economic and extractive activities. It is also worth noting that, by law, UCs take precedence over local land use and zoning regulations and are often reinforced by local environmental protection categories, such as Macro Zones , and Areas of Special Environmental Interest , thereby strengthening protection across all levels of government (Nunes et al. 2022).

For the purposes of this investigation, we excluded urban forest patches located within Full Protection Units from our analysis. This is because the inclusion of these areas could significantly skew the outcomes, as the focus of our work is to assess the distribution of urban trees in everyday spaces, where strict environmental protection rules do not apply. In the city of Rio de Janeiro, 24 areas are designated as Full Protection Units (Figure 2) and are divided into the following categories: Municipal Natural Park, Biological Reserve, Natural Monument, State Park, and National Park. These areas collectively cover approximately 25,740 hectares, representing about 21% of the city's total territory.

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[63] Federal Law 9.985 of July 18, 2000.
https://www.planalto.gov.br/ccivil_03/LEIS/L9985.htm?msclkid=d836f862bb2e11ecb0a39fd92b1c866

64 Macro Zones are large-scale zoning designations that organize the city's territory into distinct areas based on specific land-use and environmental guidelines.

[65] Areas of Special Environmental Interest (*Áreas de Especial Interesse Ambiental or AEIA*) are designated zones that receive special protection due to their ecological, cultural, or environmental significance.

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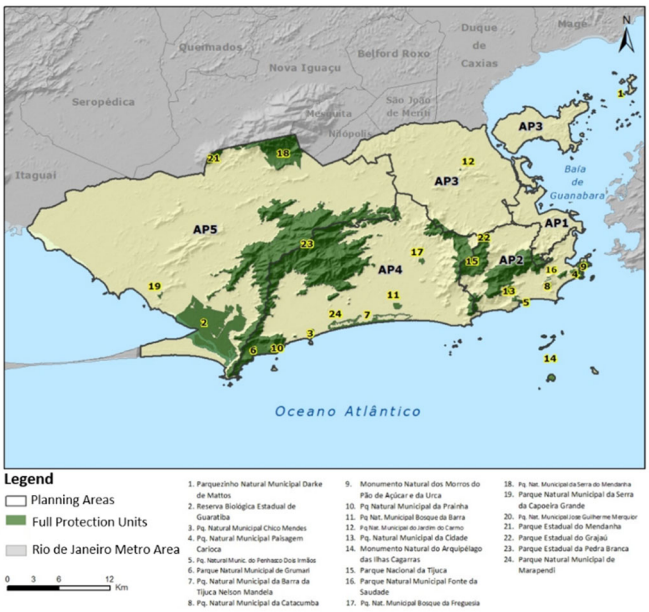


Figure 2. Full Protection Units in the city of Rio de Janeiro. Source: Data.Rio Portal, 2022.

b) Mapped tree clusters with an area smaller than 1sqm were excluded from the inventory:

Our primary objective was to focus our analysis on areas with a continuous and substantial tree canopy within the city's territory. By concentrating on these larger, interconnected green spaces, we aimed to capture and analyse tree patterns that have a meaningful impact on the urban landscape and contribute significantly to environmental quality. Smaller, isolated units, which would not have a substantial influence on the overall urban ecosystem, were intentionally excluded from the analysis to ensure that the results reflect the broader, more impactful trends. To achieve this goal, we established a criterion to exclude tree clusters smaller than 1sqm (*1m²*), thereby refining our focus on those clusters that shape significantly the urban environment.

Mapping

In the mapping process we applied the Normalized Difference Vegetation Index (NDVI) which is an indicator used in remote sensing to assess and monitor vegetation health and density, made possible due to the intensity of chlorophyll activity in tree and shrub species and their reflectance in satellite images. It is calculated by analysing the difference between the near-infrared (NIR) light, which vegetation strongly reflects, and the visible red light, which vegetation absorbs (Figure 3).

$$\mathrm{NDVI} = \frac{R_{\mathrm{NIR}} - R_{\mathrm{red}}}{R_{\mathrm{NIR}} + R_{\mathrm{red}}}$$

NDVI values range from -1 to +1, with higher values signifying healthy, dense vegetation, and lower values indicating sparse or stressed vegetation, barren land, or water bodies. The index has been extensively utilized in various studies to analyse vegetation cover and identify spatial patterns across

different landscapes (Franco and Rosa, 2004; Eduardo and Silva, 2013; Lima et al. 2013). These studies demonstrate the effectiveness of NDVI in distinguishing between diverse land cover types and assessing vegetation density. Table 1 provides a summary of the NDVI values corresponding to the primary elements identified in satellite images, highlighting the typical ranges associated with different land cover types.



Figure 3. Comparison of an orthophoto in RGB composition (red, green, and blue) and RED + NIR composition (red + infrared). Source: IPP, 2015.

Table 1. NDVI value for different mapped elements. Source: Korchagina et al. 2020.

Type of objects	**NDVI value**
High, dense vegetation (forest)	0.7 – 1.0
Sparse vegetation (shrubs, pastures)	0.2 – 0.5
Open soil	0.025 – 0.2
Clouds	0
Snow, ice, dust, rocks	-0.1 – 0.1
Water	-0.42 - -0.33
Artificial materials (concrete, asphalt)	-0.5

In this study, we applied a threshold value of 0.45 to differentiate between dense vegetation and sparse or non-existent cover. This threshold was determined after extensive testing and calibration against various spectral responses. The chosen value provided a satisfactory rate of accuracy, achieving 92.6% when compared to a manual digitizing process. This high level of accuracy demonstrates the effectiveness of the automated method in reliably identifying and categorizing vegetation density, while significantly reducing the time and effort required for manual mapping. Additionally, this threshold enabled us to consistently detect and analyse large surfaces of tree cover, ensuring that the results were both precise and replicable across different sections of the study area. To further enhance the accuracy of the mapping process, we carried out a final routine of manual verification and editing of polygons, what helped mitigate potential inconsistencies and ensured the integrity of the dynamic mapping process (Figure 4).

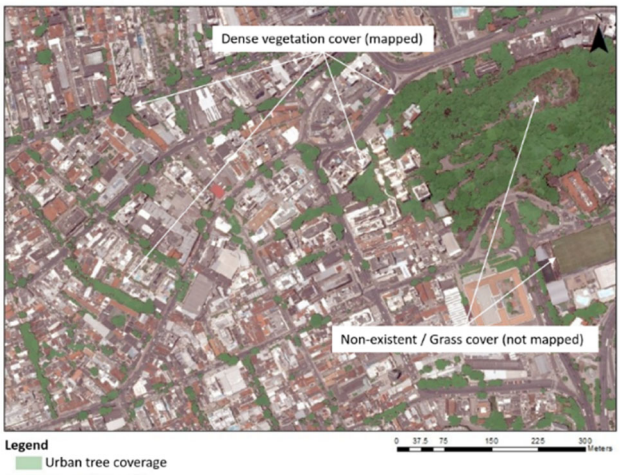


Figure 4: Results from the automated method of mapping dense vegetation cover.

Categorization

Based on previous work conducted by Tângari (2018; 2019), primarily focused on mapping and developing a typology of public and private open spaces in the city of Rio de Janeiro, we identified and proposed five (05) main categories to classify urban trees, taking into consideration where they are located (Figure 5). Table 2 summarizes the typology and presents a detailed description of each category.

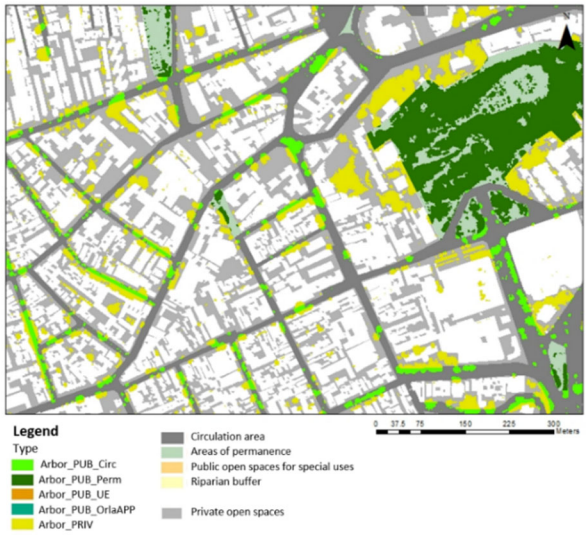


Figure 5: Map illustrating the distribution patterns of urban trees following the categorization process.

Table 2. Summary of the proposed categories of urban trees.

Category	Description
Trees located in public open spaces (circulation areas) (**Arbor_Pub_Circ**)	Trees located within public circulation areas such as streets, sidewalks, avenues, and pathways
Trees located in public open spaces (permanence areas) (**Arbor_Pub_Perm**)	Trees located within public areas of permanence such as parks, squares, plazas, and public gardens.

Trees located in public open spaces (special uses[66]) (**Arbor_Pub_Ue**)	Trees located within public areas for special uses as defined by the Brazilian Civil Code (CCB).
Trees located in marginal protection strips of water bodies (**Arbor_Pub_OrlaAPP**)	Trees located within riparian buffer areas along rivers, canals, lagoons, and beaches.
Trees located in private open spaces (**Arbor_Priv**)	Trees located within private urban lots.

RESULTS AND DISCUSSIONS

In this section, we present the findings of our research, highlighting the key outcomes derived from the data collected where we primarily focused on the spatial distribution and density of tree clusters. Figure 6 illustrates the distribution of tree clusters across the city, while Graphs 1 and 2 compare the extent of these clusters per hectare and the canopy density within each planning area. It is worth noting that the measurement of canopy density was specifically focused on private and public open spaces where vegetation can thrive and be managed, intentionally excluding water bodies, fully protected units, and built areas, in order to ensure an accurate assessment.

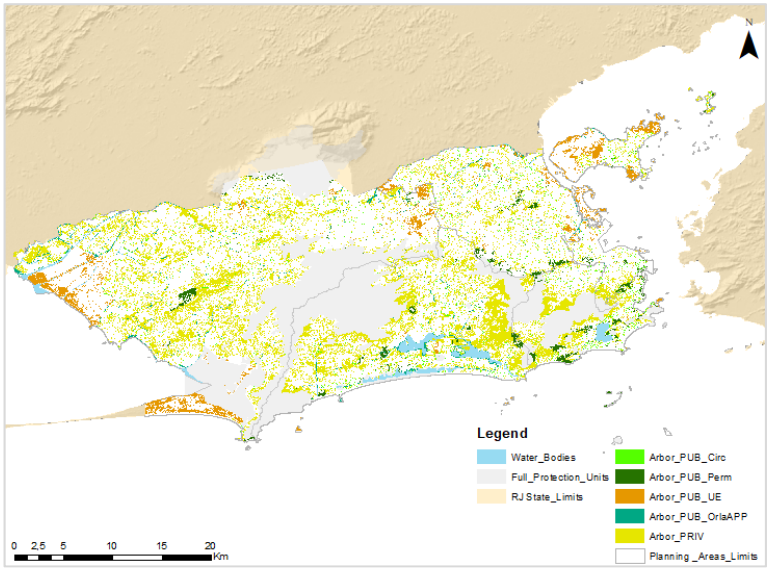
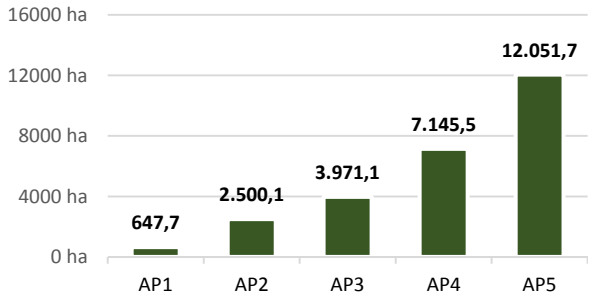


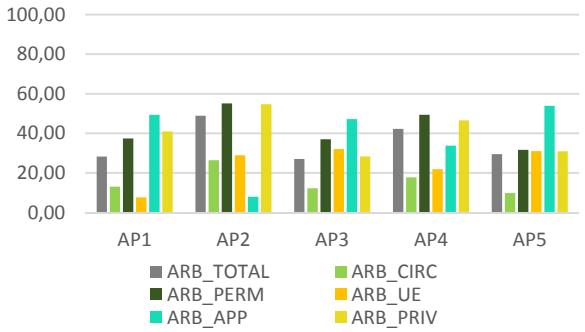
Figure 6: Map illustrating the distribution of tree clusters based on the typology of urban trees.

In absolute terms, the extent of tree clusters is naturally influenced by the size of each planning area, with larger areas tending to have extensive clusters. However, when we examine the density values, a different picture emerges—revealing significant disparities in tree coverage across the city, suggesting underlying factors beyond the land surface, further presented in this section. Furthermore, disaggregating the data into smaller areas (Administrative Regions - RAs) allows for a more granular and precise analysis of the distribution and correlation between open spaces and urban tree coverage. This approach, illustrated in Graph 3, enhanced our ability to identify localized patterns and relationships, that are overlooked in a broader scale of analysis, thereby providing deeper insights into the spatial dynamics of urban greenery.

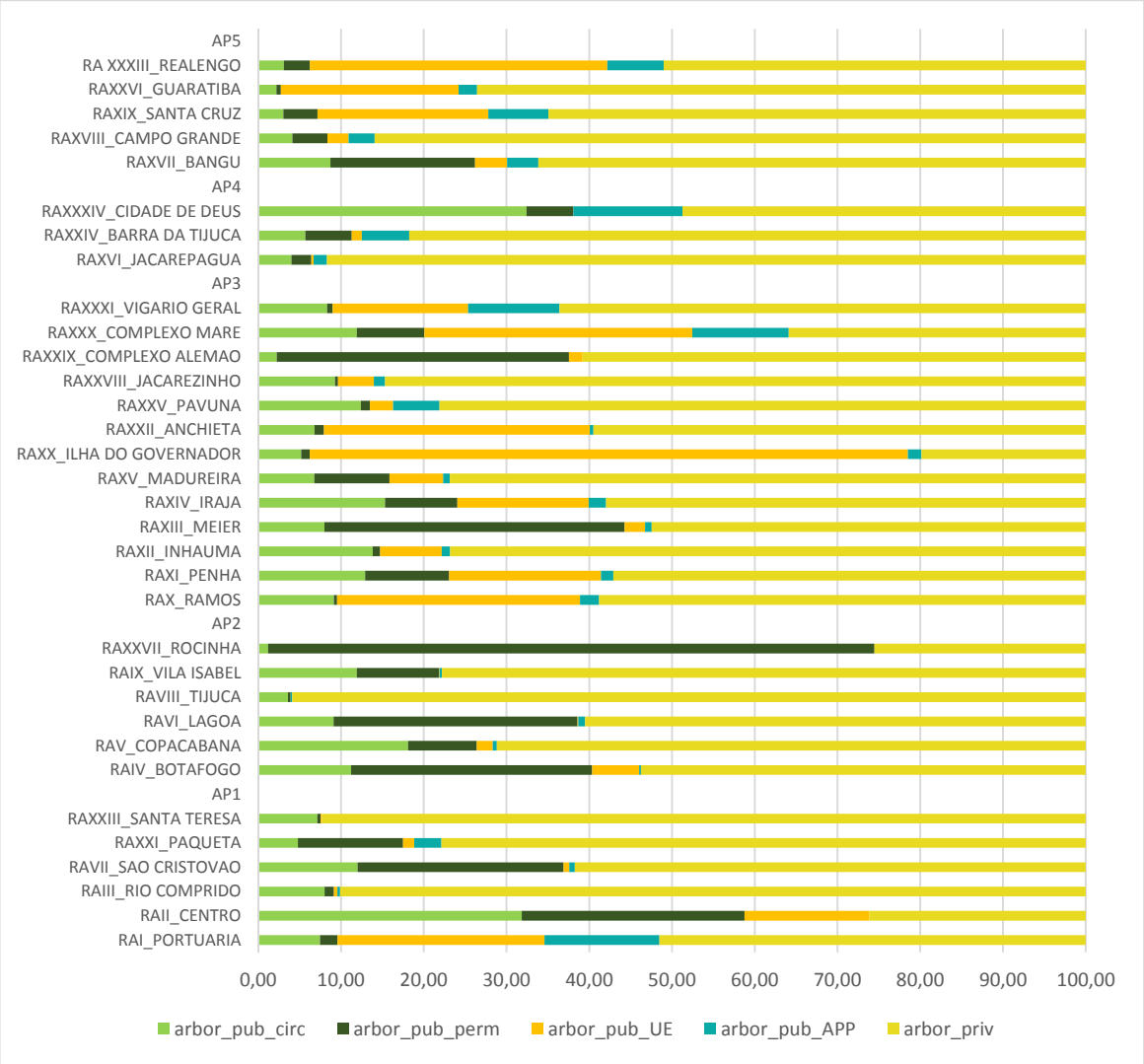
[66] These are areas designated for specific activities often used in the performance of state activities. Examples include military areas, railways, port, and airport lands, as well as spaces related to urban infrastructure such as water and sewage treatment plants.



Graph 1. Extent of tree clusters per planning area (hectare).



Graph 2. Canopy density per planning area (AP).



Graph 3. Canopy density per Administrative Area (RA)

Urban trees in densely populated and fragmented areas

In densely populated areas that are also significantly fragmented, the lack of trees is often a direct consequence of the spatial and structural limitations imposed by such environments (Heynen et al. 2006). Urban fragmentation, characterized by the proliferation of small, disconnected parcels of land that are developed with minimal open space, severely restricts the availability of greenery (Figure 7). This fragmentation not only diminishes the overall space for tree planting but also disrupts the ecological continuity necessary for sustaining cohesive clusters of urban trees.



Figure 7: Aerial image showing the fragmentation and the high built density of the urban fabric in Madureira, neighbourhood located in Planning Area 3. Source: SEL-RJ, 2016.

This combination of high building density and fragmented land use creates a challenging environment for the growth and maintenance of urban trees, leading to a significant deficit in green cover. In Rio de Janeiro, this problematic intersection is particularly evident in Planning Areas 3 and 5 (Figure 8), the most densely populated parts of the city, which, conversely, according to our mapping, show the lowest tree density in public spaces designated for circulation and permanence.

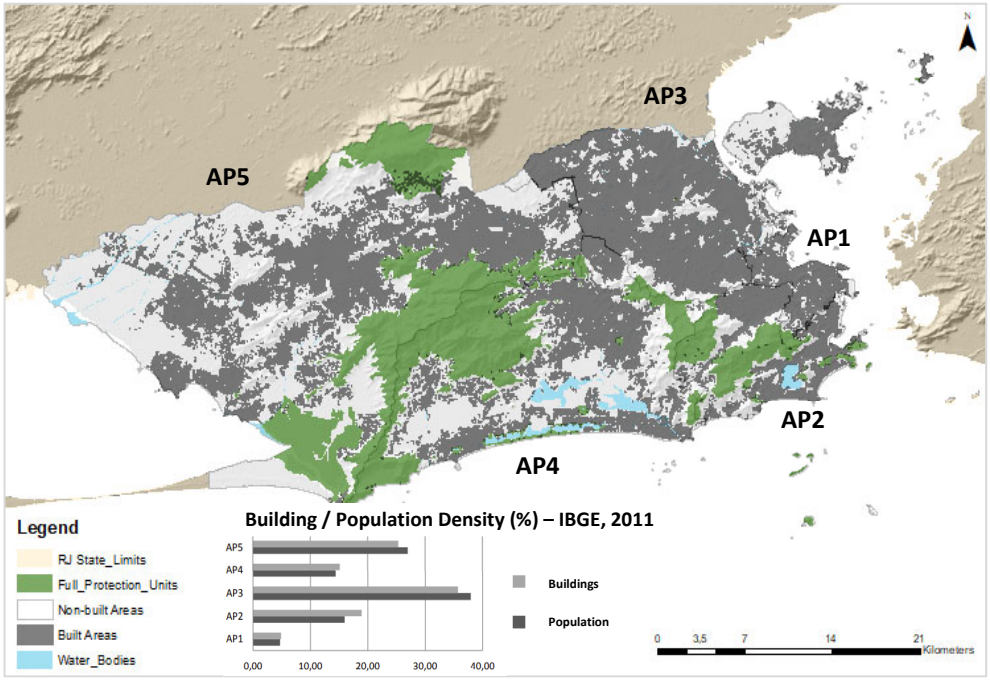


Figure 8: The figure ground map illustrates the relation between built and open spaces. It also summarizes the building / population density per planning area.

Urban inequalities and tree clustering patterns

Urban inequality extends beyond the unequal distribution of income to encompass the uneven access that different segments of the population have to essential services, such as healthcare and education facilities, public transportation systems, and likewise, public open spaces designed to support a diverse range of social activities. Despite their environmental, aesthetic, social, and economic benefits (Lynch, 1976; Cullen, 1961; Woolley, 2003; Stanley et al. 2012; Baptista et al. 2015), as explored in several studies, the open space infrastructure are often unevenly distributed across urban areas,

leaving marginalized communities underserved. In cities like Rio de Janeiro, socioeconomic disparities have historically concentrated wealth and resources in affluent areas, while a functionalist legacy in suburban and peripheral regions has delayed the development of these vital spaces (Mendonça, 2018). This imbalance plays a significant role in how these inequalities manifest spatially, affecting the quality of life for the most vulnerable urban populations.

In that sense, we highlight the existing spatial correlation between the income distribution pattern (Figure 9) and tree coverage across different areas of the city. Areas with higher income levels, such as planning areas 2 and 4, exhibit a more homogeneous distribution of trees compared to smaller and fragmented patches in less affluent regions in planning areas 3 and 5. Figure 10 illustrates these differences by emphasizing the tree-lined corridors located in the main streets (open spaces for circulation) of wealthier neighbourhoods. These corridors play a crucial role in connecting tree clusters across private and public spaces, enhancing ecological continuity, supporting biodiversity, and improving environmental quality. Conversely, in underserved neighbourhoods, the urban greenery is located in smaller tree patches, often confined to areas for special uses and private spaces.

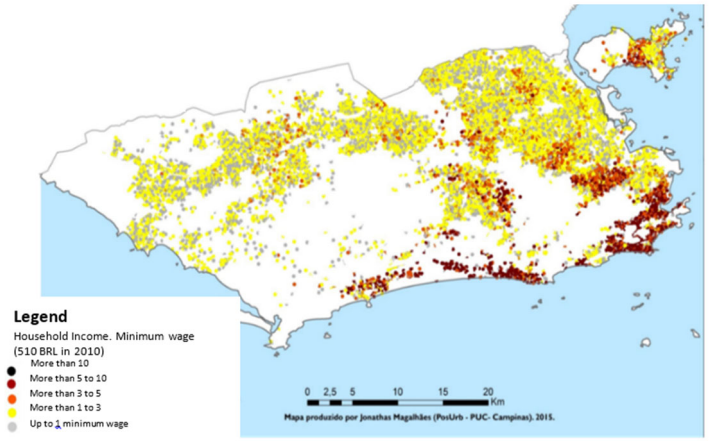


Figure 9: Income distribution pattern in the city of Rio de Janeiro. Source: Map elaborated by Jonathas Magalhães. PUC-Campinas (2018).

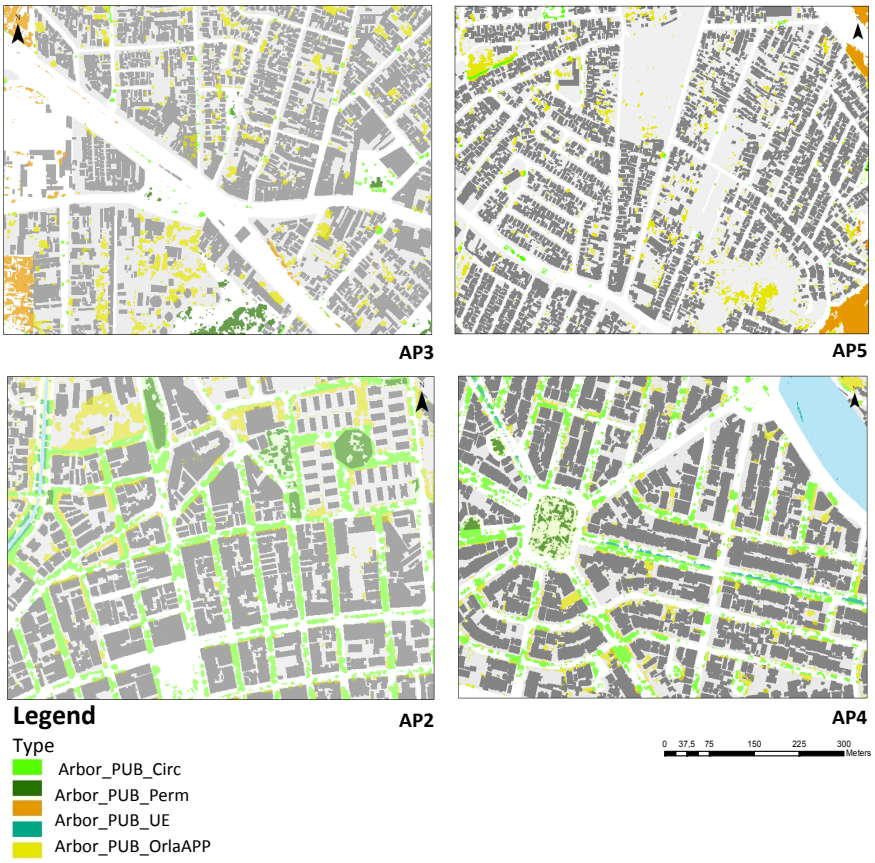


Figure 10: Comparison between tree clustering patterns in different planning areas.

Localizing tree clusters in private open spaces

As previously mentioned, a key finding of this study reveals that in many neighbourhoods within planning areas 3 and 5, where urban greenery is either non-existent or insufficient, tree clusters often occur confined to parcels designated for special uses, such as institutional grounds, and private spaces, rather than being integrated into the broader public realm. This limited and uneven distribution of trees not only reduces the environmental benefits that such element can provide, such as air quality improvement and micro climate regulation, but also restricts residents' access to open spaces that could support mental and physical well-being. However, the preservation of these areas as a compensatory measure for the lack of trees in neighbourhoods where public green spaces are scarce, seems crucial to mitigate some of these environmental challenges and enhance overall urban resilience. In this study, we identified and categorized the types of open spaces where tree clusters, as mapped and summarized in Figure 11.

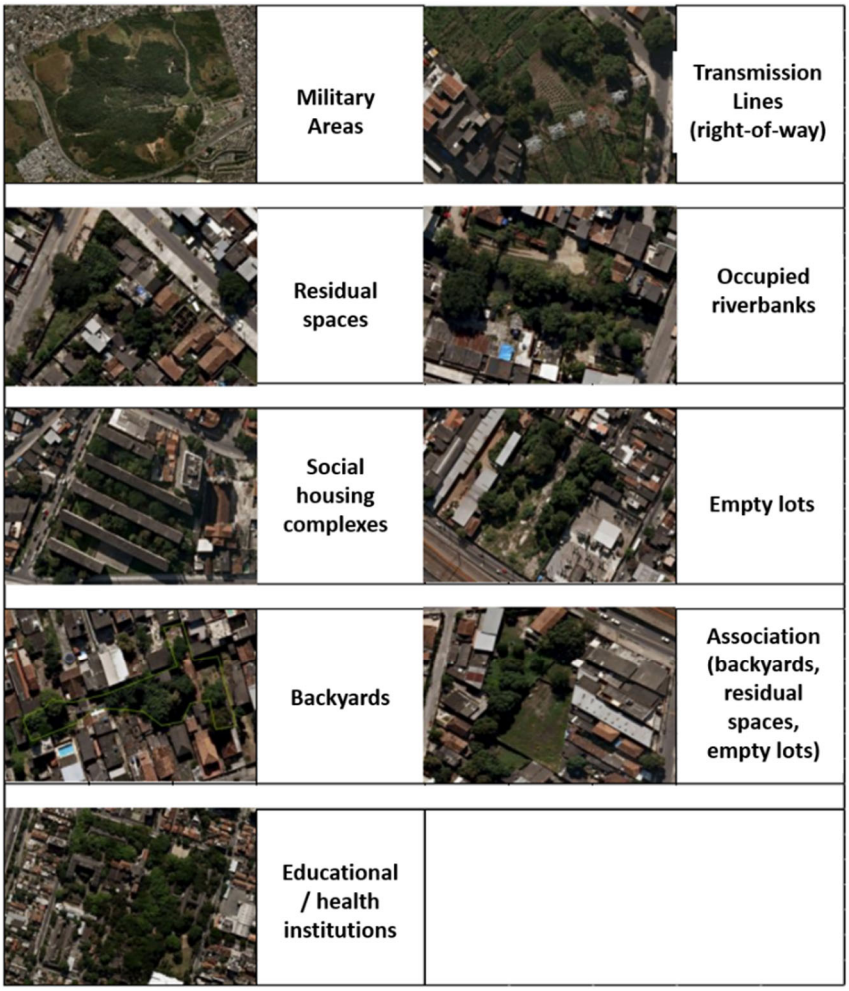


Figure 11: Comparison between tree clustering patterns in different planning areas.

- Military areas: Large, often restricted zones dedicated to defense purposes, where tree cover is typically preserved due to limited public access and minimal development;
- Energy transmission lines (right-of-way): Strips of land beneath power lines where vegetation is managed to prevent interference with the infrastructure, often maintaining a significant amount of greenery;
- Residual spaces: Undeveloped or underutilized areas within the urban landscape that often serve as informal spaces for leisure activities;
- Occupied riverbanks: Urban occupation along rivers and water bodies, informally settled, sometimes resulting in the natural growth of vegetation along these water bodies;
- Open spaces within social housing complexes: These areas often preserve significant green spaces, contributing to the overall greenery of the city;
- Empty lots: Parcels of undeveloped land within the city that may spontaneously or intentionally support clusters of trees and vegetation;

- Backyards: Private open spaces located behind residential lots, contributing to the greenery, especially in neighborhoods where low-rise buildings are predominant;

- Educational/health institutions: These institutions often maintain large campuses where green spaces are preserved or cultivated.

Green infrastructure and urban heat islands

Green infrastructure is crucial in mitigating the challenges posed by urban heat islands, a phenomenon where densely built environments experience significantly higher temperatures than their surrounding areas. As cities expand and develop, the replacement of natural landscapes with impermeable surfaces like concrete and asphalt increases heat retention, intensifying the urban heat island effect (Gartland, 2012). The lack of trees, which offer shade and promote evaporative cooling, further exacerbates this effect, making densely built-up regions noticeably warmer than areas with more greenery (Bowler et al. 2010).

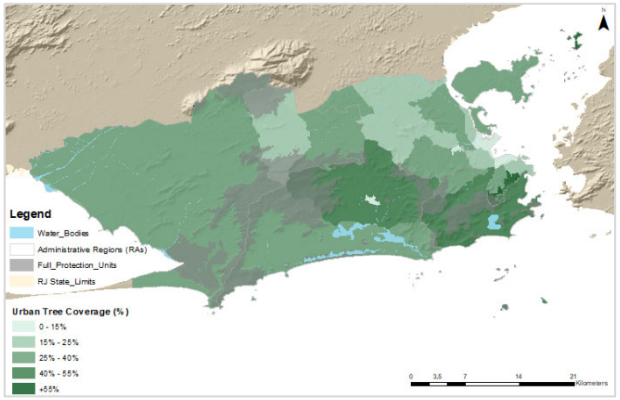


Figure 12: Tree canopy density per Administrative Region (RA).

In Rio, our analysis reveals a clear relationship between tree canopy density, mapped per Administrative Regions (RAs), and the urban heat island effect. Low-lying areas with tree coverage below 25% (Figure 12) consistently exhibit significantly higher temperatures, as shown by the red hues in Figure 13. In contrast, regions with higher tree coverage, particularly in the South, or those adjacent to or intersected by conservation units (covered by dense vegetation), correspond to cooler temperatures, indicated by the lighter yellow shades on the temperature map.

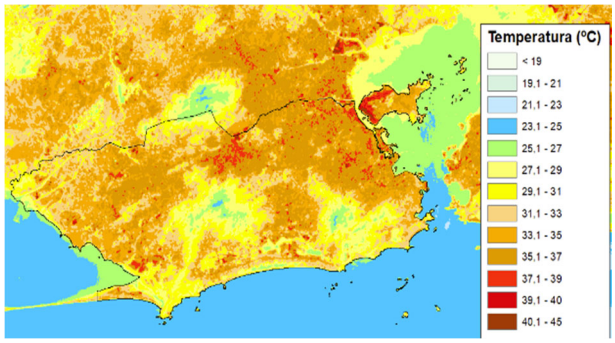


Figure 13: Map of Urban Heat Islands in Rio de Janeiro (12.01.2015) Source: Data.Rio Portal.

CONCLUSIONS

In conclusion, this study provides a comprehensive analysis of the distribution of urban trees in Rio de Janeiro, highlighting how urban sprawl and socioeconomic factors influence tree cover distribution while deepening our understanding of the city's broader environmental challenges. Through comparative analyses and cross-referencing with other indicators, such as education, health, and public safety, the findings can inform the development of public policies focused on planning, implementing, and maintaining urban afforestation. These policies must consider the spatial distribution of trees and their interactions with urban infrastructure, as well as the socio-spatial patterns and conflicts within the urban landscape, to ensure equitable and sustainable urban greening efforts.

Urban trees are critical components of sustainable urbanization, offering a wide range of benefits, from enhancing biodiversity and regulating the climate to improving residents' mental and physical well-being. However, the uneven distribution of green spaces in Rio de Janeiro mirrors broader patterns of urban inequality, where wealthier neighborhoods enjoy greater access to greenery compared to fragmented, lower-income areas. Our findings emphasize the importance of adopting a systemic approach to assessing green infrastructure across both public and private spaces, revealing the uneven distribution of tree clusters in different planning areas. Notably, private open spaces play a crucial role in maintaining urban greenery, especially in high-density areas. This underscores the urgent need for equitable urban planning policies that integrate green infrastructure into all neighborhoods, ensuring that the environmental and social benefits of urban trees are shared more fairly across the city.

In climates characterized by high temperatures and humidity, such as Rio de Janeiro, the presence of tree clusters is essential for heat regulation and well-being. On a local scale, the research highlights the potential of urban trees to mitigate the effects of urban heat islands, which disproportionately affect densely built and less vegetated areas. The correlation between tree canopy density and cooler temperatures in certain regions reinforces the need for strategic urban forestry management to enhance climate resilience. Policymakers and urban planners should prioritize expanding green infrastructure in underserved areas to reduce heat stress and promote more livable urban environments for all residents. Beyond their environmental and climatic advantages, urban trees also provide socioeconomic benefits: neighborhoods with abundant greenery often experience higher property values, attract investment, and foster economic growth. Urban trees also enhance social cohesion by offering communal spaces that promote community interactions and contribute to a sense of well-being.

Ultimately, this study contributes to the growing body of literature supporting nature-based solutions in urban development. The methodology and findings presented here lay the groundwork for future research and urban planning initiatives aimed at fostering sustainable and resilient cities. By bridging the gap between ecological conservation and socioeconomic equity, urban forestry can play a pivotal role in addressing the environmental and social challenges posed by rapid urbanization in Brazil.

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Indigenous cities in Brazil: an analysis of urban form and basic health units

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ABSTRACT

The migration of indigenous people to cities has been going on for a long time and this movement is experienced with exclusion, marginalization and discrimination, implying vulnerability of this population and harm to their health (Coimbra Jr and Santos, 2000). A study in twenty-eight (28) countries found that indigenous people have less favorable health and socioeconomic indicators than non-indigenous people (Anderson, et al., 2016), and another study found that this is the social group that suffers the most injustice (Rocha et al., 2018). Therefore, indigenous people's access to health facilities is an important factor in reducing their vulnerability. This paper analysis urban form based on the integration measures of Hillier and Hanson (1984) and compactness of Krafta (2014) as an instrument for analysing the accessibility of this population. The method, of a hypothetical-deductive nature, with explanatory analysis and a multi-case study research strategy, is divided into (1) literature review, (2) survey of socio-spatial data and (3) geoprocessing treatment. The sample of cities, totaling 10, was chosen based on the percentage of the population that self-declares as indigenous in the Census (IBGE, 2022). As main results, it was identified that there is a positive correlation between the Integration and Compactness variables, with Pesqueira/PE having the most Integrated system; Tefé/AM having the greatest access and coverage of Primary Health Care and São Gabriel da Cachoeira/AM being the least compact of the cities.

Keywords: Urban Form, Indians, Compactness, Space Syntax and Health

INTRODUCTION

Urban form, Indians, Compactness, Spatial Syntax and Health Difficulties involving the migration of Indians/indigenous people to urban spaces have existed for centuries throughout the world and these dilemmas are experienced through situations of exclusion, marginalization and discrimination, implying greater vulnerability to health problems for these people (Coimbra Jr and Santos, 2000). In addition to health problems, indigenous people face numerous limitations, among which is the lack of professional skills, with the first formal alternative being the job of labor in the construction industry of urban centers (Albuquerque, 2015).

The movement of indigenous populations has had some negative implications, and a study of 23 countries and 28 populations found poorer health and social outcomes for indigenous peoples than

non-indigenous populations (Anderson et al., 2016). The results of a study in Brazil indicate striking differences, with much higher mortality rates for indigenous people in all age groups considered (Campos et al., 2017).

Although indigenous people have gained space and rights in recent years, they appear in first place with 33.67% as the most unfairly treated group in relation to other peoples (Rocha et al., 2018). Along with inequity, health indicators are modest when compared to the investment of 200 million reais in 2003 to more than 1.4 billion reais in 2016 (Benevides Ferreira and Taveira, 2017). That is, even though there has been progress in terms of healthcare assistance and accessibility via the Unified Health System/SUS[67], the data continues to point to enormous gaps between indigenous and non-indigenous people (Mendes et al., 2018).

The injustice is so evident that, when we examine the public health services related to this population in Brazil, we see that these people came to have (indirect) access to health care from 1910 onwards with the Indian Protection Service/SPI, but it was only in 1999 that they had direct access to basic care via the Unified Health System/SUS through the Indigenous Health Care Subsystem of the SUS/SASI-SUS (Benevides Ferreira et al., 2019).

Amidst struggles and conquests, it is known that the Brazilian population, including the indigenous population, has increasingly migrated to the country's urban centers, that is, when considering the total number of indigenous people living in the country, it is noted that 622.1 thousand (36.73%) reside in Indigenous Lands and 1.1 million (63.27%) outside them and the Southeast region has the largest proportion of indigenous people living outside these delimited territories with 101.9 thousand (IBGE, 2022).

However, the city, as a structure shaped by the population that lives there, requires constant monitoring to understand its dynamics and, associated with this, there is the debate about the compact city and its level of accessibility. Therefore, researchers have considered the road network as one of the main elements to contribute to evaluating the performance of the urban form in the city (Ribeiro, et al., 2012).

There are several types of approaches that allow us to analyze urban form, and one of them is the Theory of Social Logic of Space (or Spatial Syntax). This theory seeks to understand human social organization through a spatial configuration. In other words, for the Theory, the structure of the road network, together with land use and population density in cities, determine accessibility patterns, maintaining a relationship of influence between them (Hillier and Hanson, 1984).

For Krafta (2014), the city is the result of the forces that exist within it, in which each element contributes to magnetize, polarize, distribute and conduct activities and flows. For the author, two forces that enhance this phenomenon are given by the road structure and population density; however, it is seen that investigations involving the performance of the urban form through the compactness indicator have been increasingly explored in urban studies (Maia and Netto, 2016).

[67] Universality, comprehensiveness and equality are guiding principles for access to public health services at all levels of care (Brazil, 1990).

A study that investigated the Yanomami population dynamics in four distinct periods identified that health care, through the establishment of health posts, ensured the growth of their population, however, contact with other peoples and epidemics impose the need to expand this care (Nilson and Fearnside, 2017).

A systematic review of indigenous populations in urban areas found a prevalence of physical inactivity ranging from 28.8% to 45.3% (Radicchi and Lima, 2020). Another investigation related to the topic, but with a morphological bias, analyzed spatial patterns of indigenous settlement based on Spatial Syntax, finding spatial associations between morphological and functional centrality. Furthermore, it was possible to understand the construction of alternative paths as a need to adapt the spatial configuration and promote greater spatial integration in the village (Dill et al., 2021).

Andrade and Pereira (2021), who investigated the relationship between the location of the Basic Health Unit/ABS and the urban morphology[68] of the neighborhood based on Space Syntax measurements, found evidence that the permanence of a regular grid implies an intelligible system and that the location of the UBS on the most connected road in the system tends to guarantee favorable accessibility for the neighborhood's residents.

Given studies of urban dynamics and the inequity suffered by the indigenous population, we suspect that more compact cities with coverage by Family Health Teams/ESF and Primary Care/AB tend to provide accessibility and prevention to the health of indigenous people. This study aims to analyze the level of accessibility of the urban form based on the Space Syntax of Hillier and Hanson (1984) and the compactness indicator for urban fabric of Krafta (2014) in relation to the Basic Health Units/UBS of the ten cities with the largest self-declared indigenous population in Brazil. In addition to this introductory part, this study is structured in three stages, namely: (a) method, (b) results and debates, and (c) conclusions.

METHOD

The method applied in this research is hypothetical-deductive and descriptive in nature, with data based on the Brazilian Institute of Geography/IBGE and the Ministry of Health for demographic aspects and on the Open Street Map/OSM for spatial aspects. After the bibliographic review, the method was organized into two stages (1) demographic and (2) spatial.

In the demographic stage, a survey was conducted of the first ten cities - except capitals and cities that are part of metropolitan regions - with the largest self-declared indigenous population in Brazil, considering (a) total population, (b) the percentage of indigenous people in relation to the total population and (3) population density. In the spatial stage, the technical and tool procedures were carried out by importing the road structure via the Open Street Maps/OSM database and then developing the modeling and treatment of the maps in the QGIS® software version 3.22 and processing in DepthmapXnet® version 0.35; adopting the segment map to work with the syntactic measures.

Therefore, the technical and tooling execution began with the extraction of the Spatial Syntax Integration measure and subsequent calculation of the compactness indicator for the urban fabric of individual cities. We emphasize that the integration measure (or proximity) is the main measure of Spatial Syntax and refers to how close or distant a street segment is in relation to all others in

[68] Urban morphology, urban form and spatial configuration are read as synonyms in this article.

topological distance. That is, all axes are directly connected to a given line and are one topological step away from it. The lines directly connected to these axes are two topological steps away from the first, and so on (Hillier et al. 1993 and Saboya, 2007).

The logic behind the calculation of the Theory is that lines closer to other lines in the system are considered more integrated (or shallow) and lines further away from other lines in the system are considered segregated (or deep). The Integration measure of each line is calculated based on the average depth, and lines with Integration values greater than 1.67[69] can be considered highly integrated, while those with values less than 1 are considered segregated. Generally, the values are presented on a chromatic scale, and in this study, darker colors (dark gray leaning towards black) indicate greater accessibility potential and lighter colors (light gray leaning towards white) indicate less potential (Hillier and Hanson, 1984).

After obtaining the Integration measure, we calculated the compactness indicator for urban fabrics, understanding that the compactness index is measured by the ratio between the built-up area and the urbanized area of the city. We chose this indicator because we understand that a compact city is synonymous with efficiency, since in addition to implying greater savings in the implementation and maintenance of infrastructures, compact cities tend to imply greater accessibility to urban services and equipment (Krafta, 2014). Therefore, to operationalize the equation, we considered the most integrated area and/or integrating core (Holanda, 2002) as the built-up area; that region of the map tending towards a darker tone and the polygon around the limits of the road structure as the urbanized area inclined towards a lighter tone (Figure 1).

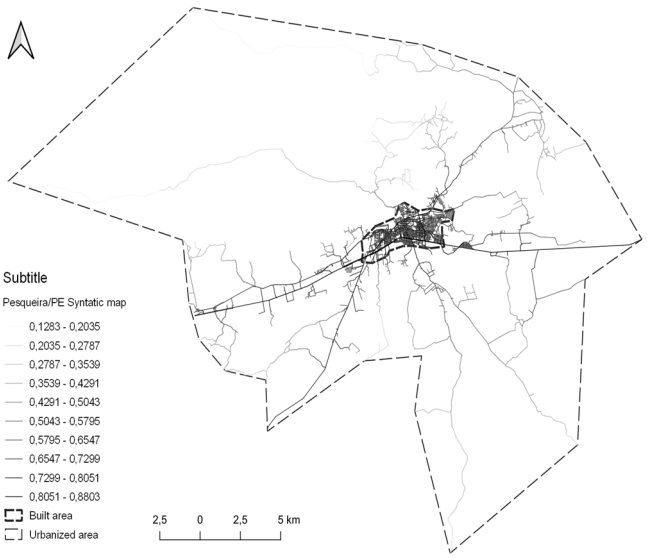

Figure 1. Compactness calculation for the city of Pesqueira/PE. Source: Open Street Maps/OSM road network, modeled via QGIS® software and processed via Depthmap®. Credit: Authors, 2024.

RESULTS AND DISCUSSIONS

The data analysis is organized into three categories, namely: (a) general population and percentage and health; (b) demographics and built and urbanized areas; and (c) urban form. This organization was chosen to initially offer an understanding of the context of the place and thus, first discuss a set

[69] These values (1.67 and 1) refer to European metropolitan cities. In the Brazilian context, Porto Velho/RO has 2.213 and Florianópolis/SC has 0.262 with Integration values (Medeiros, 2013).

individually and then make the cross-references between sets with an emphasis on measures of urban form.

Thus, we saw that of the 10 cities listed, 9 are located in the North Region and 1 in the Northeast Region. The data indicate that Tefé/AM is the city with the largest population in absolute numbers, however, the city of São Gabriel da Cachoeira/AM is the city with the largest percentage of Indians, with Tabatinga/AM and Barcelos/AM appearing as the largest and smallest demographic densities, respectively (Table 1).

Table 1 – The 10 main indigenous cities in Brazil and the relationship between Family Health Teams/ESF and coverage by Primary Care/AB. Source: IBGE (2022) and Ministry of Health (2024)[70].

	Municipality	**Total population**	**Indigenous people**	**%**	**Number of SF Team**	**Primary Health Care Coverage (%)**
1	São Gabriel da Cachoeira/AM	51.795	48.256	93,17	8	52,5
2	Tabatinga/AM	66.764	34.497	51,67	17	76,59
3	São Paulo de Oliveiça/AM	32.967	26.619	80,74	13	73,12
4	Pesqueira/PE	62.722	22.728	36,24	21	84,65
5	Autazes/AM	41.564	20.447	49,19	8	58,82
6	Tefé/AM	73.669	20.394	27,68	15	95,73
7	Santo Antônio do Içá/AM	28.211	18.882	66,93	8	77
8	Benjamin Constant/AM	37.648	17.811	47,31	9	64,62
9	Jacareacanga/PA	24.042	14.216	59,13	2	51,78
10	Barcelos/AM	18.834	14.178	75,28	7	73,59

It can be seen that the percentage of the self-declared indigenous population has increased in relation to the last Censuses, since the 1991 Census carried out in Brazil limited the counting of the indigenous population to the cities, not collecting data such as ethnic affiliation and language spoken. The 2000 Demographic Census demonstrated the population growth of this indigenous population from 249 thousand to 749 thousand people. This increase in growth resulted from the fact that people identify themselves as indigenous, mainly in urban areas (IBGE, 1991; 2000).

In order to highlight the interrelations between social inequalities and dynamic processes involving health and disease in a given population, reliable information in the form of qualitative and quantitative parameters (Coimbra Jr and Santos, 2000) is necessary to be able to carry out the analyses proposed by the study. In this sense, the city with the largest indigenous population in the country (São Gabriel da Cachoeira/AM) is the one with the least Primary Health Care/PHC coverage, while the city of Tefé/AM has excellent proportions both in terms of the number of Family Health Teams and in Primary Health Care/PHC coverage (Table 1).

[70] These data were consulted by period and by geographic unit with a base date of April 2024 and are available at https://egestoraps.saude.gov.br/

Considering the second category (demographic and built and urbanized areas) to be analyzed, it is worth noting that 9 out of 10 cities are located in the North Region of the country - cities characterized by large areas of territorial extension. It is appropriate to clarify this methodological logic and it is important to understand the context of the place, in order to later discuss the third category that deals with urban form.

Therefore, the city of Pesqueira/PE - the only city located outside the northern region - is the city with the highest population density and Barcelos/AM the lowest. Although Pesqueira/PE has a high density in relation to the 10 cities, it can be seen that its built-up area is smaller than the average of 14.21 km². Another equally important piece of information for the debate concerns the relationship between built-up area and population density of the city of Autazes/AM, that is, this city has both built-up and urbanized areas larger than the average of the cities, however, a density of just over 10% of the average (Table 2).

São Gabriel da Cachoeira/AM and São Paulo de Olivença/AM are the cities with the largest and smallest urbanized areas. The level of urbanization in the northern region is generally linked to exploitation by groups of landowners, mining companies, agribusinesses and others who, when exploiting the forest (in this particular case), end up influencing decisions about the general form of these urban settlements, resulting in a vast urbanized area, with little construction and little population. In addition to these cities having a higher cost due to these exploitations, the city is transformed into several private and closed spaces, preventing more people from circulating and moving around, no longer having time to focus on their own urban morphology (Ribeiro et al., 2008).

Table 2 – Demographic values and areas of the 10 indigenous cities. Source: IBGE (2022), QGIS (2024).

City	Population (hab/km²)	densityBuilt area (Km²)	Urbanized area (Km²)
Barcelos/AM	0,15	2,67	129,77
Jacareacanga/PA	0,45	63,79	4202,80
São Gabriel da Cachoeira/AM	0,47	18,03	4353,77
São Paulo de Olivença/AM	1,68	2,11	28,57
Santo Antônio do Içá/AM	2,28	3,06	64,65
Tefé/Am	3,11	24,99	398,00
Benjamin Constant/AM	4,32	7,64	337,79
Autazes/AM	5,43	186,44	3609,01
Tabatinga/AM	20,48	47,91	905,50
Pesqueira/PE	65,33	10,39	599,39
Média	32,89	14,21	498,69

According to Maia and Netto (2016), it is necessary to be clear between evaluating the 'form performance' and 'measuring the form' based on compactness and density values. Evaluating performance means examining the impacts of the form on dynamics beyond the form, such as social, microeconomic and environmental processes, for example. And, evaluating the urban form means mapping it, based on its attributes, in relation to another universe external to the morphology, generally linked to the city users who live in the city or periodically pass through it (Krafta, 2014).

The choice of the Integration measure and the indicator of compactness of the urban fabric for this work sought to bring together theoretical basis and technical-tool support in order to analyze and reflect on the level of accessibility of the indigenous people to health teams or public facilities in general. Therefore, we see that the city of Pesqueira/PE has an urban system with greater potential for Integration (proximity) and Jacareacanga/Am more distant (or segregated), that is, while Pesqueira/PE tends to have a greater flow of movement (pedestrians and vehicles), Jacareacanga/Am tends to have less flow. We point in this direction because in traditional syntactic studies the integration measure presents a correlation coefficient of 0.547 when related to pedestrian movement on a local scale (Hillier et al., 1993 and Hillier, 1999).

Still in syntactic terms and in comparison to other urban systems, while Florianópolis/SC presents an integration level of 0.262, considered the lowest among Brazilian capitals (Medeiros, 2013), Pesqueira/PE presents a more integrated system than the capital of Santa Catarina and Jacareacanga/PA, an urban network less integrated than Florianópolis/SC. In this perspective, Pesqueira/PE presents an integrated (or close) urban system with 0.627 and Jacareacanga/PA with 0.063 of the selected cities.

Table 3 – Relationship between cities and urban form measures.

City	Integration (NAIN)	I comp
Pesqueira/PE	0,627	0,02
Barcelos/AM	0,585	0,02
São Paulo de Olivença/AM	0,422	0,07
Santo Antônio do Içá/AM	0,373	0,05
Tefé/AM	0,378	0,06
Autazes/AM	0,330	0,05
Benjamin Constant/AM	0,275	0,02
Tabatinga/AM	0,279	0,05
São Gabriel da Cachoeira/AM	0,259	0,00
Jacareacanga/PA	0,063	0,02

Regarding the compactness indicator, none of the 10 cities obtained a value higher than two digits. Only 2 cities presented values above 0.05, namely the city of São Paulo de Olivença/AM with 0.07 and Tefé/AM with 0.06. This value of 0.05 was used as a parameter, a reference value to establish a relationship between the selected cities. Even so, considering that the compactness measures vary between 0 and 1 according to Krafta (2014), the compactness indicators of the 10 main Brazilian indigenous cities can be considered to be of very low levels, as can be seen in Table 3.

When exploring the correlation between the two measures (integration and compactness) intrinsic to the urban form, an exponential trend of 0.240 is observed. Although this may seem like a low value, perhaps due to the number of cities or the regional context in which most of them are located, the truth is that the data points to a positive correlation, that is, the higher the compactness indicator, the more integrated the urban network tends to be and vice versa. These values corroborate arguments that compact cities imply benefits (Krafta, 201), as they tend to have an intensive use of

urban space, avoiding the widespread expansion of urbanization over the natural environment (Graph 1).

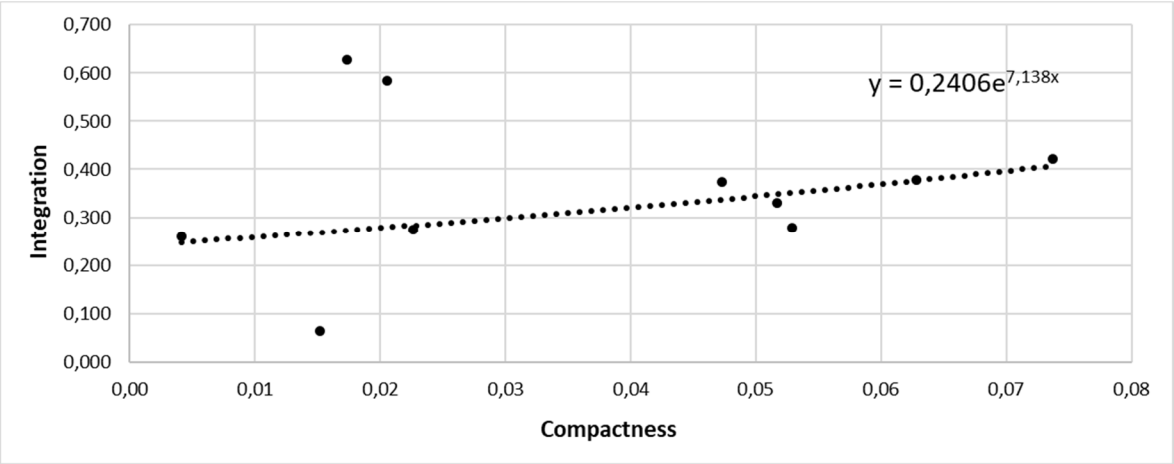

Gráfico 1. Correlation between integration and compactness measures of selected cities. Source: Open Street Maps/OSM road network and processed via Depthmap®. Credit: Authors 2024.

When crossing the results between the suggested categories, it is clear that the city of Pesqueira/PE stands out as the most integrated urban system, the densest and the largest in number of Family Health Teams. However, the findings indicate that this city has a relatively low compactness indicator and the penultimate place in terms of the percentage of indigenous population, characterizing a highly urban profile.

The city of São Paulo de Olivença/AM has the smallest built and urbanized areas, the most compact and the third largest both in terms of integration and percentage of indigenous population. Although it is considered a city with positive morphological attributes, it is a city with relatively low density; however, when observing health-related services, it can be considered of good quality, as the city has just over 73% coverage of Primary Health Care.

Jacareacanga/PA and São Gabriel da Cachoeira/AM are two cities that have the lowest values of Integration, Density and Compactness. In addition to having an indigenous population of over 60 thousand people, the two cities have the largest urbanized areas, with São Gabriel da Cachoeira/AM standing out in first place.

Regarding health care, Jacareacanga/PA and São Gabriel da Cachoeira/AM have cities with just over 50% Primary Health Care coverage for each of these settlements, while Jacareacanga/PA has 2 and São Gabriel da Cachoeira/AM has 8 Family Health Teams each. These results corroborate a scenario that has persisted for decades in which there is an unacceptable gap between several health indicators recorded among indigenous peoples and the rest of the Brazilian population, with the indigenous segment systematically disadvantaged (Mendes et al., 2018).

When analyzing the urban grids (Figure 2), we observe two distinct profiles that we call inter-Amazonian and urban. The urban forms with an inter-Amazonian profile are the 9 cities located in the northern region (images “a”, “b”, “c”, “d”, “e”, “f”, “g”, “h” and “j”) and the one with an urban profile is located in the northeast region (image “i”), including the one discussed at the beginning of this section.

The urban forms with an inter-Amazonian profile, for the most part, present a region (or nucleus) of greater Integration, that is, a place in the system that is easily identifiable, except for the cities of Autazes/AM (image “d”) and São Paulo de Olivença/AM (image “h”), which present a more spread-out system. In the cities where the Integration nucleus is more concentrated, a common characteristic can be seen between them, which are the long road axes intercepted by perpendicular roads over the urbanized area, compromising efficiency and maintenance costs.

The network identified as urban has a radial slope and its integrating core tends to expand east/west. Having a radial network and an extensive core means that the city is more efficient than a more distant and linear network such as the inter-Amazonian network, since the radical form has shorter paths/distances from one point to all others in the road system (image “i”).

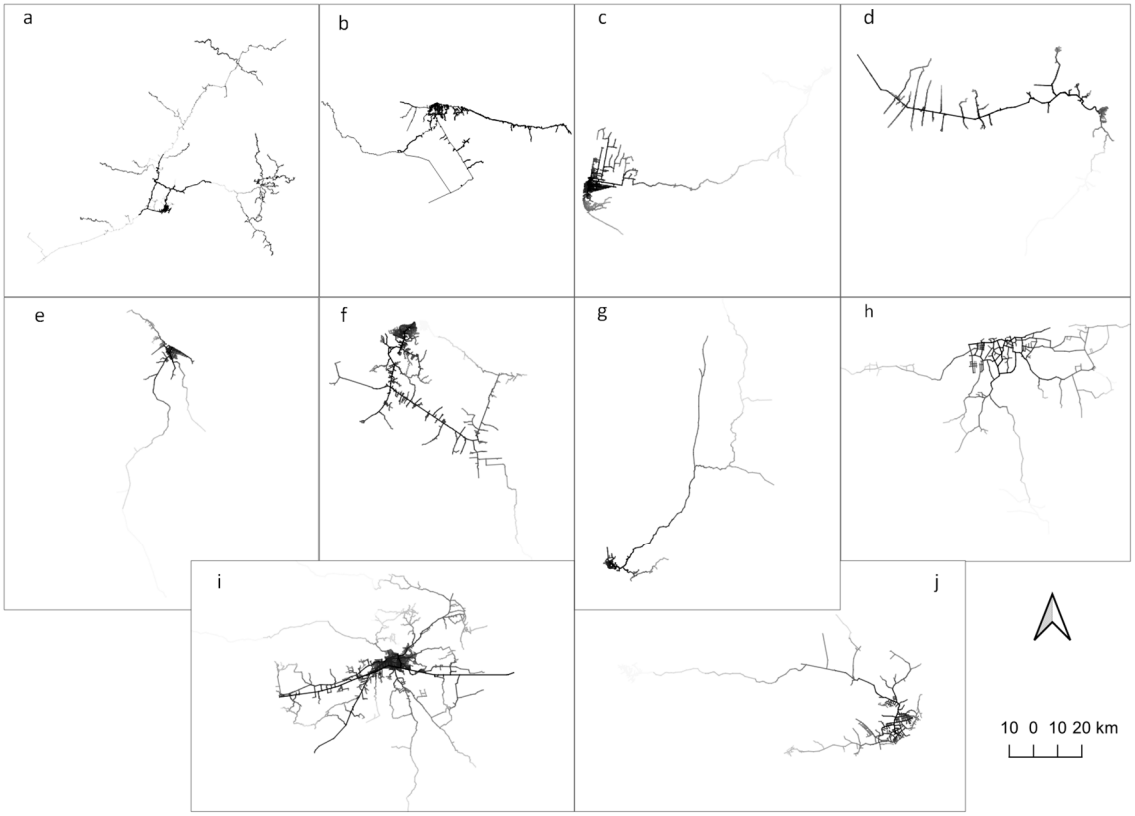

Figure 2. List of syntactic maps of the selected cities. a) Jacareacanga/PA; b) Benjamin Constant; c) Tabatinga/AM; d) Autazes/AM; e) Barcelos/AM; f) Tefé/AM; g) São Gabriel da Cachoeira/AM; h) São Paulo de Olivença/AM; Pesqueira/PE and j) Santo Antônio do Içá/AM. Source: Open Street Maps/OSM road network, developed via QGIS® software and processed via Depthmap®. Credit: Authors 2024.

The study indicates that Pesqueira/PE has the most integrated urban form and is the second city with the highest Primary Health Care/PHC coverage (84.65%). Considering that its urban system is the most integrated and that being integrated is synonymous with potential accessibility (or proximity), the results suggest that the morphological profile of this city contributes to the population in general (including indigenous people) having greater access to health facilities.

Jacareacanga/AP, Barcelos/AM, Benjamin Constant/AM and São Gabriel da Cachoeira/AM are the cities that presented a less integrated morphology and are among the urban fabrics with the lowest

compactness index of the selected cities. In addition to having a linear and distant configurational structure, their indigenous populations, which are between 47 and 93.17%, are minimally assisted by both the number of Family Health Teams/ESF and Primary Health Care/APS, compromising health problems for the indigenous people.

CONCLUSIONS

These structural difficulties (morphological, urban equipment and human resources) of the urban environment compromise the efficient functioning of human life in the city. While we have a human settlement characterized by an extensive road network, low density, less compactness and minimal health care, the results cannot be contrary to the fateful social, economic, ethnic segregation and other types of exclusion associated with scarce health promotion and prevention services in general.

The findings lead us to reflect on the importance of the topic and its limitations as well. That is, we see that it is possible to aggregate other attributes of the urban environment intrinsic to the city, which were not related in this study, such as employment, income, services and mainly which production sectors are predominant in these cities. Another limitation of the study is of a conceptual nature and deals with discussing the spatial guidelines between the built and urbanized areas. A third suggestion is to associate studies of urban form with the health area, such as identifying and quantifying the causes of hospitalizations of the indigenous population; quantifying the number of beds, emergency care units and relating whether these are within the coverage area recommended by the SUS.

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The first author would like to thank his grandmother Dorvalina Córdula de Oliveira (1932-2018) for the values and principles she taught him. Dorvalina, an honorable woman of indigenous origin, was born in the municipality of Borba in the state of Amazonas/Brazil. She was a great example of courage, perseverance, and resilience during her time among us. She encouraged this author to always seek knowledge and, in her name, the author dedicates this work to all Brazilian indigenous peoples who, like his grandmother, left their habitat to face the challenges of urban life.

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A Quantitative Approach to Comparative Study of the Characteristics of Urban Form: Nanjing, Shanghai and Copenhagen

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ABSTRACT

Urbanization has led to significant changes in the form of cities. Typically, cities that have undergone urbanization have historical areas, modern urban areas, new town areas, and urban expansion areas (suburban areas), each with distinct urban form characteristics and morphological structures. At the same time, different cities have unique historical backgrounds and cultures, resulting in varying strategies for managing urbanization. As a result, a specific urban area may exhibit different urban form characteristics and morphological structures. To clarify the relationship between the historical morphological imprint of the city, urban culture, the stage of urban development, and the town's morphological characteristics and morphological structure, this research conducts a comparative study of three cities with different historical backgrounds, cultures, and stages of development: Shanghai, Nanjing, and Copenhagen. It explores the differences between these cities in terms of characteristics of morphological structure. Six 1km by 1km areas were selected in each of the three cities based on the definitions of historical area, modern urban area, new town area, and urban expansion area. The blocks/streets and buildings were mapped, and numerical statistics on the street patterns and structures, number and size of blocks, and the size and distribution of buildings were carried out using GIS (Geographic Information System), leading to a comparative analysis of the different urban areas from a quantitative perspective. The research finds that the morphological indicators can demonstrate the similarities in urban form between urban areas with similar historical backgrounds and cultures at the same stage of development and the differences in morphological characteristics and structures between urban areas with different historical backgrounds and cultures. Additionally, it has been discovered that specific indicators can describe the morphological characteristics of street patterns and structures.

Keywords: Quantification, Comparative Study, Urban Morphological Character, Morphological Indicator

INTRODUCTION

The shaping of urban form is a complex and gradual process, which is not only profoundly influenced by the historical background and social culture of the city, but also tends to leave behind the products of different eras in the expansion and renewal of the city. On the one hand, urban morphology is related to historical context, laws and regulations, geographic location, population, economy and

culture (Scheer, 2016), and cities with different cultures tend to differ in many ways in their physical form. On the other hand, urban morphology is related to the stage of development of a city. Cities that have undergone urbanisation tend to have a variety of urban areas, including historical areas, city centres, new town areas, and expansion areas. Each of them has different functions and different characteristics of urban forms. In addition, in the context of globalisation and urbanisation, due to the wide application of modern construction techniques and planning concepts, new urban areas with different cultures may also present similar urban forms. Differences and similarities in urban form not only reflect the unique history and culture of cities, but also map the process of urbanisation.

In the past decades, many researchers have studied urban form through comparative studies to understand the differences and similarities of urban form. These studies can be broadly categorised into diachronic and synchronic comparisons (Scheer, 2016). Diachronic comparisons can reflect how the elements of urban form (e.g. street/block, building, plot) change and develop over time, so as to analyse the pattern of evolution of urban form with the process of urbanisation and the motivation. Synchronic comparisons can reflect the differences or similarities of urban form in different areas, so as to analyse the characteristics and influencing factors of urban form. Among comparative studies, although cross-cultural comparisons are relatively rare and challenging due to the diversity of urban forms, the inconsistency of related terminology and cultural differences, they are of great importance in providing a richer set of cases and research methodologies for urban morphology and facilitating an understanding of the ways in which knowledge is accumulated in different cultural contexts (Whitehand et al., 2012; Scheer, 2016).

In established research, approaches such as historico-geographical approaches, process typological approaches and the spatial syntax have been extensively employed in comparative studies of urban form, thereby providing a comprehensive theoretical foundation for urban morphology (Oliveira and Pinho, 2006; Oliveira, 2014; Wardhani and Bahri, 2020). In the 21st century, there is a shift in urban morphology towards evidence-based approaches and the quantitative approach has become an important tool in urban morphology study (Batty, 2008). A considerable number of studies have explored ways to quantify urban form from different perspectives and have used a variety of morphological indicators to measure different features of urban form (Fleischmann et al., 2021).

This study will conduct a cross-cultural comparative study using quantitative approaches to quantify characteristics such as morphological structure and street density, block size, building size and density, etc. Through diachronic and synchronic comparisons, this study reveals how urban form under different cultures is affected by factors such as historical background and culture, and how urban form under the same culture is affected by factors such as urban planning. The findings will contribute to our understanding of the physical form and morphological structure of cities in different cultures and identify effective indicators for comparative studies of urban form using quantitative approaches.

RESEARCH BASE

Most cities have developed from their historical origins, which have been influenced by a combination of geographical and cultural factors, resulting in unique and varied urban forms. The building type and morphological structure of urban areas evolve in a dynamic manner, adapting and transforming in response to many factors, including social needs, technological change and economic conditions.

Western cities have undergone significant changes in building types (Oliveira et al., 2014), a phenomenon that has been reflected in China's urban form, particularly in the housing type (Liu and Ding, 2012). Upon entering the modern pattern of urban development, the morphology of both residential areas and city centres has undergone profound changes. The diversity of urban forms that has resulted from differences in development rates, policies, urban planning and resource allocation in cities not only highlights the complexity of cities but also emphasises the importance of a deeper understanding of the factors that influence urban form.

The evolution and development of the modern city has been significantly influenced by urban planning theories and ideas, particularly those outlined in the Athenian Charter and the fundamental principles of contemporary urban zoning. The theories advocate the separation of the residential, recreational, work and transport functions of the city, and it is under the influence of these theories and ideas that many cities have developed urban residential, commercial, office areas and so on (Athens Charter, 2007). The different zoning not only shape the unique physical form and spatial characteristics of different urban areas, but also influence the functions of them and the daily lives of their inhabitants.

Differences in urban form across cultures and morphological changes during the transition from ancient cities to modern urbanisation can be revealed and understood through comparative studies. Many studies have discovered how historical culture and urbanisation influence urban form through comparative studies of morphological structures, building types, etc. (Whitehand et al., 2014; Whitehand et al., 2016; Wardhani and Bahri, 2020). In recent decades, there has been a clear trend towards the use of quantitative or numerical methods to study urban form, driven by a number of researchers (Moudon, 1997). A number of studies have been conducted using these quantitative methods to carry out comparative studies with the objective of revealing evolutionary patterns and features in urban morphology. Peponis et al. quantified morphological indicators including block size, street and intersection densities, across 118 U.S. areas, revealing a decline in street density due to 20th-century sprawl (Peponis et al., 2007). Porta et al. examined the main street network structure and street lengths in 100 urban areas worldwide, noting that historical streets were significantly shorter than modern ones, which suggests a corresponding increase in block size (Porta et al., 2014).

COMPARATIVE METHODOLOGY

Cases

In order to investigate the influence of different cultural and historical backgrounds on urban form, three cities with disparate cultural and historical backgrounds were selected for the study: Nanjing, Shanghai and Copenhagen (Figure 1). Nanjing and Copenhagen are respectively, representative of a city in China and Denmark. They reflect the cultural differences and urban characteristics between China and the Western Europe. Shanghai's semi-colonial history resulted in a fusion of Chinese and Western cultures. A cross-cultural comparison of the three cities allows for an investigation of the impact of contrasting cultural and historical (Nanjing and Copenhagen) influences on urban form. It also permits an examination of the similarities and differences between Shanghai that influenced by Western culture and Nanjing, as well as the particularities resulting from the fusion of cultures.

Nanjing, one of China's four ancient capitals, is renowned for its extensive history and cultural heritage. It serves as the capital of Jiangsu Province with a population of around 9.5 million, Nanjing has experienced significant urban expansion in recent decades. This includes the development of Hexi

New City, situated to the west of the Qinhuai River, in the early 21st century, and Jiangbei New City, located to the north of the Yangtze River, around 2015 (Figure 1a).

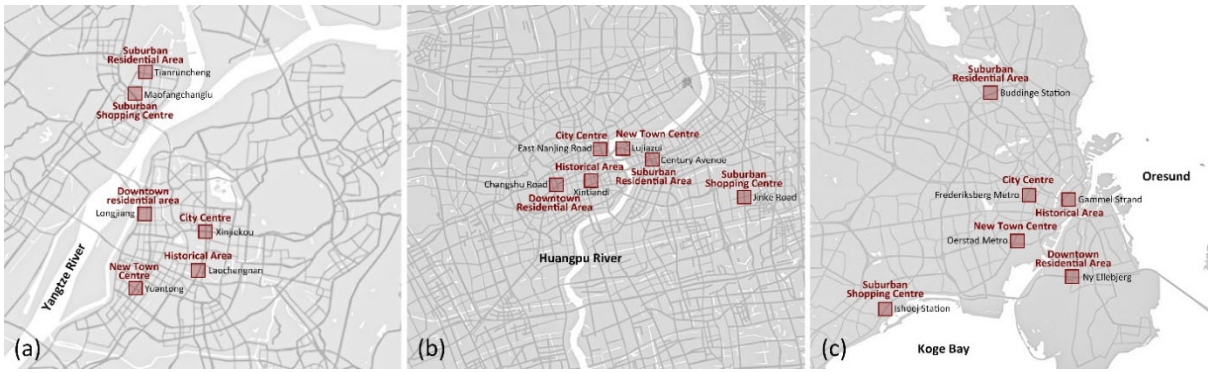

Figure 1. Case Study Selection: (a) Nanjing, (b) Shanghai, (c) Copenhagen, photo credit: all figures except Figure 2 in this paper are drawn by authors.

Shanghai, an international metropolis in China and a globally important economic and financial centre, has a population of around 25 million. From 1843 onwards, Shanghai was semi-colonial and absorbed Western influences, resulting in the blending of Chinese and Western cultures and building types. Since the 1990s, the Pudong New Area has undergone a period of rapid growth, transforming Shanghai into a cosmopolitan city (Figure 1b).

Copenhagen, the capital of Denmark, has a history dating back to the Middle Ages and a current population of around 1.3 million. The city underwent a rapid process of industrialisation and modernisation between the late 19th and mid-20th centuries, with expansion into surrounding regions and the development of new residential and industrial zones (Figure 1c).

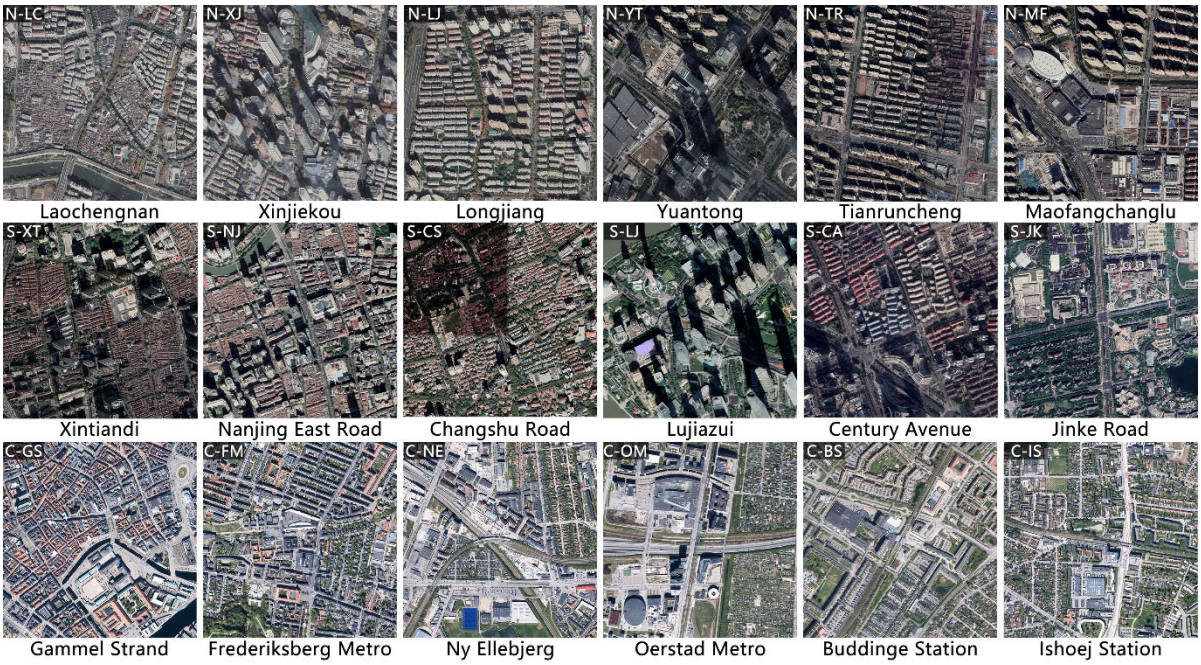

Figure 2. Satellite maps of study area with abbreviations consisting of the initials of the country and the area, photo credit: River Map (a software) and NIRAS.

Secondly, the study selects historical areas, city centres and residential areas from each of the three cities to investigate the influence of the city's stage of development on urban forms (Figure 2). ‘Laochengnan’, ‘Xintiandi’ and ‘Gammel Strand’ are selected as the study cases for historical areas. In particular, Xintiandi’, embodies a blend of Eastern and Western characteristics to highlight the cultural integration in Shanghai's historical area. Based on the location and planning, there are three categories of city centres: city centre, new town centre and suburban centre. ‘Xinjiekou’, ‘Nanjing East Road’ and ‘Frederiksberg Metro’ are selected as the study cases of city centres, which are densely populated, functionally mixed and commercially prosperous. ‘Yuantong’, ‘Lujiazui’ and ‘Oerestad’ are selected as the study cases of new town centres in the three cities respectively, which are characterised by a high concentration of companies and enterprises. ‘Maofangchanglu’, ‘Jinke Road’ and ‘Ishoej’ are selected as study cases for suburban centres. These areas tend to have large shopping malls and a large number of residential areas. In addition, 'Longjiang', 'Changshu Road', and 'Ny Ellebjerg' are selected as study cases for downtown residential areas, while 'Tianruncheng', 'Century Avenue', and 'Buddinge Station' are selected as study cases for suburban residential areas.

Cartographic Methods

The raw materials for all the study cases are collected, which are mainly provided by the research team of Nanjing University, Tongji University and NIRAS participating in the research project entitled ‘Transit-Oriented Development 2 (TOD2) – Public spaces, mobility hubs and climate neutrality toolbox’, including satellite maps, land use maps and footprint maps. The satellite map provides the fundamental features of an area, serving as an important reference material throughout the process of map creation and revision. The land use map reflects the nature of the land use and the mix of functions in an area. The footprint map includes street/blocks and buildings, based on which street/block map, street network maps, building maps (including the number of storeys), and building footprint maps are generated, which are all necessary for the study, together with the land use map, are the fundamental maps required for the study (Figure 3). These maps should be put into GIS and are described below.

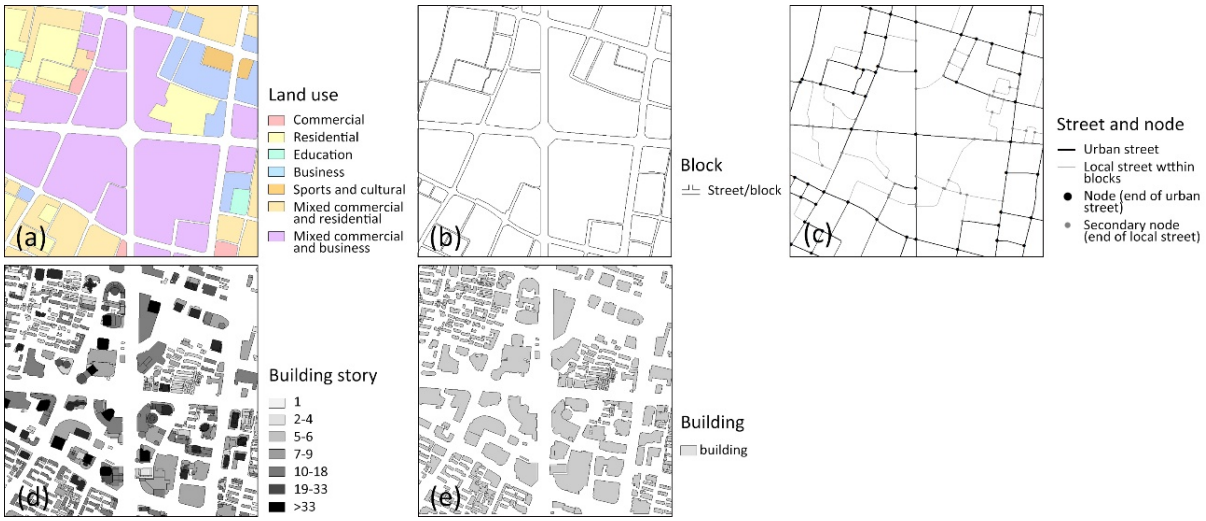

Figure 3. Five Fundamental Cartographic Maps: (a) Land use map, delineates ten distinct functions, with eight dedicated to single-use land types, including commercial, residential, and educational and the remaining two functions designated for mixed-use, comprising commercial-residential and commercial-business combinations.

(b) Map of street/block. (c) Map of street networks. (d) Map of buildings (DIM), includes seven categories according to Chinese standard. (e) Building footprint map.

Due to the influence of planning ideas, modern cities have land use maps, but different countries or areas have different criteria for classification. The study harmonised the classification of land use properties in Nanjing, Shanghai and Copenhagen into ten main functions. Based on this map it is possible to calculate indicators such as diversity and mixing degree of functions (Figure 3a).

Street/block maps and street network maps can reflect street space and street patterns. In the process of mapping, it is necessary to overcome the inconsistency of road classification between China and Denmark to ensure a uniform mapping standard. Based on the street/block map, the number, size and distribution of street blocks can be counted, and based on the street network maps, the number, density, length and connectivity of the street network can be calculated (Figure 3b,3c).

Maps of buildings (DIM) and building footprint maps can reflect the morphological characteristics of buildings. The former one contains information about the number of storeys of buildings, based on which indicators such as the number of storeys, the difference in building heights, and the floor area ratio can be calculated. The later one is based on the former one by integrating different parts of the same building through the tools in GIS. Based on this map, we can calculate the building density, ground area of buildings and other indicators (Figure 3d, 3e).

The elements of each of the five fundamental maps need to be completed in a GIS platform. Based on these, parameters such as length, area and number can be counted, which in turn allows for the calculation.

Morphological Indicators

The study analyses the three elements of streets/blocks, street network and buildings, with the aim of exploring the characteristics of street patterns, building density and building types in different areas. Previous studies have demonstrated that urbanisation has resulted in a reduction in the number of streets and blocks, an increase in the length of streets and the size of blocks, and an increase in the number of storeys and floor area ratio. Concurrently, the street network connectivity and building density have undergone significant changes. The study selects appropriate indicators that can effectively describe these characteristics, thereby enabling an accurate reflection of the impact of urbanisation and culture on urban forms.

Firstly, the Herfindahl-Hirschman Index (HHI) was selected to quantify the diversity of functions, with a value between 0 and 1 (Jiao et al., 2021). A lower value indicates a greater diversity of functions, which is associated with greater ease of living.

Secondly, morphological indicators of streets/block patterns were selected. In consideration of the frequency, clarity and stability of the indicators, the Number of Blocks per sq. kilometre (NB) and Street Density (SD) were selected to describe the density of street/blocks. Additionally, the Average Area of Blocks (AAB) and Average Street Segment Length (ASSL) are selected to describe the size of the blocks and the street length, respectively. In addition, the Connectivity Alpha Index (CAI) was selected for the purpose of evaluating the connectivity of the street networks. It can be adapted for

calculations in one square kilometre, while the resulting data reflect the diversity of actual travel choices, thereby facilitating a more accurate assessment (Song et al., 2013).

Finally, the morphological indicators of the building were selected. The Ground Space Index (GSI) and the Floor Space Index (FSI) were selected as indicators of building density. The Median Ground Area (MGA) was selected to describe the size of buildings, given that the median measure is relatively more accurate at the midpoint of the sample (Porta et al., 2014). The ratio of the FSI to the GSI, i.e., the Area-Weighted Average Storey (AWAS), was selected to describe the average height of the buildings.

Following the screening process, the study select a total of ten indicators, which were subsequently categorised into four categories (Table 1). The first category characterises to the diversity of functions. The second and third categories are concerned with the street/block pattern. The fourth category describes the characteristics of buildings. These indicators facilitate precise comparative analyses from a range of perspectives, including diachronic and synchronic comparisons.

Table 1. Selected morphological indicators to describe the characteristics of urban forms.

Category	Element	Indicator	Code	Formula	Description
1	Street/block	Herfindahl-Hirschman index [-]	HHI	$\sum_{i=1}^{k} {P_i}^2$	Where Pi is the percentage of land use i and k is the number of land-use types.
2	Street/block	Number of blocks per sq. kilometre [-/km²]	NB	/	/
		Average area of blocks [ha]	AAB	$\frac{\sum_{i=1}^{n} A_i}{n}$	Where Ai is the area of each block and n is the number of blocks.
3	Street network	Street density [km/km²]	SD	$\frac{\sum_{i=1}^{n} L_i}{A_T}$	Where Li is the length of each urban street segment and n is the number of urban street segments.
		Average street segment length [km]	ASSL	$\frac{\sum_{i=1}^{n} L_i}{n}$	Where n is the number of urban street segments.
		Connectivity alpha index [-]	CAI	$\frac{u}{2V-5}$	Where V is the number of nodes (end of links). Where u (L-V+p) is the cyclomatic number and p is the number of subgraphs.
4	Building	Ground Space Index [-]	GSI	$\frac{\sum_{i=1}^{n} A_i}{A_T}$	Where Ai is the ground area of each building and A_T is the study area.
		Floor Space Index [-]	FSI	$\frac{\sum_{i=1}^{n} A_i S_i}{A_T}$	Where Si is the storey of each building.
		Median ground area [m²]	MGA	/	/
		Area-weighted average story [-]	AWAS	$\frac{\sum_{i=1}^{n} A_i S_i}{\sum_{i=1}^{n} A_i}$	/

URBAN MORPHOLOGICAL CHARACTERISTICS AND THE INDICATORS

On the basis of the methodology described above, five fundamental maps of the 18 study areas were drawn up and the values of the indicators were calculated, with the following results (Table 2).

Table 1. Quantitative results of nine morphological indicators for eighteen study areas.

Area	HHI*	NB	AAB	SD	ASSL	CAI	GSI	FSI	MGA	AWAS
N-LC	0.21	69	1.1	16.3	0.08	0.25	0.35	1.2	52	3.4
N-XJ	0.19	46	1.8	10.7	0.11	0.15	0.35	3.7	326	10.5
N-YT	0.17	19	4.0	7.4	0.23	0.10	0.19	2.1	710	10.9
N-LJ	0.41	16	5.1	8.3	0.24	0.18	0.21	1.5	611	7.4

N-TR	0.51	8	11.7	4.2	0.30	0.04	0.15	1.2	550	7.9
N-MF	0.23	9	10.0	3.3	0.37	0	0.33	2.4	911	7.5
S-XT	0.31	39	1.7	8.9	0.13	0.35	0.35	2.0	282	5.9
S-NJ	0.14	60	0.9	11.7	0.10	0.20	0.39	2.7	350	6.9
S-LJ	0.19	24	2.5	6.6	0.14	0.10	0.18	3.1	572	17.3
S-CS	0.27	28	2.3	7.2	0.14	0.15	0.35	1.6	258	4.4
S-CA	0.24	17	3.6	5.5	0.22	0.07	0.24	1.7	440	7.4
S-JK	0.21	16	4.1	5.0	0.20	0.07	0.23	1.4	686	6.1
C-GS	0.19	105	0.8	18.2	0.07	0.27	0.42	1.7	177	4.1
C-FM	0.17	53	1.7	13.0	0.11	0.13	0.28	1.3	196	4.5
C-OM	0.18	21	4.2	7.1	0.17	0.11	0.20	1.2	56	5.8
C-NE	0.15	37	2.3	8.2	0.13	0.09	0.20	0.6	95	3.1
C-BS	0.42	34	2.7	8.6	0.15	0.05	0.16	0.3	123	2.1
C-IS	0.38	19	4.8	6.8	0.21	0.04	0.18	0.4	99	2.4

**Note: Since the two categories of mixed-use lands encompass two functions, adjustments are needed for these mixed-use lands when calculating the HHI, that is 〖P_M1/2〗^2 and 〖P_M2/2〗^2. Where P_M1 and P_M2 are the percentage of two mixed-use lands.*

In order to observe the overall trend of the multiple sets of data, the numerical results were normalised by dividing each indicator's value by its maximum value, thus ensuring that all results fell within the interval 0–1. Subsequently, the indicators were reorganised, with the second and third categories of indicators grouped together, both of which describe the street/block pattern. The fourth category of indicators was divided into two categories, with one category (GSI and FSI) describing the density of buildings and the other category (NBU, MGA and AWAS) describing the dimensions of the buildings. Finally, line plots were drawn up for the three cities, with the area defined as the horizontal coordinate and the normalised indicator scores as the vertical coordinate (Figures 4 and 5).

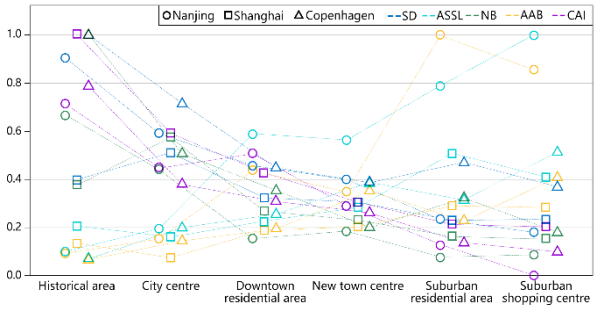

Figure 4. Comparison of quantitative results for street/block patterns.

The figure shows a gradual decrease in the values of NB, SD and CAI, while a gradual increase is observed in AAB and ASSL from the historical areas to the downtown areas to suburbs (Figure 3).

The spontaneously formed street network of the historical areas (N-LC, C-GS) has the highest SD and NB and the smallest ASSL and AAB. In contrast, S-XT was built after planning, and its grid street pattern displays the characteristics of a modern street network. The city centres (N-XJ, S-NJ, C-FM) exhibit the next highest and numerically close SD, NB, ASSL, and AAB, which may be attributed to the necessity of accommodating both pedestrian and vehicular accessibility. New town centres and suburbs are mostly formed under modern planning concepts, with sparse and wide streets, the smallest NB and SD, and the largest ASSL and AAB. In particular, the suburbs of Nanjing and Shanghai have sparser streets and larger blocks than those of Copenhagen. In many of them, the SD is less than half of that in Copenhagen, whereas the values of ASSL and AAB are two to four times higher than that in

Copenhagen, which is consistent with the phenomenon of giant blocks in Chinese cities, which has a negative impact on the pedestrian experience.

As the SD and NB decrease and ASSL and AAB increase, the connectivity (CAI) of the urban street network gradually decreases. In addition, the grid street network pattern was found to favour street connectivity. However, for areas with large ASSL and AAB, even with grid patterns, it is no longer possible to include enough complete block in 1km x 1km areas, resulting in a very small CAI.

The quantitative results of the street/block pattern demonstrate a regularity in urban development. In modern cities, there is a sparser street layout compared to historical areas, accompanied by an increase in street lengths, block sizes and a decrease in connectivity. These elements are in line with the findings of numerous established studies, which empirically demonstrate that the evolutionary patterns of urbanisation in Chinese cities (Nanjing and Shanghai) are in a consistent state with Danish cities, with a much stronger magnitude of change. They also provide quantitative evidence for understanding the differences in morphological structure between modern and traditional cities.

The population density of a city is closely related to its building density. A clear downward trend in FSI is observed in Copenhagen, with the city's population distribution is characterised by a dense population in the centre and a relatively sparse population at the edges. Conversely, the suburbs of Nanjing and Shanghai still have large populations, and in order to meet the residential needs of these people, these areas still have high GSI and FSI.

Urban building patterns are influenced by the urbanisation process and urban culture. In this process, the building types in Nanjing and Shanghai have undergone significant evolution, which is reflected in the changes in the values of the NBU and MGA indicators. Conversely, Copenhagen shows less variation in building scale and related indicators, indicating a smoother development.

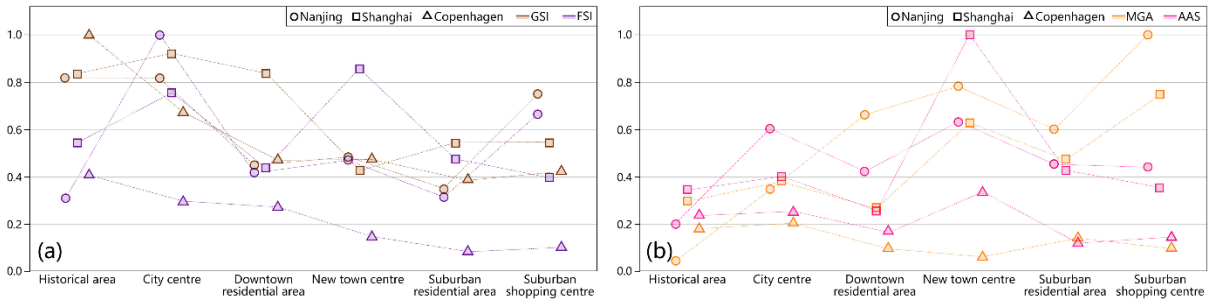

Figure 5. Comparison of Quantitative Results for buildings: (a) building density, (b) building size.

The study finds that NBU serves as an effective indicator to differentiate between historical areas and CBDs in new town, as shown in the figure, the N-LC area has an extremely high value of NBU, while the N-YT and S-LJ areas have a low value of NBU. In addition, the study points out that MGA can indicate the residential building type in one area as the individuals with MGA are usually residential buildings, and the significant differences in the MGA values for the N-LC, S-XT, C-GS, N-LJ, and S-CS areas indicate that these areas have different building characteristics. Quantitative analyses of the MGA metrics provide a direct representation of the scale characteristics of the types of residential buildings, and their validity needs to be further empirically research to verify its validity. The quantitative analysis of MGA provides a direct representation of the size characteristics of building types. However, further empirical research is required to verify the validity of it. In addition, AAS was

found to reflect the development strategy of the city. Most other parts of Nanjing and Shanghai have significantly higher AAS compared to historical areas, due to the fact that China's urbanisation tends to adopt ‘Vertical Growth pattern’ through the concentration of high-rise buildings.

COMPARISON AND ANALYSIS

The study will undertake a comparative analysis of historical areas, residential areas and city centres in Nanjing, Shanghai and Copenhagen, respectively.

The urban form of historical areas and the building type

The morphological characteristics of each city's historical areas are distinctive, and comparative analyses of building types can reveal the respective histories and cultures. However, within the 1km x 1km study areas of historical areas, only some of the buildings have been preserved in their historical forms. To accurately analyse the characteristics of urban forms and the relationships between the buildings and the morphological structure, it was necessary to redefine the study area within the original study area. The newly defined study areas are carefully screened to ensure that over 80 percent of the area are with historical forms, and was bounded by the axes of the urban streets to form the calculation area (Figure 6a).

N-LC preserved some Ming and Qing buildings and streets, and the main building type is the traditional Jiangnan houses. They are laid out in a courtyard style, with the scale of the building limited by the size of the timber and the legal requirements for residential buildings. Most dwellings comprise three ‘Jians’ (bay-room), the width of one ‘Jian’ is about 3 to 4 metres, and the depth of the dwellings is mostly 3.6 to 4.2 metres. Most buildings have a single storey, with the construction of two-storey buildings only becoming common after the end of the Qing Dynasty. The courtyard's layout is primarily symmetrical along an axis, with the central 'main room' serving as the primary activity space for the family. The ‘main room’ on the axis is the primary living and meeting space for the family, while the ‘side room’ on either side are typically used as bedrooms and auxiliary rooms. In some instances, due to the constraints of the plot's width, there may be no ‘side rooms’ or only one. The boundaries of the family plot are delineated by walls, and the ownership of the plot is distinguished.



Figure 6. Comparison of three historical areas: (a) 1km × 1km area, (b) reselected historical area, (c) one typical block, (d) elevation of the building type, (e) plan of the building type.

Shanghai's lilong houses originated in the 1950s as refugee housing and evolved with the growing property market. This resulted in the construction of a unique building type that reflected a fusion of Chinese and Western cultures (Whitehand et al., 2014). Lilong houses are densely built, constructed in close proximity to each other, with a collection of dwellings, usually 2 to 4 storeys, and with unit sizes ranging from 60 to 105 square metres to accommodate diverse resident needs (Gregory, 2015).

Danish classical buildings are usually four to five storeys high with sloping roofs, set out in rows. The buildings have narrow frontages measuring approximately 15 metres and long sides, enclosing multiple internal public courtyards. Most of the ground floors are occupied by shops or bars, with flats and offices located on the upper floors.

The numerical results for some of the updated indicators are presented in the table (Table 3).

Table 3. Quantitative results of three morphological indicators for the new study areas of three historical areas.

Area	NBU	MGA	AWAS
N-LC	148.0	31	1.4
S-XT	13.1	278	2.8
C-GS	16.5	174	4.1

The urban forms of N-LC and C-GS are both the result of natural evolution, and they are different in building types, but there are some similarities in their formation logic and morphological structure. In terms of building scale, the quantitative results of N-LC indicate that most buildings have ground areas of around 30 square metres and are one or two storeys in height, which is highly consistent with the building scale of traditional Chinese Jiangnan houses. The living units of people in N-LC are situated within courtyards comprising two and twelve buildings. Families with more people and higher economic status tend to have more buildings. The quantitative results of C-GS demonstrate that most

buildings have ground areas of around 170 square metres and are around four storeys in height. This result reveals the basic scale of Danish classical buildings. In terms of morphological structure, the courtyards in the N-LC and the buildings in the C-GS are typically aligned along the longer side of the blocks. The length of the block is typically determined by the number of courtyards or buildings in that direction, which is usually an integer multiple of the number of courtyards or buildings. The width of the block is typically determined by the number of 'Jin' in the courtyard (reflecting the size of the family) or the depth of the building, as well as the number of courtyards or buildings in that direction. Despite the differences in building types and living units across cultures, the similarity in layout patterns indicates a common underlying logic in the organisation of living space.

The buildings in S-XT are constructed according to a planned street network that considers the fundamental scale and layout pattern of lilong houses. They can vary in length by adjusting the number of dwelling units. Furthermore, the distribution and the number of units are planned according to the size and shape of the site. The quantitative results indicate that most buildings have ground areas of around 380 square metres and are two to three storeys in height. This suggests that the number of units contained in most buildings in the area is calculated to be between seven and twelve.

Residential area and morphological characteristics

The residential areas of the three cities exhibit distinctive morphological characteristics, reflecting their distinct economic and cultural contexts. There are many slab apartment in N-LJ, N-TR and S-CA, which are a typical residential building type that has entered the modern Chinese cities. These buildings are generally orientated east-west to gain more sunlight, with the spacing between adjacent north-south buildings increasing with the number of storeys. Each building usually contains a number of dwelling units, and each dwelling unit usually consists of 2-4 living units (Liu and Ding, 2012). The buildings in S-CS are mainly garden houses and attached houses built in France from the 1910s onwards, and present a variety of architectural styles such as classical European and Lilong houses. The buildings in C-NE and C-BS are mainly villas and each building is suitable for one family (Figure 7). As with the historical area, the study areas must be redefined to ensure that they are populated with residential buildings and to update the relevant indicator results (Table 4).



Figure 7. Elevations of typical types of six residential areas: (a) Slab apartment buildings in N-LC, built in 1999-2002, (b) garden houses in S-CS, built in 1941. (c) Villas in C-NE. (d) Slab apartment buildings in N-TR, built in 2010-2014. (e) Slab apartment buildings in S-CA, built in 1999, (f) Villas in C-BS.

Table 4. Quantitative results of four building morphological indicators for the new study areas of residential areas.

Area	GSI	FSI	MGA	AWAS

N-LJ	0.23	1.5	597	6.6
N-TR	0.15	1.2	550	7.9
S-CS	0.32	1.4	275	4.3
S-CA	0.24	1.5	475	6.3
C-NE	0.19	0.6	80	3.4
C-BS	0.15	0.2	120	1.6

In Chinese cities entering modernisation, the type of residential building, the number of storeys and the given FSI are highly correlated. A combination of building codes and economic factors has resulted in the predominant use of 6, 11, 18 and 33 storeys in slab apartment buildings. Property developers often choose the appropriate number of storeys and building type based on the FSI constraints in the site. Typically, economic efficiency, land price and FSI are highly correlated, and the higher FSI, the higher the number of storeys of the building (Zhang and Ding, 2013). Land prices in Chinese cities are often related to the stage of development and locations, and similar construction years tend to have similar FSIs. A comparison of the quantitative results for three residential areas, N-LJ, N-TR and S-CA, which are dominated by slab apartments, reveals that although S-CA is in the suburban area of Shanghai, it was developed in a similar era to N-LC, located in the downtown of Nanjing. Consequently, as areas developed in the same period of time in China, they have similar land prices as well as similar FSIs, which lead to their similar morphological characteristics. The quantitative results of the comparison between the residential areas of Nanjing and Copenhagen demonstrate that Copenhagen has experienced suburban developments with a low population density, which has led to the C-BS having a low GSI and FSI. This development is a result of factors such as steady economic growth, increasing popularity of villas, and a long urbanisation period. In contrast, the rapid urbanisation rate, high urban population density and the 'Nanjing villa construction ban' (posted in 2021) have resulted in Nanjing continuing to develop in a high-density pattern in the suburbs.

Shopping Centre and Commercial Configuration

Different lifestyles give rise to different commercial configurations and forms of shopping centres. The study calculated the proportions of major functions and HHI in the city centres (including city centres, new town centres and suburban shopping centres) (Table 5).

Table 5. The functional proportion of the city centre areas in three cities.

Area	Commercial	Residential	Office	Mixed commercial and residential	Mixed commercial and office	Other functions	HHI
N-XJ	2%	12%	10%	19%	54%	3%	0.19
N-YT	2%	11%	15%	0	33%	39%	0.17
N-MF	32%	32%	10%	9%	17%	0	0.23
S-NJ	11%	18%	5%	25%	36%	5%	0.14
S-LJ	1%	0	12%	0	44%	43%	0.19
S-JK	21%	23%	19%	0	10%	27%	0.21
C-FM	6%	22%	3%	43%	0	26%	0.17
C-OM	17%	34%	4%	0	16%	29%	0.18
C-IS	17%	58%	0	13%	0	12%	0.38

A statistical analysis of the data reveals that, despite significant cultural differences, the functional diversity of urban business districts in all three cities decreases with distance from the city centre (HHI increases). The city centres exhibit a high level of mixed land use, high diversity, and a wide range of commercial distribution, predominantly in the form of ground-floor businesses along the street. This

results in a high level of living convenience and urban vibrancy. The commercial activities in new towns and suburban centres are concentrated in large shopping malls, which limits residents' commercial options. Furthermore, many people are forced to use cars to get to the shopping centres in these areas due to the large scale of the blocks.

CONCLUSIONS AND DISCUSSIONS

This study reaches the following conclusions.

Firstly, the cross-cultural comparative study reveals the general characteristics and patterns of urban forms that emerge as a result of the transition to a modern mode of urban development. The diachronic analysis verifies that as the distance from the city centre increases, all three cities demonstrate a tendency for the street network to become increasingly sparse, with an accompanying increase in the length and size of blocks. This, in turn, leads to a decrease in connectivity. Concurrently, the influence of the planning concept of functional zoning has resulted in the formation of specialised commercial and residential areas in all three cities. The scale and configuration of the commercial areas in these areas are designed to meet the needs of the neighbouring residential areas they serve. It is also noteworthy that, despite their disparate cultures, the historical areas of Nanjing and Copenhagen show significant similarities in the relationship between building types and block sizes, as well as the morphological structure. This observation suggests that the morphological structure of historical areas may possess a cross-cultural universality, reflecting the limited influence of cultural factors on it.

Secondly, this study further examines the differences of urban morphological characteristics that influenced by urban history, culture and urbanisation processes. A comparative analysis of historical areas demonstrates that, despite their similar morphological structures, the building types observed therein exhibit variation according to their historical and cultural contexts. The traditional Jiangnan houses in Nanjing and the Copenhagen classical buildings reflect their unique cultural and historical backgrounds. In contrast, the lilong houses in Shanghai represent a cultural fusion, exhibiting a combination of Western planning concepts and the characteristics of the traditional Chinese courtyard in their building and room layouts. A comparative analysis of the suburbs reveals that the differing rates of urbanisation and the establishment of administrative boundaries between China and Denmark have resulted in notable differences in the density and capacity of the urban suburbs. The process of urbanisation in Danish cities has been extensive, and the low population density, has resulted in a current urban population characterised by a dense central area with sparse edges. This has led to the predominant development of low-density villas in its suburban areas. In contrast, in the 1950s, China's urban-rural dichotomy led to a massive influx of people from rural to urban areas. During this period, the population of Nanjing and Shanghai's originally designated urban fringe areas continued to grow. As a result, both cities chose to address the housing needs of these people by building high-rise housing in the fringe areas of the city, leading to the high density and capacity of the suburban areas identified in this study.

Thirdly, the quantitative approach of this study provides an objective assessment method and analytical framework for understanding the universal laws and differences of urban form. It also enables the morphological characteristics of a particular area to be described, thus allowing the

definition of urban area attributes. To illustrate, the Century Avenue area, which was previously considered suburban residential area, was found to be similar to the downtown residential area of Nanjing through quantification. This led to the conclusion that they belonged to architectural products of the same period. Furthermore, this study employed quantitative and comparative analyses to identify key urban morphological indicators, specifically street density (SD) and median ground area (MGA), which are useful for describing the morphological structure and the characteristics of building types. SD demonstrated significant differentiation ability in assessing the morphological structure and walkability within 1km × 1km areas. Its values were able to map the urbanisation of different stages of urbanisation, with SD exceeding 20 km/km² in historical areas, SD being about 10 km/km² in downtown areas, and SD usually being less than 8 km/km² in new town and suburban areas. Further research indicates that areas with SD values exceeding 8 km/km² tend to exhibit enhanced connectivity, a finding that provides a reference for planning authorities when designing the street network system in new districts. MGA is capable of accurately characterising building types across different areas by quantifying the building ground area, as individuals with a median building ground area often represent the typical building type observed in a given area. The universality of it has been demonstrated through its application in the identification of building types in historical areas.

The subsequent discussion section of this paper will focus on the experiences and strategies encountered during the research process, offering insights for future studies. The selection of typical cases and refined and standardised mapping are two crucial aspects when using quantitative approaches for comparative studies. The study selects several Western-influenced areas in Shanghai as samples of urban forms where East meets West. Although they are capable of revealing the characteristics of urban form under the influence of different historical cultures in synchronic comparisons, the S-XT and S-CS exhibit atypical characteristics in diachronic comparisons, which are mainly due to their unique historical backgrounds, and they do not represent the patterns of urban development in general. In addition, in order to ensure the accuracy of the quantitative study, the original maps must be supplemented, corrected and updated to meet the requirements of different quantitative indicators on map fineness. In cross-cultural comparative studies, unified mapping standards are particularly important, such as in the case of China and Denmark, where unified standards for the division of land use properties, street grades, etc. are needed to ensure the consistency and validity of quantitative comparisons.

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Enhancing pedestrian accessibility in mega-railway station areas towards integrated station-city development

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ABSTRACT

Railway hubs, as mega-scale transportation complexes, play a pivotal role in urban areas due to their vast scale and significance as key nodes within and outside cities. Previous studies have shown that promoting pedestrian accessibility is crucial for enhancing the vitality of hub areas and promoting regional development. Therefore, this research aims to explore which morphological forms are more effective to enhancing pedestrian accessibility from mega railway station areas to various urban functions, thereby improving the integration between mega hub stations and cities. This paper selects Tianjin station as old station and Shenzhen North Station as the new one compare with three other stations which have similar platform scale and average daily passenger flow but significant differences in pedestrian connections between the station and the city, as well as surrounding area morphology. Using tools such as sDNA, the study evaluates pedestrian accessibility of the station area in different aspects. Through the analysis of pedestrian accessibility and the morphology of the area, the research aims to identify existing issues and propose corresponding solutions of the mega railway station area in China.

Keywords: railway station, pedestrian accessibility, sDNA, station-city integration, morphology

INTRODUCTION

High-speed rail (HSR), with its powerful space-time compression effects, has restructured the spatial patterns of cities and regions. As a critical node in China's transportation network, HSR stations possess significant potential for development and redevelopment due to their high regional accessibility and the large volume of human activity they attract.

The concept of Station-city Integration is rooted in the systematic integration and organic coordination at the urban, regional, and nodal levels. At the station area level, effective pedestrian accessibility not only enhances the connection between the station and surrounding areas geographically, allowing for the rapid dispersal of large passenger flows to adjacent districts, but also promotes low-carbon station development. More importantly, it enables the station to truly function as a catalyst for regional growth.

Currently, the rapid development of mega railway station areas in China has been hampered by traditional large-scale, rapid development models which prioritizes fast car access over pedestrian accessibility in transportation approaches. This paper analyses pedestrian accessibility and the surrounding area morphology of both domestic and international cases to provide recommendations for enhancing pedestrian accessibility in existing and new-planned mega railway station areas in China.

Case selection

This study selects Shenzhen North Station and Tianjin Station in China, Utrecht Central Station in Europe, Fukuoka Hakata Station in Japan, and Liverpool Street Station in the UK as research subjects. These five stations share similar numbers of platforms and daily passenger volumes, which face comparable challenges in pedestrian flow management and have high requirements for pedestrian accessibility. However, due to differences in geographic location and development patterns, these stations exhibit distinct surrounding area morphologies. Comparative analysis of these cases will help identify pedestrian accessibility characteristics and issues under different conditions.

Table 1. Platform size and daily passenger volume of five cases, self-drawn.

Station	Location city	Construction years	Surrounding city development	Platform and track size	Average daily delivery volume
Shenzhen North Station	Shenzhen, China	2011	Planning sub-centers	20 tracks, 11 platforms	275000
Tianjin Station	Tianjin, China	1988/ 2008	regeneration city center	18 tracks, 10 platforms	110000
Utrecht Central Station	Utrecht, Netherlands	2016	Planning sub-centers	16 tracks, 8 platforms	207400
Fukuoka Hakata Station	Fukuoka, Japan	1960/ 2011	regeneration city center	14 tracks, 7 platforms	200328
Liverpool Street Station	London, Britain	1992	regeneration city center	17 tracks, 9 platforms	183471

Shenzhen North Station, which began operations in 2011, represents a later-developed station in China. It was the first to eliminate the traditional large station square, allowing passengers to transfer between various modes of transportation without leaving the station. This makes it one of the most efficient and convenient mega stations in China. By comparing Shenzhen North Station, a newly planned area, with Tianjin Station, a more maturely developed area in China, and other foreign stations with well-established pedestrian systems, this study can more effectively reflect the current pedestrian conditions around two generations of mega-stations in China.

According to the TOD (Transit-Oriented Development) model, the influence area of HSR stations can be divided into core, impact, and peripheral impact zones (Cao et al., 2020). Building on Sorensen's methodology and conclusions (Sorensen, 2000), Peter M.J. Pol redefined the potential impact areas of HSR stations into three zones and the primary one is within a 5-to-10-minute walking distance (Pol, 2002). Therefore, a 5-minute walking radius and a 1000-meter radius (approximately 15 minutes) from the station entrance is used to define the area for pedestrian accessibility studies. Additionally, a 2000-meter radius is employed as a buffer zone for modeling pedestrian pathways.



Figure 1. Core area of five station with a radius of 1000-meter, self-drawn.

Literature review

Walking is an essential component of sustainable travel and healthy, low-carbon living (Giles-Corti et al., 2016). Pedestrian accessibility specifically reflects the ease with which people can walk from one location to another. Studies indicate that areas with higher accessibility and pedestrian-friendliness increase the likelihood of residents choosing to walk (Kang et al., 2017).

Early studies on train station accessibility primarily focused on measuring walking distances to stations (Currie, 2010; El-Geneidy et al., 2014; Lin et al., 2014) or walking time (Mavoa et al., 2012; Transport for London, 2010; Yigitcanlar et al., 2008). More recent research has expanded these analyses. For instance, factors such as walkability, accessibility features, and the slope of pathways to stations were taken into consideration (Kizawa and Takami, 2008; Kita et al. 2012). Japanese researcher employed random utility theory to model the choice of nearest train stations, assessing station accessibility and finding that improving station accessibility and rail service frequency can increase resident rail usage (Terayama et al., 2015).

Another body of literature focuses on case studies. One approach analyses the design methods for individual hub-based pedestrian systems, such as Qingdao Station (Ma et al., 2021), Xuzhou Railway Station (Wang et al., 2017), examining key design features, existing issues, and planning optimizations towards it. Another approach compares multiple stations, broadening the accessibility concept including environmental factors, to establish a more comprehensive pedestrian accessibility assessment frameworks (Wu et al., 2017; Li et al., 2023; Gui et al., 2024;).

Current pedestrian accessibility assessment methods utilize new tools, such as GIS network analysis and sDNA, to evaluate the quality of facility layouts (Zhao and Zhang,2024; Fan,2024) and pathways design (Fan,2020). For example, Liu constructs an “O-D cost matrix” alongside sDNA spatial syntax models to assess street network accessibility and indicator correlations in studies analyzing Guiyang’s central district (Liu et al., 2022). However, network analysis and sDNA methods are often applied to single cases or specific areas, limiting broader insights.

Existing researches often overlook the diverse accessibility needs of urban populations and passenger groups in station area. Many studies focus on single-station evaluations, making it challenging to compare stations with varying passenger volumes, which limits the potential for generalizable findings. In this paper, we analyze both new and existing stations in different countries, incorporating population and centrality distinctions to establish refined accessibility metrics. Using new tools to conduct multi-station comparisons, this study enables more effective visualization and quantification of accessibility differences across stations, thereby identifying their unique features and issues, ultimately proposing a more specific suggestion

METHOD

This study begins with the analysis of the urban morphology surrounding five station areas that impact pedestrian accessibility, focusing on station layout, road network structure, and pedestrian connectivity patterns.

In the second step, pedestrian accessibility in mega station areas is studied in two parts based on different population attributes. First, passenger groups are key participants in enhancing the vitality of areas surrounding railway stations. Therefore, the first part uses network analysis to assess the pedestrian accessibility centred on the station. This involves analysing the reachable areas and functions based on real pathways and walking time of the travellers. The second part focuses on non-passenger groups, where movements may not have the station as the start or end point. Here, sDNA analysis is used to comprehensively evaluate the pedestrian accessibility of the whole station area, reflecting the overall pedestrian accessibility of the surrounding area and the impact of the high-speed rail station on the pedestrian network.

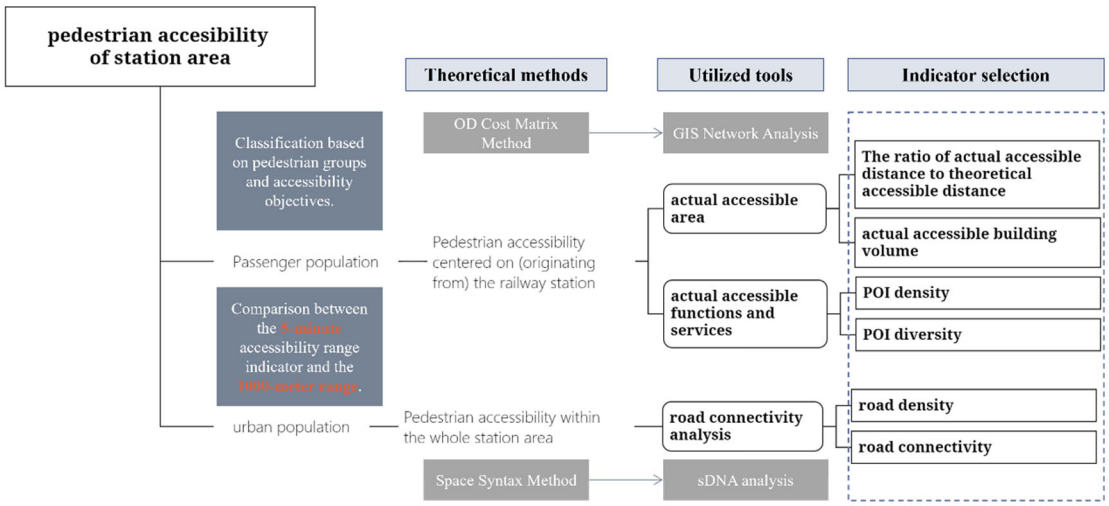

Figure 2. The research frame and selected indicators of pedestrian accessibility, self-drawn.

By comparing pedestrian accessibility across different station morphologies in a radius of 5-minute walking time and one in 1000 meters, the study identifies the characteristics and challenges of each type. Also, specific suggestions are given to Tianjin station and Shenzhen North Station as the representative of mega station area in China.

Data sources and processing

This study utilized road network data from Open Street Map (OSM) to analyse pedestrian accessibility in the mega station areas. The data were imported into ArcGIS 10.8, where road types were filtered and refined using Google/Baidu street Maps for error correction and data supplementation.

As for the accessibility of diversity functions and services, it is assessed using Points of Interest (POIs) data. Data sources vary according to case study locations. For Shenzhen North Station and Tianjin Station, Gaode Map is preferred as it provides one of the most complete datasets with minimal manual editing. For the other three stations, data is obtained from OSM which is more complete.

Analysing tools

OD Cost Matrix

The OD Cost Matrix is a time-based matrix created between supply and demand points, calculated using real travel paths based on ArcGIS's Network Analyst tool. The analysis uses the average minimum impedance, which can be expressed by the following formula:

$$MI_i = \frac{1}{n-1} \sum_{j=1, j \neq i}^{n} (d_{ji})$$

where MI represents the overall accessibility of the network, $\boldsymbol{MI_i}$ is the accessibility of node i on the grid, and $\boldsymbol{d_{ji}}$ is the minimum impedance between nodes j and i.

In this study, the analysis starts from the entrances and exits of mega stations, including height information and considering the connections between the station and external urban spaces via bridges and underground passages. A normal walking speed of 5 km/h is assumed, and the actual accessible area, reachable services and functions based on the POIs are calculated.

sDNA

The sDNA (Spatial Design Network Analysis) tool developed by Cardiff University is used to analyze accessibility and centrality in the street network. Based on the ArcGIS platform, sDNA supports the analysis of 3D networks, including vertical connections such as stairs, elevators, and escalators.

For this study, a walking radius of 500 meters is chosen, which is commonly considered a comfortable walking distance. The analysis focuses on two primary metrics: Network Quantity Penalized by Distance of Angular (NQPDA) and Two Phase Betweenness (TPBt). "Angular" (minimizing turns and intersections) is used as the measurement standard.

NQPDA measures the total number of street network topologies within a certain radius, reflecting the integration of a particular space in the system and its potential for traffic attraction. TPBt is a measure of betweenness centrality, representing the probability of traffic flow through the network within the search radius. Higher betweenness indicates stronger through-traffic potential, corresponding to higher vehicle and pedestrian flow in reality.

RESULTS AND DISCUSSIONS

Quantitative analysis of morphology

The initial step is to summarize differences in station morphology, divided into three main aspects: station form, road network, and pedestrian mode.

For the road network, scale differences can be ex/tpressed through block size. According to their structural patterns, networks can be categorized into grid, hybrid, and free-form types. (Gui and Li, 2015).

Table 2. Station form, block size and pedestrian mode of five cases, self-drawn.

Station	Station Form	Station Form	Station Site Area	Average Block Area	Road Network	Pedestrian Mode
Shenzhen North Station	Through Station	Planar (Ground-level) Station	82612	187481	Large, Grid	Passageway Connection Model
Tianjin Station	Through Station	Planar (Ground-level) Station	39636	35397	Large, Hybrid	Metro Transit Model
Utrecht Central Station	Through Station	Planar (Ground-level) Station	26030	9950	Small, Hybrid	Passageway Connection Model

Fukuoka Hakata Station	Through Station	Elevated Station	22000	6622	Small, Grid	Multi-level Connection Model
Liverpool Street Station	Terminal (Dead-end) Station	Underground Station	22900	5650	Small, Freedom	Metro Transit Model

In terms of pedestrian mode, the study classifies the connectivity between station blocks and surrounding blocks based on structural typologies: 1. Flat Monolithic Model: Stations and nearby blocks are connected on a single plane, with no additional elevated or subterranean pathways.

2.Layered Connections (2 levels): Connections are achieved through another elevated level in addition to the surface, such as footbridges, underground passages, and subway links, which includes most of the mega station cases.

3.Multi-Level Connections: Fukuoka's Hakata Station exemplifies this, with a sophisticated network of elevated walkways and underground passages. Besides functional subway exits, this category includes underground shopping streets that connect various blocks within the region.

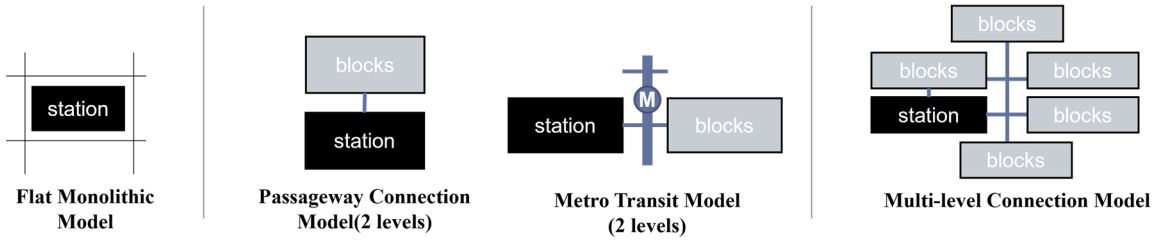

Figure 3. The pedestrian mode, self-drawn.

These differences in station form, road network, and pedestrian connectivity are primary contributors to varying levels of accessibility. It is evident that stations in China generally have much larger plot and station sizes when managing comparable passenger flows.

Actual accessible area

The actual accessible areas of the five stations are difficult to compare directly due to the involvement of numerous variables. To eliminate the impact of the number of mega station entrances and exits, as well as the presence of non-development land such as rivers and forests, focusing on station layout, road network and pedestrian connectivity patterns, this paper introduces the concept of the Actual Accessibility Ratio. The actual accessible area is calculated using the OD cost matrix based on a walking speed of 1.4 m/s over 5, 10, and 15 minutes. The theoretical accessible area is the envelope formed by circles drawn with radii calculated from this walking speed and time, subtracting non-urban land. The Actual Accessibility Ratio is the ratio of the actual accessible area to the theoretical accessible area.

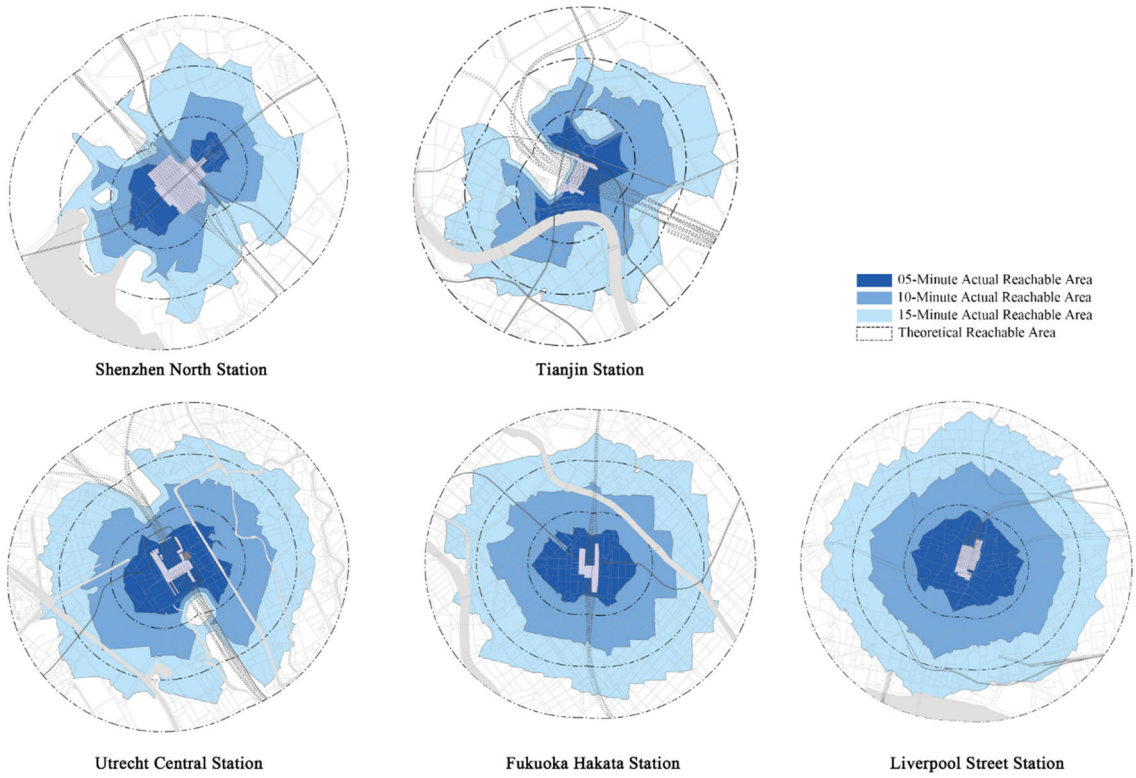

Figure 4. The accessible area of 5 stations in 5/10/15- minutes' walk, self-drawn.

According to the figure 4, all stations exhibit a spindle-shaped accessible area because of the separation between train platforms and railways. This effect is more pronounced in areas like Tianjin Station, where there are few paths crossing or near the railway tracks. Both Shenzhen North Station and Tianjin Station demonstrate poorer accessibility and balance between different directions compared to the other three stations, largely due to the design of large road networks and the lack of pedestrian paths within blocks surrounding the stations. In fact, it is difficult to walk to the theoretical 10-minute walking area around these stations.

Table 3. Actual accessible area and Accessible Ratio of five cases, self-drawn.

Station	Actual 5-Minute Reachable Area	5-minute Accessible Ratio	5-minute Accessible volume	Actual 15-Minute Reachable Area	15-minute Accessible Ratio	15-minute Accessible volume
Shenzhen North Station	265368.9	30.64%	1800780.51	2488610.3	45.71%	3575703
Tianjin Station	267503.5	36.31%	1688032.00	2745412.1	50.31%	4160000
Utrecht Central Station	421865.8	53.71%	4251124.71	3262989.5	60.02%	6363564
Fukuoka Hakata Station	362323.6	51.60%	3706798.06	3384202.2	65.38%	13338150
Liverpool Street Station	489461.0	66.42%	9434195.00	3779752.7	70.28%	15073781

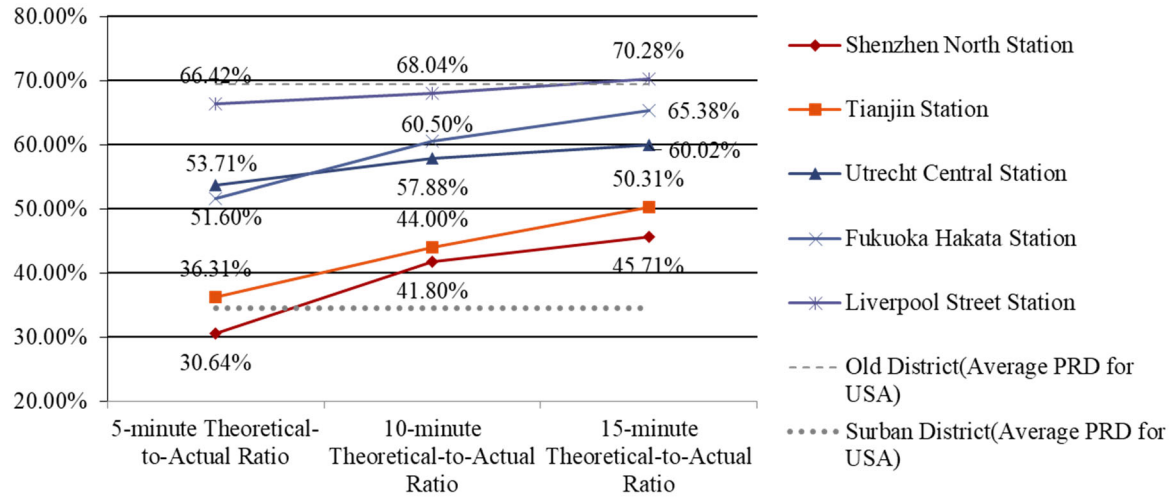

Figure 4. Actual accessible ratio of five cases, self-drawn.

For planar stations, Utrecht Central Station also displays a spindle-shaped accessible area, but the width and length of the impact caused by the tracks are smaller than those of domestic stations in China. As a result, it achieves relatively good accessibility, especially in its core area where the internal connections over the tracks are appropriately spaced.

The PRD (Pedestrian Route Directness) is the ratio of the actual walking path length to the straight-line distance between two points. Its calculation principle is consistent with the pedestrian accessibility area, meaning that the Actual Accessibility Ratio can also be derived from the PRD coefficient. According to research (Gui et al., 2023), PRD in older urban areas in the U.S. is about 1.2, and around 1.7 in newer areas, corresponding to actual accessibility ratios of approximately 69.4% and 34.6%, respectively. In contrast, the actual accessible area within the 5-minute core walking zone of Shenzhen North Station and Tianjin Station is significantly lower, nearing suburban neighborhood levels in the U.S. This is mainly due to the construction of large road networks designed for rapid car dispersal and the lack of connections across large road networks and stations.

Accessible functions and services

To enhance station-city integration and boost the vibrancy of areas surrounding mega stations, having sufficient and diverse functions is essential. As walking commuters need destinations, the density and diversity of these functions affects their choice of travel modes.

This study classifies and quantifies eight major types of functions. In the accompanying figure, we can see significant differences in POIs (Points of Interest) clustering across the five major stations in the radii of 200m, 500m, and 1000m. Newly planned stations, such as Shenzhen North Station and Utrecht Central Station, show more concentrated POIs distributions, primarily within the station area and nearby mature development zones. In contrast, older mega station areas not only have a greater number of functions but also exhibit a more dispersed distribution. Fukuoka Hakata Station, however, is bordered by a large residential area on the opposite side of the river. Given that high-speed rail in Japan often plays a more significant role in daily commuting compared to other countries, residential areas have become important destinations. Additionally, discrepancies in the number of functions may be due to incomplete map data.



Figure 5. Distribution of facilities of five cases, self-drawn.

Using Shannon's entropy formula, which measures diversity, we calculate the diversity index of functional facilities around different stations. Following the figure 6 from top to bottom, the diversity indices for each station, starting with Shenzhen North Station, are 1.48, 1.48, 1.28, 1.67, and 1.28. This shows that the differences between stations are relatively minor, indicating that intentional configurations or gradual developments have led to a fairly diverse range of functions around each station.

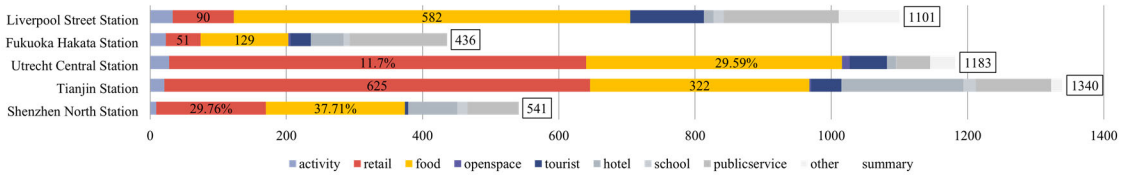

Figure 6. Numbers of different facilities of five cases, self-drawn.

After conducting an OD cost matrix analysis of these functions, they are divided into four categories: within the station, within a 5-minute walk outside the station, within a 10-minute walk, and beyond 10 minutes. Comparing the five station areas, there is little variation in the quantity and diversity of on-site service facilities. The primary differences in station function development occur in the 5–10-minute intermediate concentric layer.

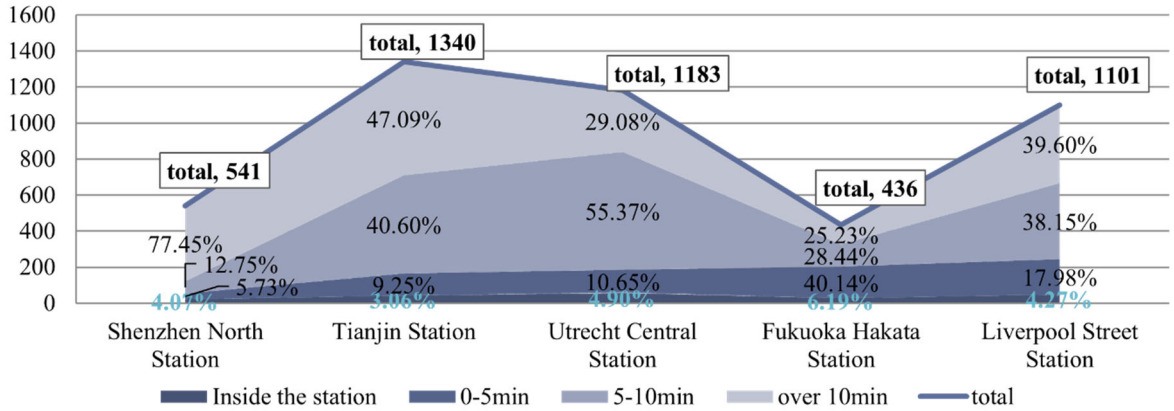

Figure 7. The portion of facilities in Iso-time zones, self-drawn.

Assuming an even distribution of POIs, based on mathematical geometric proportions, the proportion of POIs within 5 minutes/5-10 minutes/1000m should be 18%, 53%, and 29%, respectively. In terms of distribution, Utrecht Central Station closely aligns with this distribution. Fukuoka Hakata Station and Liverpool Street Station, however, exhibit a stronger "concentrated" clustering effect of station-related functions. In contrast, outside of Shenzhen North Station's station area and adjacent plots, the next layer is largely comprised of gated communities and large green spaces. Given that high-speed rail still plays a relatively minor role in daily work commutes in China, it is evident that newly planned stations like Shenzhen North Station do not prioritize station-centric function distribution in the 5–10-minute core zone.

Road connectivity analysis through sDNA

Using the sDNA tool, a walking network analysis was conducted with a radius of 500 meters, employing the natural breaks classification method for presentation. Utrecht Central Station shares similar characteristics with Tianjin Station and Shenzhen North Station. Because of their planar station layout, the pedestrian accessibility surrounding these mega stations is relatively poor.

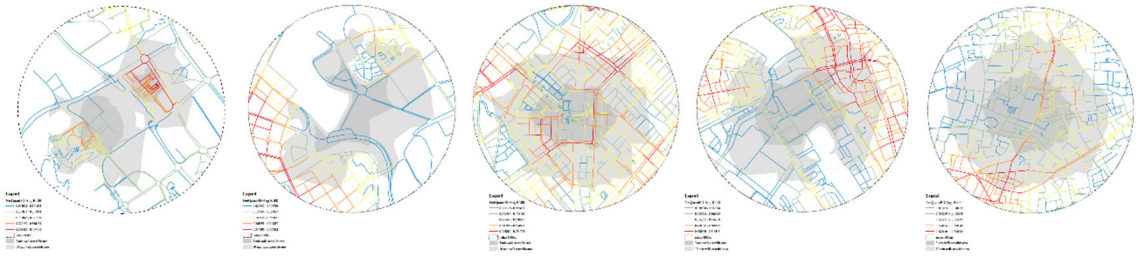

Figure 8. NQPDA500 figure of five stations using sDNA, self-drawn.



Figure 9. TpBetweeness500 figure of five stations using sDNA, self-drawn.

The analysis results from sDNA indicate that direct comparisons of values are challenging due to the different characteristics of road networks. After applying the natural breaks classification method, the accessibility values for each segment reflect its relative standing within the station area. By statistically analysing the lengths of roads within each accessibility tier, it becomes evident whether the roads surrounding the train stations are below or above the average performance within the holistic urban area.

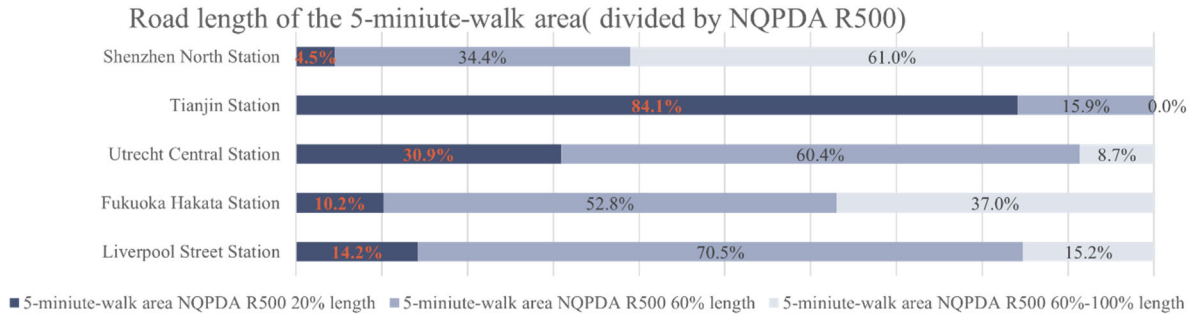

Figure 10. The portion of roads in different connectivity levels in 5-minute-walk area, self-drawn.

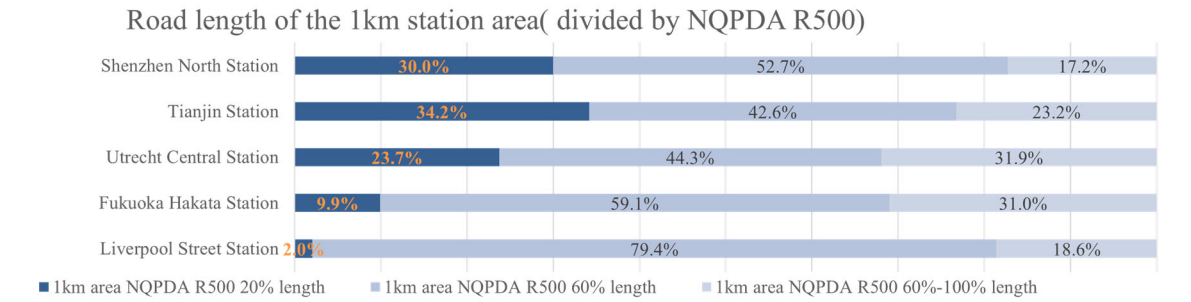

Figure 11. The portion of roads in different connectivity levels in 1km area, self-drawn.

Tianjin Station, as an older station, has a weaker pedestrian system compared to Shenzhen North Station, despite both having similar station layouts. The excessive length of underground passages in Tianjin Station significantly reduces pedestrian accessibility. Within the 5-minute walkable area, the roads falling within the lowest 20% accessibility tier—represented by the darkest blue on the map (figure 8)—account for a staggering 84%. Conversely, Shenzhen North Station, as a new station, greatly improved the pedestrian network in its vicinity but lacks external connections, currently limited to nearby commercial facilities without further extensions. In the case of Fukuoka Hakata Station and Liverpool Street Station, the road networks adjacent to these stations exhibit high levels of pedestrian accessibility.

Within the 1 km analysis range, all three planar stations display a high proportion of roads falling within the lowest 20% accessibility tier, as indicated by the darkest blue roads. Compared to the two domestic stations, which suffer from the effects of enclosed residential communities leading to dead-end roads and a large-scale road network, Utrecht Central Station demonstrates comparatively better performance.

Pedestrian accessibility evaluation

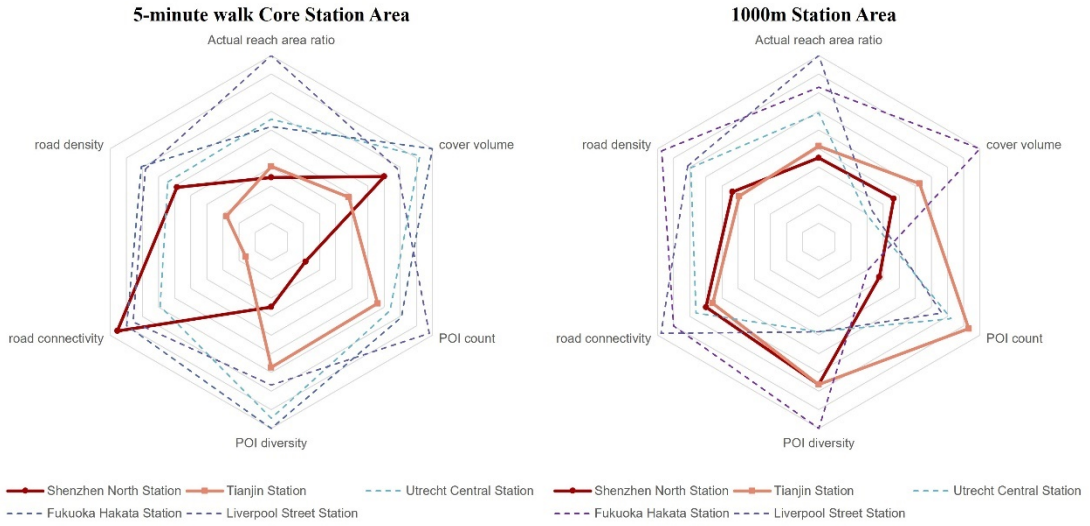

Figure 12. Comparison of the pedestrian accessibility in five stations, self-drawn.

Finally, integrating the evaluations across six accessibility dimensions, the data was normalized and presented using radar charts. In the 5-minute-walk core area of the mega station, Shenzhen North Station shows a higher design standard for pedestrian infrastructure and larger building volume. However, there are significant shortcomings in facility configuration and the extension of accessible areas. Tianjin Station, being an older station, suffers from excessively long and singular pedestrian paths across and near the station, resulting in lower connectivity in its core area compared to external regions.

To address these issues, Tianjin Station—representing existing older railway stations—should focus on enhancing connectivity through the construction of cross-station passages, improving the northern square, and better linking the station to the external city centre.

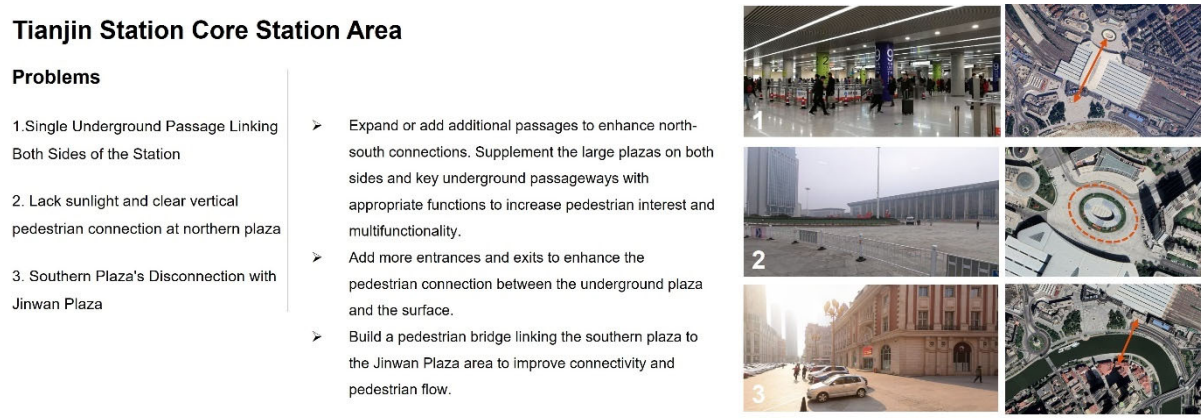

Figure 13. Suggestions to Tianjin Station, self-drawn.

In the 1 km influence range of the station, mega stations in China exhibit poor pedestrian accessibility due to differences in road network density and structure. This poor connectivity, coupled with high building volumes, may lead to a reduced choice for walking among users. Moreover, the service facilities around newly planned stations tend to be overly concentrated, lacking the development of mature commercial districts, which should be a focus for future improvements.

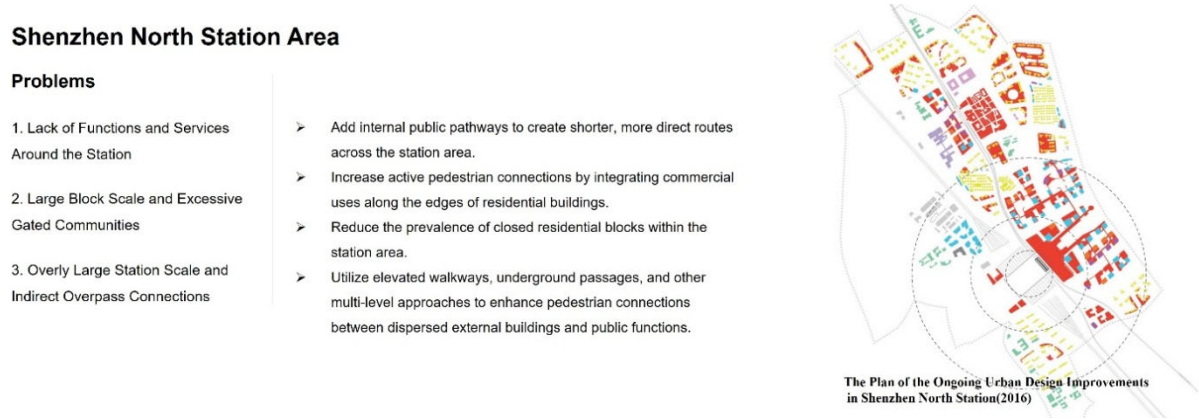

Figure 14. Suggestions to Shenzhen North Station, self-drawn.

CONCLUSIONS

After summarizing the station layout, road network, and pedestrian connectivity patterns of the five selected stations, this study evaluates their accessibility features across six dimensions. This evaluation highlights the factors driving each station's accessibility characteristics and uncovers the underlying morphological features shaping them.

The three planar stations showed relatively poor performance in accessibility assessments related to road networks. Utilizing elevated or subterranean solutions could effectively mitigate the barriers presented by tracks and platforms, thus enhancing performance in core station areas.

Chinese railway stations exhibit variability in accessibility due to differences in road networks and station scales, which is normal resulting in weaker data performance. But it can still remind us to address these accessibility challenges. Tianjin Station, as a representative older station, should focus more on its inner circle of the station, improve its accessibility to meet passenger needs and avoid becoming a walking void in the city centre. Recommendations include adding crossing passages and engaging in urban renewal to incorporate more service functions, drawing from examples of the other four stations.

For newly planned stations, like Shenzhen North Station, there is potential for improved infrastructure, yet more focus should be placed on controlling station scale and enhancing the density and diversity of functions in the surrounding area. The limited extension of the walking system beyond adjacent blocks and weak surrounding accessibility may hinder the development of the 1 km area. Therefore, urban design should not only focus on connections with adjacent blocks but also consider the overall walking system of the urban area, appropriately positioning gated communities and adjusting block scales to avoid negative impacts on pedestrian accessibility.

Limitation

This paper emphasizes qualitative research, as the relationship between morphological features and accessibility assessments is multifaceted. The limited number of case studies and significant differences in planning and station construction across countries complicate direct definitions of specific morphological impacts. Future research can expand in three directions:

1. Increasing the case database, focusing on diverse geographic regions, and conducting quantitative analyses of multiple morphological features against specific accessibility indicators to derive stronger correlations.

2. Enhancing accessibility evaluation metrics through methods such as hierarchical analysis and entropy methods to develop a more comprehensive and applicable station accessibility scoring system.

3. Comparing new and old domestic stations, addressing their distinct morphological differences and varying accessibility challenges, to further consolidate understanding in this area.

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From the Ground Up: Mapping Change in Favelas through Aerial Imagery

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ABSTRACT

Brazilian favelas face chronic infrastructure and urban services deficiencies, safety against hazards, housing quality, and access to green spaces. Often occupied by low-income populations, improving it aligns with Sustainable Development Goals (SDGs) 6 and 11. However, a critical obstacle is effectively diagnosing their needs and setting priorities for intervention. Slum upgrading programs aim to address the built environment deficits based on precise field surveys to support projects and works for infrastructure provision and safety against geotechnical and flooding risks. However, surveys covering all precarious areas of the city are costly and rare, becoming shortly obsolete given the dynamics of constant and incremental growth of favelas. This paper presents a low-cost method for mapping the transformations of the housing fabric in all favelas of a city or region, considering a pre-established time frame. Changes are verified through visual analysis of images from the Google Earth Pro application. Comparing two aerial images from different dates, transformations are identified and classified according to type (removal or expansion) and intensity (moderate or intense). Transformations can then be mapped, highlighting typology, intensity, and spatial distribution as a basis for further analysis of their impacts on urban and environmental quality and identification of general trends. The results reveal issues such as the impact of road infrastructure on transformations and the increase of precarious housing in environmentally protected areas such as riverbanks, water bodies, or forests, among others. The increase or reduction of slum-type housing fabric shows the efficiency of urban and housing policies. It is also an indicator for measuring the trend toward achieving the SDGs directly related to the phenomenon. The method was tested in Campinas (SP) and Macapá (AP), cities with distinct urban characteristics and spatial data availability, demonstrating its potential for replication in other contexts.

Keywords: Deprived urban areas, Morphological analysis, Cartography of transformation, Data-driven interventions, Social Urbanism

INTRODUCTION

Like many cities worldwide, contemporary Brazilian cities exhibit a diversity of urban quality and form across their territories, partly driven by the phenomenon that Caldeira (2017) defined as “peripheral urbanization.” This model of urban development has resulted in numerous neighborhoods self-built by their residents, providing housing for a significant portion of the urban population for decades (Abramo, 2012; Davis, 2006; Maricato, 1979, 1996). Within this realm of urban informality lies a particular type of housing: the favela. According to UN-Habitat, the number of people living in suboptimal housing has never been higher (Rowe, 2022). Despite decades of efforts to urbanize and improve living conditions in favelas, the trend has been one of expansion rather than reversal in many parts of the world (UN-Habitat, 2018). As a result, global commitments such as the 2030 Agenda and the achievement of the SDGs are severely jeopardized, along with the ability to monitor their progress.

The need for more understanding of the causes behind the housing crisis in many cities and the lack of precise data hinder assertive action to recognize residents as rights-bearing subjects who require effective public policies to meet their urban housing needs. In Brazil, despite changes in urban legislation aimed at recognizing and upgrading precarious neighborhoods, and the existence of policies involving all three levels of government that could shift this scenario, the lack of consistent investment in cities (exacerbated by the Covid-19 pandemic) has hampered efforts to transform urban areas into healthier and more inclusive environments.

This article aims to shed light on the growth and spatial transformation of favelas over the past decade, drawing on case studies from two major cities: Campinas (SP) and Macapá (AP) (Figure 1). The first city is located in the Southeast region of Brazil, where urbanization began much earlier than in Macapá and has stabilized in terms of population growth. Macapá, on the other hand, is the capital of the state of Amapá, located in the Northern region, experiencing rapid population and urban growth since the late 20th century. The objectives are: a) to present a method based on visual analysis of aerial images to capture spatial transformations in favelas and b) to reveal the different growth trends in these two urban contexts, along with their impacts on urban and environmental quality.

The article begins with a review of contemporary efforts to quantify the population living in favelas, emphasizing the Brazilian trajectory. Based on available official data, it then describes the two cities in terms of their geomorphological context, urban development processes, and deficits in infrastructure and urban services. Since the two cases are part of distinct research projects, the “Method” section presents and justifies the procedures adopted in each case.

As a result, the study demonstrates the replicability potential of the method and provides an overview of recent transformation trends in both cities. While the term “favela” can be broadly applied across different contexts, the realities of these areas are particular, as the transformations they undergo. The adopted procedures successfully capture this phenomenon. With this, we aim to highlight the importance of a more careful approach in formulating strategies to address urban challenges, ensuring more efficient and appropriate outcomes.



Figure 1. Location of the cities of Campinas (Southeast region) and Macapá (North region) in Brazil. Map credit: National Online Project, 2024

The extent of housing precariousness captured by census surveys and aerial imagery

Like many in the so-called Global South, Brazilian cities have historically faced significant barriers to providing broad segments of the population with access to adequate housing through the market or public policies. The causes of the phenomenon of exclusionary urban development in Brazil are complex and will not be explored here. However, one of its territorial consequences is the emergence of neighborhoods composed of houses, streets, and urban services that the residents partially or entirely build.

Different names across Brazilian cities know self-built neighborhoods, but the term "favela," which originated in the Southeast region and adopted in cities like Rio de Janeiro and São Paulo, has become predominant. Beyond regional variations, favelas display significant morphological diversity, influenced by the biophysical characteristics of the sites they occupy, the development processes of their respective regions, their location within the city, and the degree of urban precariousness that defines them (Silva, Samora, 2020).

In Brazil, the Brazilian Institute of Geography and Statistics (IBGE) conducts census surveys every ten years. It has been developing and refining methods to quantify the number of households in favelas since 1950. In 1991, the IBGE began classifying census tracts containing favela-type housing as “subnormal,” enabling a more precise definition of the population living in these areas. The most recent data for this category is from 2010, which recorded 1.4 million people residing in subnormal census tracts—about 6% of the country’s population (Agência IBGE, 2011; Instituto Brasileiro de Geografia e Estatística, 2013).

However, due to the methodological limitations adopted, the IBGE data presents a significant underestimation. Some studies compare local data with IBGE databases (Brueckner et al., 2019,

Castro, 2018; Catalá & Carmo, 2021; Ferreira et al., 2016; Souza et al., 2020), while others attempt to assess, based on a sample of cities, the population living in favelas that resides in areas not classified as subnormal, revealing nearly double the number of people living in favelas (Marques et al., 2007). Since 2010, the IBGE has considered local surveys conducted by municipalities to delineate subnormal tracts and correct these distortions. In this process, municipalities provide the IBGE with the favelas' boundaries, preventing census enumerators from classifying these areas in the field. However, at least in the case of Macapá, this procedure has not prevented underestimation, as we will see.

Advancements in georeferencing and access to updated satellite imagery have enabled significant progress in understanding the phenomenon of deprived urban areas or favelas (Abascal et al., 2024; Kuffer et al., 2016, 2020). Research initiatives such as SLUMAP and IDEASMAP utilize these images to produce global assessments of the population living in favelas, supporting monitoring the Sustainable Development Goals (SDGs). The analysis can be performed automatically through machine learning techniques or by trained individuals who interpret the visual aspects of the phenomenon. A notable example of systematic monitoring in Brazil is the Mapbiomas Project, which tracks the increase in land occupied by favelas based on Landsat imagery (Souza et al., 2020). The accessibility of these images allows for increasingly precise identification and measurement of favelas, uncovering settlements in remote areas that are rarely included in traditional surveys.

In Brazil, the National Housing Policy, established in 2005, promoted the production of assessments of local housing needs (for cities with populations over 20,000) by conditioning the allocation of federal resources on the development of Local Social Housing Plans (PLHIS). Drawing from successful experiences in favela urbanization undertaken by local governments since the late 1980s—a practice recognized by the UN—the national policy acknowledges that many favelas' households suffer from a "qualitative deficit". It means that, through slum upgrading and land regularization, self-built dwellings can achieve the status of decent housing.

The concept of "housing needs" aims to address two distinct situations: housing deficit, which refers to the need to increase the stock of homes for families without housing, and qualitative deficit, which assesses the number of homes lacking urban services and legal status (Fundação João Pinheiro, 2021). To this end, the PLHIS diagnoses these needs, revealing the number and location of favela households classified as experiencing qualitative deficit.

Thus, many municipalities surveyed the existing housing stock in favelas or other types of precarious housing, as seen in the cases of Campinas and Macapá. The assessments included in the PLHIS were expected to reflect local realities more accurately than the censuses produced by the IBGE had managed to do so far. However, since 2016, the Federal Housing Policy has ceased to foster the development of local diagnostics. As a result, the national census, despite all its limitations, has become the only data source available to capture the reality of urban precariousness in many cities. The lack of accuracy and consistency in the quantitative assessments of the number of households in favelas hinders systematic monitoring of territorial transformation. It complicates the measurement of the effectiveness of policies aimed at overcoming housing precariousness.

City of Fields, City of Waters: Context and Universe of the Favelas of Campinas and Macapá

Campinas and Macapá are two Brazilian cities that developed at distinct historical moments, occupying natural sites with unique characteristics. The urban processes in both locations have resulted in spaces with diverse characteristics, which is reflected in the typology and conditions of housing precariousness, as presented below.

Campinas, SP: favelas in the City of Fields

Campinas is located in the state of São Paulo, in the Southeast region of Brazil. It serves as the headquarters of the Metropolitan Region of Campinas, which is part of the São Paulo macro metropolis, the territory with the highest Gross Domestic Product in the country. It is fully integrated, through processes of conurbation, with the metropolitan areas of São Paulo, Vale do Paraíba, Santos, and Sorocaba, as with the urban agglomerations of Jundiaí, Bragança Paulista, and Piracicaba. The city developed in 1850 in a geographic space characterized by rolling topography occupied by two biomes: the Cerrado and the Atlantic Rain Forest. In these higher topographic areas, the lush Atlantic Forest, primarily found in the floodplains, gives way to the fields of the Cerrado that name the city.

The economy of coffee production was the main driver of the urbanization process in Campinas. The accumulation of resources in the hands of local landowners enabled the economic and political elite to invest in railways to transport their produce, marking the region as an important railway hub. This advantageous condition regarding regional infrastructure availability was crucial for many industries to settle around the traditional urban site in the 20th century, shaping what Farah (2024) referred to as the “first historical periphery” of Campinas. After 1950, the country began investing in road transport, Campinas also benefited from highways such as the “Anhanguera”. This road significantly impacted the local urban morphology of the city by acting as a segregation element, increasing the value of land in the northern portion of the city. From the second half of the 20th century onward, it would be primarily to the south of the Anhanguera highway that working-class neighborhoods would concentrate, whether built through public policies or self-construction, determining “the place of the poor in the city” (Rolnik et al., 2015).

Throughout the 20th century, Campinas experienced significant urban expansion through the development of low-density housing neighborhoods, interspersed with urban voids. Starting in the 1980s, in the context of a severe economic crisis preceding the deindustrialization of the following decade, the city saw a growth in its favelas and the emergence of another specific housing type: segregated condominiums for the middle and upper classes.

In the 2011 Local Social Housing Plan (PLHIS), the City Hall of Campinas presented its first and only diagnosis of the housing conditions of low-income families, revealing that the city had 194 favela-type settlements, comprising a total of 29,078 households (Prefeitura Municipal de Campinas, 2011, p. 299). A year earlier, the census recorded the total population of Campinas at 1,074,659 people, of which 148,278 lived in subnormal census sectors, resulting in 153 subnormal clusters (AGSN), in turn containing 40,099 households (Instituto Brasileiro de Geografia e Estatística, 2010). These sectors are not limited to the favela typology but encompass other forms of precarious housing, such as those found in irregular subdivisions. In the diagnosis conducted by the city hall, this typology accounted for 40 neighborhoods, with an estimated 24,287 households.

In 2020, the IBGE released a preliminary announcement of the perimeters of subnormal clusters (AGSN) encompassing all Brazilian cities, estimated for the census scheduled for that year. In Campinas, for the year 2019, the IBGE estimated 149 AGSN in the city (a decrease compared to 2010), with 41,344 households showing low growth compared to 2010. Since no other housing diagnosis has been conducted and the data from the 2022 Census has yet to be presented with a breakdown of the favela typology, these are currently the most recent available data to portray precarious housing in Campinas, which justifies studies aimed at understanding the current situation of this universe, such as those we will report next.

Regarding spatial morphology, many favelas in the city are located on land that is not suitable for occupation according to urban legislation, typically along watercourses, in flood-prone areas of the city's rivers, abandoned railway beds, and vacant land neglected by the real estate market operating in the city. These are very dense occupations, with self-built houses that can reach up to three stories. The open spaces within the settlements are used for the circulation of people and vehicles, as illustrated in Figure 2. Most houses are connected to water and electricity networks; however, they lack sanitation systems, with wastewater being disposed of in septic tanks and rainwater flowing directly into the streets.



Figure 2. Viela com infraestrutura urbana precária na região do Parque Oziel/Jardim Monte Cristo. Campinas, photo credit Google Street View, março de 2020.

Macapá, AP: Stilt Houses in the Ressacas of the Water City

According to Carvalho (2020), the urban site of Macapá is characterized by "ressacas" (floodplains), a regional term used to describe areas of water accumulation influenced by river and rainfall regimes that drain internal and surface waters into the Amazon River basin and play an essential role in regulating the microclimate, serving as habitats for diverse fauna and flora. The most recent survey identified 24 floodplain areas (see Figure 3), which form a sizeable interconnected water system. The classification distinguishes between rainfall-influenced, river-influenced, and those affected by both systems, all protected by federal environmental legislation.

In the 1950s, Macapá began its expansion to the south, and between 1961 and 1973, new neighborhoods were established following the urban grid (SEMDUH, 2011). This growth soon encroached upon the floodplains, which began to be altered through filling, constriction, sedimentation, and the construction of infrastructures such as wooden stilt houses and access walkways for internal circulation. These changes impact the ecological characteristics and water quality, a situation worsened by lacking basic sanitation (Carvalho, 2020; Takiyama et al., 2012), exacerbating flooding (Sousa et al., 2021).

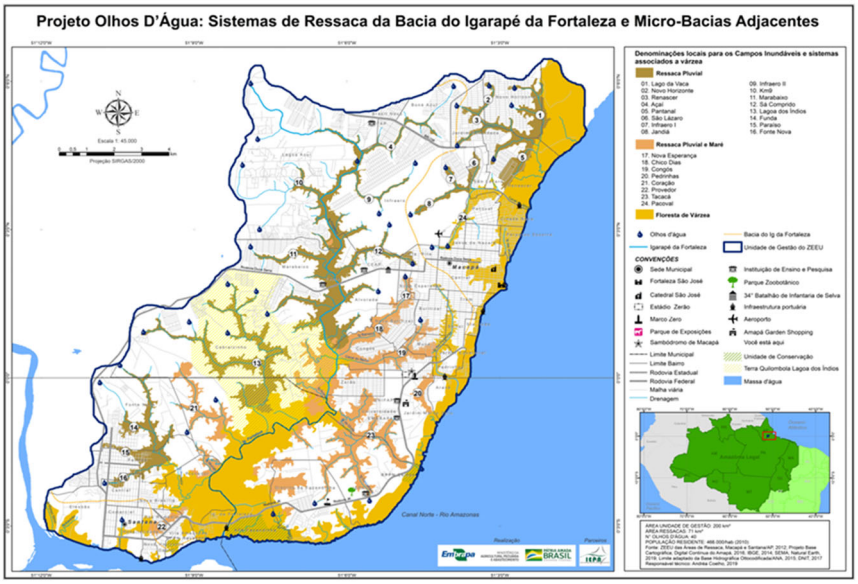

Figure 3: Olhos D'Água Project. Source: EMBRAPA, 2022.

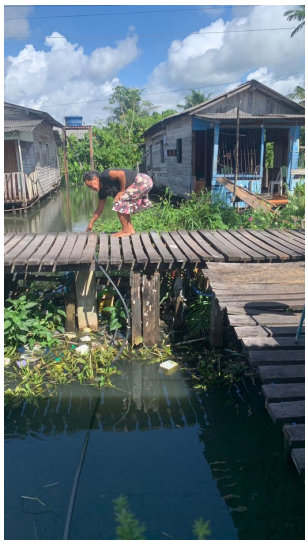

Figure 4: Stilt ways to the stilt houses in the Ressaca Chico Dias Community, Congós, Macapá (Brazil). Source: Authors' Archive, 2024.

As highlighted by Carvalho (2020), the communities that settle in these territories, which are the only areas accessible to large segments of the population in Macapá, face severe vulnerability conditions, mainly due to insufficient infrastructure and deprived housing conditions, further exacerbating the risks associated with human occupation. In these flooded areas, stilt houses predominate, accessed by wooden walkways— elevated paths over the water—constructed by the residents.

Whitouth municipal data on the universe of housing occupying floodplains, the IBGE data regarding subnormal clusters (AGSN) is the only available source. An estimated 16,757 households were identified in 84 AGSN in 2019. There is no clear differentiation between how many of these areas consist of settlements on dry land or in flooded areas, which is why the method described below outlines the procedures for estimating the number of neighborhoods with stilt houses in the floodplains (figure 4).

METHOD [Heading 1]

The research group "Territorial Policies and Water in Urban Areas" employs the method of "Transformation Cartography" to develop cartographic products derived from analyses of transformations within a specific area. After defining the temporal and spatial scopes of the transformations to be observed, analytical categories are established based on the study's objectives. The data used for analyzing transformations are satellite images collected on different dates and compared. The main indicator for determining visible transformations in the satellite images is the presence of slabs or roofs, which are counted as corresponding to a building. However, particularly in Campinas, it is impossible to associate each building with a single household, as many consist of more than one floor and may contain multiple households.

The cases of Campinas and Macapá address the transformations of the same urban phenomenon, the favelas, but they integrate research with different purposes. As a result, in each case, the dates of the images and the territorial scope adopted varied. Moreover, the data sources used come from different origins. Since the studies do not cover all favela neighborhoods in both cities or all households in these conditions, the results obtained cannot be interpreted as quantitative data but rather qualitative. While both cities have developed their housing plans, only Campinas has made the diagnostic data by neighborhood publicly accessible. Macapá's plan is more general and does not provide locational and population data for its favelas. The only available data containing the perimeters of the subnormal clusters (AGSN) come from the IBGE for the years 2010 and 2019.

Campinas, SP

Two distinct analyses were conducted to capture favelas' transformation and to characterize the related databases in Campinas. The first analysis involved comparing aerial images from 2010, 2011, and 2019, along with the perimeters of favelas (according to the PLHIS) and subnormal clusters (according to the IBGE). The objective was to identify coincidences and discrepancies and to understand the causes of variations between the municipal and the IBGE data.

The second analysis investigated how the 194 favelas mapped in 2011 by the PLHIS transformed over a ten-year period, using human interpretation techniques of satellite images for each favela in 2011 and 2021. We classified the transformations according to the categories in Table 1, and a summary of the results is presented in Table 3.

In this process, we excluded some areas due to limitations of the available material, resulting in 188 classified favelas. We mapped the results for further analysis regarding the environmental impact of the transformations, vulnerability to disaster risk, and urban infrastructure deficits, among others (SAMORA et al., 2024). The results discussed in this work come from the second evaluation, specifically the one that assessed the transformations of the perimeters mapped by the municipality in 2011.

Table 1. Transformation Categories used in the case of Campinas.

Transformation Category	Description
Consolidation	No growth or increase in dwellings by 10%

Minor Partial Removal	Up to 30% removal of dwellings
Moderate to High Partial Removal	30% to 50% removal of dwellings
Severe Partial Removal	Removal greater than 50% of dwellings (but not total)
Total Removal	100% of dwellings removed
Low to Moderate Expansion	10% to 30% increase in the number of dwellings
Moderate to High Expansion	30% to 50% increase in the number of dwellings
High Expansion	Increase greater than 50% of lots

Macapá, AP

Macapá lacks a municipal survey detailing the perimeters of wetlands occupied by stilt houses. Therefore, the only available territorial database comes from the IBGE, using proxies from subnormal clusters (Instituto Brasileiro de Geografia e Estatística, 2020).

The analysis in Macapá aimed to understand how the city's stilt house occupations transformed over time. Thus, the territorial scope focused on subnormal clusters formed entirely or partially by stilt houses located in wetlands or any existing floodplain areas. To exclude clusters established on "solid ground" from the sample, we needed to establish a procedure to define the study universe. Since the IBGE does not differentiate stilt house settlements from others, the first step involved examining each of the 84 subnormal clusters listed in the 2019 database. Out of these, 13 contained the word "ressaca" in their identification. In addition to this nomenclature, we selected other areas through typological assessment to include in the research universe. This procedure resulted in selecting 69 areas that exhibited characteristics of neighborhoods formed by stilt houses, thereby establishing the sample size.

The next step established the transformation categories for analyzing the selected subnormal clusters (Table 2). As in Campinas, we compared two images from each location (2010 and 2019), described the results in data sheets for each subnormal cluster, and summarized them in Table 4.

We identified significant differences in the perimeters from 2010 and 2019, leading to the development of a case study in the subnormal cluster named “Ressaca Chico Dias,” an area that experienced substantial growth in the number of precarious dwellings during this period. The case study aimed to understand the origins of the perimeter differences and determine the underreporting of existing stilt houses in 2010 that were not included in the subnormal cluster perimeter established at that time.

Table 2. Transformation Categories used in the case of Macapá

Transformation Category	**Description**
New occupation	Area not occupied in 2010
Moderate expansion	Up to 10% increase
High expansion	10% to 50% increase
Severe expansion	+50% increase

RESULTS AND DISCUSSIONS

Tables 3 and 4 present, respectively, the summary of transformations in both cities

Table 3. Transformation of Campinas Favelas 2011-2021 by category

Transformation Category	**Settlements**

Consolidation	129
Minor Partial Removal	12
Moderate to High Partial Removal	4
Severe Partial Removal	5
Total Removal	7
Low to Moderate Expansion	16
Moderate to High Expansion	2
High Expansion	13

Table 4. Transformation of selected subnormal clusters in Macapá 2010-2019 by category.

Transformation Category	Description
New occupation	1
Moderate expansion	13
High expansion	32
Severe expansion	23
Total	69

Types and Trends of Transformation

Using the same technique, we identified different transformation trends in the favelas of Campinas and Macapá. In the first city, the category "consolidation" best describes the transformations of favelas, while in the Amazonian city the transformations are much more intense, characterized by the "expansion" of stilt dwellings, a trend evident in all areas.

The consolidation of favelas observed in Campinas indicates that there was no expansion of households in the 129 perimeters where this trend is evident. However, further studies are necessary to analyze the growth of new perimeters after 2011, which was not the focus of this research. Additionally, the analysis of the urban characteristics of areas classified as "consolidated" shows that, despite the stability in the number of buildings, there are no significant transformations in the quality of infrastructure, as demonstrated by the image in the Oziel Favela (figure 1).

In Campinas, the category "consolidation" refers to areas with little modification regarding horizontal expansion within the perimeter, specifically a growth of up to 10% in the constructions observed in the aerial image. The morphology of these areas has little or no space between buildings, preventing excessive expansion that would extend the original boundary of the settlement. Thus, labeling a space as "consolidation" makes sense when the resulting form allows for little or no horizontal expansion. The local needs for population growth in many of these areas are addressed by the vertical expansion of households, meaning an increase in the number of stories of the buildings. However, this vertical expansion cannot be captured by aerial imagery, demanding other procedures not included in this research but reported in other works by the group, such as Bastos (2023).

In Macapá, we classified situations where the growth of buildings was up to 10% into a category called "moderate expansion." Unlike in Campinas, these settlements feature generous spaces between the buildings, allowing for almost unlimited horizontal expansion without being confined to a predetermined perimeter. Additionally, because they consist of stilt houses, the vertical growth of households is more complex than in the masonry and reinforced concrete structures that characterize the favelas of Campinas.

Macapá did not experience transformations resulting from the "removal" of households (either total or partial), but this phenomenon affected 28 locations in Campinas. These removals can be attributed to urbanization interventions in favelas, financed by the federal government, between 2007 and 2016 (Bianco, Bueno, 2019). By mapping these transformations, we can see that the favelas near the removal areas experienced expansions, which may indicate increased housing precariousness for the residents. Macapá did not receive any interventions similar to those in Campinas. However, the city is investing in places like Ressaca Chico Dias to replace wooden walkways with concrete ones and improve access to electricity. It demonstrates that, at least for now, there is no intention to remove the stilt settlements.

Considering the stilt settlements, the analysis concluded that the category "high expansion" best characterizes the transformations we observed in Macapá, followed by "severe expansion." This situation contrasts sharply with what we saw Campinas.

Underreporting of the Phenomenon in Macapá

Another relevant fact concerns the underreporting of the phenomenon in Macapá. In 2010, IBGE recorded 24 subnormal clusters (AGSN), but by 2019, it mapped 84 locations, doubling the number of areas identified in the previous survey. However, many of these neighborhoods existed in 2010 but did not receive AGSN classification in that year's census. Only one of the 69 areas analyzed in this research can be considered a new occupation emerging after 2010. In consultation with the IBGE office in Macapá in June 2024, officials informed us that the municipality is consulted to validate the AGSN perimeters used in the census survey.

The Ressaca Chico Dias favela case in the Congós neighborhood exemplifies the challenges of comparing the AGSN perimeters from 2010 and 2019. Figure 5 shows two images from Google Earth Pro of this favela for 2010 and 2019, with the perimeters labeled as “Ressaca Chico Dias” delimited in the two surveys. The yellow line represents the 2010 perimeter, while the red line indicates the perimeter defined in 2019. In 2010, many dwellings fell outside the yellow perimeter and were not included in any other subnormal cluster. The 2019 perimeter appears more accurate than its former counterpart, even though it excludes an entire alley in the lower left corner of the image that was part of the 2010 perimeter. This variation highlights the difficulty of conducting a comparative analysis, as situations that existed in 2010 were overlooked. As a result, these were counted as new households in the 2019 base, even though they had been present since at least 2010. Nevertheless, considering the 2010, we concluded that the category that best represents the transformation is “high expansion.”

Among the 69 areas analyzed, only one case represents an occupation that occurred after 2010, an indicator that reinforces the underreporting present in the 2010 base, which included only 24 AGSN perimeters.

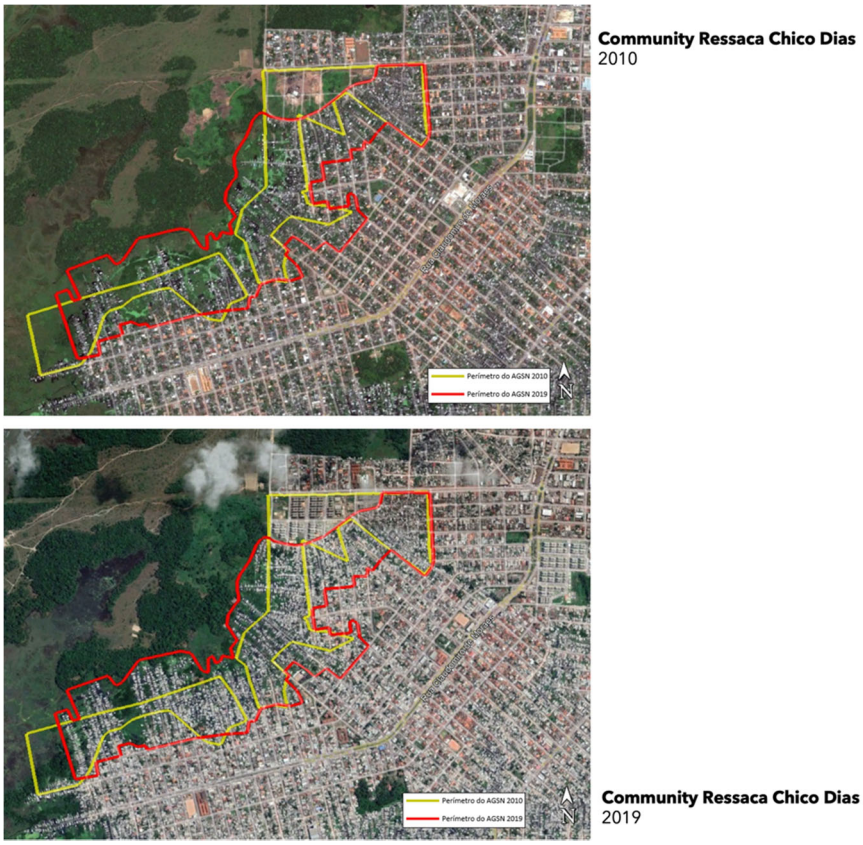

Figure 5: Case Study in Ressaca Chico Dias 2010 - 2019.

CONCLUSIONS

The method for analyzing transformations proved to be quite versatile, applicable in contexts as distinct as those of Campinas and Macapá. The different histories of urbanization in these country country partly explain the predominance of consolidated favelas (or, more precisely, favela perimeters) in Campinas, and the strong growth of dwellings in Macapá.

The insufficiency of data in Macapá's 2010 census base is not new, underscoring the importance of producing local data. The census cannot serve as the only source of housing data, or we risk underestimating the country's precarious housing conditions.

Regarding actions to address infrastructure in these areas, Macapá has been expanding primary networks and consolidating walkways, yet still fails to provide satisfactory access to water and sewage treatment. In the context of unlimited housing expansion in areas of permanent preservation, neglecting sanitation places both residents and the environment in precarious conditions. Thus, it is worth noting that many communities in Campinas still lack adequate sanitation, even after being established for over a decade, which presents additional challenges for these cities in achieving the Sustainable Development Goals (SDGs).

The analyses reveal significant differences between Campinas and Macapá regarding favelas transformations and the challenges faced by each city. In Campinas, the predominance of "consolidation" indicates stabilizing existing settlements without significant expansion. This situation contrasts sharply with Macapá, where the "high expansion" category highlights a notable increase in precarious housing, particularly in the form of wooden stilt dwellings. The findings underscore the

importance of addressing the data discrepancies from previous censuses, as the lack of accurate information in both cities contributes to ongoing challenges related to urban infrastructure and housing conditions. These differences reflect not only the unique historical contexts of urbanization in each city but also emphasize the need for tailored policy interventions to address the specific needs of their respective populations.

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Graphic diagrams of urban occupations: a contribution of morphology to the typification of brazilian cities

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ABSTRACT

Since the 1988 Brazilian Constitution the sectoral policies have as a pressure mechanism the offer of resources for municipalities to plan and implement sectoral policies at the municipal level. If, on the one hand, this sectoral view helps to face certain issues that are difficult to prioritize local policies, such as environmental sanitation, urban mobility, housing, disaster mitigation, among others, on the other hand, it ends up generating a deterritorialization of demands, since resources are allocated by sector and not by territorial needs. Given the scope and regional differences of the Brazilian territory, there is a difficulty in planning territorial-based national policies. It is necessary to create arguments that strengthen territorial-based public policies in order to consider the typologies of Brazilian cities. Some efforts have already been made by researchers from different areas of knowledge to build a typological study of cities that makes it possible to establish specific programs defined by national policies. The present research aims to contribute to the typological studies of cities by adopting knowledge accumulated by research carried out in the area of urban morphology. Specifically, the objective is to verify whether it is possible to identify patterns of urban forms existing in the municipal territories of different Brazilian regions. Through previous research, we were able to apply the method of characterization of urban occupation over the municipal territory in 62 small and medium-sized cities located in the interior of the State of São Paulo. It is now intended to expand it to other regions of the country and to verify if it is possible to identify patterns that help in the studies of typologies of Brazilian cities. The results obtained make it possible to quantify the degree of dispersion and fragmentation of cities.

Keywords: Urban Form, Morphology, Territorial Policies, Typologies of Cities, Federative Structure

INTRODUCTION

To understand the relevance of this research, it is necessary to make a small preamble about the option taken, since the 1988 Constitution, to adopt National Policies of a Sectoral nature. We will briefly present the obstacles to its elaboration and continuity, as well as the difficulties that Brazil has been facing in attempts to implement it.

It should be noted that this debate is not new. Technicians and researchers have been working on creating strategies to foster territorial-based policies. The implementation of the Ministry of Cities in 2003 was a hope to treat cities through territorial-based policies where, for example, housing would

not be reduced to the provision of housing units. Unfortunately, the hopes for the action of the Ministry of Cities were not realized in that period (MARICATO, 2011).

In 2019, the Ministry of Regional Development (MDR) absorbed the technicians of the former Ministry of Cities (MC). Despite the times of dismantling of public policies, which devastated the country between 2018 and 2022, the National Urban Development Policy (PNDU) continued to be discussed in the MDR, which is characterized by being a State policy and not a Government policy, that is, a discussion that goes beyond the management of this period, after all, the formulation of the PNDU had been debated since the 1988 Constitution.

> "A existência da PNDU no Brasil é controversa. Diferentes atores-agentes, gestores e pesquisadores do campo do planejamento urbano divergem sobre a existência da PNDU e sobre sua efetividade (COSTA; GOMES; ADRIANO, 2017). A inexistência de uma política formalizada enquanto tal, por meio de norma específica, significa, para alguns, que não há uma PNDU. O capítulo constitucional da política urbana deixou a questão em aberto e o EC, ao trazer as diretrizes e instrumentos da política urbana, regulamentou aspectos da política urbana em geral, especificando o que havia sido estabelecido pela CF 88, mas não tem a envergadura esperada de uma PNDU que trouxesse maior objetividade e permitisse operacionalidade para efetivar tal política."
>
> (Ipea, 2020, p. 14)

Technicians from the former Ministry of Cities and researchers linked to INPE – National Institute of Economic Research with support from IBGE – Brazilian Institute of Geography and Statistics and ANPUR – National Association of Urban and Regional Research, had been debating in seminars the research developed that investigated the methods for the creation of the typologies of Brazilian cities. It is expected that with the next administration, through the resumption of processes that will strengthen institutions, this debate will gain strength. Therefore, we are going through a historic moment, where efforts to understand the Brazilian territory can contribute to territorial-based public policies.

Since the 1988 Constitution, sectoral public policies have been formed, strongly driven by National Policies that define national plans for each sector (sanitation, housing, mobility, etc.), establishing programs and resources. This structure induces municipalities to follow sectoral policies as they place the formulation of municipal sectoral plans as a condition for receiving resources from the sector. In view of the scarcity of resources that municipalities face, especially when since the 1988 constitution there has been an imbalance between the obligations and the resources allocated to the municipalities (TOALDO & HERMANY, 2013).

If, on the one hand, this sectoral vision helps to cope with the distribution of resources, on the other hand, it ends up generating a deterritorialization of demands. The ongoing research, which resulted in the present publication of preliminary results, problematizes this process through the analysis of some national public policies and their impact on the municipalities and analyses the spatial configuration of urban occupation on the municipal territory in different contexts and regions. It is not intended to establish a direct relationship between the practice of sectoral policies and the resulting urban territorial configuration, however, it is worth reflecting on how much this practice, which results

in the deterritorialization of local policies and actions, does not end up creating obstacles to territorial planning.

Sectoral policies have been developed since the 1988 constitution. A set of national policies were painstakingly built through extensive debates between 1988 and 2015, we can highlight: Water Resources (1997); National Risk Reduction Plan (2012); National Basic Sanitation Plan (2007); National Housing Plan (2009); National Mobility Plan (2012); Ten-Year Energy Expansion Plan (2012); National Plan for Integrated Solid Waste Management (2010). It is also worth remembering that many changes to these sectoral policies emerged between 2016 and 2021 after the coup, weakening them even more (BASTOS, 2017).

The formulation of a national policy is costly in terms of time, negotiation and construction of the concepts and principles that guide it. Take, for example, the National Water Resources Policy, a sector that has several correlations with the others. Law No. 9,433/1997, which institutes the National Water Resources Policy, creates the National Water Resources Management System and regulates item XIX of article 21 of the Federal Constitution, establishing the national water resources management system and defining criteria for granting rights to use water, which is fundamental for the sector's programs and policies. The continuity of this debate is put at risk 22 years later with Law No. 13,844/2019, which changes the composition of the National Water Resources Council. We take this sector only as an example, to demonstrate the difficulty in continuing the debate.

Another example is the National Urban Mobility Policy. In 2008, Brazil aligned itself with the international mobility policy through the European Union-Brazil Sector Dialogues Support Project with the objective of fostering the transfer of experiences, knowledge and consolidation of the social pacts of the Sustainable Urban Mobility Plans from European to Brazilian cities. Four years later, in 2012, through Federal Law 12.587, which establishes the guidelines for the National Urban Mobility Policy, the premise is taken as the sustainable development of cities in order to prioritize federal investments in non-motorized means and collective modes, in addition to establishing the regulation of services and fare policy. In this context, the Urban Mobility Plan became the instrument for implementing the National Mobility Policy (PMU) stipulating the obligation of municipalities, with more than twenty thousand inhabitants, to develop the PMU. The development of the municipality's PMU becomes a condition for it to receive federal resources for urban mobility projects. In addition to being integrated into the city's Master Plan, the PMU should establish the actions, objectives and concrete goals that meet the demands of the population in a participatory way, including the different agents

Despite the technical assistance offered by the Federal Government, the lack of technical, financial and technological resources found in most Brazilian municipalities proved to be obstacles to face the technical complexities involving the PMU (OLIVEIRA, 1972).

In January 2016, the then Ministry of Cities carried out a survey of the 3,342 municipalities that, by May 2015, should have prepared the PMU, to compete for federal financial resources. Of the 2,066 respondents, only 189 municipalities had prepared the PMU. Of these, 142 (83%) are located in the South and Southeast regions (Brasil, 2016) and 133 (78%) have up to 250 thousand inhabitants.

The low adherence of municipalities to compliance with Law No. 12,587/2012 prompted the proposition of Bill No. 7,898/2014, which ended up becoming, in 2016, Law No. 13,406/2016,

postponing the PMU deadline to 2019. However, a new law, in 2020, (Law No. 14,000/2020) extends the date of delivery of the Urban Mobility Plans (PMU).

The research of Laura Machado, Lívia Salomão Piccinini (MACHADO; PICCININI, 2018) develops a table that lists 43 cities that declared to have prepared the PMU, and in 29 of these (68%), it was found that the plans do not define concrete actions, postponing decisions for more specific plans, such as: bicycle paths, public transport, sidewalks, urban forestation, universal accessibility or public lighting plan. In this way, the Urban Mobility Plan is no longer effective and hinders the desired integration between modes.

In Brazilian cities, characterized by socio-spatial segregation (SILVA, 2016; VILLAÇA, 2011), the search for public resources for the implementation of concrete actions on the territory, within a sectoral logic, end up deterritorializing the look and time of the place. National and local agendas are not always aligned and compete for the resource without clearly evaluating the city that is being formed. (CARDOSO et al., 2016).

The data presented demonstrate the difficulties in implementing national sectoral policies. It happens that territorial-based policies favor electing actions that normally demand different sectors, however the difficulty lies in the management in view of the continental scale of the country and, mainly, the regional differences and between the types of existing municipalities, either from the dimensional point of view of population and territory, or their insertion in the network of cities, or even the financial and technical capacity of the local public staff.

Given the scope and regional differences of the Brazilian territory, there is a difficulty in planning national policies based on territory. It is necessary to create arguments that strengthen territorial-based public policies in order to consider the typologies of Brazilian cities.

It should also be noted that the search to strengthen territorial-based policies is of great importance for the adaptation of cities to climate change. The process of occupation and transformation of the Brazilian urban territory is characterized by socio-spatial segregation, and the urban form reflects these processes (SANTOS, 2014). Without territorial-based programs, it is impossible to intervene in a systemic way in order to avoid the impacts that are to come.

Some efforts have already been made by researchers from different areas of knowledge – involving universities and institutions such as IBGE (2020), IPEA (2020), etc. – to build a typological study of cities that makes it possible to establish specific programs defined by national policies.

In 2018, the IBGE publishes the REGIC - Regions of influence of cities 2018, updating the references of the Brazilian urban network. It would be the fifth version of this line of research that establishes the hierarchies and links between the Cities and delimits their areas of influence.

The previous versions were published in 1972, 1987, 2000 and 2008, which makes it possible to understand the historical evolution of the urban phenomenon in Brazil. This line of research helps to identify the networks, the nuclei and the isolations. These data were considered in the proposed typology of cities; however, they are not sufficient for their establishment.

In turn, IPEA (2020) contributes to this discussion with economic parameters, analysing the different financial capacities of municipalities and the relationship with the network system and parameters to establish the typologies of cities.

It is not enough to characterize these differences by population size, or by the five regions (South, Southeast, Center, Northeast and North). As we have presented, the studies on the typification of cities have been working with a set of approaches: management capacity (IPEA, 2020), position in the network of cities (IBGE, 2020). However, these approaches are still insufficient. The present research investigates how an analysis of the degree of dispersion or concentration of urban areas in the municipal territory can help in the typification of cities. Cartography is used and from the cartographic data a graphic synthesis is drawn that favours comparative analysis and perception of patterns.

The objective of the ongoing research is to contribute to the typological studies of cities by adopting knowledge accumulated by research carried out in the area of urban morphology. Specifically, the objective is to verify if it is possible to identify patterns of spatialization of existing urban forms in municipal territories.

The research intends to apply a cartographic method of analysis that results in a graphical synthesis making it possible to identify similarities and dissonances. To do so, it uses morphological reading as an instrument of analysis.

METHOD

With a view to the quantitative and qualitative reading of the process of urban dispersion, we undertook two stages of research. The first, through the interpretation of images from Google tools: Earth, Maps and Street View; the second by field observation work. The quantitative form measures the number of dispersed urban fabrics found, as well as their dimensions. Dispersed fabrics are defined as those that are not part of the main urban area of each municipality. The qualitative form typifies each of these occurrences.

In the first stage of the work, satellite images were initially analysed, made available by Google Earth, between the second half of 2020 and the first half of 2021. We sought to identify the entire urbanized area, both in the main urban area, which we refer to as the city, as well as the other areas separated from the main area and identified as urban, due to the presence of some of the urban morphological elements such as: blocks, roads, lots and buildings. The criterion adopted was to consider urban area any occupation greater than 2ha, with road access other than a highway and parceling in lots less than 2,000 m2. For the purpose of this research, this is the minimum urban cell, equivalent to about two blocks in a common urbanization, where some relationship of neighbourhood and locality begins to be established.

When there was doubt in identifying the locations, we also consulted Google Maps with the resources of markers and user information, and finally Google Street View, which, when available, is very effective in identifying the type of occupation. The relevance of typological characterization lies in providing elements for the interpretation of the factors that generate the dispersion process.

From this observation, we first mapped the main urban sprawl and all the fragments outside it. With Google Earth's polygon drawing feature, each of them was saved as a file, named, and numbered. The same resource allows us to extract the area and perimeter information and assign a color, with which we identify the typology of the occupation, as exemplified in figure 1. To make the structure of urban

dispersion more visible and to make it comparable between cities, diagrams were drawn up, converting the previous information into a schematic graphic representation (figures 2 and 3).

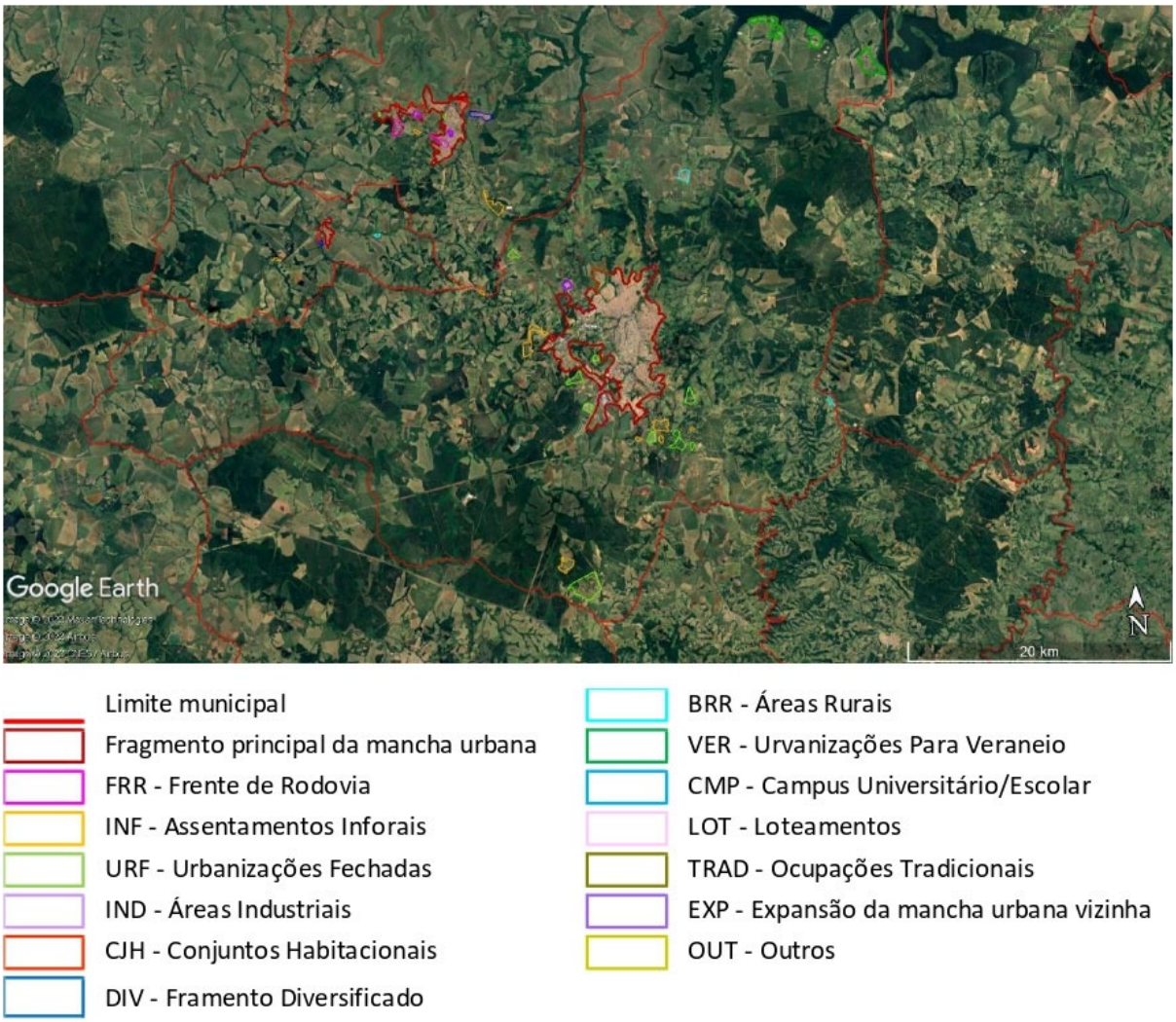


Figure 1: Analysis of urban dispersion in the municipalities of Botucatu, São Manuel and Pratânia. Source: Almeida Filho, 2024.

The identification of dispersed urban areas and their delimitation effectively contains the information desired by the research and provides the numerical data that we will analyse later and allow the interpretation of the reality of dispersion in the municipalities analysed. However, its visualization is difficult, due to some factors: a. the scale of the maps, which cover the territory of the municipality in its entirety; b. the small size of some dispersed urbanizations and c. the competition with the other elements of the satellite image in the background. In addition to these factors, it was observed that the morphological diversity of the spots identified in each municipality makes the comparison itself difficult. A first possibility of observation would be to work with two images. The first as shown in figure 1 and the second where the image in the background would be suppressed, highlighting the drawn polygons. It was perceived that there would still be losses in the interpretation of the result, as the difficulty arising from the competition with the image in the background would be circumvented, but not the one that comes from the diversity of forms. There are still other factors and one of significant importance is that the distance that is relevant to understand the degree of isolation of a dispersed urban sprawl is much more road than geometric. To explain: if an urban area is two kilometres, in a straight line, from the main area, it is close. However, if there is a geographical

accident that makes direct access impossible, such as a mountain range or watercourse, and the contour requires a journey of ten or more kilometres, it is far away.

Faced with this situation, we chose to create diagrams that support the analysis of the result. By reducing the information to the essential in graphic terms, we were able to observe in a direct and intuitive way the situation of urban dispersion. To this end, all urban spots, main and dispersed, are represented as circles, with an area equivalent to that measured in the analysis of satellite images. Considering the angle between the center of each urban area and the main urban center, the direction in which each circle will be inserted in the diagram is defined. The distance is represented by the shortest road distance between each spot and the center of the main urban area, informed by the Google Maps route query tool. The axes that connect the circles represent schematically the road system that connects them, reduced to straight lines with as few derivations as possible. Finally, a second circle, in a dashed line, was thrown around the circle that represents the main area, which represents the area equivalent to the sum of all the urban areas found in each municipality, in order to perceive the total degree of dispersion in each municipality. For information on the typology of each stain, colour legends were used. Figure 2 explains the elaboration of the diagrams:

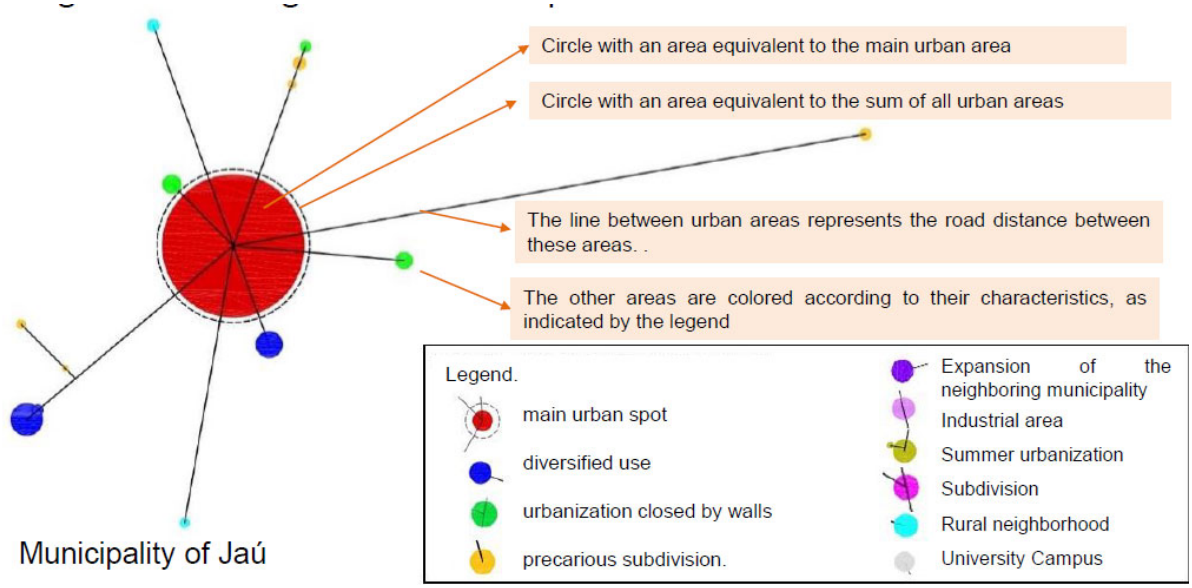


Figure 2: Interpretation of images by the construction of diagrams – Diagram from Jaú/SP. Source: Almeida Filho, 2024.

We can now examine, in figure 3, the diagrams that represent the three municipalities depicted in figure 1, and perceive not only the dimension, but also the structure of the dispersion.

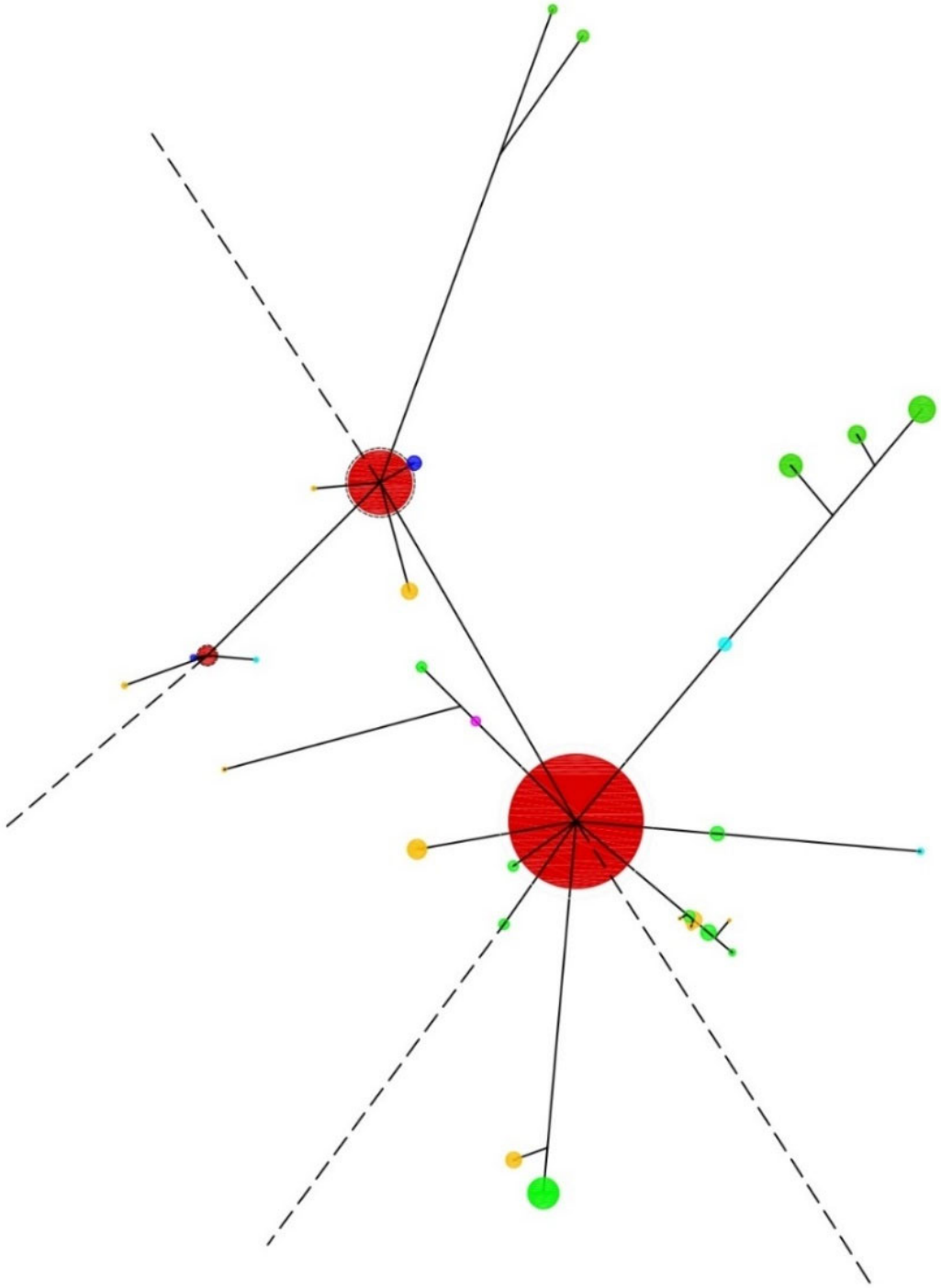


Figure 3: Scatter plots of the municipalities of Botucatu, São Manuel and Pratânia. Source: Almeida Filho, 2024.

It should be noted that we assume an action research methodology in which the researcher's experience, culture and professional experience directly affect the perception of the place Lakatos (1985, pg.193). Therefore, this reading was confirmed, case by case, in the second stage, by the field view. To this end, we visited, throughout the second half of 2021, 40 of the 62 cities in the sample, including all those with an urban population of more than 20 thousand inhabitants and 10 among the 32 cities with less than that.

RESULTS AND DISCUSSIONS

The method was applied to a sample of 62 small and medium-sized cities in the interior of São Paulo, selected based on a socioeconomic reading from a previous survey (Almeida Filho, 2019), presented in figure 4:

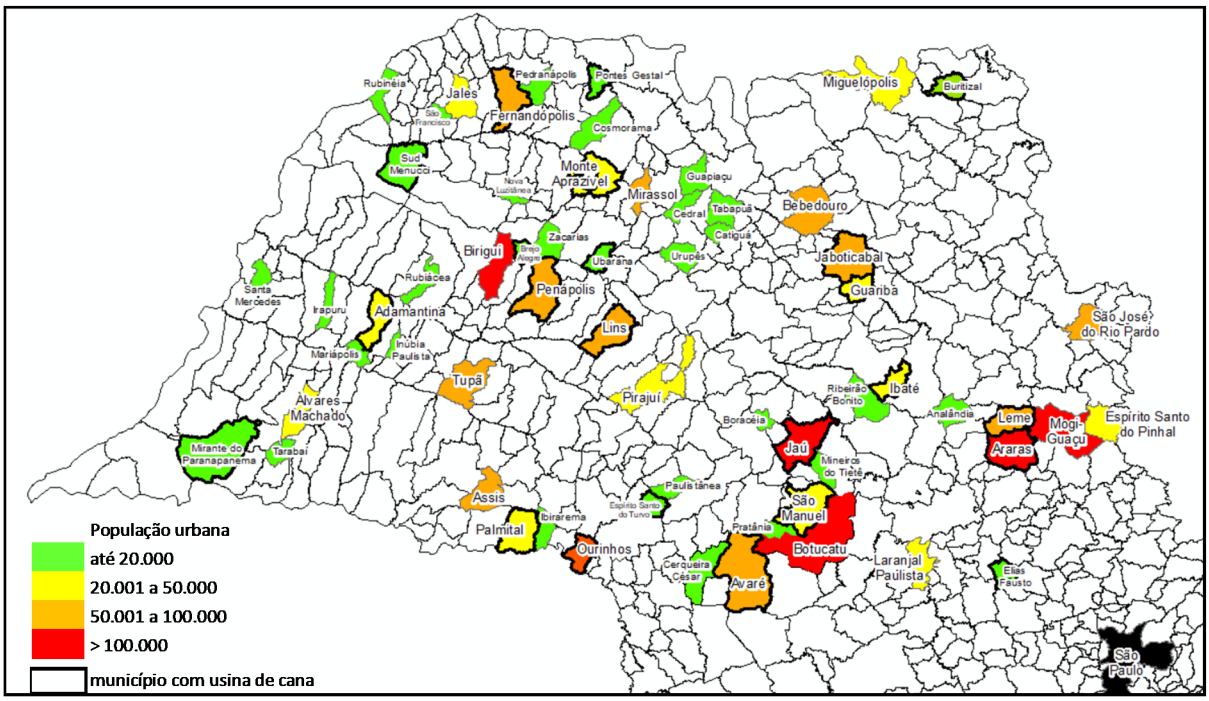


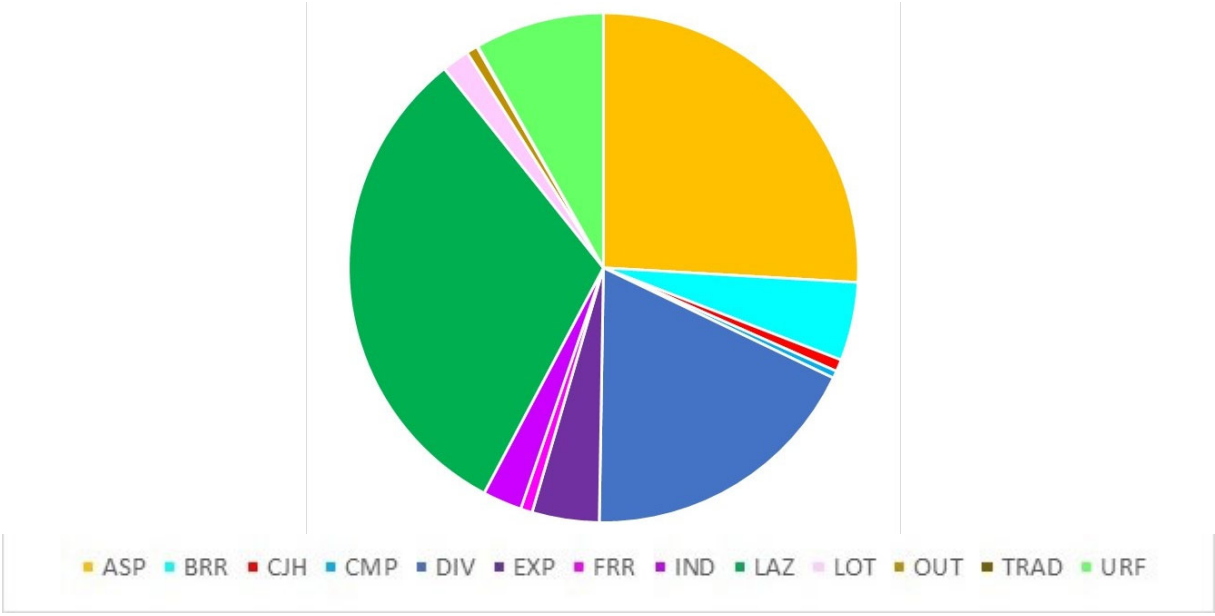
Figure 4: sample of 62 cities. Source: Almeida Filho, 2024.

The dispersion analysis consists of verifying the proportion of the area occupied by the external fragments in relation to the area of the main urban area (Table 1). This indicator contemplates the process of dispersion of urbanization and presented very different results: from a group of eight cities where we did not find any urban area outside the main area to the other extreme, also with eight cities, where the dispersed occupations make up an area greater than that of the main area. That is, in the first case, the city remains absolutely cohesive within the municipal territory and, in the second, there is more than another city dispersed in this territory. As the main urban area, we adopted not necessarily the largest, but the one that houses the main urban center. Among the various situations, it is certain that the process of dispersion of urbanization is not exclusive to large cities, as several studies point out, but also affects medium and small cities.

	Município	Proporção	região do Estado (1)	Distância rodoviária à capital (2)	População urbana (3)
1	Rubinéia	316,00%	Norte	> 450 km	Até 20.000
2	Álvares Machado	207,54%	Oeste	> 450 km	20.001 a 50.000
3	Zacarias	197,70%	Norte	> 450 km	Até 20.000
4	Brejo Alegre	177,50%	Oeste	> 450 km	Até 20.000
5	Catiguá	156,45%	Norte	301 a 450 km	Até 20.000
6	Elias Fausto	126,13%	Norte	Até 300 km	Até 20.000
7	Pedranópolis	116,92%	Norte	> 450 km	Até 20.000
8	Avaré	113,29%	Oeste	Até 300 km	50.0001 a 100.000
9	Guapiaçu	88,92%	Norte	301 a 450 km	Até 20.000
10	Ubarana	87,60%	Norte	> 450 km	Até 20.000
11	Laranjal Paulista	77,36%	Oeste	Até 300 km	20.001 a 50.000
12	Ribeirão Bonito	66,50%	Norte	Até 300 km	Até 20.000
13	Miguelópolis	62,47%	Norte	301 a 450 km	20.001 a 50.000
14	São José do Rio Pardo	44,31%	Norte	Até 300 km	20.001 a 50.000
15	Sud Menucci	38,89%	Norte	> 450 km	Até 20.000
16	Rubiacéa	35,44%	Oeste	> 450 km	Até 20.000
17	Mineiros do Tietê	35,37%	Norte	Até 300 km	Até 20.000
18	Pratânia	32,98%	Oeste	Até 300 km	Até 20.000
19	Boracéia	29,73%	Oeste	301 a 450 km	Até 20.000
20	Botucatu	26,46%	Oeste	Até 300 km	> 100.000
21	Cerqueira César	25,90%	Oeste	Até 300 km	Até 20.000
22	Mogi Guaçu	24,79%	Norte	Até 300 km	> 100.000
23	Espírito Santo do Pinhal	23,63%	Norte	Até 300 km	20.001 a 50.000
24	Cedral	23,29%	Norte	301 a 450 km	Até 20.000
25	Assis	21,07%	Oeste	301 a 450 km	50.0001 a 100.000
26	Araras	18,49%	Norte	Até 300 km	> 100.000
27	São Manuel	17,17%	Oeste	Até 300 km	20.001 a 50.000
28	Penápolis	16,95%	Oeste	> 450 km	50.0001 a 100.000
29	Cosmorama	16,50%	Norte	> 450 km	Até 20.000
30	Santa Mercedes	16,45%	Oeste	> 450 km	Até 20.000
31	Tabapuã	15,15%	Norte	301 a 450 km	Até 20.000
32	Lins	14,64%	Oeste	301 a 450 km	50.0001 a 100.000
33	Analândia	13,38%	Norte	Até 300 km	Até 20.000
33	Ibirarema	13,71%	Oeste	301 a 450 km	Até 20.000
34	Urupês	13,65%	Norte	301 a 450 km	Até 20.000
35	Espírito Santo do Turvo	13,58%	Oeste	301 a 450 km	Até 20.000
37	Tupã	13,27%	Oeste	> 450 km	50.0001 a 100.000
38	Jaú	12,26%	Norte	301 a 450 km	> 100.000
39	Guariba	10,10%	Norte	301 a 450 km	20.001 a 50.000
40	Pirajuí	9,10%	Oeste	301 a 450 km	20.001 a 50.000
41	Paulistânea	8,51%	Oeste	301 a 450 km	Até 20.000
42	Monte Aprazível	8,32%	Norte	> 450 km	20.001 a 50.000
43	Fernandópolis	7,76%	Norte	> 450 km	50.0001 a 100.000
44	Ourinhos	7,54%	Oeste	301 a 450 km	> 100.000
45	Birigui	7,41%	Oeste	> 450 km	> 100.000
46	Jaboticabal	6,14%	Norte	301 a 450 km	50.0001 a 100.000
47	Leme	5,78%	Norte	Até 300 km	50.0001 a 100.000
48	Adamantina	5,19%	Oeste	> 450 km	20.001 a 50.000
49	Ibaté	5,17%	Norte	Até 300 km	20.001 a 50.000
50	Nova Luzitânia	4,29%	Norte	> 450 km	Até 20.000
51	Mirassol	3,83%	Norte	> 450 km	50.0001 a 100.000
52	Mariápolis	3,00%	Oeste	> 450 km	Até 20.000
53	Bebedouro	2,02%	Norte	301 a 450 km	50.0001 a 100.000
54	Palmital	1,29%	Oeste	301 a 450 km	20.001 a 50.000
55	Buritizal	0,00%	Norte	> 450 km	Até 20.000
55	Inúbia Paulista	0,00%	Oeste	> 450 km	Até 20.000
55	Irapuru	0,00%	Oeste	> 450 km	Até 20.000
55	Jales	0,00%	Norte	> 450 km	20.001 a 50.000
55	Mirante do Paranapanema	0,00%	Oeste	> 450 km	Até 20.000
55	Pontes Gestal	0,00%	Norte	> 450 km	Até 20.000
55	São Francisco	0,00%	Norte	> 450 km	Até 20.000
55	Tarabaí	0,00%	Oeste	> 450 km	Até 20.000

Table 1 – Dispersion of the urban area: proportion between the area of the dispersed spots and the main area. Source: Almeida Filho, 2024

Regarding the typology of the external fragments (graph 1), both in number and in occupied area (148 and 36.77 km2), informal settlements (inf) emerge as a preponderant factor in the process of dispersion of urbanization. In the urban universe researched, precariousness means the non-compliance with the legislation on subdivision and, therefore, with the guidelines of a possible municipal urban planning, but not necessarily precariousness in the socioeconomic sense, associated with social vulnerability.



Graph 1 – External fragments by typology – area. Source: Almeida Filho, 2024.

There are 72 rural neighborhoods, whose occupied area is not very expressive (7.06 km2). They all have an evident hierarchical relationship with the main urban center. Diversified fragments, on the other hand, have a priori an opposite meaning. They are less numerous and more expressive in area (31 and 25.74 km2) and almost always closer to the main urban area and the main road structure. These are places that have lately attracted various activities, on the initiative of various agents. They are growth poles of the cities disconnected from the main area, possibly with more regional than local articulations.

Included among the closed urbanizations, the gated communities have a very marked impact throughout the interior of São Paulo, and it is no different in the medium and even small cities of the sample (35 and 11.63 km2). It is not difficult to infer that they constitute the most ostensible form of denial of the city, ideally understood as a place of encounter between people. They are recent and visibly expanding structures, conceived, on the contrary, precisely to segregate people.

The other typologies found make up 27 fragments and an area of 9.91 km2. They are housing complexes, University Campuses, Highway Fronts, Industrial Districts, allotments, Traditional Occupations and others, not defined.

Regarding the dispersion process of the main urban area, we observed that the surface of urbanization outside this area reaches about 18% of its area, sometimes reaching almost four times larger than it. Considering both the number of occurrences and the extent of the occupied areas and in descending order of importance, the main causes found in the sample are:

- the growth of cities along the highway fronts and their relationship with these linear structures, especially radial highways, connecting the capital and the interior;
- the disarticulation between regional and local, industrial and residential, large or small uses in these portions of the territory; the barrier effect of these structures;
- informal settlements, implanted visibly outside the standards of federal legislation on land parceling, according to satellite image analysis, in isolated, sometimes remote locations;
- urbanizations aimed at leisure, practically all on the banks of rivers and dams, often have large extensions, low density and, in some cases, also very low occupation of lots;
- diversified expansion nuclei, when a growth pole is detached from the main urban sprawl;
- closed urbanizations, in a process similar to what occurs in the intra-urban sphere.

SCATTER AND TYPIFICATION DIAGRAMS

The view of the set of diagrams allows us to rehearse a first discussion about the typification of cities in terms of the mode of dispersion. For the sake of space in this article, we have selected some significant diagrams for this first digression.

First, we identified medium-sized cities, where dispersion is intrinsic to the growth process itself. In them, we perceive tissues dispersed in different directions and typologies, seeming, at first glance, to be the result of an expansion that is not established by a single or preponderant factor.

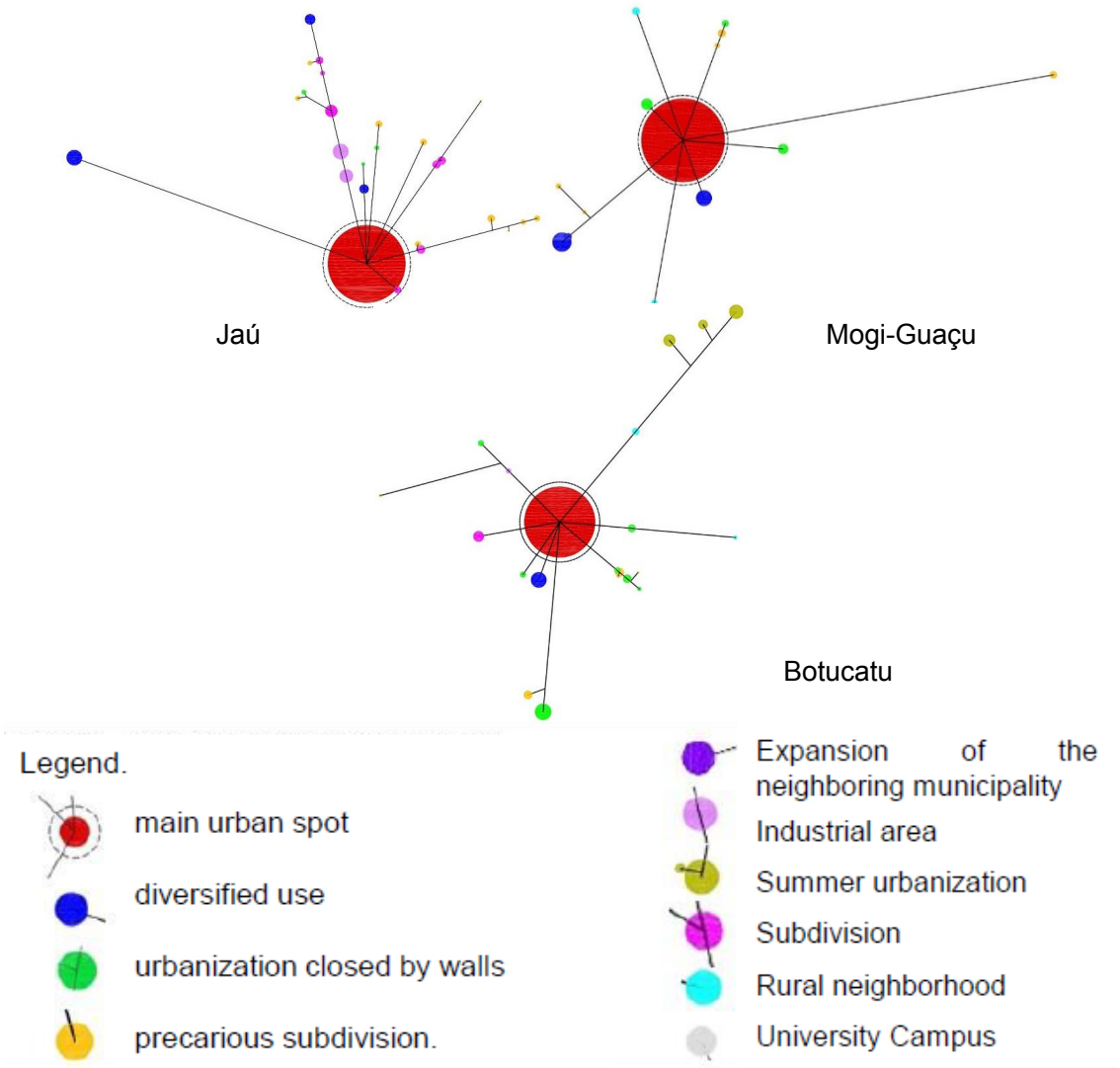


Figure 5: Diversified scatter plots in medium-sized cities.

We identified another group of small cities that, being neighbors of regional capitals or metropolitan areas, behave like satellites and see their expansion conditioned to the process of the main city, detached from its own center. Dispersed fabrics of a residential nature predominate. These are the cases, among others, of Álvares Machado (bordering Presidente Prudente), Guapiaçu (São José do Rio Preto) and Elias Fausto (Piracicaba). In the first two, the dispersion occurs predominantly towards the pole of attraction.

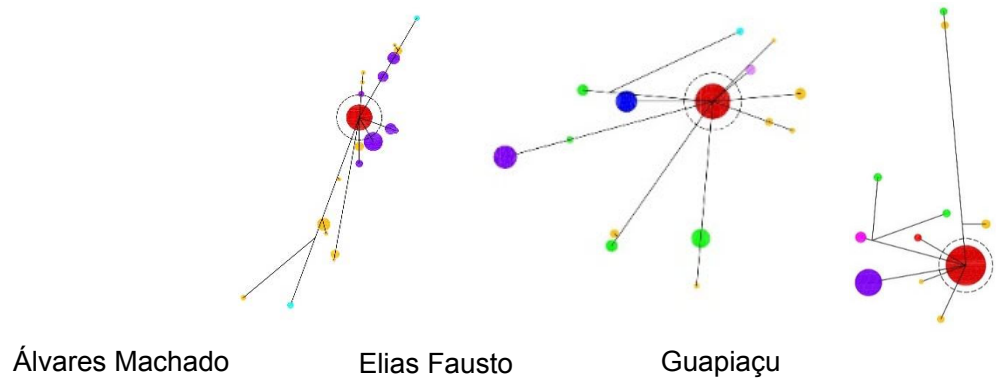


Figure 6: Scatter diagrams in cities neighbouring regional capitals and metropolitan region.

There are cases in which dispersion results from geographical aspects, such as the presence of rivers and hills, as in São José do Rio Pardo:

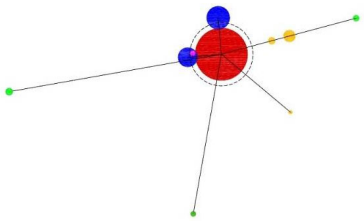


Figure 7: Scatter diagram resulting from geographical accidents. Source: Almeida Filho, 2024

In the state of São Paulo, the process of dispersion linked to tourist attractions or second homes is also remarkable. Whether in municipalities marginal to rivers and dams, such as Miguelópolis, where subdivisions at the water's edge predominate, or closer to the capital, such as Laranjal Paulista, where condominiums and informal subdivisions with large lots, the so-called "chacreamentos", appear.

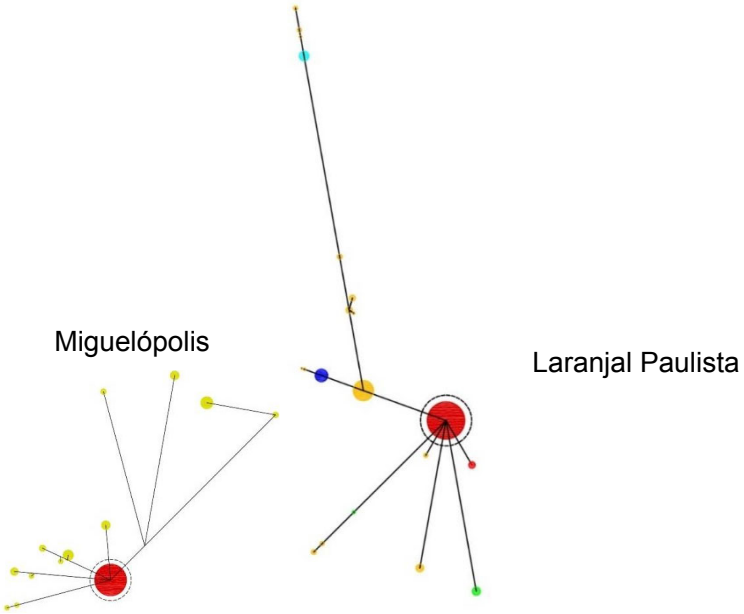


Figure 8. Scatter diagrams and tourist cities.

Finally, there are medium-sized cities that, contrary to the general tendency to disperse, remain cohesive.

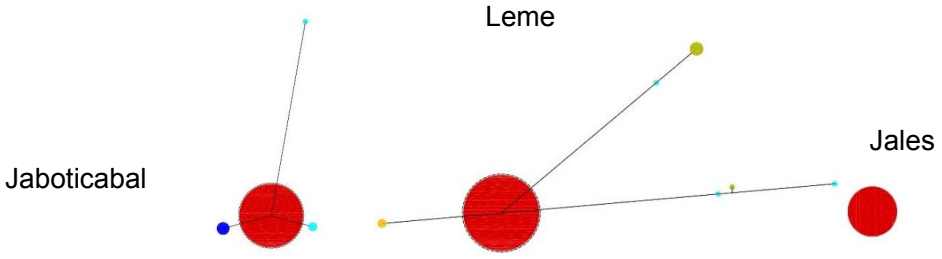


Figure 9: Scatter plots of municipalities with low or no dispersion:]

CONCLUSIONS

The present research aims to contribute to the typological studies of cities by adopting knowledge accumulated by research carried out in the area of urban morphology. It is expected as a result the preparation of the diagrams of the cities analyzed and the verification of the existence of patterns of the existing urban forms in the municipal territories of different Brazilian regions. It is expected to contribute to the development of a cartographic analysis method that results in a graphic synthesis of the spatial distribution of urbanization over the municipal territory.

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Housing production as an interface for socio-spatial justice: converging experiences from Argentina, Peru and Uruguay

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ABSTRACT

The study takes a historical approach to the production of housing in three South American countries – Argentina, Peru and Uruguay – and compiles a qualitative and quantitative overview of the contributions and challenges of each of the main experiences. In addition, for the nine most significant case studies, the insertion of housing into the urban fabric was investigated. The results showed obstacles and the lack of funding sources, the importance of pluralizing actions and the different demands of the actors, as well as the continuity and conclusion of some experiences.

Keywords: housing, South America, socio-spatial equity

INTRODUCTION

Latin America is one of the most urbanized regions in the world, with around 79.5% of the population living in cities (ECLAC, 2017), especially in metropolises. The existence of common structural conditions brings the urbanization process in these countries closer together. These include colonial inheritance, which was decisive to produce an oligarchy of landowners whose was in the land a source of primitive accumulation, on the one hand, and the formation of an immense mass of excluded people who were not served to by an agrarian and urban reform policy, on the other. Furthermore, the way in which rapid urbanization took place, based on peripheral industrialization and low wages, led to the formation of a macrocephalic interurban network based on the creation of an immense informal fabric around the formal city. Historically, despite a popular housing market and the existence of important state provision policies, some of them applying experiences produced in the central countries and carried out by strong, populist governments, they were not accessible to the economic standard of the families or were not sufficient to satisfy the immense demand, so that precarious settlements have been consolidated as an important form of access to housing, forging the so-called informal city. These processes are exacerbated by a clandestine market for the sale of plots and the difficulty of the families ascending to the formal renting of qualitative properties. In numbers,

23% of South America's territory is made up of precarious settlements (Lopes, 2023), while public production reaches 8% (Lopes, 2023) and market production 13.1% of regional GDP (Habitat, 2024).

Despite these obstacles, the subcontinent has stood out for successful experiences in access to housing. These include the regularization of precarious settlements, carried out by multidisciplinary teams with an accumulation of knowledge, through participatory practice and the originality of the solutions found on a case-by-case basis. Part of these discussions were captured by the United Nations Habitat (UN-Habitat) and by funding from multilateral agencies, which encouraged this action as a policy to confront the fiscal adjustment to which these countries were subjected in order to adhere to neoliberalism. In addition to mutual aid actions, which have proven to be a qualitative response to the promotion of well-located housing, despite the numerical limitations of the action. In such a way that the historical challenge of confronting this immense problem persists, linking housing well located in the urban fabric within an urban planning process that is able to consolidate instruments that are adhere to the social, economic and environmental conditions of this sui generis type of urbanization. No wonder, the Latin American Urban Planning Congresses were spaces for reflection and proposing these ideas, with the 1968 Andes Charter being an important document for disseminating these principles.

In this way, the aim of this work is to promote a historical reflection on the production of housing in three South American countries – Argentina, Peru and Uruguay – and compiles a qualitative and quantitative overview of the contributions and challenges of each of the main experiences. To do this, the method included a theoretical analysis of the historical trajectory of housing production (item 1) followed by an empirical analysis of nine important cases of access to housing in these three countries (item 2). The empirical analysis sought to explorer the insertion of housing into the urban fabric was investigated, in terms of diversity and density of existing typologies, links to urban mobility and the physical environment, and the provision of collective facilities and participatory decision-making bodies. Finally, sought to draw up a conclusive balance of alternatives and challenges in tackling the immense problem.

Housing policy in Argentina, Peru and Uruguay

Observing the particular case of Latin America, Abramo (2011) shows that the provision of social housing can take place through three logics – the typical promotion of the formal, popular market, selling plots on installments; through state housing policy, by the provision of subsidized or financed new housing; the logic of informal occupation of land, usually public and environmentally fragile, as a solution to the compulsory and immediate need for housing of those segments who are not solvent in the market and who are not reached at scale by the state. The author also identifies subsystems in the interface between these logics – the operation of a clandestine market for the subdivision and sale of grabbing plots, generally acquired by the excluded segments, even without the title of property, followed by the self-construction of housing; and the corrective action of the state, in the sense of promoting titling, as well as other socio-urban improvements in these informal and illegal territories occupied by the excluded families. In such a way that own home, even if not recognized by law, is a “magic formula” for families' budgets, in the context of an economy based on low wages and/or informal/unstable employment; the informality of housing is thus the most immediate

reflection of precarious work, something that covers around 50% of the Latin American population (WB, 2019).

Abramo also extends these three logics for access to social housing through rent – with the operation of a formal, popular and peripheral market; through state policy, by rental assistance, electronic vouchers to reduce the excessive burden of rent, urban stimulus for popular market rentals or the construction and maintenance of a state rental park. Likewise, the author recognizes subsystems at the interface between these logics – with an informal rental market operating in precarious settlements, through densification (tenement) or for the rental of rooms; and with the action, albeit restricted, of the state in partnership with communities, in the sense of making abandoned properties available for retrofitting and occupation. In such a way that renting is still a fragile policy in Latin America, as it is not seen as a way out for families, as it would mean subjecting a limited and uncertain family budget to a fixed monthly obligation.

The trajectory of social housing in Argentina, Peru and Uruguay reflects the complexity of the actions of these agents and forms of housing provision (see table 1).

Table 1. Déficit nos países estudados. Source: 1- Cippec-ACIJ-TECHO Argentina, 2023. 2- MVOT, 2020. 3- INE Encuesta Continua de Hogares, 2022. 4- Ministerio de Vivienda, Construcción y Saneamiento, 2024.

Countries	Precarious Housing (Quantitative Deficit)	Excessive Rental burden	Precarious Settlements	Total
Argentina	1.3 million[1]	1.6 million (80% of all[1] rented properties)	2.6 million[1]	4 million[1]
Uruguay	51,889[2]	152,806[3]	169,573[2]	221,462[2]
Peru	378,000[4]	---	1.44 million[4]	1.8 million[4]

In the case of Argentina, the import substitution industrialization that began in the 1930s boosted urbanization, which had already been taking place since the mid-19th century. This rapid urban growth was supported by a popular market for the sale of plots on installments, while the excluded segments formed villas de emergencia, the way precarious settlements are known in the country. The production of new housing by the state (“turnkey” policy) only began in the 1930s, when the first bodies dedicated to this issue were created – the Institutos Provinciales de Vivenda (IPVs), including the one in the province of Buenos Aires, and the Banco Hipotecario (BH), created in 1937 and 1886 respectively. These structures are associated with the establishment of a Welfare State, which accompanied the first developmental phase, led by military governments (1930-1946) and the populism of Juan Perón (1946-1955).

Given Argentina's tradition of conducting housing policy at provincial level, from 1972 were created the other IPVs, as well as the Fondo Nacional de Vivienda (FONAVI) by Law nº 19.929. The first IPV actions accounted for a small number of units produced (Manes, 2016). Between the 1950s and 1976 (when the military government began), Argentina experienced its second development phase, marked by the introduction of foreign capital and the alternation of unstable governments, with the return of Peronism (1973-1976). The creation of large technocratic structures – such as the Comisión Nacional de la Vivienda (1955), the new Buenos Aires IPV (1956), the Fondo Federal de la Vivienda (1959), the Secretaria de Estado de Vivienda (1965) e the FONAVI (1972) – gave support to the centralized policy.

Despite this apparatus, the period saw the construction of few units, with more comprehensive actions, under the influence of modernism.

It was curiously at this moment of the country's most violent dictatorship that the first actions to regularize the villas de emergencia emerged, in response to the 1976 United Nations Habitat. In this context, the instability created by the coup resulted in an increase in rental prices and a reduction in mortgage credit, contributing to the exponential growth in the number of precarious settlements created by the population not served by the "turnkey" policy (Wagner, 2005). Despite these initiatives, in the province of Buenos Aires, a policy along the opposite lines prevailed, with the compulsory removal of villas de emergencia, through the Plans for the Eradication of Precarious Housing, financed by the central government. Di Virgilio et al. (2014) note that the creation of more specific rules for the implementation of subdivisions by the market, through Law nº 8.912 of 1977, would have contributed to the retraction of the popular market in the period.

The country's return to democracy was accompanied by a political and economic crisis, with inflationary pressure and a fiscal deficit (Wagner, 2005), ushering in a long period of fiscal adjustment and adherence to neoliberalism. The result of this situation was a further increase in the number of villas de emergencia.

The neoliberal transition meant decentralization. It is in this context that the Sistema Federal de Vivienda was created, through Law nº 24.464 of 1995, consisting of a holistic structure formed by FONAVI, IPVs and Consejo Nacional de la Vivienda (CONAVI). The Law guaranteed greater powers to the provinces, not only in the use of resources (as was already happening through their co-participation in FONAVAI), but in deciding the allocation of resources. In this restructuring, the provinces were obliged to allocate funds to FONAVI to cover the deficit caused in the financing system, while BH was privatized.

The combination of the reduction in the transfer of funds and the increase in average construction prices meant that the policy of promoting new housing throughout the country came to a standstill. Thus, the policy of improving precarious settlements and building smaller housing complexes, putting individual credit programs into operation to keep the system functioning (Realini et al., 2019), became the prevailing programs. Wagner (2005) points out that this is the time of the greatest increase in urban poverty in the country.

In this context, it was enacted the Economic Emergency Law, Law nº 23.697 of 1989, which gave the National State the prerogative to transfer ownership of tax land declared not necessary for management to private individuals. In addition to Decree nº 1.001 of 1990, which enabled the transfer of tax land in the precarious settlements of Buenos Aires and Decree nº 2.411 of 1990, which extended this same condition to the other precarious settlements of Greater Buenos Aires (Di Virgilio et al., 2014). In addition, the regulation of Law nº 24.374 of 1994, known as the "Pierri Law", allowed private land to be titled to occupants.

More recently, the legal titling of properties passed an important moment with the enactment of Law nº 2.639 of 2008. This new legal framework established the Single Provincial Housing and Habitat Register (Registro Único Provincial de Vivienda y Hábitat), which allowed municipalities to carry out

comprehensive urban planning projects, financing the construction of new homes, housing improvement modules and infrastructure, thus reinforcing decentralization. Despite these initiatives and the large qualitative deficit (table 1), Argentina does not have a unified methodological procedure for land regularization, even though the period saw the implementation of important actions in precarious settlements through the Programa de Melhoramento de Bairros (PROMEBA). Created in 1997, the program aims to make systemic improvements in these territories, with land titling, infrastructure and environmental sanitation works, actions to reverse social vulnerability, in a financial agreement with the Inter-American Development Bank (IDB). Between 2003 and 2024, PROMEBA financed 39,068,518,614.47 dollars, covering 760 projects and 40,533 families, of which 690 projects, benefiting 39,198 families, have already been completed (SDTHV, 2024).

The state's promotion of new housing in this neoliberal phase began in 2003, when housing was chosen as a strategy for leveraging the economy in the face of the crisis, in a context in which the majority of the population did not have access to long-term financing on the private market (Barenboim, 2021). This restructuring took place with the re-centralization of the system, starting with the drafting of the National Housing Plan in 2003, and the creation of the Programas Federales de Vivienda (PFV), in which the Construcción de Viviendas I subprogram is included. This subprogram aimed to build 120,000 homes in phase 1, from 2003 to 2007, and a further 300,000 homes in phase 2, from 2007 to 2009. The third version took place with the launch of Techo Digno in 2009, with the aim of guaranteeing the continuity of existing infrastructure works and carrying out other complementary works essential to housing (Barenboim, 2021).

The Program currently in force for the production of new housing in the Casa Propia, governed by Resolution nº 16 of 2021, with the objective of financing 120,000 housing in the period 2021 to 2023, under the management of SDTHV. The Program Argentino de Crédito do Bicentenário para Habitação Unifamiliar (Pro.Cre.Ar.), created by Decree nª 902 of 2012, also currently in force, aims to finance the construction of new housing for the low-income and lower-middle-income segments; according to its operational design, the State makes tax land available for the location of developments, for those who do not have their own site, and finances the units to the beneficiaries, at reduced interest rates, from its own fund, linked to the Banco Hipotecário, and also constituted by the sale of tax land assets (Barenboim; Elinbaum, 2017). Is worth noting that the Programa de Incentivo a la Construcción Federal Argentina y Acceso a la Vivienda, created by Ley 27.613 of 2024, aims to grant credit to complete housing works that were paralyzed in the country.

Regarding the promotion of housing through mutual aid, Law nº 14.449 of 2012, called Fair Access to Habitat Law of the Province of Buenos Aires, represents an important current effort to strengthen the capacity of the state (provincial and municipal) and social organizations to promote fair access to habitat. The law, through credit at a subsidized rate, for the purchase of the land, the construction of the building and the hiring of an interdisciplinary technical team that accompanies the cooperative throughout the process. Zapata (2022) shows that there are currently 110 properties bought by cooperatives in the heart of urban Buenos Aires, with 45 cooperatives having already completed the construction work and almost 1,300 families currently living collectively in these housing estates. However, the program still has fewer resources than the others. Another important measure, the publication of the Plan Nacional de Solo Urbano, by Resolution nº 19 of 2020, consists in make urban land available for the promotion of housing, coordinating technical advisory actions.

In terms of rent, the worsening of the housing crisis, especially after the pandemic, has resulted in a situation where 80% of families who rent in Argentina commit 41% of their budget to paying rent (Encuesta Nacional Inquilina, 2024), an impactful value for the general poverty situation. This lack of plurality in actions, which are highly dependent on limited public funding, means that the problem is becoming more complex in the country, despite some successful initiatives.

In the case of Peru, urbanization began in the 1940s with the influx of migrants from the Andean region to Lima, but it intensified during the late process of industrialization by import substitution, which only took place during the Belaúnde Terry government (1964-1967) and reached its peak during the Velasco Alvarado dictatorship (1968-1975). The peripheral technological level of this industrialization did not favour the integration of the internal market, so that urban growth was not absorbed by the traditional mechanisms of the market for the sale of plots on installments, nor by the state's housing policy, causing barriadas, the way precarious settlements are known in the country, to become the main type of housing.

In fact, the state's housing policy, which began in the 1930s with the construction of barrios obreiros according to the principles of modernism (Romero et al., 2005), had a number, design and price of units that were not in line with the needs of the low-income segments (Castro; Riofrío, 2013). The Corporación Nacional de la Vivienda (CNV) was the body responsible, between 1940 and 1960, for the construction of some qualitative housing estates, in the body of ideas brought by the deputy, architect Belaúnde Terry (Espinoza, 2014).

Faced with urban growth from the 1950s onwards, Lima's traditional barriadas, which had been restricted to the hills of the central areas in previous decades, expanded into the peripheral, desert areas, the banks of the Rímac River and the Andean slopes, as discussed in classic studies (Matos Mar, 2012; Driant, 1991). In this context, the state began to support the barriadas, instead of eradicating them, as had been the case until then. Thus, the populist government of Manuel Odría (1948-1956), through the CNV, gradually set up modular urban centers, with plots and services, so that families could build their own homes (Castro; Riofrío, 2013). That this symbiosis between the state and the population represented a sui generis case of the formation of a spontaneous city, by the hands of the population, but with state provision of the necessary facilities.

The liberal government of Prado Ugarteche (1956-1962) represented a new attitude towards barriadas. The understanding was that self-construction, facilitated by the state, would be a low-cost solution to the housing problem (Castro; Riofrío, 2013); thus, through the Comisión para La Reforma Agraria y La Vivienda (CRAV), an intervention methodology was adopted based on holding technical advisory workshops so that families could build homes in mutual aid schemes, under the guidance of the state (Collier, 1978). The enactment of the Barriadas Law, Law nº 13.517 of 1961, represented a legal milestone so that these precarious settlements, as long as they were not located in inappropriate areas, could be subject to “physical and legal sanitation”, although the formation of new barriadas was not allowed.

The Prado Ugarteche government was also responsible for creating the Instituto Nacional de Casas Populares (INVI) in 1960, with the aim of building “satellite cities” based on the idea of “elemental housing”, according to which the state would be responsible for producing minimum housing modules

and providing technical support so that families could progressively complement the self-construction of their homes (Kahatt, 2015).

With the great urban growth of the 1960s, bodies were created to finance new housing, especially for the middle class, such as the Banco de la Vivienda del Perú (BVP), inaugurated in 1962, and the Junta Nacional de la Vivienda (JNV), created in 1963, with the task of managing the system and building the new units. Contradictorily, the balance was that the Belaúnde Terry government directed more resources to the middle class (91%) than to the popular sectors (9%), so that the JNV's own performance in these territories, at this time, was marked by total discredit, contrasting with the expectations brought about by the Barriadas Law.

It is worth noting that the barriada policy of the 1970s was taken over by the JNV, incorporating the ideas put forward by John Turner. The architect, after years of research and action on Peru's barriadas, advocated a methodology of neighborhood consolidation by the hands of the population itself, in its freedom to self-construct the space, as opposed to the rigidity of state planning and housing measures (Maldonado, 2015). FONAVI, created in 1979, was responsible for the housing policy of the period, with the intention of increasing the role of the construction sector within the BVP. FONAVI's resources came mainly from the compulsory contribution of formal and informal workers, but its actions were mainly directed at the middle class.

With the political and economic crisis of the 1980s, the country went through a somber period of armed struggle between extremist groups – the Tupac Amaru Revolutionary Movement and the Sendero Luminoso – and harsh repression by the police forces. The rise of Alberto Fujimori's dictatorship (1990-2000), as an unfortunate consequence of these conflicts, resulted in a rigid neoliberal transition in the country. It is in this context that the regularization of precarious settlements emerged, in line with the neoliberal thinking of Hernando de Soto and funding from multilateral agencies. So through the Comisión para la Formalización de la Propiedad Informal (COFOPRI), the country promoted the world's largest legalization programme, issuing more than 1.6 million public tiles. Ramírez and Riofrío (2006) show that this policy of widespread distribution of property titles in the short term, to the detriment of more comprehensive qualifications, has meant the legalization of fabrics outside the urban network and in situations of environmental and geotechnical risk.

The neoliberal adjustment of the Fujimori government meant that the policy of producing new housing almost disappeared, delegating the resolution of the issue to the private market (Calderón, 2015). The market's own pressure to resume financing resulted in the reconstruction of the system, with FONAVI being abolished in 1998 and replaced by the Mi Vivienda Fund (FMV), created by Law nº 26912 of 1997. The Mi Vivenda Program is a mortgage credit that allows the purchase of housing between 65,200 and 464,200 Soles, for different low-income groups, requiring the beneficiary to make a 7.5% down payment. Techo Proprio, created by Ministerial Resolution nº 054 of 2002, is the arm of the policy aimed at the lowest income segments (family groups between 2,706 and 3,715 Soles a month), with a one-off bonus granted by the state of 44,805 Soles for the purchase of housing, 30,900 Soles for construction and 11,845 Soles for housing improvements.

Calderon points out that Mi Vivenda reached its peak during Toledo's transitional government (2001-2006), directing resources towards financing new housing for the middle class, in a format in which

construction companies are responsible for selecting the land, designing and approving, building and selling the developments, while the government provides a subsidy to the private sector. The author points out that the 2008-2015 Housing Plan itself assumes the objective of reducing the deficit, placing the market as a facilitator of the process, which still represents the view that the sector is responsible for economic activity.

The period 2002-2006 saw great numerical success, with the state injected approximately 600 million dollars into the banking system (Caldéron, 2015). The program's actions meant construction for the middle class in the central area of Lima, with very few resources going to the lower class (7,111 bonuses), of which 7,037 were for new housing and only 74 for their own homes. This was because families did not have the minimum conditions to access the financing, due to job instability, so that the policy had difficulty competing with the illegal land-grabbing market and even with COFOPRI's own titling policy (Caldéron, 2015).

The program was restructured in 2006, under the García government (2006-2011), and began to target the lower classes, still with the primacy of private initiative, something that led to the vertical growth of cities based on real estate mortgages (Caldéron, 2015). The policy was thus divided into three modalities – new housing, construction on one's own site and housing improvements. Calderon notes that while first modality is led by construction companies, the second has attracted small construction companies (Technical Entities), usually made up of an engineer and a lawyer, working to regularize informally occupied areas or those acquired through land grabbing, although the processes are slow (Caldéron, 2015). And the third is the one that has received the least funding, with little interest from private companies, large or small.

Concerning the regularization of precarious settlements, the Programa de Mejoramiento Integral de Barrios (PUI), launched in 2007, is the current policy for intervention in these territories. The policy loses the aim of carrying out comprehensive improvements in each of the precarious settlements separately, in order to carry out a large number of small interventions in several settlements simultaneously, focusing above all on improvements to the road system, the placement of squares and community facilities, and the stabilization of risks, within the strategy of gaining scale in the overall impact on the population's living conditions. Medina et al. (2011) show that by 2010, the Program had worked in 1,363 settlements, with a total of 476,600 families served. One line of action within this framework is the Barrio Mio Program, created by Ordinance nº 1625, with the aim of implementing projects in vulnerable areas of Lima, based on the construction of geotechnical containments, stairways, squares and green spaces, designed in an integrated way with community leisure and circulation spaces; the identification and implementation, with community participation, of a portfolio of community equipments (culture, sport, health, leisure), which make it possible to improve the quality of life in the neighborhoods; and the implementation of social projects in these territories. Despite the tradition of self-construction of homes and cities, based on the historical buttom-up consolidation of the barriadas, the country does not have a tradition of mutual aid construction sites, with entities and cooperatives taking on the role of coordinating and technically supervising the work fronts. And although renting represents a small proportion of the housing stock, within the paradigm of home ownership as a magical housing solution for peripheral economies, the country has no tradition of a rental policy.

In the case of Uruguay, urbanization began at the end of the 19th century and especially in the first half of the 20th century, more as a way of applying agrarian rents to urban modernity than as a change in the direction of this main vocation towards industrialization. This growth was absorbed by the market production of installment lots and rental houses (Barenboim; Agudelo, 2010), while the excluded segments went on to form the country's first precarious settlements, the conventillos as they are known. One of the first initiatives, the Conventillos Law of 1878, aimed to improve the sanitary condition of these settlements and tenement houses. It was only with the creation of the Banco Hipotecario del Uruguay (BHU) in 1892 that the country's first policy of financing new housing began, which resulted in housing being built near factories (Barenboim; Agudelo, 2010). Subsequently, the Housing Rights Act of 1921 encouraged workers, military personnel and civil servants to obtain loans for housing construction (Barenboim; Agudelo, 2010).

An important milestone in housing production, within the formation of a relatively well-established Welfare State in the country, was the creation of the Instituto Nacional de Viviendas Económicas (INVE) in 1937, with the aim of building low-income housing for workers, with infrastructure for essential urban services, for rent or sale (Barenboim; Agudelo, 2010). However, the political and economic crisis from 1955 to 1958 had a major impact on housing production and it was precisely in this context that the country's landmark housing policy was approved, the Vivenda Law, Law nº 13.728 of 1968. Through it, housing was recognized as a right and an institutional structure was created to deal with the issue, made up of the Dirección Nacional de Vivienda (DINAVI), the BHU (financial body), INVE (central policy body) and the Fondo Nacional de Vivienda. The Law also established the need to plan housing demand and supply, through Five-Year Housing Plans, linked to economic plans, with housing targets to be achieved (Nahoum, 2008).

The law was responsible for institutionalizing cooperativism in housing policy, stipulating that cooperatives would be one of the forms of housing production (Nahoum, 2008). The law guarantees not only technical support through Technical Assistance Institutes (IATs), but also the provision of financing channels (around 22% of the housing fund) and the provision of land by municipalities (Nahoum, 2008). According to the Law, different types of cooperatives can be formed, depending on the format (head office or branch), the property situation (collective or owned), and the construction condition (with third-party labor or own labor – self-construction or mutual aid). In self-construction, each family builds its own house and on the construction site, through mutual aid, everyone works to build the units, which are then allocated by lottery.

According to the Law, municipalities must participate in the process by reserving land for acquisition by cooperatives, through the Cartera de Tierras (Decree nº 24654 of 1990), which also allows for better housing locations in the city, linking housing policy to urban policy. By utilizing various types of land (central voids, retrofitting abandoned buildings), cooperative production is diverse. The financing for the works comes from the National Housing Fund, which covers approximately 85% of the total cost of the work; families can commit a maximum of 20% of their family income to paying the financing (Nahoum, 2008). The Law provides for some types of subsidies, the most widely used currently being the amortization quota, in which the State pays the difference in monthly payments if families are unable to pay the full amount. In terms of numbers, more than 12,000 homes have already been built through cooperatives in the country, and the houses produced in cooperatives were the cheapest (according to data from 1969) (Nahoum, 2008).

The expansion of precarious settlements in Uruguay only occurred later and in smaller numbers than in other Latin American cities (Rivadulla, 2014). Most of the occupations were consolidated after the neoliberal opening up of the country, which, in a way, affected the tradition of a welfare policy, with the very retreat of the BHU, and exposed work to greater informality, which ended up accentuating poverty and, consequently, precarious settlements. As a result, the lowest-income segments, not served by the mechanisms of the market and the state, will find a way out of housing in the organized collective or individual occupation of public land, followed by self-building. The state's relationship with these occupations covers a myriad of situations: from non-recognition and removal, to recognition, titling of plots and progressive improvements.

It is in this context that the Programa de Integración de Asentamientos Irregulares (PIAI), launched by the MVOT in 1999, represented the first significant intervention policy in these areas. Carried out with resources from the IDB, as part of the prevailing policy of multilateral agencies to finance land regularization on a larger scale in Latin America in the context of fiscal adjustment, the program aimed to comprehensively improve the neighborhoods. The institutional design of the Program consists of the coordination of actions by the national government in conjunction with the departments. Thus, through the Planning and Budget Office (OPP), the departments submit the projects and the national government selects those eligible to receive the funds. The PIAI also assumed that the settlements would be on public land and with a minimum housing density; other versions of the Program allowed for action on land of private origin, but which had been expropriated by the government for regularization. The Programa de Mejoramiento de Barrios continued the PIAI using a mix of resources from the national government (30%) and the IDB (70%) (MVOT, 2020). The PMB has a more comprehensive approach than the PIAI, seeking to include the population in society. Between 2005 and 2019, 80 barrios were regularized, while between 1999 and 2004, 11 projects were approved (MVOT, 2020). Uruguay has a national social housing policy, provided for in the Quinhenal Plan. Thus, the rent can be given by value supply, so that the beneficiary can rent housing in the market, or from the rent of the state stock, built within the BSF. Between 2015 and 2019, 8,719 rental guarantee contracts were signed (MVOT, 2020).

Critical analysis of important housing experiences in Argentina, Peru and Uruguay

In Argentina, faced with the immense challenge of producing new low-cost housing, one of the significant programs is Pro.Cre.Ar., among them the one located in San Miguel, a municipality in the Northwest region of the province of Buenos Aires. The project consisted of land subdivision of around 125,000 m² for the construction of housing; and, although the selection of the land was the responsibility of the state, this meant the peripheral extension of the fabric. The presence of government teams, or in ad-hoc arrangements, are responsible for designing the project and construct the basic infrastructure, in this case of an entire new neighborhood, and building the complexes. Pro.Cre.Ar San Miguel consisted of 96 two-bedroom apartments and 136 two- and three-bedroom detached houses, ranging from 60 to 98 m² each, six of which are adapted for people with special needs; the units have a pantry, kitchen, bathroom and bedrooms (figure 1). The typological variation and the good use of concrete allowed for a better quality of the whole, despite the cost-saving prerogative inherent in this type of project. Nevertheless have a central area with green spaces and community leisure, the neighborhood lacks commercial areas. The project offers few collective equipment in the surrounding area. The units cost 454 million pesos and were distributed to

beneficiaries registered as eligible for the Program, with financing from the Pro.Cre.Ar Fund (Argentina, 2018).



Figure 1. San Miguel aerial view (i), typologies (ii), location (iii). photo credit: Argentina, 2018 (i-ii) authors (iii).

Argentina also has a major land regularization challenge and one of the most significant programs on the subject is PROMEBA. The Program's operational design determines that municipalities must present the most pressing local projects for regularization, while the national government is in charge of selecting the proposals that will receive the funds. One of PROMEBA's most significant experiences was the Vila Tranquila, located in the municipality of Avellaneda, which is part of the Buenos Aires metropolitan area. The area experienced rapid growth in the second half of the 20th century as a result of industrial activities and the existence of the railroad and dock port in El Partido (Bettati, 2008). However, with the stagnation of the region's industrial fabric, Villa Tranquila became a place where 40% of the population was unemployed and 80% of families were below the poverty line, resulting in a serious situation of social vulnerability and violence (Bettati, 2008). The regularization of Villa Tranquila was an attempt at multisectoral action, for which an executive unit was created, with representatives from various bodies, and with prominent popular participation.



Figure 2. Villa Tranquila typologies (i-ii), location (iii). photo credit: Argentina, 2018 (i), GoogleMaps®(ii) authors (iii).

The regularization involved funds from the Federal Government, for the construction of 730 new homes, and from PROMEBA, for urban infrastructure works (Bettati, 2008). There was also municipal funding for technical assistance, through an agreement with a university, and for complementary works. The intervention project covered an area of 374,907 m² and included urban redesign, with the conformation/reorganization of new blocks, the definition of public and private spaces, as well as the improvement of basic infrastructure; the installation of community equipments (mainly through the transfer of abandoned industries to the state); the creation of opportunities for professionalization,

employment and income for the community (figure 2). The urban improvement works were carried out in stages, due to the limitations of the occupation. Existing homes were also improved and new ones built, in order to relocate the families affected by the urban remodeling of the subdivision, with the release of the non-aedificandi strip protection from the railroad and the opening of new roads. It should be noted that new constructions, semi-detached buildings, have been undergoing various modifications to adjust to the needs of families. In addition, there was the titling of the properties.

Argentina has little tradition of cooperativism, but the institution of Law 341 of 2000, which created the Programa de Autogestión de la Vivienda (PAV) in the province of Buenos Aires, have enabled some actions with mutual aid. One of the Program's recent experiences is the building Amancio Alcorta 1601/07, located in Barracas, in the southeast of Buenos Aires. The project was carried out by the Alto Corrientes Cooperative, which was responsible for commissioning the architectural design, carried out in 2002, and the construction company, which carried out the work between 2006-2009. The site, with an area of 131.00 m², is very well located in the urban fabric, with a significant range of commercial and institutional areas and, therefore, employment options in the surrounding area, as well as green areas. The project consisted of converting an old hotel into 14 residential units. As it was not possible to make use of the existing equipaments, the building was demolished and the new building was erected on the site, consisting of 4 duplex units and 10 single-room units plus mezzanine. The collective areas are restricted to circulation spaces and a courtyard inside the building (figure 3). The technical team did some training work, but the project was not carried out by mutual aid. Despite the cooperative initiative, ownership of the units is individual. Each unit cost around $ 30,000.

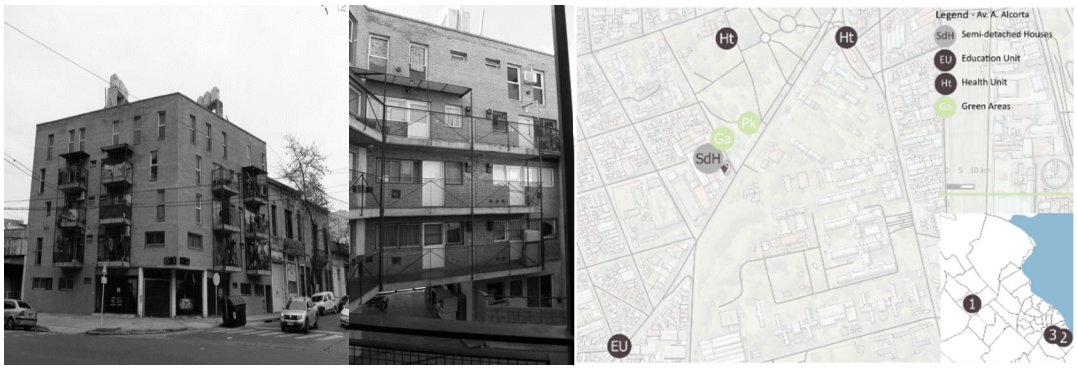

Figure 3. A. Alcorta typologies (i-ii), location (iii). photo credit: Zapata, 2022 (i), GoogleMaps®(ii) authors (iii).

In Peru, the policy of producing new housing has traditionally been insufficient and discontinuous, and a typical example of the current program MiVivenda, is Ciudad Sol de Collique, located in Comas, north of Lima.



Figure 4. CidSol de Collique typologies (i-ii), location (iii). photo credit: Zapata, 2022 (i), GoogleMaps®(ii) authors (iii).

The very prospect of land and scale gains determines the peripheral location of the land, a former airfield, acquired from the public authorities at a low price (Calderón, 2015), and the choice of the mega-ensembles, showing the difficulty of reconciling housing and urban policy. The project has 16,000 units, 5,000 linked (with 8-storey buildings) to Techo Próprio and 11,000 (with 12-storey buildings) to Mivivienda, in a total of 15 blocks (2 for commercial use). The housing units consist of a kitchen and laundry room, 2 bedrooms, a living room and a bathroom. There are collective uses such as a playground, squares and bike paths. Housing costs 43,200 soles in Techo Próprio and between 60,000 and 103,000 in MiVivenda (figure 4).

Peru, following the Latin American context, has precarious settlements as an important form of access to housing. One of the most emblematic cases of land regularization is Vila El Salvador (VES), located 23 km south of Lima. The site was regularized in the 1970s and, with the reproduction of informality, there was a new intervention under the PUI, so that it can be examined through two generations of programs. The VES was occupied as part of the formation of the Velásco government's assisted barriadas in the 1970s, when a group of 200 families settled on an extensive desert site; the next day there were already 9,000 occupants and two months later 20,000 families (Bocanegra, 2009). There has thus been a long history of mobilizations and conquests, with the site receiving various interventions, promoted by different actors, until it became one of the main popular fabrics in the metropolis of Lima. The process began with essential works and the recognition of the Comunidad Urbana Autogestionaria de Villa El Salvador as responsible for conducting the qualifications together with the government. The project consists of a basic nuclei for the organization of community life; initially, 100 residential groups were built, each made up of 16 blocks with 24 plots and the neighborhood's collective equipments were allocated in the center of these, designed to be collective properties and products of the cooperative work of the residents of each “residential group”. This sorganization would also form, at the top level, a self-organization by sectors.

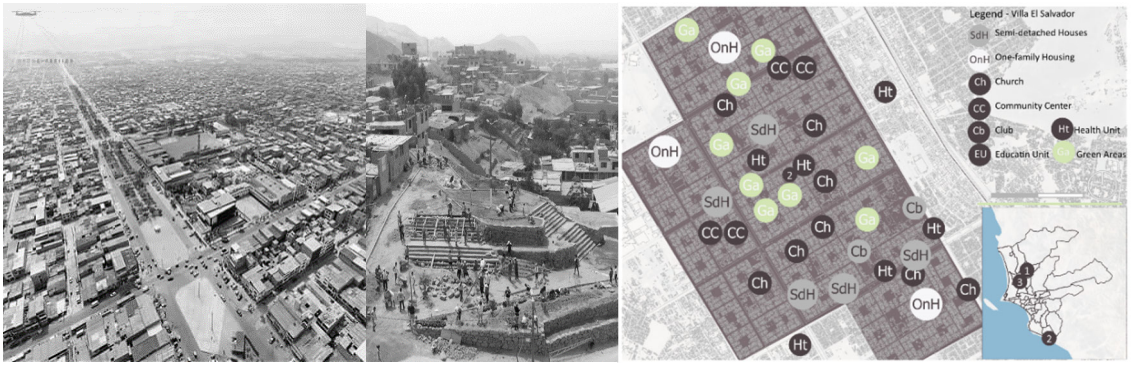

Figure 5. VES aerial view (i), Barrio Mío (ii), location (iii). photo credit: Zapata, 2022 (i), Zapata, 2022 ii), authors (iii).

The social struggles continued in the following decades, especially in the face of the retreat of government support under the Bermúdez government and the dark period of penetration of the Sandero Luminoso movement in the VES. The site was also the object of work by various organizations and technical assistance workshops in working class neighborhoods. More recently (2012-2014), VES was one of the 17 areas of Lima that received the actions of the Barrio Mío Program, with the improvement of squares and public spaces and investments in social equipments (figure 5).

In Peru, one of the historical experiences of self-managed production is the Proyecto de Vivienda Experimental (PREVI), carried out in Lima in 1965, as part of a joint initiative between the Peruvian government, UN-Habitat and the BVP (Land, 2008), seeking to place the housing issue within urban planning. So four projects were proposed, the first plan focused its efforts on disseminating debates on housing and proposed a housing complex with experimental residential typologies. The second aimed to redevelop housing and urban areas in precarious sectors of the city and the third created a plan for self-built plots and services, expanding social networks. The fourth plan was dedicated to developing construction procedures capable of withstanding earthquakes. PREVI is part of the first plan, representing the questioning of the large modernist housing estates advocated in the post-war period by the second CIAM. According to the competition, each typology had to comply with the limits of built area, set at between 120 and 60 m², with one or two floors, with the potential for expansion up to the third floor, to meet the needs of the families. The housing concept consisted of “courtyard homes” that would allow for future extensions (figure 6). The plan includes 24 residential groupings designed by different architects, with public facilities and communal spaces. The various layouts of the residential groupings formed a densely occupied neighborhood, rich in cultural diversity, integrated with mixed uses. The PREVI Plan interpreted the demand for housing in a self-sufficient way, giving the user back the leading role in articulating with the built space. The initiative allowed each family to have control over the construction of their homes and future extensions were assured in the guidelines imposed for all typologies (Land, 2008). Many typologies were modified, de-characterizing the original architectural proposals, mainly with new colors and interventions on the façades.



Figure 6. PREVI mockup (i), typologies (ii), location (iii). photo credit: Zapata, 2022 (i), GoogleMaps® ii), authors (iii).

In Uruguay, the experience of producing new housing through the market is less significant, given the tradition of cooperatives and the choice of small units sprayed on the fabric. The main program in this area is carried out by the Banco de Previsión Social (BPS), aimed at retirees, pensioners and lower-income social groups, in the form of direct allocation (with 6754 houses), subsidizing rent in units similar to the BPS for those enrolled who have not yet been offered housing (with 102 houses); granting subsidies or paying for housing services in homes for the elderly enrolled in the Program (with 746 houses); however, the number of units offered by the BPS Program covers only 10% of total demand (MVOT, 2020). According to the Program's design, the MVOT is responsible for constructing the buildings through bidding from construction companies, which become part of the BPS residential stock; the beneficiaries are selected by the MVOT and the Organización de Jubilados y Pensionistas, registered in the Program. A case of construction of new units under BPS policy is the Parque Riviera Building, located in the east zone of Montevideo. The 1500 m² plot is located in a predominantly residential area, with availability of equipment. The project consists of a three-story building with 40 one-bedroom apartments, as well as a multipurpose space.



Figure 7. Parque Riviera typologies (i-ii), location (iii). photo credit: Zapata, 2022 (i), GoogleMaps® ii), authors (iii).

The regularization of precarious settlements in Uruguay has been addressed through specific programs. However, it was the PIAI which played a more significant role in these territories. One of the most significant examples of PIAI is Boix y Merino, located in the eastern part of Montevideo. The urban intervention covered an area of 106,577 m² and benefited 1133 families (282 lots). The process unfolded from 2005 to 2012 in three stages: project preparation, execution of works and post-intervention actions. The development of the project was preceded by a Participatory Social Diagnosis of the site carried out in 2005, in which the total number of homes and people (282 and 1133 in 2005

respectively) were mapped, the legal situation of the lots, the existing infrastructure and urban equipment, the buildings and existing environmental problems. Approval of the project depended on validation by at least 70% of the local community and the technical and economic viability of the solutions, according to the available resources, and, from there, a bidding process followed. The urban interventions included improving roads so that children could access school and ambulances could enter, in addition to opening passages to provide access to sports courts, and installing a sewage system, which had not existed until then. The land titles were also issued. The Diagnostics identified that almost 40% of the houses did not have a bathroom and that 55% did not have sanitation. Thus, mutual aid efforts were carried out to improve housing, primarily installing bathrooms. The work was supervised by the Sindicato Único de la Construcción (SUNCA), which also worked to professionalize the work fronts so that, in addition to improving their own homes, the population could receive a Training Certificate at the end of the works. Families that needed to be relocated were assisted by policies for the acquisition of new units or existing ones.



Figure 8. Boix y Merino aerial view (i), typology (ii), location (iii). photo credit: GoogleMaps® (i-ii), authors (iii).

In the case of Uruguay, housing cooperatives are based on the country's already deep-rooted vocation for self-construction. They emerged in the wake of the workers' and cooperative movements (Nahoum, 2008), and thus went through a long history of struggles until they were granted legal provision in the 1968 Vivenda Law. One of the most virtuous cases of the work of housing cooperatives was the recent construction, in 2011, of the cooperative neighborhood “Juana de América” (Mesa 5), located in the center of Montivideo. The meetings are occasions when a group of cooperatives come together to promote the construction of the complex. The neighborhood, located in the western area of Montevideo, has a total of 420 homes, divided into four-story semi-detached housing blocks. The neighborhood was built with a regular orthogonal urban layout.



Figure 9. Juana de América typologies (i-ii), location (iii). photo credit: GoogleMaps® (i-ii), authors (iii).

CONCLUSIONS

Despite the complexity of the problem, South America has virtuous solutions to address the quantitative deficit, such as the recent attempt to associate the supply of urban land with the financing policy for new housing (Argentina), something important compared to the typical peripheral and homogeneous solutions characterized by market production (Argentina in the PFVs and Peru), or the policy of public stock for sale or rent (Uruguay). However, it is necessary to cross housing policy with urban policy, applying instruments to capture plus values and subsidies for better located developments. It also has a long tradition in land regularization, whether in methodologies that allow for scale-up of interventions (Peru) or holistic actions in each project (Argentina and Uruguay), although it requires greater innovations for property titling and scale-up of actions, also favoring housing improvement policies, based on reform assistance programs with technical advice from entities. Very structured around the magic formula of home ownership, renting is still fragile in the subcontinent, and it is worth highlighting the successful experience of Uruguay.

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Towards Incremental development analysis of street patterns in informal settlements

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ABSTRACT

The last decades of urban expansion have resulted in significant spatial changes on a global scale. Greater intensity of these spatial shifts has been observed in Global South contexts, particularly on the African continent. These changes are caused by demographic, economic, and political shifts. Cities in Sub-Saharan Africa exhibit fragmented morphological patterns in terms of urban development. These patterns include planned and unplanned areas. Informal settlements, once peripheral to mainstream urban studies, now demand critical engagement as part of the broader urban landscape. Understanding the spatial evolution of these areas is vital to formulating urban strategies. This research seeks to clarify how emerging urban morphologies in informal areas can inform current urbanization trends in the Global South through the use of systematic and analytical spatial observation. The paper aims to analyze the morphological evolution of street patterns in informal settlements, testing a proposed methodology on Kibera, Nairobi, over a 20-year period. The objective is to understand how incremental changes in access networks reflect on broader urban dynamics, contributing to discussions on infrastructure planning and urban integration. The study applies GIS and Space Syntax to analyze the spatial changes in Kibera's street network over a 20-year period (2004–2024), using satellite imagery at five-year intervals. By focusing on measures such as integration and betweenness, the study tracks incremental changes in street connectivity and accessibility. Results indicate that Kibera has become increasingly integrated into Nairobi's broader urban network over time. Infrastructural developments related to the city's masterplan have improved connectivity, though they have also led to the displacement of residents. It is argued that while infrastructural improvements can enhance connectivity, they also risk marginalizing local communities. The study illustrates that GIS and Space Syntax methods are potentialy capable of capturing the dynamic, evolving nature of informal settlements, providing insights into their spatial transformations. The findings suggest that systematic spatial analysis can improve the understanding of informal settlements' morphologies and their relation to the broader urban fabric. These methods offer a tool for analyzing urbanization trends in informal areas, with potential applicability in other cities.

Keywords: Informal Settlements, Space Syntax, Kibera, Nairobi Spatial Integration

INTRODUCTION

Global urban expansion has significantly increased the extent of urban areas, driven by of population growth, economic development, and socio-political factors (Seto et al., 2011). This expansion has broad about significant changes in the way cities are structured, particularly in the Global South, where urbanization is characterized by rapid city growth, significant inequities in access to services, and the enduring impacts of colonial legacies (Myers, 2003). As a result, informal settlements have proliferated, becoming a defining characteristic of many urban areas. These settlements, characterized by spontaneous, incremental growth and a lack of formal planning, present unique challenges. Understanding how these emerging urban morphologies evolve over time is crucial for addressing broader urbanization trends in the Global South. While much of the existing urban research has focused on formal city development, there is an increasing acknowledgment that informal settlements demand specialized analytical approaches to effectively capture their dynamic characteristics (Lall, et at., 2017; Gutu Sakketa, 2023).

Urban informality, far from being an exception, has become a consistent mode of urban space production (Dovey et al., 2020). Although informal urbanization is not a recent phenomenon, it has historically been overlooked in urban morphological studies. In recent decades, scholars have called for a better understanding of informality but a challenge remains in terms of how we can better understand these urban forms and the processes that shape them. Recent scholarship highlights the importance of adopting a systematic, analytical approach to studying these settlements, one that goes beyond simply describing them as deficient or irregular (Gilbert, 2007; Zarate, 2016; Dovey et al., 2018). Informal settlements share common physical characteristics across diverse contexts. Their growth is typically self-organized and incremental, leading to a fragmented urban morphology that alignes newer additions with more stable cores of earlier settlement (Iranmanesh and Kamalipour, 2023). Developing strategies to address the challenges of informal settlements and incorporating them into the wider urban environment requires a deep understanding of how these settlements evolve over time.

The study seeks to address this question: How can the study of emerging urban morphologies shaped by informality help clarify current urbanization trends in the Global South?. The paper argues that this can be achieved through the systematic observation and analysis of urban forms and their dynamics. The study employs Geographic Information System (GIS) techniques and Space Syntax analysis to establish a methodological framework for understanding the evolution of spatial configurations of informal settlements evolve over time. Kibera, Nairobi's largest informal settlement, is used as a test case to assess the applicability of these methods in studying informal urban morphologies. The importance of the research lies in its potential to provide analytical approaches for urban planners and policymakers in rapidly urbanizing cities. By systematically mapping changes in the selected informal settlement's street network over a 20-year period (2004–2024), the study tests whether Space Syntax and GIS techniques can effectively capture the incremental spatial changes typical of informal settlements. The findings can potentially inform broader discussions on how such methods could be used to address the challenges posed by urban informality. Thus, the aim of this paper is not only to examine the morphological changes in the selected case but to demonstrate the value of systematic spatial analysis in understanding informal urban growth. The methodological approach applied in this study can be a tool for understanding the broader urbanization trends in other cities facing similar challenges.

This paper is organized as outlined: The first section reviews existing literature on urban morphology and informality as well as the applicationof space syntax in studies dealing with informal areas. The second section describes the methodology, focusing on the use of GIS and Space Syntax for spatial analysis. The results section presents findings from the 20-year analysis of the test case's street network, followed by a discussion on the broader applicability of these methods in understanding informal settlements. Finally, the conclusion reflects on the potential and pitfalls of these analytical tools to inform urban planning.

Urban Morphology and Informality

The field of Urban morphology, which studies the form and structure of urban spaces (Oliveira, 2016), provides valuable perspectives into the dynamics of informal urban areas, which emerge as spontaneous and incremental responses to local conditions and needs. Unlike formally planned urban areas, informal settlements evolve without the guidance of master plans or regulations, leading to complex, often irregular spatial structures (Dovey and King, 2011). Despite this apparent disorder, the spatial configurations of informal settlements are shaped by adaptive processes that reflect the ongoing negotiation between residents and their environment. These areas often feature small building increments, narrow pathways, and uneven access routes that form in response to resource availability and immediate social needs (Dovey et al., 2020). The gradual densification of informal settlements leads to morphological consolidation, where once-peripheral areas become integral to the settlement's internal structure, as well as to the broader urban system (Tessari, 2020). Despite the significant role of informal settlements in urban development, the morphological study of these areas has often been overshadowed by other relevant discussions on economics, land tenure, and infrastructure (Owen et al., 2013). Recent scholarship has shifted focus towards the spatial characteristics and developmental logics of informal settlements. Researchers are increasingly recognizing that the form and structure of these areas reveal underlying spatial patterns and urban dynamics that are crucial to understanding broader urbanization trends (Kamalipour and Dovey, 2020).

Traditionally, urban morphology has been dominated by three major schools of thought—the British, Italian, and French schools—that focus on the historical and typological evolution of cities (Oliveira, 2016). These schools offer insights into formal urban environments, emphasizing historical cartographic analysis, building types, and street layouts (Conzen, 1968; Caniggia and Maffei, 2001). However, the fluid nature of informal settlements challenges these conventional approaches, as these areas operate outside of regulatory frameworks. To address this gap in urban morphology, scholars have begun incorporating morpho-analytical tools to explore the spatial logic of informal settlements particularly those utilizing space syntax (Karimi et al., 2007; Loureiro, 2017; Cutini et al., 2019; Iranmanesh and Kamalipour, 2023) and historico-geographical and process-typological approaches (Maretto et al., 2014; Iovene et al., 2017).

Challenges of studying the morphological aspects of informal settlements have been recognized as related to availability of high-quality spatial data. Acquiring maps and cartographic data on informal settlements has become feasible in recent decades. Busgeeth et al. (2008) outline several reasons for the difficulty in obtaining spatial data for informal settlements, including unclear municipal boundaries, the lack of formal plot boundaries, challenges in conducting in-situ surveys, and the ever-changing nature of the settlements. Information designed for city planners, technicians, or military use was once restricted and required bureaucratic access. As Fabricius (2008) points out, details about

a city's spatial relationships, such as proximities, densities, and inhabited areas, were closely guarded. The constraints in gathering data on informal settlements have been mainly addressed through the use of remote sensing technologies (Musakwa & Van Niekerk, 2015) and approaches and technologies that include open-source software, mobile applications, and volunteered geographic information.

Space Syntax as methodological tool for informal settlements

In physical terms, cities are networks of streets and open spaces that connect buildings and blocks, forming a backbone of urban life. Socially, these spaces facilitate movement, interaction, and activities, creating a dynamic urban environment. Space Syntax, developed in the 1960s offers a methodological tool for examining the relationship between the spatial configuration of urban environments and social and economic dynamics. By focusing on the connections between spaces rather than their physical attributes, Space Syntax provides insights into how spatial configurations influence movement patterns, land use, and social behaviors within a city (Van Nes and Yamu, 2021).

The core measures of Space Syntax, angular integration and angular betweenness (choice), provide quantitative data on spatial relationships that relate to how spaces are connected and accessible. The first measure, angular integration, is considered a "to-space" measure. It refers to how easily one can reach other parts of a spatial system from a given location, considering the angular change in direction required to move through space. A space with high angular integration is typically more central, indicating that fewer angular deviations are needed to reach it from other spaces. It is a key indicator of how integrated or accessible a particular space is within a network. The second one, angular betweenness, is considered a "through-space" measure. It refers to the extent to which a particular space lies on the shortest paths between other pairs of spaces. A space with high angular betweenness is often a critical connector in the network, frequently used as a route between other spaces. This measure is crucial for understanding how traffic or movement might flow through a network (Hillier 1996). These measures can be calculated at global - referring to the entire network- and local scales- referring to subsections of the network- offering different insights of potentialities of places and networks.

Space Syntax has proven useful in understanding the underlying spatial structures of informal settlements (Karimi, 2012, Cutini et al., 2019; Tufek-Memisevic, 2023). Studies using this methodology have shown that despite their seemingly chaotic appearance, informal settlements often exhibit structured networks that facilitate social and economic interactions (Cutini et al., 2019). The application of these quantitative spatial tools has allowed the mapping, analyzing, and interpretation of connectivity of street networks and the ways in which informal settlements are integrated into or remain isolated from the broader urban system. The emerging focus on the morphogenesis of informal settlements—the process by which their form changes over time—reveals that as informal street networks grow, they often become more hierarchical and structured (Iranmanesh and Kamalipour, 2023). The incremental development process is critical for understanding the spatial evolution of these settlements and their potential integration into the formal city (Karimi et al., 2007).

Examples of applications offer insights into how these areas evolve, adapt, and integrate with broader urban systems. Although limited to some studies, this methodology has been effectively employed in various contexts to understand the structural and social dynamics of informal areas. Results obtained by applying space syntax enable topological and statistical analyses, revealing underlying urban

patterns. Such studies have been used for the identification of areas with low integration pointing to suggestions on targeted interventions (Karimi et al., 2007), or evaluation of proposals for interventions in such settlements (Tufek-Memisevic, 2023); recognition of discernible patterns in the morphology of informal areas (Cutini et al., 2019); influence of street accessibility on the distribution of small businesses (Mohamed et al., 2022); and explorations on the morphogenesis of street patterns (Iranmanesh and Kamalipour, 2023).

METHOD

This study developed a street network model for a whole city and a 15 km buffer around it, using road center line (RCL) data obtained from OpenStreetMap (OSM) datasets (data downloaded in March 2024). The use of RCL maps in Space Syntax analysis allows for the systematic representation and analysis of the spatial configuration of urban street networks. The methodology for creating this model involved two key steps, the first step was a general inquiry into the entire site, which included simplifying the citywide network through predefined Space Syntax methods, including error removal and data generalization (Kolovou et al., 2017). The generalised RCL data was then used to create a segment network, on which centrality analysis was conducted to calculate integration and choice values for each segment using the Place Syntax Toolkit (PST). The analysis was carried out across various radii, allowing the identification of integrated and segregated areas at both global (total, radii 10 km, 15 km) and local scales (radii 1 km, 2 km). These calculations involved determining topological depth and normalizing the integration values to account for the size of the network, which provides a picture of the relative spatial importance of different areas within the city's urban fabric.

The second step of the methodology focused on a specific area of the city, an informal settlement, to perform diachronic mapping of network modifications within and around the settlement. Figure 1 and Figure 2 depict the proposed methodological approach for the study. The systematic mapping was developed using historical satellite imagery from Google Earth. A database of satellite images obtained at regular intervals (2004, 2009, 2014, 2019, 2024) was created by georeferencing the images in QGIS. Urban mapping techniques were then applied to map modifications in the settlement's street network. Mapping informal areas with satellite images has been effective in studying the morphology of such settlements (Kuffer et al., 2016; Dovey and Kamalipour, 2018; Samper et al., 2020; Ricchiardi, 2022). The resulting networks for each time interval were analyzed using Space Syntax to compare spatial configurations across the five periods. Visualization of the results were then created through color-coded maps that highlighted areas of high and low integration. These visualizations aided in the interpretation of spatial dynamics, helping to identify trends in accessibility and movement patterns within the settlement over time.

The case study selection for testing the proposed methodology was primarily driven by the availability of data. Kibera, located in Nairobi, stands out as a particularly significant case study due to the extensive data gathered for the settlement. It is not only one of the most well-known informal settlements in Nairobi but also one of the few where street network data and building foorprint has been comprehensively mapped through the collaborative Map Kibera Project (Map Kibera, n.d.). This initiative facilitated the addition of Kibera’s street data to OpenStreetMap (OSM), making it an exceptional case for urban analysis. The documentation and mapping effort in Kibera provides a stark contrast to the data scarcity typically associated with informal settlements, making it a valuable subject for testing the methodology central to this research.

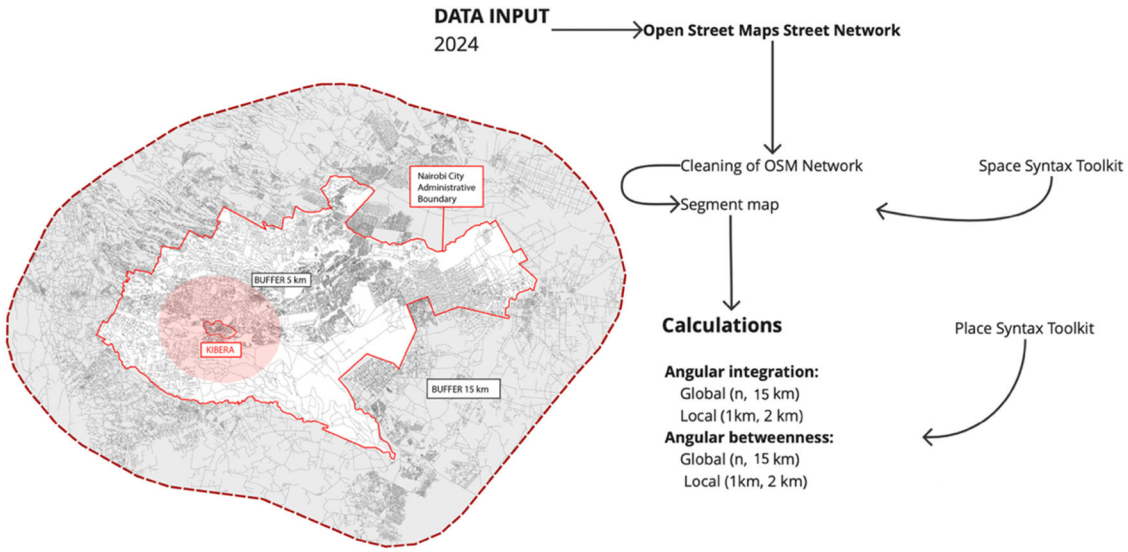

Figure 1. Methodological proposal for general model. Credit: Autors.

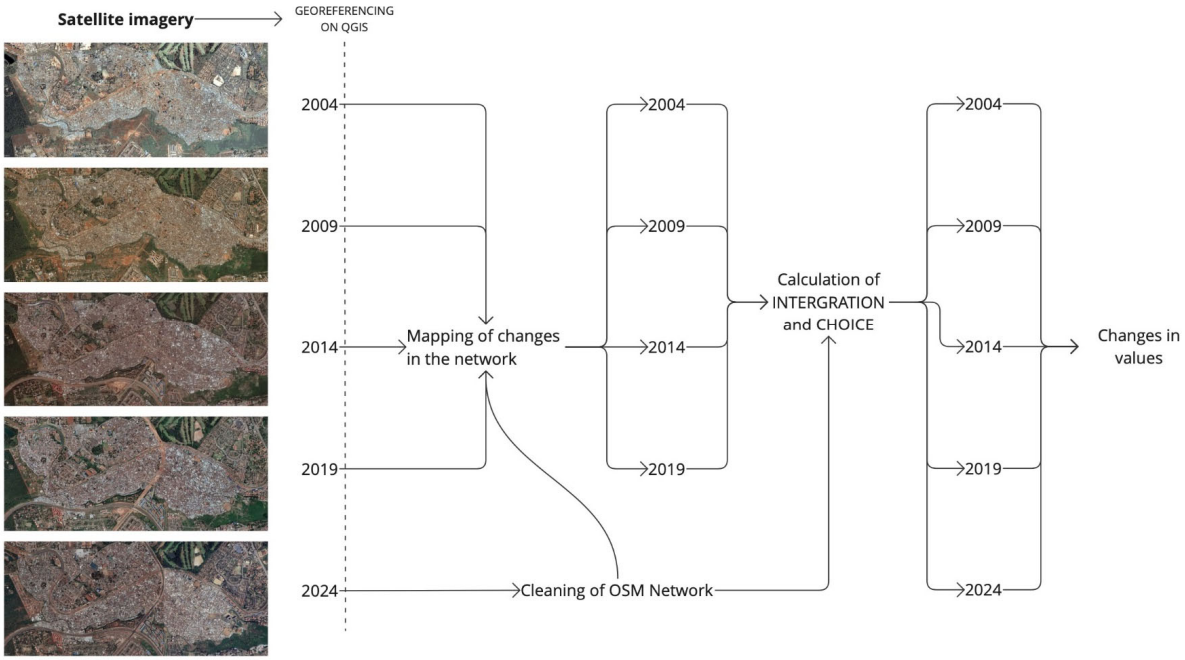

Figure 2. Methodological proposal for diachronic mapping. Credit: Authors, Satellite Images from Google Earth.

Application of the methodology - Nairobi & Kibera

As with many cities in the Global South, Nairobi presents a complex case study of contradictions and contrasts. The city exemplifies the design and structural tensions typical of Sub-Saharan African cities, where rapid urban growth often occurs alongside significant socio-economic disparities. Frequently cited as a model of a colonial city, Nairobi also embodies a hybrid post-colonial identity found in most major urban centers across the region (Myers, 2016). Its population has surged from approximately 30,000 in the late 1920s to over 5.5 million by 2024 (United. Nations, 2024). The city's rapid expansion is marked by a stark contrast between modern infrastructure and sprawling informal settlements. Studies on urban development plans in Nairobi reveal widespread non-compliance with zoning regulations over the past few decades, further compounding city's challenges (Karanja and Achola, 2021).

Nairobi originated along a caravan route connecting Kenya's interior to the Indian Ocean. As a British colonial railway town, the city's spatial patterns were shaped by a political framework of imperial extension (White et al., 2015). The layout of the city followed a segregated urban plan, which allocated distinct functions to different zones, a legacy that persisted well into the post-independence era (Owuor and Mbatia, 2012). Although official segregation was abolished after Kenya's independence, new forms of discrimination—based on income, ethnicity, and religion—emerged, influencing the urban fabric (Otiso, 2005). Colonial spatial strategies have continued into the post-colonial period, but alternative spatial strategies have also emerged, particularly in informal settlements (Myers, 2003). These settlements have appeared in areas historically designated for "Africans," such as the eastern side of the colonial city, but have also emerged in wealthier western neighborhoods (Médard, 2010). Responses to informal areas have varied widely, ranging from indifference to harsh demolitions (Murunga and Nasong'o, 2006). By 2008, Nairobi had around 150 informal settlements, covering only 5% of the city's residential land but housing over 1.8 million people—more than 50% of the city's population (Slum Dwellers International and Pamoja Trust, 2009). Many of these informal settlements are located near the central business district (Figure 3).

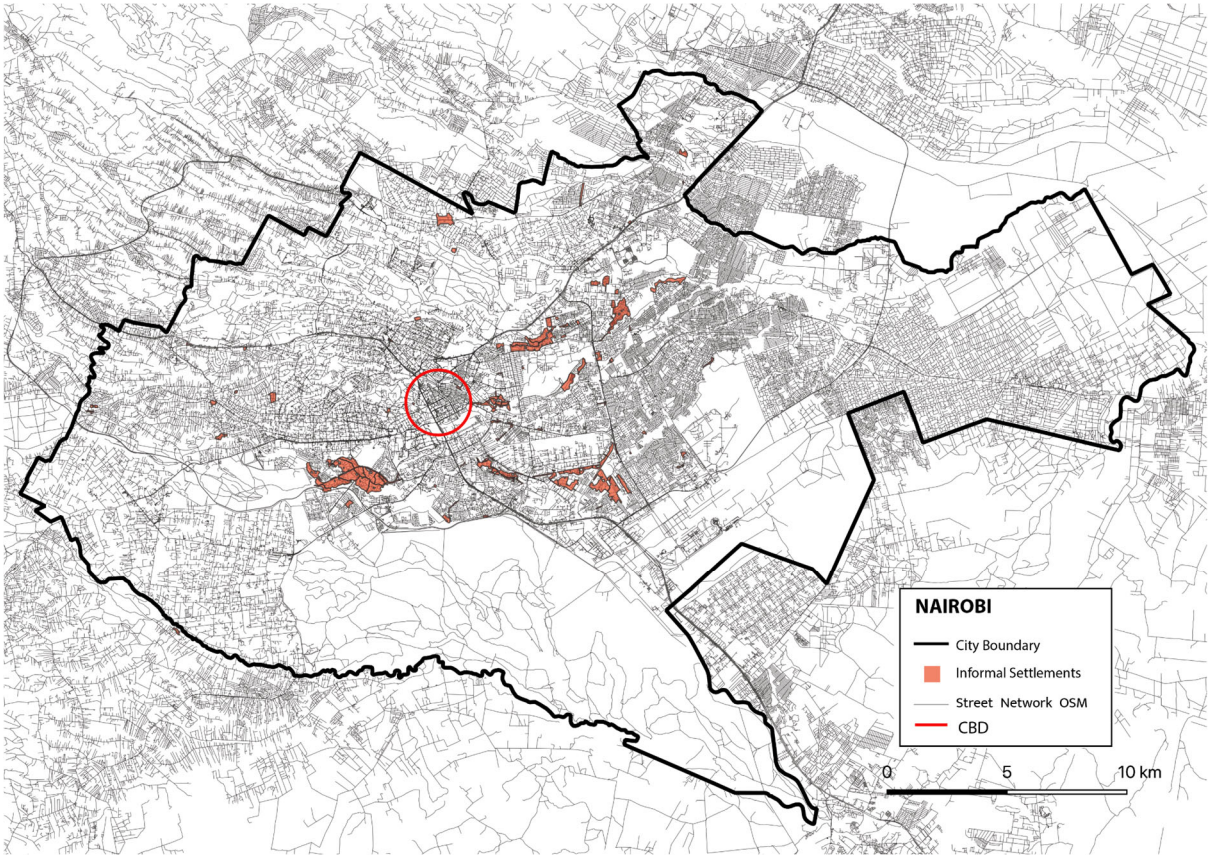

Figure 3. Informal settlements in Nairobi as 2010 from Kenya Land Use. Data Source: Columbia University's Center for Sustainable Urban Development. Visualisation by Authors.

As colonialism set the foundation for urban development in Nairobi, post-colonial nationalism, globalization and urban neoliberalism have since reshaped the city's urban identity. The hybridity of Nairobi's urban form reflects these multiple layers of influence (Myers, 2016), as the city's urban fabric continues to extend far beyond the boundaries of Nairobi County (OECD/SWAC, 2020). Structural adjustments imposed by international financial institutions have further entrenched these contradictions, contributing to the rapid construction within informal settlements (Huchzermeyer, 2011). At the same time, the rise of gated communities and upscale apartment complexes for Nairobi's affluent population adds another layer of inequality. Nairobi's most recent urban strategy, the Nairobi

Integrated Urban Development Masterplan (Nairobi City County, 2014), aims to address many of the city's challenges. The plan outlines priorities such as the renewal of Eastlands, the redevelopment of the railway city, and the integration of a greater central business district with sub-centers involving changes in the street network of the city.

Kibera

Established in 1912, Kibera is located approximately 5 kilometers from Nairobi's city center. The name "Kibera" comes from the Nubian word 'Kibra,' meaning "wilderness" or "bush" (Bodewes, 2005). Following Kenya's independence, when colonial restrictions on indigenous Africans' movement were lifted, Kibera experienced a wave of rural-to-urban migration. Unable to afford formal housing, many migrants settled in Kibera, constructing makeshift homes. Today, the settlement has become very consolidated in the city and is now surrounded by upper middle-class housing estates. The Nairobi Integrated Urban Development Master Plan (NIUPLAN) has significant implications for Kibera. While the plan includes infrastructure upgrades such as roads, water, and sanitation that could improve living conditions, these improvements have carried the risk of displacement as zoning regulations and land use planning are not managed to protect residents' rights (KDI, 2018). The tension between upgrading infrastructures and maintaining the social fabric of informal settlements like Kibera is a recurring theme in Nairobi's urban planning discourses.**RESULTS AND DISCUSSIONS** **[Heading 1]**

Provide a concise, clear and precise description of the results and their interpretation. You may use tables, drawings, figures, and diagrams to illustrate your findings. Make sure to dedicate enough space for discussing your results and to reflect on how they can be interpreted from previous studies' perspectives and the working hypotheses/research questions. The findings and their implications should be discussed in the broadest context possible, and the limitations of the work should be highlighted. **[Text body]**

RESULTS AND DISCUSSION

The Space Syntax analysis of Nairobi provides insights into the city's hierarchical urban structure (Figure 4). At the local scale, areas with high integration, highlighted in red, suggest that certain neighborhoods and streets are more accessible within their immediate surroundings. These zones likely act as critical nodes for local movement, serving as hubs where pedestrian and vehicular traffic converge. On the global scale, the analysis reveals a broader pattern of connectivity across the city. The red zones in the global integration map point to areas that are not only locally accessible but also central within the entire urban system. These areas, primarily consisting of major roads and central districts, facilitate city-wide movement and serve as key destinations for people from various parts of Nairobi. The contrast between the well-connected areas and the less accessible peripheral zones underscores the disparity in spatial accessibility within the city. The central and eastern parts of Nairobi emerge as highly integrated both locally and globally, suggesting a concentration of activities and movement in these regions. This likely stems from a combination of historical development patterns and infrastructural investments. Conversely, the peripheral areas, particularly in the western and southern parts of the city, exhibit lower levels of integration, indicating a more fragmented urban fabric.

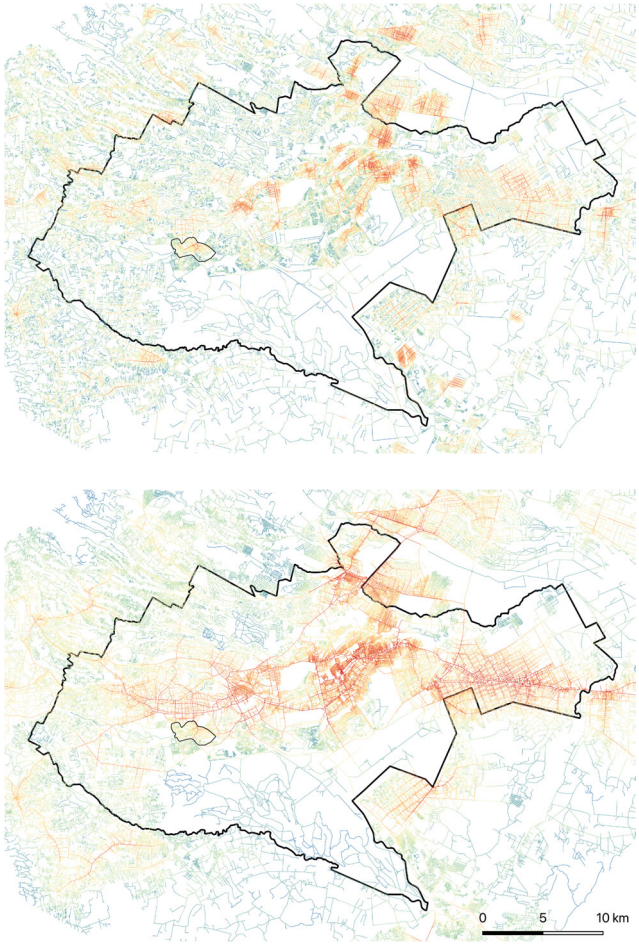

Figure 4. Up, Local angular integration. Down, Global angular integration results in Nairobi.

The incremental Space Syntax analysis of Kibera from 2004 to 2024 demonstrates significant transformations in both local and global spatial integration, as well as betweenness values. These changes reflect Kibera's evolving connectivity and accessibility, both within the settlement itself and in relation to Nairobi's broader urban network. (Figure 5 and Figure 6)

Local Scale Analysis: In 2004, Kibera exhibited relatively low local integration, with few areas displaying high levels of accessibility within the settlement. However, by 2024, local integration has markedly increased, particularly in the northern sections of the settlement. This suggests that infrastructural developments over the past two decades have significantly improved local movement networks, making certain streets and areas more central and accessible within Kibera. The increase in choice (betweenness) values, though modest, indicates that certain routes are becoming increasingly important for local navigation and movement, particularly those that cut across the settlement in an east-west direction.

Global Scale Analysis: From 2004 to 2024, Kibera's integration within Nairobi's urban fabric has notably increased, signaling the settlement's consolidation. In 2004, Kibera appeared relatively peripheral, with only a few routes showing high global integration. These routes served as primary connectors between Kibera and the rest of Nairobi. By 2024, the analysis indicates that Kibera is becoming more integrated into the city, with increased global integration values along its northern and central axes. This suggests that Kibera has transitioned from a somewhat isolated informal settlement to a more connected and accessible part of Nairobi's urban system. Two major

infrastructural changes—the Southern Bypass and the Lang'ata Link road—have played crucial roles in this shift, though these developments also led to the displacement of thousands of residents and the demolition of several community facilities, such as schools (KDI, 2018). The integration of unplanned areas like Kibera into the broader urban context poses challenges that go beyond infrastructural adjustments. While such integration is often framed as necessary for urban development, it can prioritize superficial connectivity over the social, cultural, and economic dynamics inherent in informal settlements.

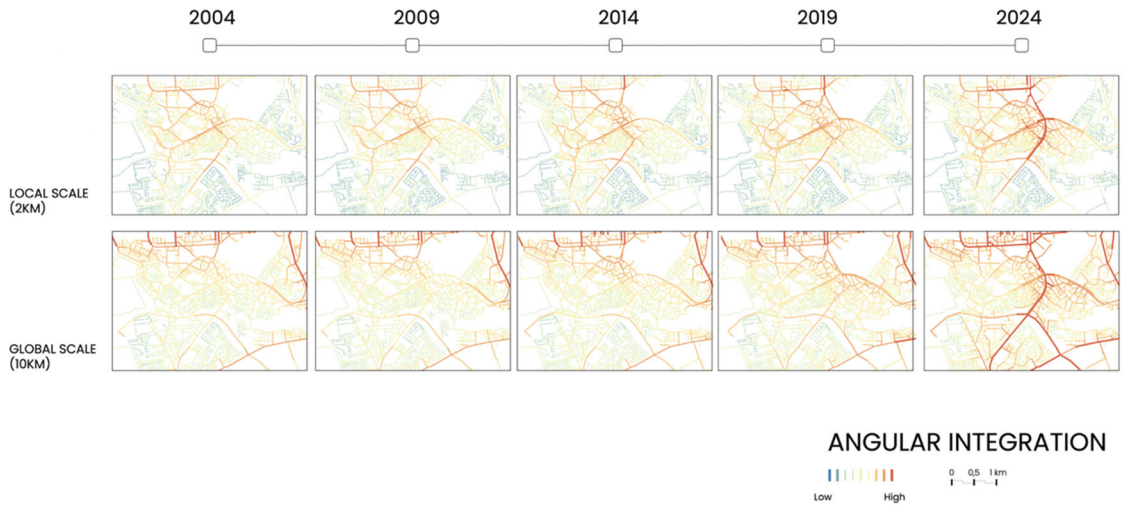

Figure 5. Local and global angular integration analysis results for Kibera.

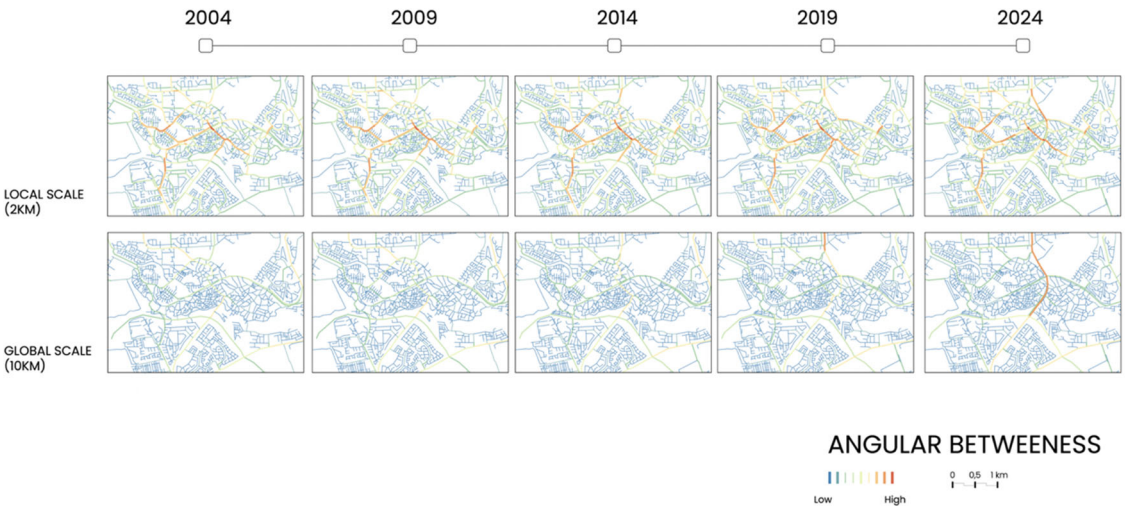

Figure 6. Local and global angular betweeness analysis results for Kibera

The analysis of incremental processes in this particular case reveals both the potential and pitfalls of using Space Syntax as a tool to study the development of street networks in these contexts. One pressing concern in integrating informal settlements is the tendency to create "pass-through" infrastructures—roads, highways, and transit systems that facilitate movement but fail to engage with local communities (KDI, 2018). These infrastructures serve broader urban agendas rather than catering to the needs of residents, which can lead to further marginalization of communities in informal settlements.

Space Syntax emerges as a valuable tool that can uncover configurations that often go unnoticed in conventional surveys for planning. By highlighting areas of varying integration and connectivity,it can potentially enable a more informed approach to urban planning and development, identifying zones that require specific attention. However, relying solely on Space Syntax introduces limitations. The lack of reliable and detailed spatial data in informal settlements can influence results, while the dynamic and complex nature of informal areas makes it difficult to capture stable findings over time. In this sense, and given the context-specific nature of informal settlements, ground verification becomes critical. Many informal networks are obscured by physical structures, such as roofs, making accurate mapping and analysis challenging. Combining quantitative tools like Space Syntax with qualitative assessments is essential for a better understanding of such settlements. Engaging local communities in the research process can provide insights that purely analytical methods might miss, such as lived experiences and community-driven dynamics that inform the spatial layout. Qualitative assessments can explore important factors such as place identity and community character, which go beyond what spatial analysis can capture helping with the limitations encounter in the study.

CONCLUSIONS

This study addressed the spatial dynamics of informal settlements, with a focus on how they could inform broader urbanization trends in the Global South. The central question guiding this research was how the study of urban morphologies shaped by informality can help clarify current urbanization patterns. By using Kibera as a case study, the research demonstrated how the application of tools like GIS and Space Syntax allows for a systematic observation of urban forms and their transformations over time. The study validated the methodological framework proposed. By analyzing Kibera's spatial configurations over a 20-year period, the research revealed how the settlement changed in relation to infrastructural interventions in terms of integration to the broader urban fabric. This emphasizes the importance of viewing informal settlements as dynamic spaces that contribute to the overall urban system, rather than as peripheral or isolated areas.

The exploration of unplanned urban areas emphasizes the need for a fundamental change in how interventions are approached in such settlements. Understanding the spatial dynamics of these areas is crucial for addressing the challenges of rapid urbanization. The findings highlight the significance of ongoing research into informal settlements, not only as a pressing academic concern but as a critical component of creating more adaptive urban policies. Morphological studies of informal settlements offer valuable insights into how communities adapt. This study reaffirms the notion that informal settlements embody unique spatial characteristics that are often overlooked in traditional urban planning frameworks. Urban planners and policymakers must recognize these characteristics and their potential to inform broader urban development strategies.

The complexity of informal settlements requires researchers to develop tailored methodologies that capture their evolving nature. The need for continued exploration and engagement with informal settlements is clear. The future of urban planning depends on our willingness to learn from and adapt to the realities of these critical city spaces. Transformative approaches that incorporate both formal and informal urban growth patterns will be essential for creating cities that serve all residents, particularly in rapidly urbanizing regions.

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Intra-urban spatial structure in metropolitan contexts: a modelling approach

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ABSTRACT

Global South Metropolitan Regions are experiencing significant growth and transformation, characterized by rapid urbanization and extensive conurbations. In these regions, satellite cities often face problems stemming from the external dynamics with local impact, such as the presence of metropolitan transportation infrastructure, and housing demand. The objective of this study is to analyze some impacts of the metropolisation from the point of view of a peripheral city's spatial structure using network analysis. Specifically, we focus on Embu das Artes municipality, in the Metropolitan Region of São Paulo, to examine the distribution of intra-urban centralities for population and economic activities, considering the metropolitan road infrastructure and the proximity to São Paulo peripheral urbanization. Two network measures are modelled using GAUS (Graph Analysis of Urban Systems), a set of scripts for calculating configurational metrics in QGIS: accessibility and centrality, weighted by population and local economic activities. Among the main findings, the analysis reveals clustered and hierarchical internal spatial structure tensioned by the metropolitan process. Topographic features, associated with the metropolitan transportation infrastructure, act as barriers, inducing the formation of two clusters: one around the traditional downtown and another closer to São Paulo's border. A population cluster distant from the historic center indicates a concentration of metropolitan commuters living in low-standard urbanization. In conclusion, this study provides an approach to the investigation of the underlying intra-urban spatial structure of cities, offering insights to support decisions in urban and regional planning.

Keywords: Urban networks; Modelling; Cities' spatial structure; GAUS; Metropolitan regions; Embu das Artes

INTRODUCTION

Metropolitan regions in the Global South are experiencing rapid growth and transformation, driven by accelerated urbanization and the emergence of extensive conurbations. These regions, also referred to as urban-regional arrangements (Moura, 2012), have become critical hubs of population and hold significant economic, social, and technological importance. Characterized by high urban

density, strong regional integration, and intricate complexity, they are shaped by multidirectional flows of people, goods, knowledge, and power. However, the process of metropolization affects municipalities unevenly. Those with the necessary technological, scientific, institutional, and cultural capacities to participate in the agglomeration process tend to prosper, while others remain excluded from these developmental gains.

Morphologically, metropolitan regions expand by incorporating urban centers along with their surrounding urban and rural areas, forming either continuous or fragmented spatial units. This expansion enhances connectivity and promotes shared functions with adjacent agglomerations, contributing to a more complex urban structure and an extended regional scope. The genesis and growth of this phenomenon are driven by two key factors: the search for locations with greater access to economic opportunities and the peripheralization of urban poverty, a process influenced by real estate market dynamics.

Satellite cities frequently face challenges stemming from external dynamics with local implications, such as the expansion of metropolitan transportation infrastructure, increasing housing demand, and the growth of large private developments, including gated communities. In contemporary urbanization, the historical trajectory of regions significantly shapes both their form and dynamics (Moura, 2004: 86). The inherited geographical conditions constrain the development of regional systems, as emerging dynamics often reinforce and intensify pre-existing relationships, further shaping their morphological evolution.

Understanding the morphology of contemporary urbanization requires the adoption of new methodological approaches, particularly those that are systemic and multi-scale. Regions should be conceptualized as interconnected networks comprising social and spatial elements in constant interaction and flux. One promising method for addressing this complexity is through urban modelling and configurational studies (Batty, 2013; Crucitti et al., 2006; Hillier and Hanson, 1984). These approaches treat cities and regions as spatial systems, facilitating their representation and quantitative analysis, especially regarding hierarchies and properties such as accessibility and centrality.

The objective of this study is to analyze some impacts of metropolisation on the spatial structure of a peripheral city using network analysis. Specifically, we focus on the municipality of Embu das Artes, located in the Metropolitan Region of São Paulo, to examine the distribution of intraurban centralities in terms of population and employment. This analysis considers the influence of metropolitan road infrastructure and the city's proximity to the peripheral urbanization of São Paulo.

Configurational methodologies have been applied to regional-scale studies, as demonstrated in the works of Serra and Pinho (2013), Krenz (2017), and Kaplan et al. (2022). These studies use configurational accessibility and centrality in a multiscale assessment of natural or emerging centralities. In Brazil, Ugalde (2013) focused on the Porto Alegre Metropolitan Region, analyzing how the spatial structuring of the conurbation shapes movement routes across different regional scales. Colusso (2015) examined the influence of regional systems on urban forms, proposing a regional tension model based on spatial interaction and betweenness centrality. Other studies employ spatial models to identify emerging hierarchies in regional systems using weighted centrality measures (Espínola, 2003; Calvetti, 2016; Maraschin et al., 2021).

Ribeiro et al. (2016) applied configurational models to the city of Embu das Artes, utilizing centrality measures and performance indicators such as Accessibility, Betweenness, Spatial Convergence, and Spatial Opportunity (Krafta, 1994; 1996). Their analysis involved the development of two distinct spatial scenarios / two geographical scopes to assess the city's urban structure and its performance in terms of configurational efficiency and equity.

In this paper, we build on these previous studies by employing a weighted centrality model to investigate the impacts of metropolitan processes on the spatial structure of a peripheral city. The next section outlines the methodology, followed by the results and discussion of the case of Embu das Artes.

METHOD

To examine the spatial structure and dynamics of the distribution of employment and residential locations we use configurational models. These models employ methodologies that break the city down into components (e.g., elementary spatial units, spatial attributes) and their relationships (e.g., topological descriptions, adjacencies, centrality). Graph theory serves as the analytical foundation for calculating various measures and properties of the urban network. The models are based on the shortest path hypothesis, assuming that connections between cells in the network will always occur via the shortest routes. As a result, cities exhibit spatial differentiation, forming a hierarchy where certain cells (spaces) stand out due to their relative position and/or the number of connections with others.

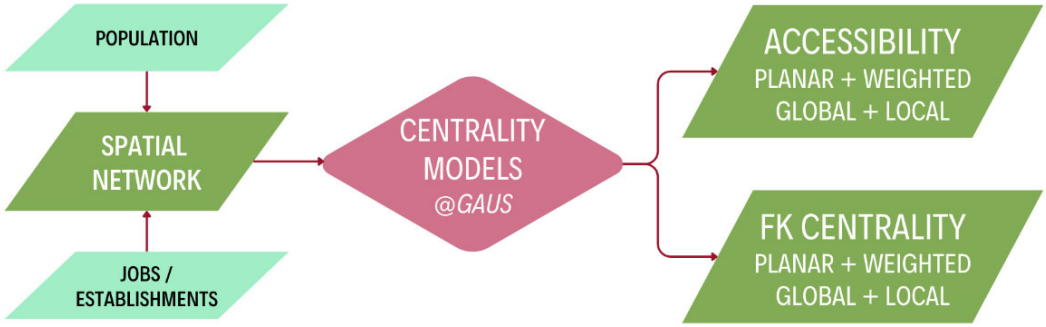

Figure 1. Methodological strategy. Credit: authors (2024).

Modeling process involves the transformation of city street grids into urban spatial networks. We adopt a spatial representation by street segments (Batty, 2004; Krafta, 2014; Kruger, 1979), which consists of a set of lines representing street segments or portions of streets situated between pairs of corners or road intersections (Krafta, 2014). In this graph, each street segment functions as a node, and the connections between them are the links. This representation allows for a fine level of spatial disaggregation, making it well-suited for studies focused on intra-urban scale. Resulting street network is composed of 24,890 segments, including a 5 km buffer to minimize edge effects — which was later removed for further analysis.

It is important to highlight that the configurational software utilized – GAUS (Dalcin and Krafta, 2021) – allows distance computations with edges having lengths equal to the actual distances between the midpoints of adjacent street segments. This correction ensures that the length of these edges accurately reflects the real distances they represent.

In the following step, the network is loaded with specified attributes: population and non-residential establishments (i.e., institutional, commercial and services establishments, industry, etc.). Population data is sourced from the 2022 Population Census, survey by the Brazilian Institute of Geography and Statistics – IBGE (2024b). For non-residential establishments, we used data from the National Register of Addresses for Statistical Purposes, survey by IBGE (2024a).

Geoprocessing resources facilitate the transfer of population quantities from the census tracts polygons, and non-residential establishments quantities, represented as points, to the street segments. Influence areas are determined for each street segment using Voronoi polygons (Kolahdouzan and Shahabi, 2004). Influence area "captures" point data located within it. Concerning polygonal data, we clipped the polygon inputs (census tracts) with influence areas to determine the total counts of inhabitants spatially coincident to each street segment. This procedure resulted in the street segments network weighted with the origin and destination attributes (Ribeiro, 2017).

Network measures are modelled using GAUS – Graph Analysis of Urban Systems (Dalcin and Krafta, 2021), a set of scripts for calculating configurational metrics in QGIS: Accessibility and Freeman-Krafta Centrality, weighted by working-age population and local jobs.

In the context of graph theory and network analysis, different centrality measures for a vertex in a graph indicate its relative importance, or in urban networks, how significant a road is within the system.

- Accessibility is broadly defined as ease of access or the ability of a node in the system to be reached (Ingram, 1971). It represents a measure of proximity between two points, which in this case is quantified by the relative distance of each urban location to all others.

- Planar Freeman-Krafta Centrality considers only the configuration of the spatial network, disregarding any attributes assigned to the network nodes. This centrality measure uses the concept of shortest paths and the interaction between non-adjacent elements, placing greater emphasis on nodes positioned along these paths. Such nodes gain strategic significance due to their role in facilitating connections between many other nodes, thereby indicating their relative importance within the network. Typically, higher centrality values tend to be found near the geometric center of the network.

- Weighted Freeman-Krafta Centrality incorporates the concept of weighting by assigning values to the tension between each pair of nodes, with a fraction of this value distributed across the nodes forming the shortest path between them. In this study, the attributes of population (IBGE, 2024b) and non-residential establishments (IBGE, 2024a) are applied to the network nodes to weight the centrality measures.

This approach provides a nuanced understanding of how central nodes function both in terms of spatial configuration and their demographic and economic importance.

RESULTS AND DISCUSSIONS

Contextualization

Established in 1973, the São Paulo Metropolitan Region is the largest urban agglomeration in South America, ranking sixth among the largest in the world. The region comprises 39 municipalities, with a population of over 20 million inhabitants (IBGE, 2024b). Embu das Artes is a historic municipality located in Metropolitan Region of São Paulo, with a population of 250,691 inhabitants (IBGE, 2024b) is 36 km from the capital, São Paulo (Figure 2). Embu is considered a touristic destination due to the concentration of artists, among painters, sculptors, musicians and singers living in the city and a renowned Arts and Crafts Fair that occurs in the Historic Center.

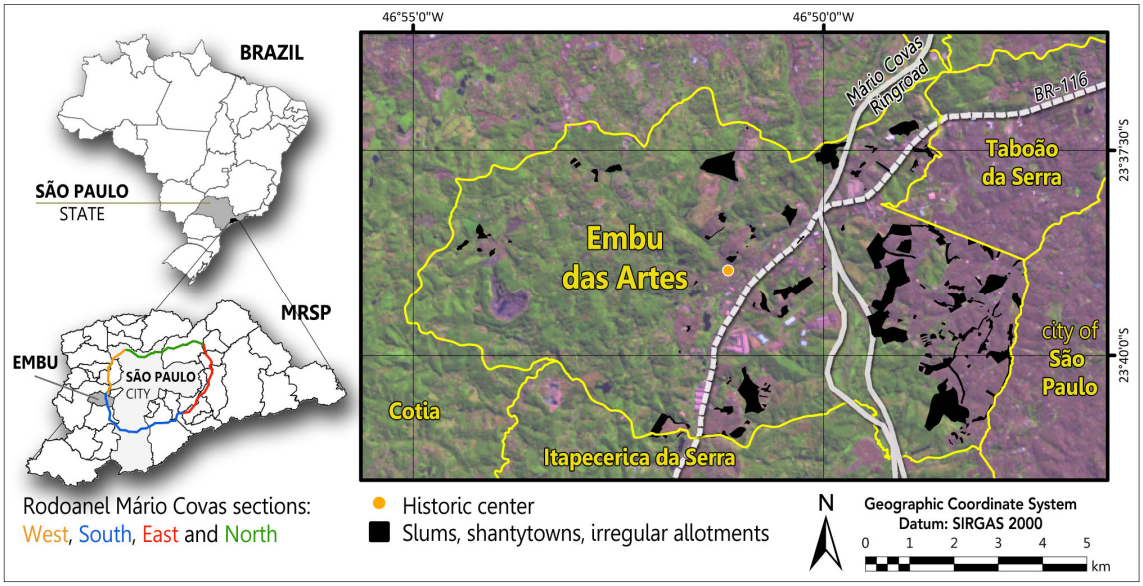

Figure 2. Location of Embu das Artes in Brazil and in the Metropolitan Region of São Paulo (MRSP). Source: authors (2024).

Embu experienced a disorganized urbanization process and a significant increase in population, primarily as a result of the sprawl of the São Paulo metropolitan area. The opening of the Régis Bittencourt Highway (BR-116) in 1961 significantly contributed to the population growth in the area. In this period, the occupation of existing subdivisions was consolidated, along with the availability of new subdivisions. Additionally, there was the beginning of migratory movements towards São Paulo, reinforcing the suburbanization process in the region (Azevedo, 2017). The commuting flows were intensified by the construction of an important ring road (Rodoanel Mario Covas) in 2002.

Embu das Artes is considered to have a very high level of integration into the dynamics of the São Paulo Metropolitan Region (Ribeiro et al., 2012). This classification was based on criteria such as population size, economic and functional aspects, degree of urbanization, density, land use, and population mobility (Figure 3).

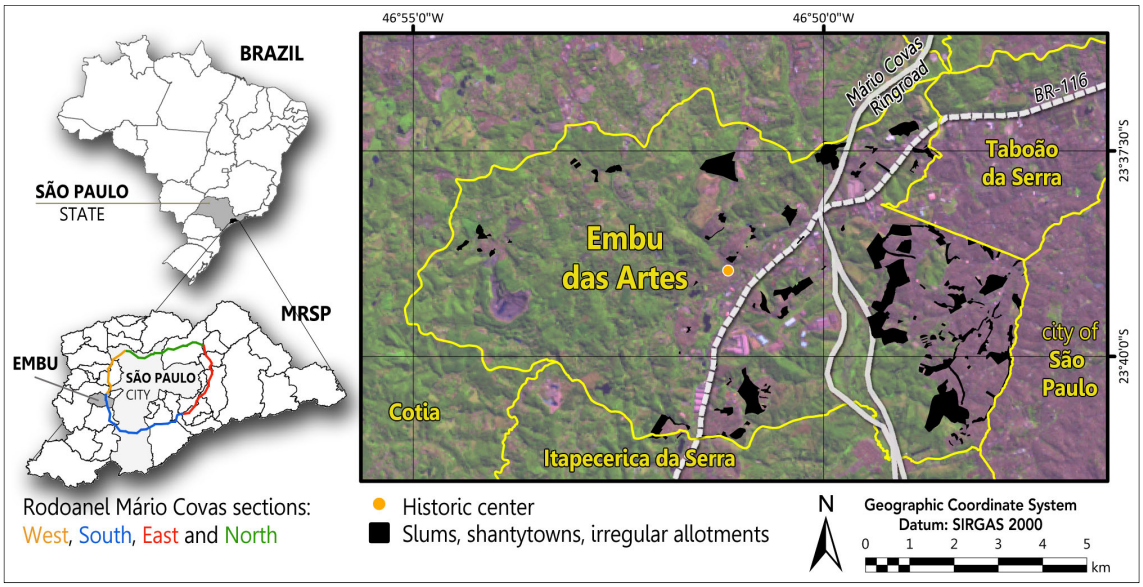

Figure 3. Levels of integration into the dynamics of São Paulo Metropolitan Region in 2010. Source: authors, based on Ribeiro et al. (2012).

The rural area of Embu das Artes was increasingly utilized by the population of São Paulo as a leisure destination, with the establishment of small farms and vacation homes. The eastern area, closer to São Paulo, experienced greater development of residential lots for low-income commuters, as well as the construction of homes through self-build initiatives. This process was facilitated by lower land costs, which were significantly cheaper than those in the city of São Paulo (Azevedo, 2017). This author identifies a dichotomy between the western and central regions and the eastern region, referring to them as the "two Embus" (op cit: 109). The following sections aim to investigate this dichotomy and its impact on the spatial structure of the city.

Network Centrality in Embu das Artes

The analysis of the accessibility of Embu's road network (Figure 4-A) highlights the street segments that result in shorter relative distances within the spatial system. It can be observed that the regional highways are the most accessible areas, followed by the eastern portion, which also includes the historic center and partially the western region. When this measure is weighted by the population per road segment, the results change significantly (Figure 4-B). Beyond the highways, the importance of the eastern sector becomes evident, demonstrating the influence of the high density of residents in that area. In this case, the historic center is perceived as "distant" from areas with concentrated populations.

The measure of centrality assesses the relative importance of segments within the interconnections of the spatial system. Planar Freeman-Krafta Centrality (Figure 4-D) highlights the significance of highways in regional connectivity. Other roads also play important roles, particularly in the eastern portion. When the population is included in the measure (Figure 4-E), there is a notable increase in the hierarchical importance of the roads in the eastern area.



Figure 4. Results obtained from the centrality models: [A] - Planar accessibility, [B] - accessibility weighted by population, and [C] - by economic activities. [D] - Planar Freeman-Krafta centrality, [E] - FK centrality weighted by population, and [F] - by economic activities. Source: authors (2024).

When analyzing the urban network, it is important to highlight the influence of urban barriers, which create discontinuities in the street network and in the urban fabric. These barriers often result from transportation systems but can also arise from landscape features shaped by natural phenomena or engineering projects, such as highways or railways. In the case of Embu, its terrain is highly diverse, with steep hills to the west, plains along the rivers in the central area, and rolling hills to the east. This

topography influences the street layout and generates difficulties in the road connections. Regarding the barriers related to the transportation system, the two major road infrastructures (BR-116 and Rodoanel) create a significant separation between the east and west sides. These are highways with extremely high traffic volumes, featuring complex intersections, tunnels, and associated roadworks, which discourage local and pedestrian movement in their vicinity. Along these highways, there is large-scale urban development, including industries, logistics activities, and other services.

A complimentary analysis of the FK centrality measure is presented in Figure 4-F: economic activities are loaded to the network to calculate the weighted FK centrality. Once again, there is an increase in centrality values in the eastern portion when compared to the planar measure, revealing areas of more intense centrality than the historic center itself.

When these previous model results are discussed in light of some socio demographic data, certain findings are reinforced. Population density is significantly higher in the eastern portion (Figure 5-A), while per capita income is higher in the western portion (Figure 5-B).

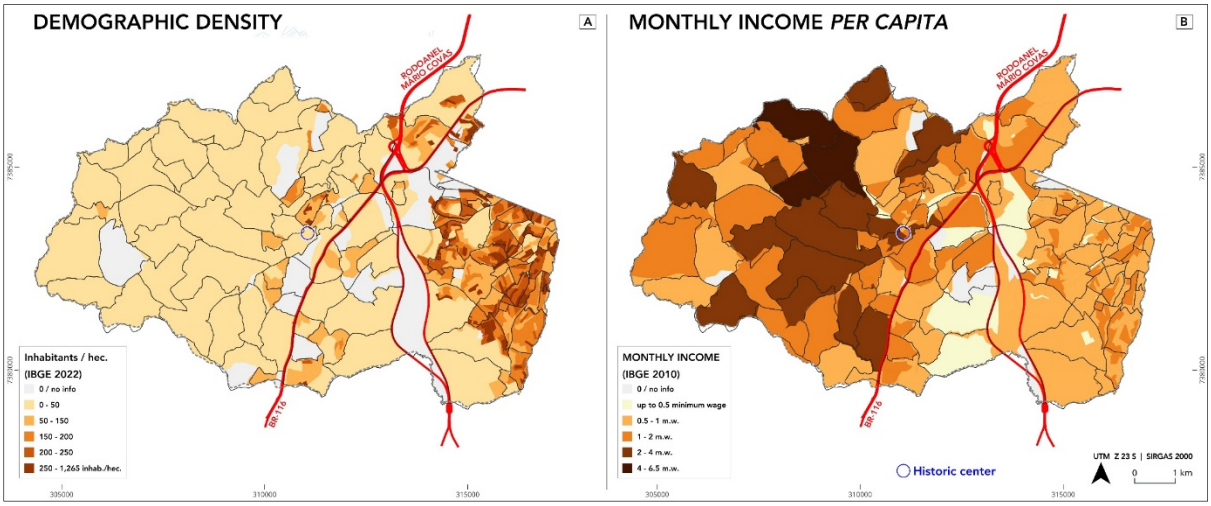

Figure 5. Demographic data aggregated by enumeration area: [A] - Demographic density, and [B] - Average monthly income per capita. Neighborhoods are outlined in black. Source: authors, based on data from IBGE (2024b; 2011).

Analyzed data reveals a city that is highly unequal in terms of both population density and income distribution. The eastern portion of the municipality, closer to São Paulo, exhibits a high concentration of inhabitants, with Embu functioning as a dormitory city. Additionally, the population is concentrated near the Historic Center and along the northern and southern borders.

The analysis of the spatial distribution of economic activities (Figure 6) highlights the role of the Historic Center in concentrating some economic dynamics. However, it is surpassed by the eastern portion, which emerges as an autonomous area with its own economic activity.

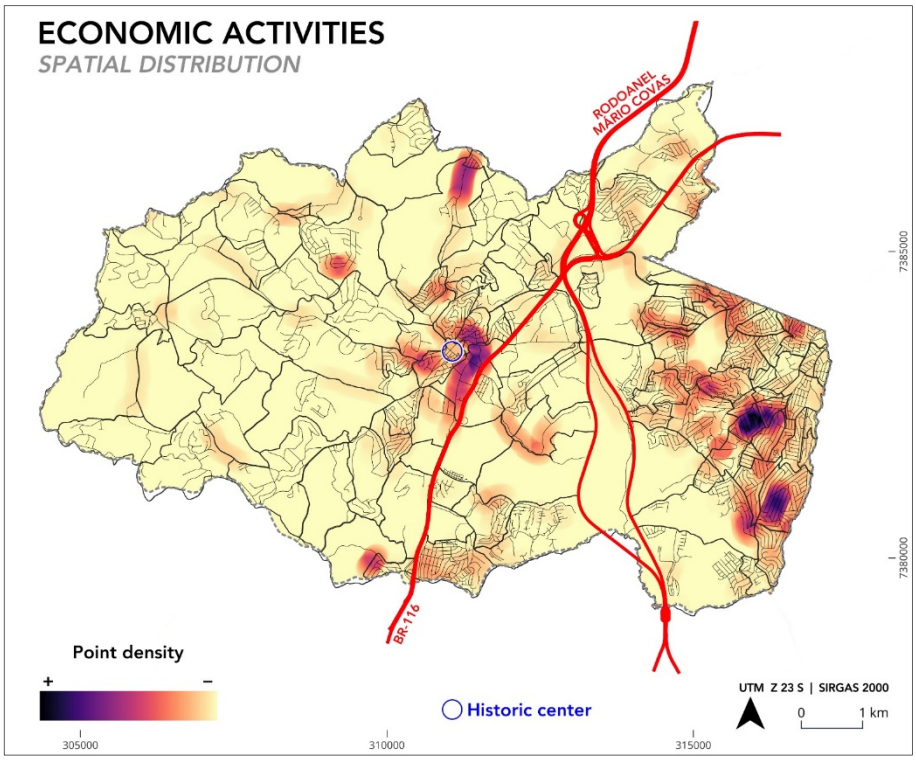

Figure 6. Density of economic activities in Embu das Artes. Source: authors, based on data from IBGE (2024a).

The urban configuration of Embu both reflects and amplifies the existing metropolitan socioeconomic tensions. Regional highways shape and reinforce the system's centrality, impacting mobility and access. The eastern portion, marked by lower income levels and high population density, remains highly dependent on São Paulo for economic opportunities. In contrast, the western portion, characterized by higher income levels and lower population density, experiences less reliance on external economic centers. Meanwhile, the Historic Center has lost its significance in a city fragmented by these socioeconomic and spatial disparities.

The distance between residents and workplaces can be viewed as a matter of equity, reflecting a spatial mismatch between residential areas and employment centers (Gonçalves, 2011). However, when considered from an efficiency perspective, this distance or dispersion of non-residential activities becomes undesirable. From the standpoint of economic efficiency, agglomeration—or the closer proximity of these activities—is preferable, as spatial proximity can reduce costs associated with internal interactions (Netto, 2014).

CONCLUSIONS

The configurational analysis of Embu revealed a process of spatial centralities shifting from the historic center toward the metropolitan highways and to the east, closer to São Paulo. This process has led to a fractured and unequal spatial structure. This clustered and hierarchical internal spatial structure is shaped by metropolitan processes. Topographic features, combined with metropolitan transportation infrastructure, act as barriers, fostering the formation of two distinct clusters: one around the traditional downtown and another closer to São Paulo's border. A significant concentration of the working-age population, distant from jobs and schools, suggests a high number of metropolitan commuters residing in areas of lower-quality urbanization.

In recent years, São Paulo Metropolitan Region has evolved into a “macrometropolis” (Bogus, Magalhães and Pasternak, 2021), a metropolitan complex spanning 200 km around the capital, São Paulo, formed through the conurbation of various metropolitan centers. The development processes and territorial structuring in this region are marked by internal inequalities, both in terms of human development indices and existing infrastructures, presenting significant challenges for local and regional management and planning.

To contribute to this task, the present study provides a methodological framework for investigating the underlying intra-urban spatial structure of cities, offering insights to support decision-making in urban and regional planning. The adopted method employs a quantitative approach, enabling the description of the socio-spatial impacts generated by the metropolis on the local system of a city. The conducted modelling facilitated the integration of the spatial system configuration (street network) with various social attributes (population, income, jobs etc.). This enhances the models' suitability for representing the complexity of urban environments.

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Morphological characterisation of informal urban gardens in residential neighbourhoods of Piura, Peru

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ABSTRACT

The emergence of informal activities has long been a part of urban life, filling up unused land in large and mid-sized cities worldwide. They routinely occupy or appropriate urban spaces, revealing new functions of these places, such as urban gardening. With these activities, the inhabitants move beyond the limits of formal strategies in terms of occupation, urban design, planning, and construction. However, the issue of informal gardening has rarely been formally discussed at the governmental level in the Global South. Based on a case study of three neighbourhoods in Piura, Peru, this research explores patterns of form, accessibility, and visual interaction for urban gardening. The study aims to reveal similarities and particularities in the configuration of individual objects, analysing equipment, materials, and the structural environment. Using a qualitative approach, morphological characterization is considered as an analytical key to interpret the connections between the elements that make up a space. These observations include data gathering and analysis, mapping, sketches of the gardens, as well as aerial photographs as a complementary method. Through graphic representations of floor plans, the results demonstrate the physical appearance and accessibility of the gardens and their relation to the built environment. The gardens vary in size, and have multiple functions, such as storage, parking, or drying laundry, in addition to gardening. The vegetation consists of a variety of plants, including decorative flowers, vegetables, and fruit trees. The gardens also feature water infrastructure, furniture, and designated areas for plants and vegetables, providing spaces for relaxation and family gatherings. The findings provide valuable insights into the design possibilities and potential benefits of incorporating informal gardening practices into urban planning and development strategies.

Keywords: informal practices, public space, urban gardening.

INTRODUCTION

The presence of informal activities has been a longstanding aspect of urban life, occupying vacant areas within cities worldwide. Such activities related to informal occupation often repurpose urban spaces and introduce new functions. Inhabitants engage in these practices, surpassing the boundaries set by formal strategies in terms of occupation, urban design, planning, and construction.

The term "informal" is often understood as the opposite of "formal" (Huchzermeyer, 2011). Debates on informality in cities focus mainly on two interrelated but often separately addressed aspects:

debates on informal employment and debates on spatial informality. The first refers to economic activities outside regulated markets. Since the 1940s, these activities have been studied from three main approaches. One is technocratic, represented by authors such as Germani (1973), who focus on national modernisation projects and the eradication of the informal sector. Castells (1973), on the other hand, criticises this approach and seeks to dismantle the myth of marginality by analysing the causes of informality with arguments based on dependency theories and Marxist approaches. A more recent stream, represented by De Soto (1989), adopts a dualist approach that sees the informal sector as a source of value that must be integrated into the formal sector in order to promote forms of popular capitalism. Parallel theories have focused on spatial informality, particularly as manifested in the unplanned settlements of Latin America in the 1950s. These theories examine the activities that affect land use, land values, and its physical expansion within developing cities. The studies by Matos Mar (1957) and Turner and Fichter (1972) on such settlements in Peru are examples of this work, viewing informal settlements as the initial stage of an incremental construction process. Other studies have attempted to analyse these human settlements using concepts of self-help and self-construction, as well as different political perspectives. Davis (2006) is considered one of the seminal works in this tradition.

In more recent studies, both aspects have been combined, focusing on urban informality in general as well as the growth of cities in the Global South. In addition to these approaches, primarily academic research has focused on the socialisation and daily life experiences in informal settlements, as well as their capacity to generate forms of resistance and alternative urbanisation. Some examples include the work of Holston (2008) on insurgent citizenship, and the work of Roy and AlSayyad (2004), which incorporates ethnographic and anthropological aspects to study informality as a way of life. In this sense, Gilbert (2004) highlights the challenge of defining informality due to its interconnectedness and relationships with formality. Informal urbanisation can be defined as urban development that occurs outside the established legal frameworks, planned procedures, and regulatory processes of city development, generating uncertainties regarding spatial property. According to Azuela and Tomas (1996), the concept of irregularity is subordinate to the presence of norms. The authors state that "irregularity enters our consciousness at the moment when the State decides to normalise practices previously considered marginal" (Azuela and Tomas, 1996, p. 234).

However, despite the resurgence of interest in community gardening in the United States driven by growing attention to issues of health and urban food systems, the topic of informal gardening has received limited formal recognition and attention at the governmental level, particularly in the Global South. Urban gardens are multifaceted spaces that foster creativity, activity, and a sense of identity and belonging within a specific environmental context (Crouch and Wiltshire, 2005). Contemporary theory suggests that the positioning of gardens relative to other green spaces is a crucial characteristic. Atkinson (2007) posits that the garden has arisen as a preferred spatial type over the park, which can be understood by examining the divergent modes of production associated with these spaces. Specifically, the notion of a "garden" implies both a productive activity and a physical entity, whereas a "park" is an object that people primarily engage with as consumers.

There are various reasons behind the emergence of new gardening initiatives. Each region and country have its own unique context, and the social actors involved approach their projects from their own distinct concerns. However, there are some recurring urban and social processes that can be observed.

One key factor is the link between the crisis and the rise of urban gardens. This can be seen in the case of the community gardens that appeared in New York City during the oil and financial crises of the 1970s (Matesanz Ventura, 2018). A grassroots movement led by a group of artists and activists called the Green Guerrillas was inspired by concerns related to human well-being, community building, and the improvement of everyday living spaces in neighbourhoods (Eizenberg, 2012). These community gardens and urban farms served as models that were later replicated in the UK and the Netherlands, where counterculture and environmentalism also played a role (McKay, 2011). Additionally, in this period, some European countries also saw people's demands for greater participation in urban development decision-making, as well as dissatisfaction with the traditional planning system (Cabral and Weiland, 2016).

Informal gardening refers to gardening without official permission, on property that belongs to someone else, typically a municipal authority. As noted by Hou (2014), the informal nature of community gardens has been both an asset and a challenge for community gardeners and their supporters. On the positive side, the informal and open-ended character of these spaces allows communities to transform underutilised urban areas into productive landscapes at relatively low cost. It may enhance the built environment in situations where the civil society perceives the government and other development actors to be falling short. Community gardens have enabled residents to organise and take collective action to address issues such as neighbourhood improvement, safety, food production, and the need for green spaces and social gathering places. Informal urban practices, therefore, have far-reaching implications for both local communities and broader urban policies (Douglas, 2014). However, the perception of community gardens as temporary or interim uses, coupled with a lack of institutional and legal support, often leaves them vulnerable to displacement or eradication. The informal status of these spaces can put them at risk, despite the important roles they play for local communities. Contemporary urban theory suggests that it is crucial for urban planning to support and accommodate informal gardening practices. This is because no future scenarios for the development of urban gardens can be adequately planned, controlled, or predicted without a proper understanding of these community-driven initiatives.

As a spatial practice, urban gardening in the public serves to build social capital, assert the right to the city, and catalyse community capacity building in the context of neighbourhood improvement (Chase, Crawford and Kaliski, 2008; Lydon and García, 2015; Hou, 2020). While studies of urban morphology have mainly focused on the typology of buildings, the space between buildings, i.e., public space, has received much less attention (Han, Xu and Wang, 2014), with some exceptions such as studies by Conzen (1960), Jacobs (1967), Hertzberger (1991), Caniggia and Maffei (2001) or Gehl (2011). A certain consensus has been reached on the formal and spatial character of public space typologies. However, research has mainly focused on formal public spaces that are within the scope of official planning, such as parks and squares.

Urban morphology deals with the knowledge of the logic of form, in this case, the urban form. As an established field of study, urban morphology focuses on urban forms by examining the patterns of the constituent parts, as well as the agents and processes that influence their transformation. It also addresses the historical influences, such as spatial organisations, principles, components, relationships, structure, and configuration of physical elements at different levels of resolution (Moudon, 1997). This approach is addressed across multiple disciplines and focuses on observing the physical characteristics, structure, relationships, and transformations of objects and their constituent

elements. There is no common definition of urban morphology, and the research of the International Seminar on Urban Form (ISUF) has been heavily influenced by three main schools of thought: the Italian typological process structured around the work of Muratori et al. (1963) and Caniggia and Maffei (2001), the British historical-geographical approach consolidated by Conzen (1960), and the mathematically-oriented space syntax of Hillier and Hanson (1984).

The typomorphological approach of the Italian School, as developed by Muratori and Caniggia in the early-to-mid 20th century (Cataldi, Maffei and Vaccaro, 2002), is the most relevant for this study. This method involves exploring the physical and spatial structures of cities, which are both typological and morphological, describing urban form (morphology) through detailed classifications of buildings and open spaces by type (typology). The Italian School's approach involved empirically observing the forms and productive processes of urban habitats at multiple scales, including urban circulation, building layout, land subdivision, infrastructure, and building typologies. In this way, the different types of urban fabric were considered the results of various economic, social, cultural, and political factors (Maretto, 2013).

The examination of morphological characteristics in informal urban areas has primarily focused on informal settlements, from a global perspective and based on certain spatial criteria. Over the past few decades, researchers such as Dovey and King (2011), Dovey (2012), Kamalipour (2016), and Jones (2019) have highlighted how the study of informal urban forms can greatly contribute to the understanding of key and emerging urban processes. These studies help explain how informal settlements emerge within the spatial morphology of the city and how perceptions of informality develop within the discursive realm of public space and urban life. Dovey and King (2011) argued that informal settlements have a formal morphological structure, but exhibit differences in their interactions with the formal city, as well as in their topography, climate, culture, materials, economics, and politics. Suhartini and Jones (2020) defined rules as principles that contribute to the existing spatial order, distinguishing between defined norms and implicit norms, such as accepted protocols and unspoken conventions. These rules emerge through processes of self-organisation and coexist, as well as co-evolve, with modern and traditional rules as the settlement grows. Despite the significant progress in the field of spatial forms of urban informalities, none of these studies have specifically focused on the form of public spaces or the informal urban gardens themselves.

Based on a case study of three neighbourhoods in Piura, Peru, this research explores patterns of form, accessibility, and visual interaction for urban gardening. The study aims to reveal similarities and particularities in the configuration of individual objects, analysing equipment, materials, and the structural environment.

METHOD

This research is part of a broader investigation into the morphogenesis of informal public spaces. It encompasses the identification of spatial characteristics found in informal urban gardens in three residential neighbourhoods of Piura, Peru.

Side selection

Piura is the fifth largest city in Peru. In different phases since the 1960s, the urban form has experienced growth driven by the need for housing and the occupation of urban land (through

invasions or illegal land markets) which, combined with the use of various mechanisms established by law, give the actor a certain legality (e.g., obtaining a certificate of possession or being registered) (Calderón Cockburn, 2019). This process is not recognised by official planning, but is considered as a marginal urbanisation process. Another aspect is the informal occupation and use of public space. Neighbours look after the few existing parks with their own resources and add elements such as benches or vegetation or suitable abandoned and empty spaces. What emerges from the analysis is the need for the community to build meeting and recreational spaces, aspects that, historically, have not been considered for the consolidation of public space.

Three initiatives of informal urban gardens, products of residents' involvement in three different neighbourhoods were selected (Figure 1): (1) AH Santa Rosa, Parque San Judas Tadeo Sector 5B, (2) Urb. Santa María del Pinar, Parque Las Fresas, (3) AH Túpac Amaru III, Humedales Santa Julia.

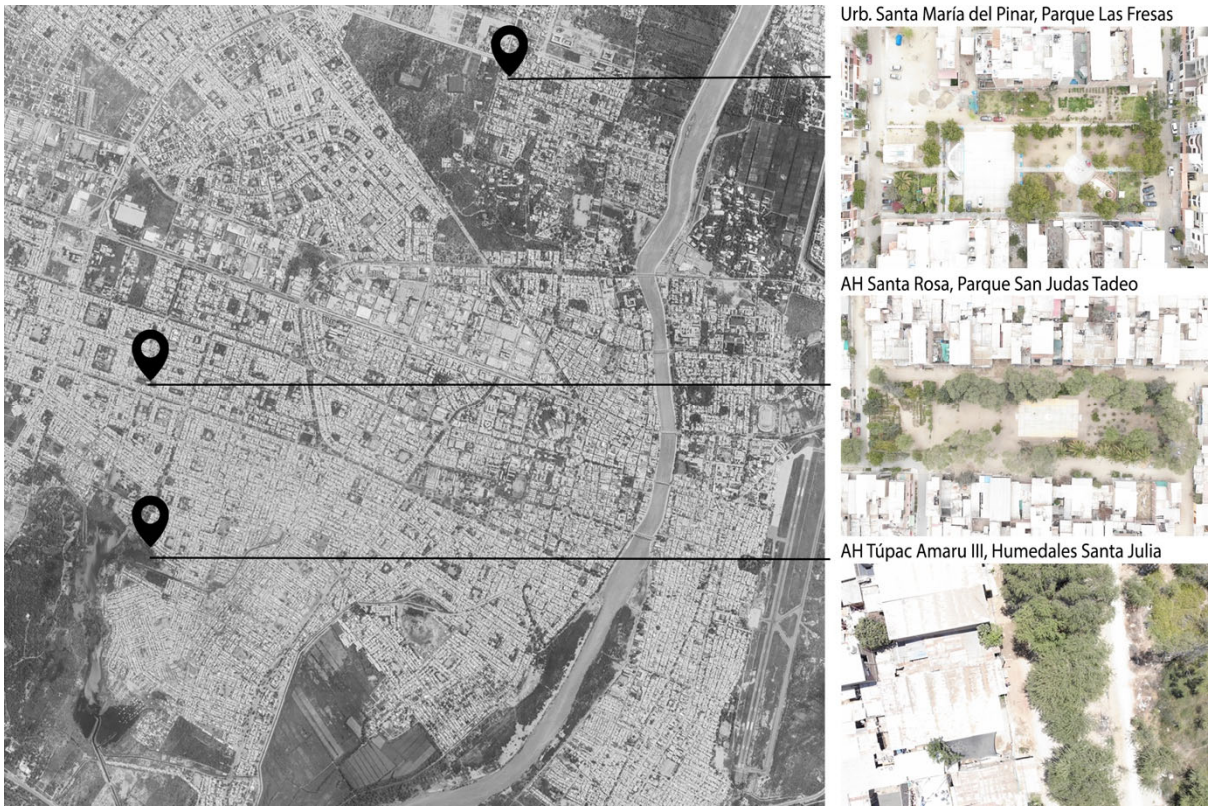

Figure 1. Location and aerial photo of the three case studies in the city.

The criteria for selecting these communities followed three principles: (1) the presence of a neighbourhood-initiated informal gardening initiative, which was confirmed by pre-exploration fieldwork; (2) a different composition of residents living in each of the selected initiative neighbourhoods, in relation to their socio-economic status; (3) the location in a relatively central part of the city, where urban gardens are less common, as opposed to the outer suburbs. Furthermore, it is worth mentioning that the three neighbourhoods of the initiatives show very different characteristics in terms of the years of construction of the buildings within the urbanisation process of the city and include neighbourhoods built in different decades of the last 60 years. Furthermore, there are differences with respect to the origin of the neighbourhood, whether it followed official standards or is part of land occupation with neighbourhood or informal characteristics, and its level

of consolidation. The table 1 shows the main characteristics of each neighbourhood where the urban gardens are located.

Table 1. Information about each neighbourhood with urban gardens analysed in this study

	Urb. Santa María del Pinar	**AH Santa Rosa**	**AH Tupas Amaru III**
Urban growth	1983-2000	Before 1962	1975-1990
Urban density (Inhabit. /block)	181	237	254
Consolidation state	Asphalt street & pavement	Mainly asphalt street & pavement	Mainly only asphalt pavement
Household income	High	Medium / medium high	Medium low
Origin of neighbourhood	State planning	Formalised neighbourhood	Informal / Formalised neighbourhood

Data collection

Using a qualitative approach, the spatial characteristics are considered as an analytical key to interpret the connections between the elements that make up a space. These observations include data gathering, mapping, sketches of the gardens, as well as aerial photographs as a complementary method. Through graphic representations of floor plans, the results demonstrate the physical appearance of the gardens and their relation to the built environment.

Based on observations, a table was used that included a set of categories derived from these: 1) size, 2) equipment, 3) material and 4) comments. In terms of equipment, the parameters included recreational elements that referred to games installed in the space, furniture such as benches and tables, shade that referred to facilities that provided protection from the weather, sports elements such as exercise equipment; as well as cultural elements such as religious elements with local relevance or constructions such as cabins or workshops, for example. In addition, it was documented whether the space has trees or green areas. The most available, cheapest, most intelligible and most appropriate materials of today are those with which informal spaces are constructed. Referring to Coxito (2014) these materials are: hidden materials, industrial materials or recycled materials. In addition, the option of natural materials from the area such as bamboo or reeds and vegetation is added. It is important to note that it was allowed to tick more than one option in each category.

RESULTS

Initial observations revealed a logic in the production of informal urban gardens in Piura's neighbourhoods. In the three initiatives, it was possible to map 36 gardens (Urb. Santa María del Pinar: 7 AH Santa Rosa: 19 y AH Tupac Amaru III: 10) generated with varied uses, methods of execution, activities, and elements. These spaces differ in size, level of development, availability of green areas, facilities, and furniture. However, some similarities can be observed in both similar equipment and use. Table 2 shows the information collected.

Table 2. Information collected on mapped spaces.

	Size			Equipment								Materials			
	< 20m2	m2	> 100m2	Playground elements	Furniture	Shadow	Sports equipment	Cultural elements	Shelters	Tress	Grass / Flowers	Hidden	Industrial	Recycled	Natural
C.	4	22	10	3	24	12	2	2	5	29	36	12	7	16	31
%	11%	61%	28%	8%	67%	33%	6%	6%	14%	81%	100%	33%	19%	86%	97%

The informal gardens are located in spaces that, according to the urban development plan, are considered recreational areas (parks) or natural spaces. It was observed that the gardens tend to have sizes ranging from 10 to 200 m2. The width depends on the available space and can vary, however, the length is oriented to the length of the lots, as shown in Figure 2. People tend to use an area on the site opposite their house.



Figure 2. Distribution of informal gardens in the three case studies.

Many spaces are delineated by fences, and the materials used in these places have included wood, bamboo, and recycled materials such as corrugated metal sheets or tires. Other spaces show a clear delimitation through vegetation, such as natural hedges or living fences. In some cases, the space is closed off with a lock, making it more private, for reasons that vary (private use, plant protection, or protection against animals). The ground material is soil, but with vegetation such as vegetables and fruits.

The gardens have an internal organisation with separate zones for different types of plants, such as a vegetable garden area and a flower area. Figures 3, 4, and 5 provide plant layout drawings of exemplary cases from the three initiatives.



Figure 3. Exemplary plant layout drawings, Urb. Santa María del Pinar, Parque Las Fresas.

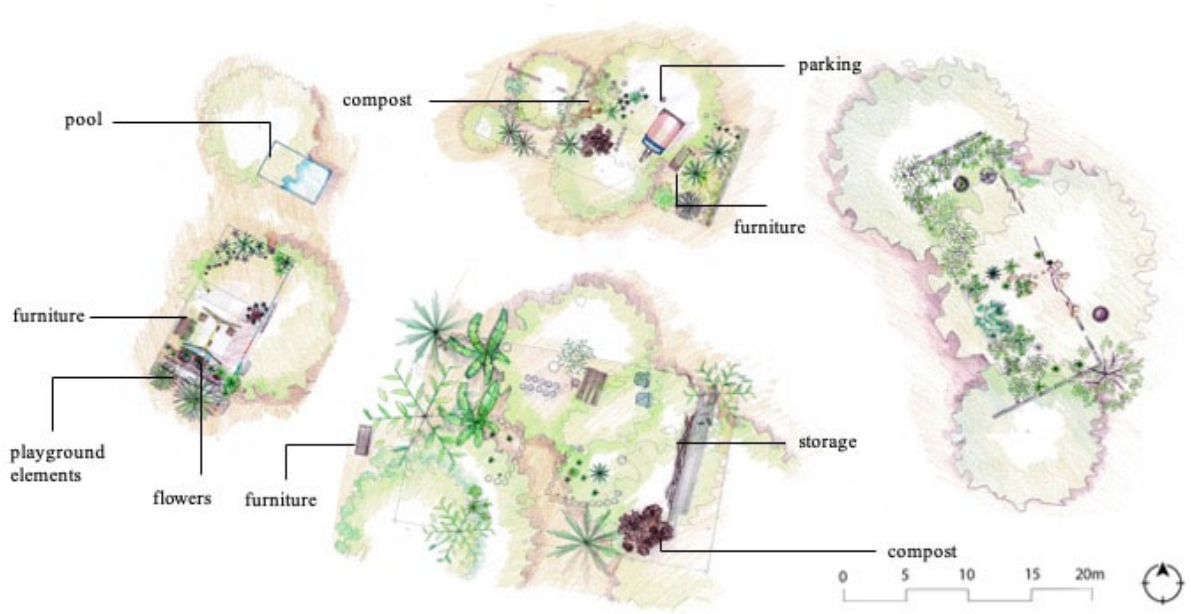

Figure 4. Exemplary plant layout drawings, AH Santa Rosa, Parque San Judas Tadeo Sector 5B.

All these spaces share an abundant presence of plants distributed throughout the surface. Trees provide shade in all the examples. The vegetation varies from decorative flowers to productive plants such as corn, squash, tomatoes, or fruit trees. The differences between the gardens and the surrounding neighbourhood are quite interesting. Spaces located in formal urban development's often have grass on the ground and decorative plants, such as flowers. In the spaces of formalised settlements, there are more fruit trees and vegetables, generally within the space. Some examples include a composting area surrounded by vegetation. Generally, the taller plants and shrubs are found at the boundaries of the space to delineate it, while the smaller plants, vegetables, and herbaceous

plants are protected within the space. Regarding water infrastructure, only one of the spaces has its own water connection, while water from the houses is usually used for the maintenance of the spaces.

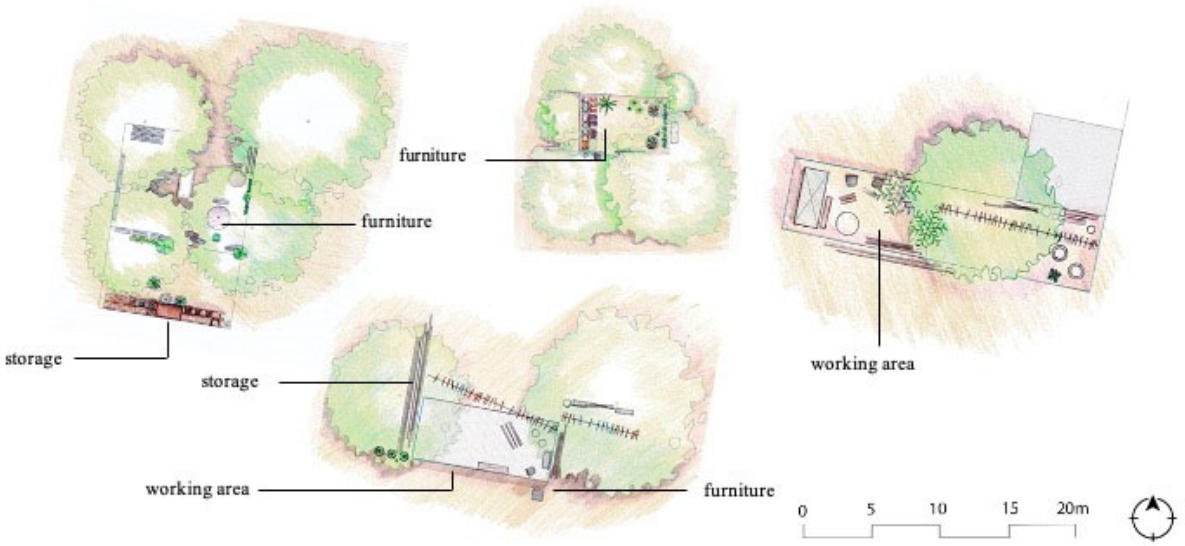

Figure 5. Exemplary plant layout drawings, AH Túpac Amaru III, Humedales Santa Julia.

Many of these spaces have furniture such as benches, chairs, or tables. The furniture is often strategically placed, in the shade of the trees or under a structure that provides shade. People use these spaces to sit, relax in the evenings, or have family gatherings on weekends. The type and conditions of furniture varies by neighbourhood, with Hollywood swings or garden furniture sets being more common in formal urban developments, while in the formalised neighbourhoods, recycled or old furniture is used. Additionally, old elements integrated into the space, such as play equipment like swings or metal climbers, now serve other functions.

Although the primary activity in all the examples is gardening, many of them also have benches, chairs, and tables. The spaces are sometimes equipped with small additional structures, such as sheds or storage units. The functions depend on local needs, but they are mainly related to workshops like carpentry. Additional functions are added, such as car parking or private uses. The parking is generally located in a central part of the space, either using the main access or providing a rear access. Furthermore, people use the space for functions that cannot be accommodated inside the house due to lack of space, such as washing and drying clothes. Some parts of the space are used as storage for construction materials. Materials such as wood, bamboo, old furniture, and industrial materials are stored in a part of the space, in some cases in the back or by separating a corner for this purpose.

Characteristic data about the typology and size of plots, plants etc. may be seen in Table 3.

Table 3. Data about urban gardens in the three selected sites.

Location	**Parque Las Fresas** **Urb. Santa María del Pinar**	**Parque San Judas Tadeo** **AH Santa Rosa**	**Humedales San Julia** **AH Tupac Amaru III**
Surface area total	3.500m2	6.000m2	1.500m2
Date of establishment	2014	2000	2010
Users	Direct residents	Direct residents	Direct residents

Cultivated plants/crops	Nim, ficus, cypress, papaya, poinciana, croton, aloe vera, coconut palm, bougainvillea, acalypha, hibiscus, rose, elephant's ear	Cactus, aloe vera, carob tree, mango, neem, lemon, corn, banana, coconut palm, soursop, croton, bay laurel, hibiscus, guava, marigold, palm tree, arrowroot	Orange, lemon, papaya, tamarind, aloe vera, mango, guarana, coconut, epazote Almond, soursop, mamey, tangerine, pomegranate, cactus, prickly pear, plantain, guava, carob, chinaberry
Ways of garden usage	Gardening, gatherings, rest	Gardening, sports, picnic, recreation, gatherings, rest, walking pets	Gardening, gatherings, rest
Garden equipment	Water, electricity, benches	Compost, benches, garden fences	Garden fences

DISCUSSION AND CONCLUSIONS

In urban studies, informality is a form of fluid, resilient, and flexible urbanisation that fills the gaps left by the state's incapacity or indifference (Fawaz, 2017; Marx and Kelling, 2019). The three case studies describe how (parts of) public spaces have slowly been transformed into what is described in various ways as a garden. Through the activities of local users, these plots have been transformed into lived spaces.

Informal gardening activities often emerge in response to a lack of community management, neglected public infrastructure, and disregard for residents' living needs, such as personal well-being, social activities, and access to green spaces. These grassroots efforts have become spontaneous expressions of an urban counterculture, aimed at resisting the perceived power of technocratic and bureaucratic planning. This phenomenon demonstrates that inadequate planning principles can result in ad-hoc solutions, negotiation of different interests, and the emergence of innovative forms of "producing" meaningful spaces through everyday life practices. The informal nature of the studied gardens allows them to be temporary, flexible, and adaptable to various social and political contexts, thereby challenging traditional notions of urban development with their hybrid character.

The objective of this work was to explore patterns of form, accessibility, and visual interaction for urban gardening. It aimed to reveal similarities and particularities in the configuration of individual objects, analysing equipment, materials, and the structural environment. Through the representations of these spaces, the results demonstrate the implementation of urban gardening spaces that arise from the population's own initiatives.

The spaces exhibit distinct constellations of activities that are generally rare in the public realm (though not particularly unusual in private spaces), such as gardening, installing benches, painting, grilling, and planting trees. These activities are often restricted to private realms, like backyards (or perhaps allotments). However, in the informal space, all of these activities seem to be "permitted". By analysing the specific elements, materials, and structural configurations of these informal garden areas, the research aimed to uncover both the commonalities and unique features present.

Finally, questions related to urban design and urban gardens are examined. This poses an apparently contradictory challenge: What can we learn from informal production in gardens? Additionally, there is a reflection on how the presented patterns can possibly facilitate future ways of formalisation and/or improvement. However, as observed in the study by He and Zhu (2018), many people remain

opposed to informal community spaces, primarily because they view them as a misuse of public resources and believe that informally transforming the space could diminish their quality of life.

Devlin (2018, p. 4) argues "that for planners to engage with urban informality in a progressive way, they need a conceptual compass undergirded by normative values of inclusiveness and economic and socio-spatial justice." Many cities have unused spaces, such as parking lots, abandoned buildings, or vacant lots. These spaces can be transformed into parks, community gardens, and other types of urban infrastructure. The case studies confirm that urban gardens integrated into the urban fabric and densely populated areas, as well as within the wider green landscape, have the potential to serve a variety of functions, resulting in benefits to the population (UK Green Building Council, 2015). Municipalities and local authorities can embrace and facilitate this type of activity across the city, enabling more residents to participate in informal initiatives and feel empowered to revitalise the urban environment. However, a disconnected sequence of poorly managed green infrastructure elements delivers far fewer public benefits than their potential (European Environment Agency, 2011).

The findings contribute to a deeper understanding of the role that the temporary use of public space can play in urban planning and development strategies. The definition of synergy, ultimately, allows for the interpretation of how informal production in public space - in this case, urban gardens - influences the built environment. The growing acceptance of these practices and recognizing their determinants would, consequently, raise awareness of this concept in the city, along with the adoption of appropriate regulations, which would undoubtedly be of immense relevance in formalised planning systems for greater flexibility and timely change. Design criteria must take into account the dynamics of communities and the identities of citizens, and be flexible enough to adapt to as many variables and conditions as possible over time. There are several possibilities for future research opportunities to build upon the work already done. The most obvious is to continue monitoring the ongoing production of the case study site as it evolves and changes over a longer period.

However, the case study results are inevitably partial. The gardens stand out in contrast to the broader area, which is worth exploring further. This also supports the concern that different approaches must be taken to understand informality in urban gardening in the city context. It is a cross-sectional, multidimensional study, heavily correlated with other aspects of society.

Acknowledgements

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Morphological diversity among informal settlements in Fortaleza, CE

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ABSTRACT

The cities that typically inform the international theoretical debate about urban form are in countries of the Global North. Expanding urban morphology to countries of the Global South implies recognizing the structural nature of informality in peripheral cities. Fortaleza, capital of the state of Ceará, is one of the largest and most socially unequal cities in Brazil, with more than 40% of its population living in informal settlements. Since 2009, Fortaleza has designated special zones of social interest (ZEIS), which, when implemented, redefine land use and occupancy parameters to encourage or allow social housing. Although progress has been slow, the city has seen important advances in implementing some of these zones, with data production, planning, and special regulations. Building upon this progress in data production regarding informal areas, this paper aims to comparatively analyze the urban form of three of these zones, located in different parts of the city (central, peripheral, and intermediary). We seek to understand the diversity of occupations and contribute to the discussion on the regulation of informal settlements in Fortaleza. To achieve this, we applied a qualitative methodology that includes a literature review, secondary data collection, and production of relevant georeferenced primary data for morphological analysis, followed by cartographic production using geoprocessing software. The results indicate that the zones' location within the city, and consequently the population's income and land prices, significantly impact their urban form. Additionally, factors such as the urban form of the surroundings and the duration of occupation also play a role. The findings support the idea that informal settlements cannot be seen as homogeneous, especially when developing public policies that impact these territories

Keywords: urban form, informality, ZEIS

INTRODUCTION

The Special Zones of Social Interest (ZEIS) have the potential to foster more inclusive cities by recognizing diverse urban occupations. In Fortaleza, ZEIS were established through the PDPFor after advocacy from local social movements. However, their implementation continues to face challenges (Freitas and Pequeno, 2012). ZEIS Type 1, which is the focus of this project, comprises 45 designated areas characterized by irregular settlements with unplanned occupation. These areas, primarily inhabited by low-income populations, are located in public or private spaces and are considered

precarious in terms of urban and housing conditions, intended for land, urban, and environmental regularization.

Despite some advancements, the implementation of ZEIS has been slow compared to the interests of the real estate market. While distributed across the city, ZEIS are few relative to the numerous precarious settlements. Currently, only 10 ZEIS have developed their Integrated Land Regularization Plans (PIRF), with two others still in the early stages.

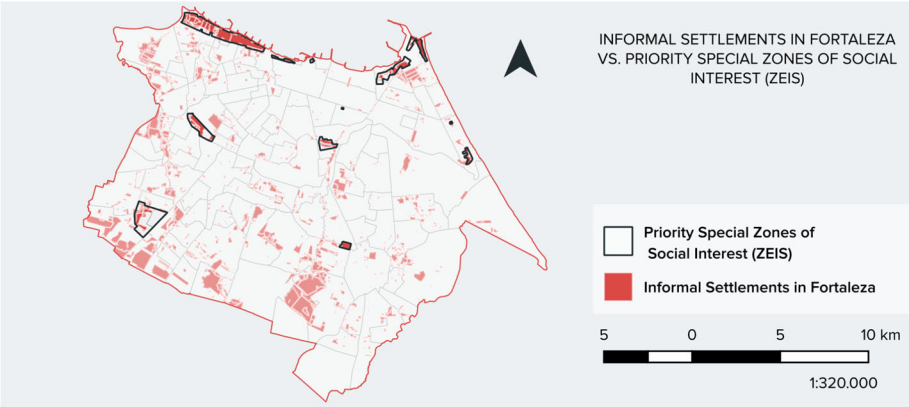


Figure 1. Map of informal settlements versus Priority Special Zones of Social Interest (ZEIS) in Fortaleza, based on the PLHIS-FOR (2013) and ZEIS SEUMA (2018) classifications. Credit: Compiled by the authors (2024).

To assess the potential impact of urban instruments across different territories, it's essential to grasp the specific dynamics of spatial production in each context (Santos, 2008). A thorough understanding of local realities, supported by accurate representation, is indispensable. Investigating these dynamics uncovers the diversity of territorial characteristics, which are often oversimplified by generalizing frameworks, potentially limiting the applicability of these instruments. Therefore, adapting to the unique features of each territory is crucial for effective implementation. Pequeno and Freitas (2012) emphasize this by stating that:

> [...] well-located favelas, equipped with infrastructure and mobility, tend to be more densely and intensely occupied, in order to supplement income, even as a resistance strategy by their residents to remain in the area. On the other hand, areas that are more distant and in precarious conditions have larger areas, fewer people per domestic unit and, consequently, a larger area per inhabitant (Pequeno and Freitas, 2012: 45, own translation).



Figure 2. Map of the selected ZEIS in Fortaleza—one central, one peripheral, and one intermediate—illustrating informal settlements per PLHIS-FOR (2016) and ZEIS SEUMA (2018). Credit: Compiled by the authors 2024.

Urban morphology is a vital tool for analyzing urban differences, providing a framework for interpreting cities as physical constructs. Although traditionally focused on historic European cities, this approach is increasingly relevant for cities in the Global South, revealing both commonalities and unique features. This research conducts a morphological analysis of three priority ZEIS in Fortaleza—Bom Jardim, Mucuripe, and Lagamar—each exhibiting distinct spatial characteristics. Bom Jardim, situated in the southwestern periphery, contrasts with Mucuripe, closer to the urban core, while Lagamar is smaller yet densely populated and centrally located. By comparing these areas, the study aims to explore the diversity of occupations and contribute to discussions on regulating these zones, enhancing our understanding of urban space production within Fortaleza's ZEIS.

The research employs an exploratory, qualitative approach. The first phase establishes a theoretical foundation on urban morphology and informal settlements through extensive bibliographic research. The second phase involves collecting georeferenced data for morphological analysis, which will be used for cartographic outputs and geospatial analysis using QGIS software.

LITERATURE REVIEW

Urban Morphology

Morphology is the study of form. Lamas (2010) defines it as the science that examines the structure and configuration of objects, considering the forces that shape them. In urban contexts, urban morphology focuses on the physical structure of cities and the historical and social processes behind their development. Lamas emphasizes the interdisciplinary nature of this field, which is crucial for understanding and planning urban environments. This analysis provides key insights into urban space development (Del Rio, 2000).

Moudon (2017) outlines three core principles of morphological analysis: form, scale, and time. This framework examines the distribution of buildings, roads, and public and private spaces, along with the social and economic relationships within these contexts.

In urban design, this approach serves as a crucial analytical tool, enabling the identification of principles, patterns, and typologies that inform future city interventions (Del Rio, 2000). Lamas (2010) emphasizes the close relationship between urban form and city design:

> At this point, urban form can be defined as: an aspect of reality, or the way in which the morphological elements that make up and define urban space are organized, in relation to the materialization of functional and quantitative organizational aspects and qualitative and figurative aspects. Form, being the ultimate goal of all design, is in connection with “drawing”, that is, with lines, spaces, volumes, geometry, planes and colors, in order to define a mode of use and figurative communication that constitutes the architectures of the city. (Lamas, 2010: 44).

To effectively interpret urban form, it is essential to investigate its fundamental components. Rego and Meneghetti (2011) emphasize that the city can be "read" and analyzed through its physical structure, and researchers agree that morphological analysis should focus on the basic elements of urban form.

Panerai (2006) defines "urban fabric" as the intricate interactions among blocks, streets, buildings, and public spaces that shape cities, identifying the road network, land parcels, and buildings as its core components. Lamas (2010) further categorizes urban form into three dimensions: sectorial, urban, and territorial. The sectorial dimension includes elements like façades and vegetation; the urban dimension focuses on neighborhood structures such as streets and parks; and the territorial dimension examines urban form at a larger scale, including transportation networks and geographic zones.

Historically, three main schools of urban morphology have emerged: the English School, led by Conzen (n.d.), emphasizing cognitive understanding; the Italian School, shaped by Muratori and Caniggia (n.d.), focusing on typological analysis; and the French School, influenced by Lefebvre and Chastel (n.d.), which adopts a critical perspective on urban life (Moudon and Oliveira, 2017). Research in Global South cities highlights the relevance of these methods, though local challenges, such as informal settlements, must be considered. Santos (2023) points out that formal cities adhere to planned infrastructure, while informal cities develop spontaneously.

To enrich this analysis, four key studies on urban form were selected: two examining urban settlements broadly and two focusing specifically on the typomorphological development of informal settlements.

Urban morphology applications

In Urban Morphology in Planning Practice: Towards an Integrated Methodology for City Analysis and Proposal, Ana Cláudia Monteiro (2020) introduces the Methodology for Analysis and Proposal (MAP), focusing on Porto's urban form by integrating various morphological perspectives into urban planning. She compares three approaches—historical-geographical, typological process, and space syntax—examining elements such as scale, representation, and results to identify convergences and divergences in morphological regions and typological processes.

Rosaneli (2009) applies Conzen's theory to Brazil's coffee frontier in Urban Morphology as a Methodological Approach to the Study of the Form and Landscape of Urban Settlements. Her analysis focuses on the urban project and the detailed morphology of plots, blocks, streets, and public spaces, revealing patterns in public and private domains through block geometry and plot orientation.

Fabiana Izaga et al. (2022; 2023) conduct a typomorphological analysis of informal housing in Rio de Janeiro's Planning Area 3 (AP3). In Typomorphology of Favelas, they examine transformations in

communities like Morro do Céu and Vila N. Sra. da Glória, categorizing favelas based on Panerai's (2006) urban fabric elements—road networks, land parcels, and buildings—into four types: enclave, line, block, and grid, linking urbanization processes to changes in urban form over time.

Farias (2019) explores factors influencing urban form in favelas, particularly Rocinha, Rio de Janeiro. She references Santos's (1985) concept of urban morphology, viewing it as shaped by land use and spatial organization, along with Kostof's (1991) Configuration Factors, which emphasize patterns, topography, and types of expansion.

Based on these studies, a morphological analysis methodology for the ZEIS was developed, integrating elements from each reference to establish categories for analysis. The following section outlines these categories and their contributions to understanding urban form

METHODOLOGY: CATEGORIES OF MORPHOLOGICAL ANALYSIS

The following methodology is primarily based on the analyses of Monteiro (2020) and Farias (2019), who employed summary matrices to compile and compare various morphological approaches. The analysis will focus on the following categories: (1) Location within the city; (2) Road system; (3) Land division (including blocks, plots, and open spaces); (4) Buildings; and (5) Typomorphology.

Table 1. Summary of Morphological Approaches. Credit: Compiled by the authors (2024).

CATEGORY	DESCRIPTION	AUTHORS
Location In The City	Proximity to the urban center has a certain influence on the development and infrastructure of peripheral spaces.	Santos (1985), Panerai (2006), Farias (2019)
Street System	Road networks can connect and limit urban spaces, influencing circulation and accessibility.	Lamas (2010), Panerai (2006), Moudon (2017), Conzen (2009), Rosanelli (2009), Izaga Et Al (2022, 2023), Farias (2019)
Land Subdivision (Blocks, Plots, And Open Spaces)	The organization of plots, blocks, and open spaces helps to understand the urban structure and its transformations over time.	Panerai (2006), Moudon (2017), Conzen (2009), Rosanelli (2009), Farias (2019)
Buildings	Physical elements such as height, shape, and use of buildings can shape the urban landscape and influence city functionality.	Panerai (2006), Moudon (2017), Conzen (2009), Monteiro (2020), Farias (2019)
Typomorphology	Classification of urban typologies such as enclaves, line, block, and grid for understanding spatial configuration and organization of the urban fabric.	Panerai (2016), Izaga Et Al (2022, 2023)

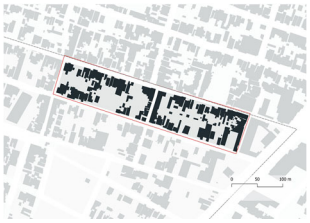
Santos (1985) explores the center-periphery dynamic, noting that city centers concentrate economic activity, while peripheral areas often lack infrastructure. Panerai (2006) adds that urban elements influence growth based on their location and the city's development stage, particularly focusing on Fortaleza's Bairro Centro, its oldest and densest area, while considering natural features like topography and hydrography.

Lamas (2010) emphasizes the critical role of the road system in shaping urban spaces, a perspective supported by Panerai (2006), Moudon (2017), and Rosanelli (2009), who highlight its hierarchical structure and impact on circulation. Izaga et al. (2022, 2023) and Farias (2019) further stress the importance of roads as connectors between formal and informal areas.

Panerai (2006) also views land subdivision—plots, blocks, and open spaces—as essential for understanding urban form. Moudon (2017) and Conzen (2009) discuss how land division shapes urban evolution, while Farias (2019) links land parceling in favelas to power dynamics.

Buildings play a vital role in the urban fabric, affecting both perception and functionality (Panerai 2006; Moudon 2017). Monteiro (2020) analyzes building characteristics to identify urban patterns, while Farias (2019) considers building height an indicator of urban consolidation in informal areas. Izaga et al. (2022, 2023) focus on typomorphology to understand favela growth, classifying ZEIS typologies as enclaves, lines, blocks, or grids, reflecting various stages of urban development influenced by topography.

Table 2. Morphological categories. Credit: Compiled by the authors.(2024)

CATEGORY	DESCRIPTION	REFERENCE
Enclave	Space Included In A Larger Territory With Divergent Characteristics, Not Easily Accessible Or Isolated, Usually With A Main Entrance.	
Line	Growth Around A Linear Urban Infrastructure, Such As Rivers, Walls, Or Roads, With A Rectangular And Linear Form.	
Block	Space Delimited By Streets, Understood As A Block Intended For Building Or Open Space.	
Grid	A Set Of At Least Three Blocks, With Both Regular And Organic Sections, Over A Variable Terrain.	

Note: Enclave is an isolated area (Morro do Teixeira, ZEIS Mucuripe); Line shows growth along infrastructure (Sapori, ZEIS Mucuripe); Block represents street-defined spaces (Rei do Gado, ZEIS Bom Jardim); Grid consists of interconnected blocks (Lagamar, ZEIS Lagamar).

In view of the above, the categories defined will be submitted to the three selected ZEIS: Bom Jardim, Mucuripe and Lagamar, in order to carry out the analysis and draw a comparative pattern.

RESULTS AND DISCUSSIONS

The Bom Jardim ZEIS spans 285.68 hectares across the Bom Jardim and part of the Siqueira neighborhoods in southwest Fortaleza. This peripheral area has a lower Human Development Index (HDI) and income levels, along with limited infrastructure coverage (Costa Lima, 2017). It is situated approximately 12-15 kilometers from the city center, translating to a travel time of 30 to 45 minutes by car. In contrast, the Mucuripe ZEIS covers 84 hectares in the northeastern part of the city, encompassing the Varjota, Mucuripe, Vicente Pinzon, and Cais do Porto neighborhoods. This highly sought-after area is close to the waterfront, located just 6 to 10 kilometers from the city center, allowing for a travel time of about 25 minutes by car. Lastly, the Lagamar ZEIS, the smallest at 48.42 hectares, is situated between the São João do Tauape and Alto da Balança neighborhoods, approximately 5 kilometers from the city center.

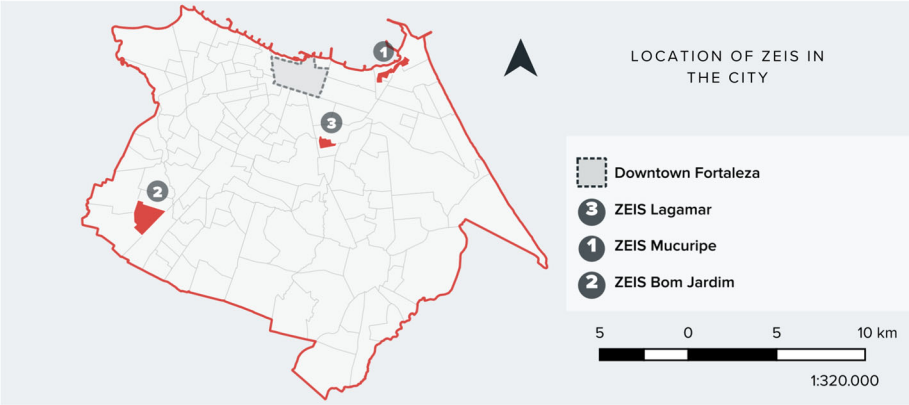


Figure 3. Location of the Bom Jardim, Mucuripe, and Lagamar ZEIS in the city. Credit: Compiled by the authors based on data from SEUMA (2018).

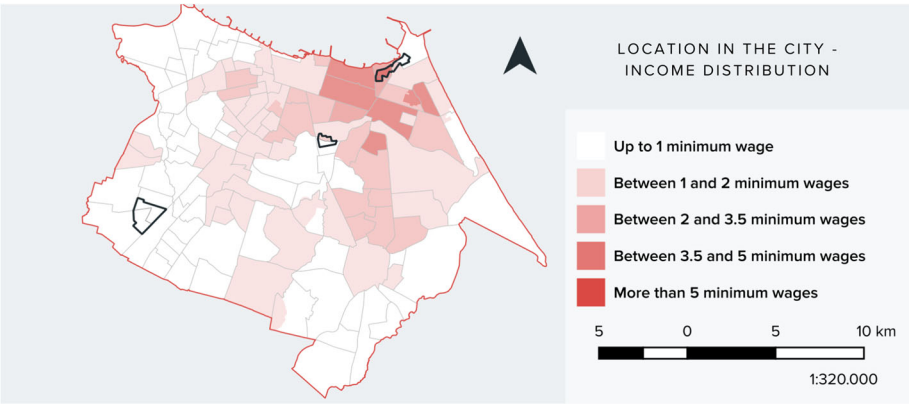


Figure 4. Location of the Bom Jardim, Mucuripe, and Lagamar ZEIS along with income distribution. Credit: Compiled by the authors based on data from SEUMA (2018) for ZEIS and PLHIS (2013) for settlements, and IBGE (2010) for income distribution.

The Mucuripe ZEIS (Figure 5) has 8 precarious settlements: (1) Castelo Encantador, (2) João Arruda, (3) Praça do Coqueiro, (4) Rua João Arruda, (5) Santa Edwirges, (6) Saporé, and (7) Terramar. These settlements vary in size, with the largest located in the eastern part of the territory. The Maceió stream crosses the area and meets the sea. The Bom Jardim ZEIS (Figure 5) has 15 precarious settlements within its territory. They are: (1) Comunidade Canal Leste, (2) Comunidade Parque Santo Amaro, (3) Irmã Dulce, (4) Veneza/Daniel Batista, (5) Rua General Rabelo, (6) Rua Cesarina Batista, (7) Rua Alexandra, (8) Rei do Gado, (9) Travessa Itú, (10) Favela Pantanal/Nova Friburgo, (11) Ocupação

da Paz, (12) Marrocos/Invasão Urucutuba, (13) Mutirão da Urucutuba, (14) Rua Francisco Machado, and (15) Rua Indiara. It is noteworthy that most of these settlements are located along the water resources of the Maranguapinho River, indicating a level of environmental fragility in the occupation. The Lagamar ZEIS (Figure 5) has two precarious settlements: Lagamar (1) and Santo Expedito (2). Lagamar is significantly larger than Santo Expedito.

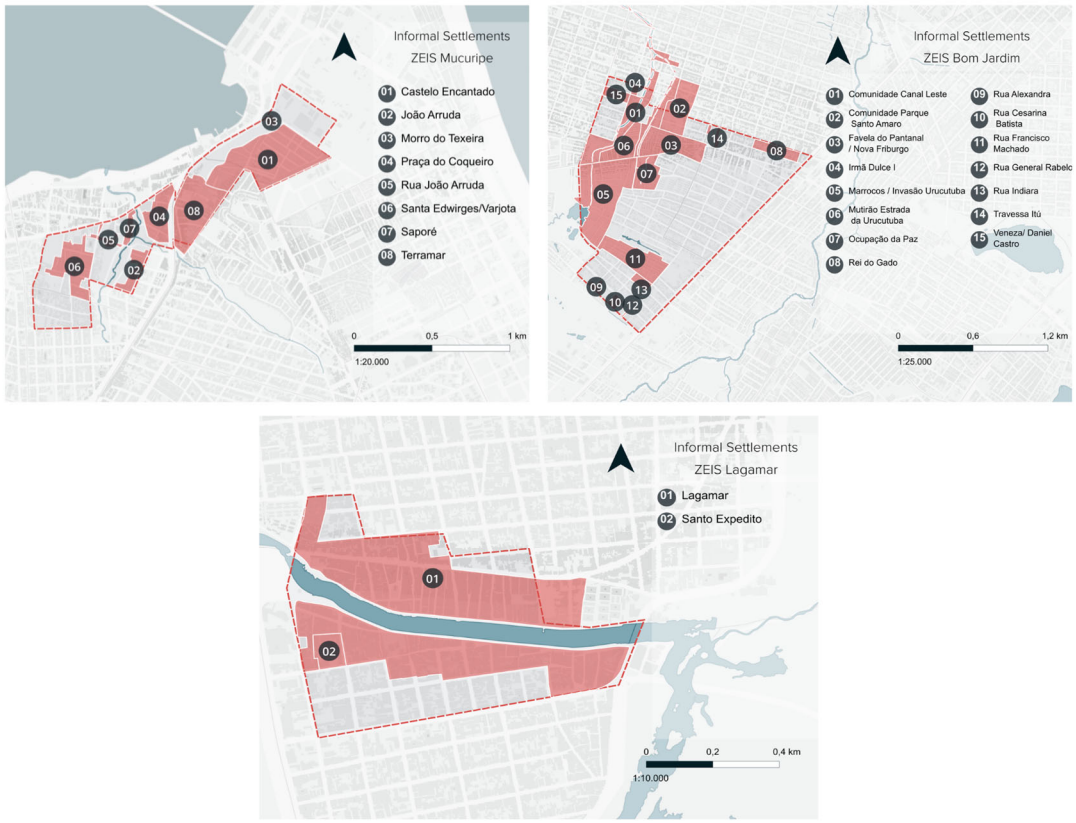


Figure 5. Map illustrating the precarious settlements within the ZEIS of Bom Jardim (right), Mucuripe (left), and Lagamar (below). Compiled by the authors based on data from PLHIS (2013) for settlements and SEUMA (2018) for ZEIS boundaries.

In the Bom Jardim ZEIS (Figure 6), most settlements are located in lower areas where water resources are concentrated, putting them at risk of flooding. In contrast, the Mucuripe ZEIS (Figure 6) features settlements along its length, with a significant portion occupying higher regions characterized by steep slopes. This illustrates a clear relationship between the concentration of settlements and areas with low real estate interest. In the Lagamar ZEIS (Figure 6), the terrain shows relative uniformity around water resources, where smoother contour lines indicate areas with less slope.

The street system (Figure 7) in each ZEIS presents its own challenges. The older settlements of Mucuripe and Lagamar have a more consolidated street network, but with irregular layouts due to the informal nature of the occupations that started in the 1930s. Meanwhile, Bom Jardim, with its more recent occupation, shows a more fragmented and less planned street system, contributing to the area's accessibility issues and the disconnection from the formal urban grid.

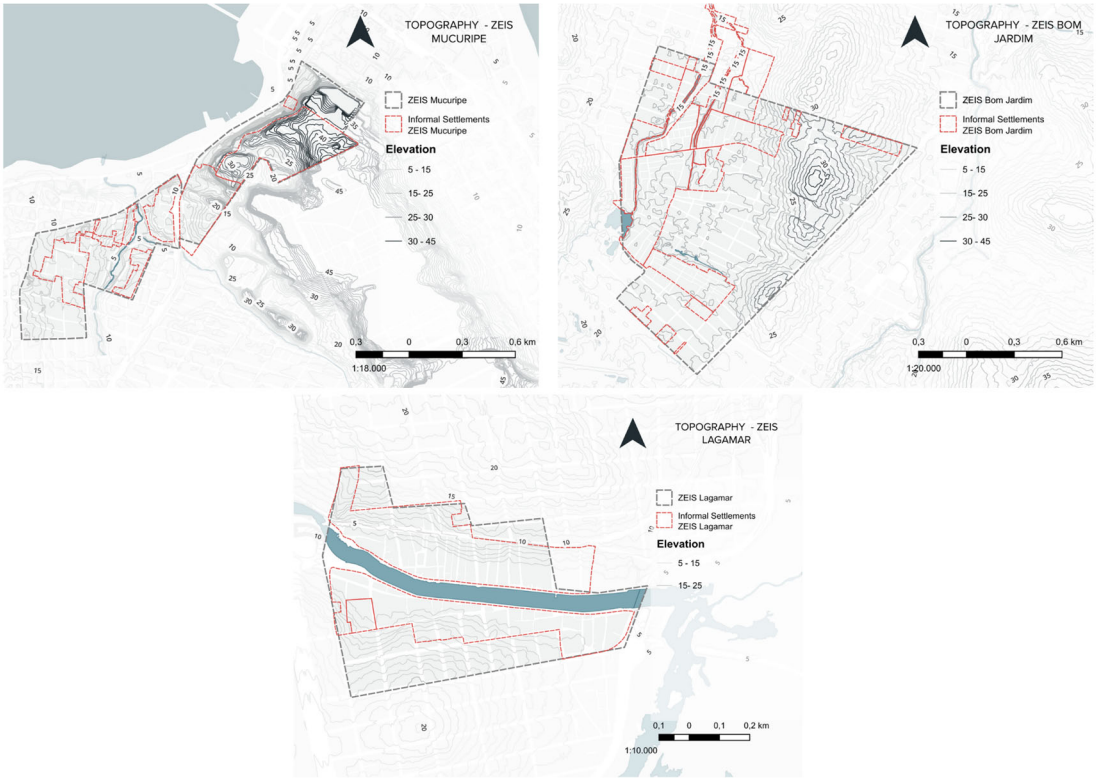


Figure 6. Map illustrating the topography of the Mucuripe ZEIS (left), along with the Bom Jardim ZEIS (right) and Lagamar ZEIS (below). Compiled by the authors based on data from SEFIN (2016).

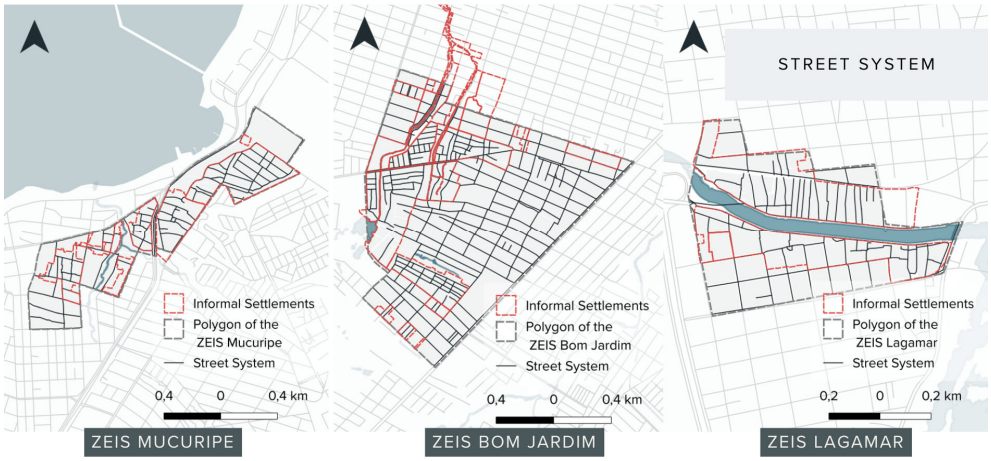


Figure 7. Map showing the street system. Compiled by the authors based on data from SEFIN (2016).

The differences in building occupancy among the three ZEIS significantly impact their composition (Figure 8). The Mucuripe and Lagamar ZEIS, which date back to the city's first informal settlements in the 1930s, exhibit a higher density of buildings. Notably, Mucuripe still contains large vacant areas, primarily walled plots resulting from real estate speculation. In contrast, the Bom Jardim ZEIS, with informal occupations emerging more recently in the 1990s and 2000s, features a sparser built environment characterized by larger backyards.

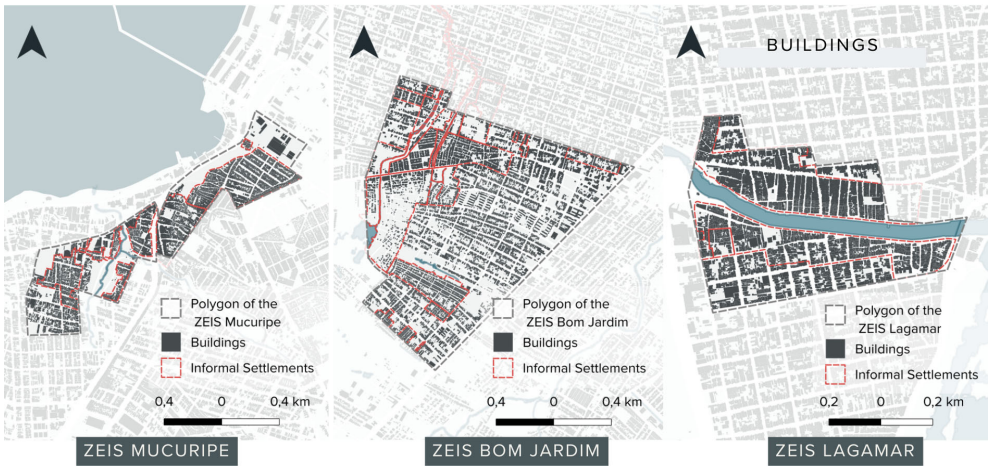


Figure 8. Map showing the buildings. Credit: Compiled by the authors based on data from SEFIN (2016).

An analysis of solids and voids reveals distinct patterns across the three ZEIS. Bom Jardim has densely built-up areas interspersed with significant urban voids, while the Novas Canudos and Pantanal communities are almost entirely developed. Mucuripe, in comparison, has a greater density than Bom Jardim, reflecting its historical context. The analyzed settlements in Mucuripe include Castelo Encantado, Santa Edwiges, and Saporé. Although the plots in Castelo Encantado are irregular, they maintain a cohesive layout. In contrast, Santa Edwiges and Saporé feature more haphazard plots, with some located far from the formal road network, leading to poor access.

In Bom Jardim, open areas are limited to two small squares and one green space, highlighting a significant lack of public leisure facilities (Figure 9). In contrast, the Mucuripe ZEIS offers more options, enhanced by the Maceió stream and Otacílio Teixeira Lima Neto Park (Bisão). The Lagamar ZEIS similarly suffers from a scarcity of free spaces, with its largest water resource lacking infrastructure for quality use.

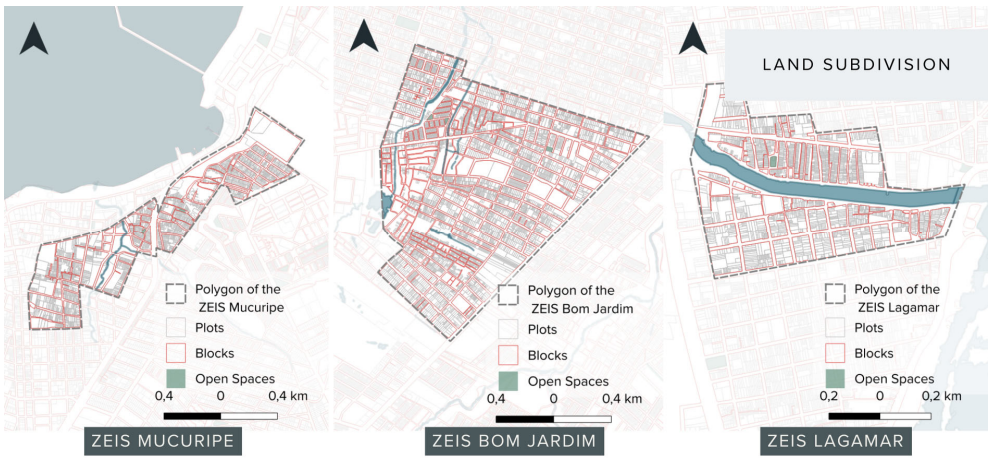


Figure 9. Map showing the land subdivision. Credit: Compiled by the authors based on data from URBFOR (2019) for green areas and SEFIN (2023) for lots and blocks.

The analysis of plots (Figure 9) highlights the complexity of the urban fabric, revealing significant diversity in sizes and shapes across the ZEIS. This contrasts the urban form of precarious settlements with the formal fabric of the city. Three settlements from each ZEIS were selected for closer examination: in Bom Jardim, Marrocos, Ocupação da Paz, and Mutirão da Urucutuba. Among these, Mutirão da Urucutuba, a housing complex, features more regular and orderly plots, while Marrocos

and Ocupação da Paz predominantly consist of irregular plots with notable variations in area and shape. Overall, the ZEIS displays a wide range of plot formats, yet a degree of regularity persists within the settlements, even if they do not conform to the surrounding formal fabric.



Figure 10. Map showing the building height . Credit: Compiled by the authors based on data from SEFIN (2016).

Regarding height (Figure 10), the Mucuripe ZEIS showcases taller buildings compared to Bom Jardim. However, these taller structures are not part of the precarious settlements, which, like those in Bom Jardim, primarily exhibit horizontal development. Similarly, the Lagamar ZEIS also trends towards horizontal growth, with minimal vertical expansion throughout the area.

Based on the work of Izaga et al. (2022, 2023), four typomorphological categories were established: (E) Enclave, (L) Line, (Q) Block, and (G) Grid. Settlements like Comunidade Canal Leste, Irmã Dulce I, Rua General Rabelo, and Travessa Itú in the Bom Jardim ZEIS, along with Saporé in the Mucuripe ZEIS (Figure 11), were classified as lines, reflecting their linear development along infrastructures such as roads and waterways. For instance, Comunidade Canal Leste is defined by the route of the canal it shares its name with.



Figure 11. Maps illustrating the typomorphology of the Lagamar, Bom Jardim, and Mucuripe ZEIS, highlighting their unique urban configurations. Credit: Compiled by the authors based on Izaga et al. (2022, 2023).

In contrast, Comunidade Parque Santo Amaro, Veneza/Daniel Castro, Rua Cesarina Batista, Rua Alexandra, Rei do Gado, and Rua Indiara in Bom Jardim were classified as blocks, enclosed by streets and consisting of one or two blocks designated for building or open spaces. Notably, no such cases were found in the Mucuripe ZEIS. For example, the Rei do Gado settlement features two well-defined blocks resembling formal ones, despite being classified as a precarious settlement (Figure 12).



Figure 12. Maps showing the Morphological Type Analysis for the Mucuripe, Bom Jardim, and Lagamar ZEIS. Credit: Compiled by the authors (2024).

The settlements Favela do Pantanal/Nova Friburgo, Ocupação da Paz, Marrocos/Invasão Urucutuba, Mutirão Estrada da Urucutuba, and Rua Francisco Machado (Nova Canudos) in the Bom Jardim ZEIS,

along with João Arruda, Praça do Coqueiro, Rua João Arruda, Santa Edwiges, and Terramar in the Mucuripe ZEIS, were classified as grids. This classification reflects the formation of continuous urban complexes comprising at least three blocks and characterized by a degree of heterogeneity. For instance, Rua Francisco Machado (Nova Canudos) in the Bom Jardim ZEIS exemplifies this typology.

No enclaves were identified in the Bom Jardim ZEIS, but Castelo Encantado and Morro do Teixeira in the Mucuripe ZEIS were classified as enclaves due to their isolation, limited access, and distinct physical and social characteristics compared to their surroundings. Notably, Morro do Teixeira features a steep slope that complicates access, as indicated in the topographic analysis map. In the Lagamar ZEIS (Figure 12), the Lagamar settlement was classified as a line due to its extension along the water resource, while Santo Expedito was classified as an enclave.

CONCLUSIONS

The study of morphological diversity in Fortaleza's priority ZEIS—Bom Jardim, Mucuripe, and Lagamar—reveals a complex and dynamic landscape of urban occupation shaped by historical processes and urban interventions over time.

In the Bom Jardim ZEIS, diversity is marked by various self-constructed housing types, reflecting spontaneous occupation. The differing shapes and sizes of buildings, along with the presence of open spaces, suggest an ongoing spatial reconfiguration. This underscores the urgent need for public policies that promote land regularization and enhance infrastructure, ultimately improving social inclusion and residents' quality of life.

Mucuripe, located near high-value real estate areas, exhibits a mix of precarious housing and larger buildings. This spatial heterogeneity results from real estate pressures and socio-economic disparities. The findings emphasize the need for interventions that balance urban development with the preservation of the local community's social and cultural identity.

In the Lagamar ZEIS, situated in an intermediate area of the city, occupation follows the banks of the Lagamar Creek. The urban fabric combines regular areas near main roads with fragmented zones featuring alleys and narrow streets, highlighting occupation in an environmentally vulnerable region where many homes are at risk. Urgent urban interventions are needed to upgrade these areas, improve infrastructure, and ensure residents' safety and quality of life.

In conclusion, well-located ZEIS with adequate infrastructure and mobility, such as Mucuripe and Lagamar, tend to be more densely populated. In contrast, Bom Jardim, located on the city’s outskirts and facing precarious conditions, has more open spaces and larger areas per inhabitant.

The morphological diversity seen in Bom Jardim, Mucuripe, and Lagamar underscores the necessity for inclusive and participatory urban planning. Urban policies must account for each area's specific characteristics, promoting integrated solutions that address residents' needs and foster urban sustainability. Understanding these morphological dynamics is essential for guiding actions toward a more just and equitable city, where all citizens have access to adequate infrastructure and a decent quality of life.

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On the path to development or on the edge of the abyss? The dominant discourse and the anti-urbanity model

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ABSTRACT

This study discusses the response to the demand for housing in the context of population and economic growth in medium-sized Brazilian cities, considering the urban morphology of vertical housing areas. The objective is to analyse the current local discourse, reported by the press, based on the resulting urbanity in an area of recent verticalization. The case study is presented, the city of Sorocaba, one regional capital of the state of São Paulo, which has supported large numbers of vertical constructions, that occasionally illustrate news headlines related to the city's growth. Investigations were carried out in newspaper reports on the topic, published by the city's main newspaper, to obtain an understanding of these narratives. The aim is to discuss the quality of the area of recent verticalization based on the analysis of its urban form in the connexion between the implementation of the towers and the consolidation of streets, and the diagnosis was possible through mapping of the urban fabric. It is possible to point, through this examination, that the process of consolidating vertical areas has generated public spaces without urban quality, despite being seen as positive in the absorption of an expanding housing demand by the press. These spaces are the result from practices that prioritize the real estate market to the detriment of urbanity, in other words, the narrative presented to the population does not serve the collective sphere of the city. It also highlights the effectiveness in shaping a narrative that, instead of providing citizens with access to information, resigns itself to being another advertising tool for the real estate market.

Keywords: verticalization; medium-sized cities; public place; housing; real estate market

INTRODUCTION

This study focuses on reflections on meeting housing demand in the context of population and economic growth in Brazilian cities, considering the urban form of new housing areas. Research into current settlement cores is necessary to understand communities, their relationships with urban form, the natural environment, and quality of life and sustainability conditions.

In an increasingly urban society (UN-Habitat, 2022), it is pertinent to examine the effects of urban growth from the perspective of people's access and opportunities in spaces designed to accommodate such expansion demands. Data on population and households from the Brazil's last Census

demonstrate national growth in the 2010-2022 intercensal period with different regional, state, and municipal spatial dynamics that, however, demonstrate the robustness of population displacement in this period (IBGE, 2023). Furthermore, when examining the highest absolute growth rates, there is an increase in the number of apartment households in cities classified as regional capitals by the latest report on Regions of Influence of Cities – REGIC, 2018 (IBGE, 2020 and IBGE, 2023).

Verticalization can be a competent resource in responding to the demands of urban growth, from the perspective of instrumentation in a planning that seeks articulation between different factors that build up cities. Verticalization can be an instrument in promoting opportunities so that a greater number of people can live in spaces with better urbanity indices, access to jobs and public infrastructure (Rolnik, 2014), simply by maximizing the use of the appreciation of urban land (Ayoub et al, 2021). In addition to establishing new ways of living, urban networks and offering the possibility of land multiplication, the verticalization process has the potential to enable proximity and reduce travel time (Silveira; Silveira, 2014). From the perspective of urban sustainability, it can be an important ally in curbing expansion and increasing densities, building more compact territories (Roso; Oliveira and Beuter, 2021). However, what we see in many Brazilian cities is the persistence of peripheral expansion, together with the verticalization of other areas, whose urban development pattern is inadequate to support public life, that is, incapable of encouraging people's presence, coexistence and appropriation of public spaces (Yunda; Sletto, 2020). This pattern of vertical occupation is added to the unequal conditions of access to goods, services and infrastructure in cities by different groups in society, generating segregation, exclusion and the sprawl of the city, including over environmentally fragile areas. The current economic system is interested in reinforcing these modes of production and reproduction that, through neoliberal logic, promote systemic urban chaos (Smith, 2009).

Furthermore, the recent verticalization process does little to promote urban vitality and the use of existing infrastructure, as it does not emphasize permeability, the connection with the surrounding public space, the quality of pedestrian space, among other benefits provided by greater urban density (Gonçalves et al, 2008; Symmes, 2017; Rios et al, 2022). However, the current pattern of vertical developments largely declines connection with public space, occupying large plots of land and characterized by walled extensions, marking the urban landscape with the volumes of the towers and/or the enclosures of the various parking floors next to the sidewalk (Holanda et al, 2012; Alas, 2013). Such implementations reject the values of urbanity and vitality in public space and, despite being equipped with cameras, access controls and barriers, do not result in security (Whyte, 1980; Bentley et al, 1999; Carmona, 2021).

Public spaces can offer something essential to urban life: the freedom to come and go, to use and appropriate them by any citizen. They enable unexpected encounters between people from different groups, ideologies or social classes, and that is why they play a fundamental role in this urban dynamic (Innerarity, 2010). It is possible to say, therefore, that public spaces play a fundamental role in urban life, because, without them, a dense and highly built-up terrain does not constitute a city (Sassen, 2013). The urbanity of a place refers to its characteristics and capacity to welcome people (Aguiar, 2010). Thus, the synthesis of architectural and urban attributes that, together, facilitate interaction and appropriation of people with places, is expressed in the different degrees of urbanity, to the

extent that it presents a greater or lesser capacity to welcome people. In turn, urban vitality comprises the flow and permanence of people in public spaces (Holanda et. al, 2012). Within this dimension, urbanity is something that the urban environment offers through its main morphological elements. Therefore, a high degree of urbanity corresponds to high levels of accessibility, density, diversity and spatial continuity.

The phenomenon of the emergence of new vertical neighbourhoods as result of the logic of the real estate market raises the question addressed by this research, namely, understanding the effects of urban form resulting in a territory that is shaped by the implementation of buildings that reject the relationship between the private and the public, observing the information transmitted to the population about this context. This work addresses the context of verticalization in Brazilian regional capitals with significant population growth rates, in dynamics that expose urban conflicts between the actors that produce intra-urban space and the citizens. Thus, the objective of this study is to analyse the current local discourse, reported by the press and by the municipal government, considering the quality of the resulting urban spaces in an area of recent verticalization, guided by the diagnosis of the conditions of block sizes, road network, connectivity, permeability and accessibility. To achieve the intended scope, we present a diagnosis of a case study in the city of Sorocaba-SP, headquarters of the Sorocaba Metropolitan Region (RMS), highlighted as one of the geographic reference points for population growth in the interior of Brazil in the intercensal period (IBGE, 2023). The arrangements of blocks and lots, the connectivity of the street layout and the alternatives for displacements in the urban form of Parque Campolim were examined, in the perimeter where the urban fabric is in the process of consolidation through the processes of construction of the verticalized landscape, in contrast with the diagnosis of the consolidated area of the Center, also verticalized

Quality of urban form and verticalization

Topics such as urban form, land use, traffic, community, built environment, citizens, urban economy, sociocultural environment and facilities are inextricably linked to urban vitality through certain characteristics and conditions (Liu et al, 2022). Urban vitality is a possible contribution to the establishment of community social ties, at the interface between the built environment and social cohesion, as a prerequisite for a safe and successful city in terms of street life, being conceptualized and evaluated as urban spaces have life and animation (Mouratidis and Poortinga, 2020).

To achieve responsive environments, it is imperative to ensure spaces provided with urban vitality, with attention to the attributes of permeability, variety, legibility, robustness, visual appropriation, richness and personalization for the development of urban area projects (Bentley et al, 1999). Urban design should contribute to the well-being of individuals, considering the reality of the current context, in which opportunities are constrained by the economic market and legislative political articulations. The design, as a process, should be seen as an activity of common integration for all those involved in the generation and maintenance of areas so that they have characteristics that guarantee successful spaces for the use and coexistence of people (Carmona et al, 2021).

Different forms of urban and landscape expansion, land use and occupation, building patterns, different degrees of population density, mobility and population diversity have different effects and provide different stimuli in urban life. The connectivity of the road network, traffic accessibility and the density of intersections – which are closely related to land use – improve the mobility of the population of the blocks and increase their vitality (Liu et al, 2022). Ignoring issues of connectivity,

accessibility and flexibility of use leads to the reproduction of less sustainable urban forms, with lower levels of social equality and obstacles to long-term economic viability (Carmona et al, 2021). The new centralities have the functional density of the historic centers but are not as physically dense. The new areas tend to be shaped by the logic of the automobile and the privilege of their space requirements, rather than the distances travelled by pedestrians (Russin, 1999).

In relation to urban verticalization, it constitutes processes that determine landscapes, resulting in new residential values, location, security and infrastructure. Therefore, their connections in relation to city spaces should guarantee urban evolution that generates wealth, environmental quality and life for people. In recent terms, housing verticalization has translated into a form of urban precariousness at first, but with the prospect of future housing precariousness, in a process similar to what occurs in other countries (Symmes, 2017), implying hyper densification.

In Brazil, from the 1970s onwards, cities classified at lower levels of urban hierarchy (when compared to large metropolises) began to attract investments and undergo socioeconomic changes. Federal development public policies for medium-sized cities were implemented to reduce metropolitan migration. Thus, medium-sized cities have shown growth and transformations generated with horizontal and vertical urban expansion (Oliveira; França, 2012).

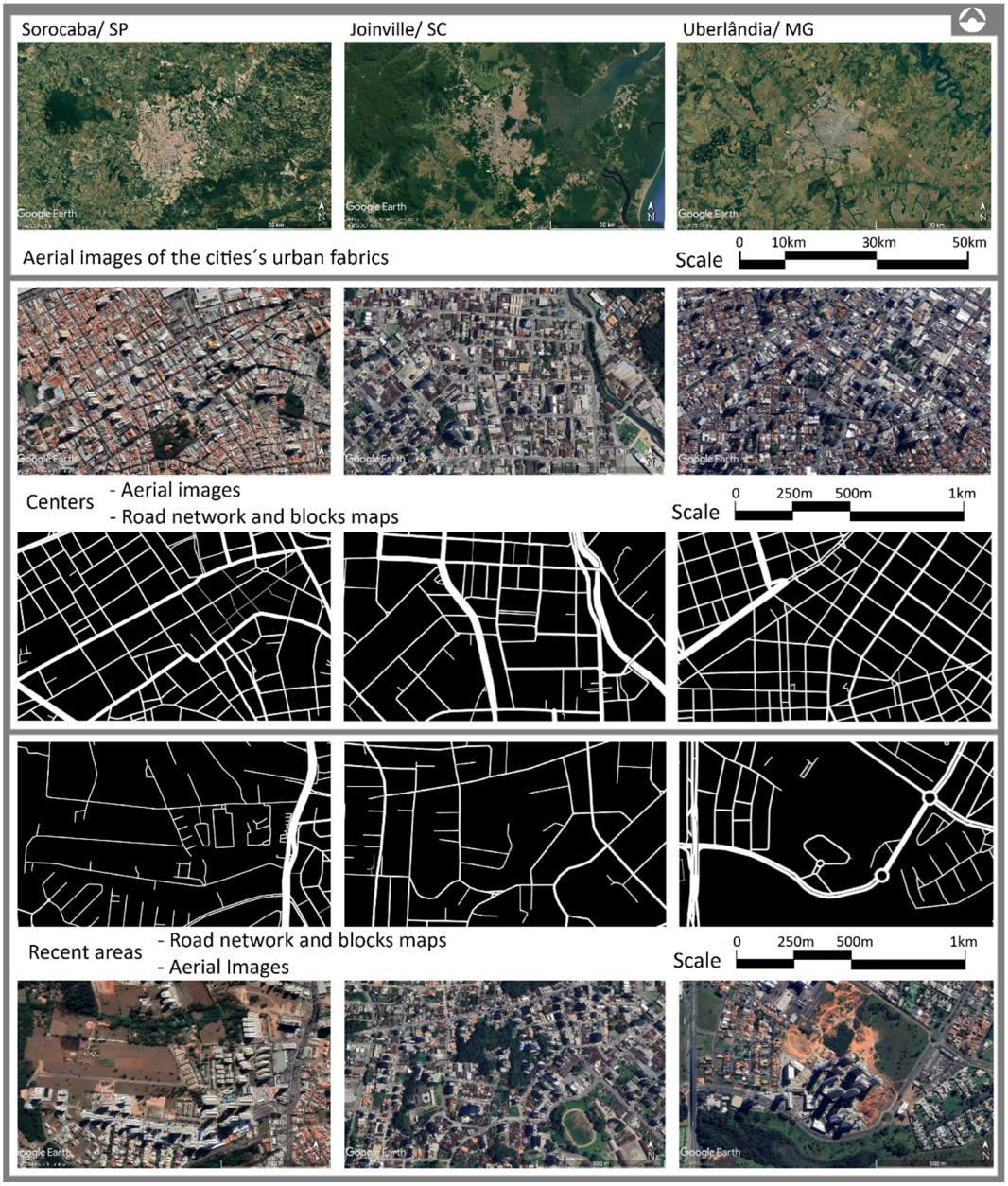


Figure 1. Sorocaba, Joinville, Uberlândia. Prepared by the authors based on Google Earth, 2024.

Figure 01 demonstrates, using satellite images, the urban areas of the cities of Sorocaba/SP, Joinville/SC and Uberlândia/MG – three expanding regional capitals, experiencing processes of urban verticalization. The diagrams (Figure 01) indicate the differences in the road networks of central areas, already consolidated, and areas that are currently undergoing consolidation processes. Figure 02 brings together three reports from local newspapers about the verticalization of these cities and the association of these processes with economic and population expansion.



Figure 2. News about verticalization in Sorocaba, Joinville, Uberlândia. Prepared by the authors .

In this context, this work is guided by the deepening of the conditions of road permeability and connectivity of the street fabric, combinations of blocks arrangements, accessibility and comfortable walking distances and the opportunities for choices and multiplicity of possible paths for people, through analyses of the urban form and layout – in land and subdivision patterns, dimensions of blocks and lots and connections with the road system in the vertical urban fabric of Parque Campolim and Centro in Sorocaba-SP.

Verticalization in Sorocaba

Sorocaba is in the interior of São Paulo (Figure 03), has 723,574 inhabitants, and is the 7th most populous city in the state of São Paulo and the 27th most populous in the country (IBGE, 2023). In addition to the population increase of 23.3% in relation to 2010 Census data, there is economic growth, occupying 7th place in the national ranking of interior cities. Furthermore, the Gross Domestic Product (GDP) of the Metropolitan Region of Sorocaba (RMS) grew 0.7% in the first quarter of 2023, being the highest GDP in the interior regions of São Paulo in this period (IBGE, 2023; SEADE, 2023).

The institutionalization of the RMS, in 2014, accelerated the processes of local metropolitan consolidation and expansion of its area of influence. The city of Sorocaba receives people who seek better living conditions, coming from smaller cities in the RMS and the south of the State of São Paulo and who end up offering their workforce to macro-metropolitan arrangements. From the perspective of economic dynamics in the territorial context between the Metropolitan Regions of Sorocaba, São Paulo and Campinas, in addition to proximity, there is an openness to new investments and the functional subordination of the RMS in relation to the other metropolitan regions. It is pointed out that the demographic and economic growth of Sorocaba and the region must consider the limitations existing by the political, social and economic agents involved in combating the socio-spatial inequalities produced, with a view to a socially fair expansion (Mauá Filho and Lima, 2023).

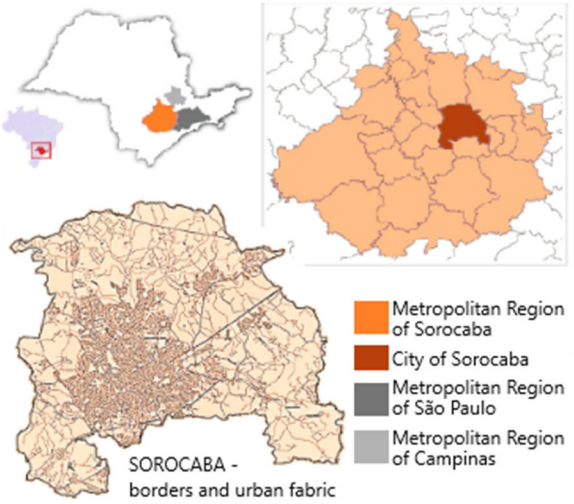
In the 2022 Census (Figure 03), Sorocaba is included in the largest population size class, with more than 500,000 inhabitants. Together with the 40 other centers of the same classification, it makes up 0.74% of Brazilian municipalities which, in total, are home to more than half of the total national population (58,876,980 inhabitants). The city was highlighted as the 4th Brazilian municipality with the highest absolute variation in demographic growth. Among the Regional Capitals, Sorocaba obtained the highest percentage of growth, followed by Joinville-SC, Uberlândia-MG (Figures 01 and

02). These data demonstrate the context of regional capitals undergoing accelerated demographic expansion, in notably higher percentages in relation to large metropolises.

Largest population expansions in cities - more than 500.000 inhabitants

Cap.	39º	Florianópolis	SC	537.211
	41º	Serra	ES	520.653
	27º	Sorocaba	SP	723.682
	34º	Joinville	SC	616.317
	28º	Uberlândia	MG	713.224
Cap.	31º	Cuiabá	MT	650.877
	29º	Ribeirão Preto	SP	698.642
Cap.	20º	João Pessoa	PB	833.932
Cap.	7º	Manaus	AM	2.063.689
Cap.	17º	Campo Grande	MS	898.100
Cap.	10º	Goiânia	GO	1.437.366
Cap.	3º	Brasília	DF	2.817.381
Cap.	1º	São Paulo	SP	11.451.999

SOROCABA



View of the city:



Image source: Bild Blog, 2022.

The 41 most populated cities in Brazil

Cap.	1º	São Paulo	SP	11.451.999
Cap.	2º	Rio de Janeiro	RJ	6 211 223
Cap.	3º	Brasília	DF	2.817.381
Cap.	4º	Fortaleza	CE	2 428 708
Cap.	5º	Salvador	BA	2 417 678
Cap.	6º	Belo Horizonte	MG	2 315 560
Cap.	7º	Manaus	AM	2.063.689
Cap.	8º	Curitiba	PR	1 773 718
Cap.	9º	Recife	PE	1 488 920
Cap.	10º	Goiânia	GO	1.437.366
Cap.	11º	Porto Alegre	RS	1 332 845
Cap.	12º	Belém	PA	1 303 403
	13º	Guarulhos	SP	1 291 771
	14º	Campinas	SP	1 139 047
Cap.	15º	São Luís	MA	1 037 775
Cap.	16º	Maceió	AL	957 916
Cap.	17º	Campo Grande	MS	898.100
	18º	São Gonçalo	RJ	896 744
Cap.	19º	Teresina	PI	866 300
Cap.	20º	João Pessoa	PB	833.932
	21º	São Bernardo do Campo	SP	810.729
	22º	Duque de Caxias	RJ	808.161
	23º	Nova Iguaçu	RJ	785.867
Cap.	24º	Natal	RN	751.300
	25º	Santo André	SP	748.919
	26º	Osasco	SP	728.615
	27º	Sorocaba	SP	723.682
	28º	Uberlândia	MG	713.224
	29º	Ribeirão Preto	SP	698.642
	30º	São José dos Campos	SP	697.054
Cap.	31º	Cuiabá	MT	650.877
	32º	Jaboatão dos Guararapes	PE	644.037
	33º	Contagem	MG	621.863
	34º	Joinville	SC	616.317
	35º	Feira de Santana	BA	616.272
Cap.	36º	Aracaju	SE	602.757
	37º	Londrina	PR	555.965
	38º	Juiz de Fora	MG	540.756
Cap.	39º	Florianópolis	SC	537.211
	40º	Aparecida de Goiânia	GO	527.796
	41º	Serra	ES	520.653

Large metropolises
Metropolises
Inserted in metropolitan regions
Capitals A
Capitals B

Figure 3. Sorocaba and the cities in expansion in Brazil. Prepared by the authors based on IBGE, 2023.

Given this situation, vertical growth and a wide range of residential real estate developments can be observed. In the last 12 years, such growth can be seen in the city's landscape, in surveys by the Union of Property Purchase, Sale and Administration Companies (SECOVI-SP) and in news from local newspapers that highlight the increase in Sorocaba's population preference for housing in apartments (Jornal Cruzeiro do Sul (JCS), 2023a; JCS, 2023b). Even the Covid-19 pandemic did not negatively

impact civil construction production in Sorocaba; on the contrary, the numbers of commercialization and construction of buildings have been increasing (JCS, 2020a; JCS, 2020b; JCS, 2021; JCS, 2022a; JCS, 2022b; JCS, 2022c).

To identify the areas in which such processes have been occurring, data on buildings with more than five floors in the city were systematized according to location and years of implementation. The Municipality's Building Code (1966) establishes the mandatory use of elevators for buildings taller than 10 meters, counting from the access level. In addition, buildings with five or more floors identified by research documenting constructions with three or more floors in Sorocaba until 2018 were selected (Monteiro; Mauá, 2019). This data was complemented by information on the years the buildings were completed and updated with the most recent detections (from 2019 to 2024), through surveys on construction companies' websites, portals with public information on condominium registrations, and on the collection platform available for subscribers of Jornal Cruzeiro do Sul (JCS, 2024) and through field confirmations initiated on August 6th, 2023, updated on March 9th, 2024 and August 28th, 2024.

In this way, mappings were created that identify tall buildings (Figure 04) with urban perimeters established based on the understanding of road connections when reading the street system in the city plan of Sorocaba. The city plan is made up of the complexities of street elements (street systems), parcels (blocks) and buildings (deployment plans) (Conzen, 2022). The historic core of Sorocaba is the second region with the largest number of tall buildings in the city. When considering the period from the 2000s onwards as another centrality, it is noted that Parque Campolim began to absorb the housing demand aimed at the high-income population, which until then occurred in the city center.

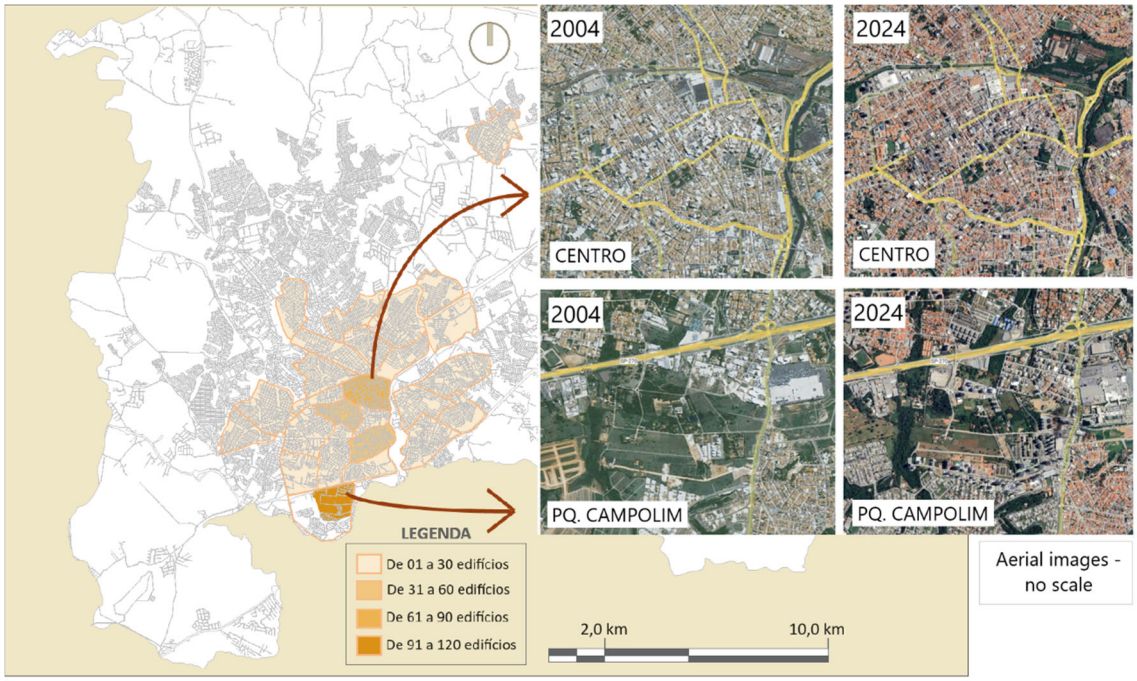


Figure 4. Occurrence of tall buildings in Sorocaba. Prepared by the authors based on Google Earth, 2024.

The occupation process to the south of the perimeter suggests accelerated civil production at the site, given that, while in the 2004 aerial photo the division established by the adjacent condominium of houses is noted, in the 2024 image, the strip that was previously characterized as empty, presents an

emphatic presence of buildings, which are even taller than the first vertical constructions in the region to the northeast. Thus, this street, Antônio Perez Hernandez, concentrates recent tall buildings, with the back of lots sharing walls with the condominium's houses

METHOD

Since this is a late and current verticalization process, it was found that the information about this context in the city of Sorocaba, except for the work by Barreto (2007), is that published in the region's newspapers. Thus, to verify the discourse of the local press, surveys were carried out of reports on the subject, published between 2012 and 2022 (intercensal period), as well as the most recent ones, from 2023 to August 2024, using the keywords “verticalization” and “tall building” in the city's largest circulation newspaper. The news items were organized in a table, with the systematization of the elements: date of publication, headline, subtitle, newspaper section. After verifying the central themes of each one, those that did not relate to the focus of this study were discarded: understanding the discourse of the local press on urban verticalization in Sorocaba. To obtain the delimitation of the objects of analysis, that is, the fabrics of the regions in which recent urban verticalization is observed in Parque Campolim and the Center, the Morphological Regions were identified by checking the street plans, subdivision and buildings of the urban plan (Conzen, 2022). The block arrangements, the connectivity of the street layout and the alternatives for displacement in the urban form of Parque Campolim and the Center were examined. The guidelines organized in the Morphological Dimension of Urban Design (Carmona et al, 2021) discuss block groups and the need for limits and diversity of block sizes in an urban grid that allows accessibility and good mobility conditions for people, through connectivity and permeability (Bentley et al, 1999; Jacobs, 2000 and Carmona et al, 2021), thus ensuring the multiplicity of possible paths (Rapoport, 1978; Jacobs, 2000; Bentley et al, 1999 and Carmona et al, 2021) at comfortable distances for travel (Rapoport, 1978).

To this end, the following were prepared: (1) Urban fabric maps that contrast the designs of the block subdivision layouts and road communications - using the figure and background method, the blocks are emphasized by filling in black; (2) Map of road hierarchy, where arterial connections were marked in red, collectors in yellow and local streets in green; (3) Map with lot divisions, showing the layout inserted in the blocks; (4) Map of block dimensions, where the initial classification (up to 2,500 m²) was based on the hypothesis of the total footage of a short block, with extension on all sides of 50 meters – the other classifications were established with results of footage considering, in relation to the previous one, the doubling of one of the sides; (5) Map of block dimensions, using as a guiding criterion the current local legislation, namely, the Municipal Building Code (1966) – obtaining the establishment of the first classification with blocks of eighty meters in length on both sides, resulting in 6,400 m² of area; and, successively, the others up to the “superblocks” in fabrics with 180,000 m2 of area.

RESULTS AND DISCUSSIONS

The systematization and study of reports on the topic of urban verticalization in the local newspaper of Sorocaba (Figure 05) indicates one report per year until 2016, the gap that occurred in the years preceding the Covid-19 pandemic and the increase in occurrences on the subject in recent years. It is worth noting that advertising materials or those with a bias towards social records of events, such as, for example, the launch of new projects, were discarded.

REPORTS	VERTICALIZ.	ED. ALTOS	BOTH	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Total	22	49	71													
About the topic	10	4	12*	1	1	1	1*	1*				1		2	3	1
Touch on the topic	3	6	9	2		2						1		2		2
Specific projects or companies	3	16	19	3	2			1			2	6	4	1		
Opinion column	2	1	3	1	1	1										
History of the city	1	0	1										1			
Discarded	3	21	24	* two of them are the same - one from 2015 e the other one from 2016												

2012	Lançamento de imóveis novos cresce 70%	New property launches grow by 70%
2013	Cresce verticalização em Sorocaba, mostra pesquisa do Secovi	Verticalization grows in Sorocaba, shows Secovi research
2014	Área agrícola encolhe 47,8% em quatro anos, em Sorocaba	Agricultural area shrinks 47.8% in four years in Sorocaba
2015	Zona sul de Sorocaba está verticalizada e valorizada	The southern part of Sorocaba is verticalized and valued
2016	Sorocaba cresce para cima e com edifícios cada vez mais altos	Sorocaba is growing upwards with increasingly taller buildings
2020	Mercado imobiliário cresce na cidade	Real estate market grows in the city
2022	Pesquisa mostra que o sorocabano tem mais interesse por apartamento	Survey shows that Sorocaba residents are more interested in apartments
2022	A contribuição da construção civil em tempos de pandemia	The contribution of civil construction in times of pandemic
2023	Sorocaba 'ganha' 110 novos condomínios em apenas quatro anos	Sorocaba 'gains' 110 new condominiums in just four years
2023	Veja o que muda no Alto da Boa Vista com o novo acesso a Aparecidinha	See what changes in Alto da Boa Vista with the new access to Aparecidinha
2023	Para o alto, sem esquecer o que importa	Upwards, without forgetting what matters
2024	Sorocaba chega aos 370 anos transformada	Sorocaba reaches 370 years transformed

Figure 5. Systematization of reports on urban verticalization in Sorocaba. Prepared by the authors based on Jornal Cruzeiro do Sul, 2024.

Even so, many reports deal with a specific project or construction company, with an almost advertising tendency, even though, for the most part, they appear in the Economy section, some examples of this are shown in Figure 06. Likewise, most of the news items that address local verticalization are linked to discuss such processes as a result of economic growth and expansion of the city.



Figure 6. Example of reports. Prepared by the authors based on Jornal Cruzeiro do Sul, 2024.

Except for one of the reports from 2024, the news discourse does not address the consequences of construction on the formation of new neighbourhoods or transformations of already consolidated areas, presenting a positive discourse from an economic perspective. The news from February 2024 (Figure 07) stands out, regarding the revision of the Municipal Master Plan, where it is mentioned that "accelerated urban expansion and vertical growth are a concern for the population and city councillors" – it is interesting to note that the photo in the headline is not of a recent vertical condominium, having been completed years before the last revision of the Master Plan, carried out in 2014. Figure 07 also indicates other examples of reports that touch on the subject – such as the interference of cranes and large construction equipment in the city spaces. The analyses of urban form presented here are aimed at clarifying the attributes of connectivity, displacements and the conditions and alternatives in the urban form occupied primarily by vertical housing; The recommendations that aim to create quality urban spaces seek to provide the parameters for analysis to understand public space. The aim is to clarify the levels of accessibility and mobility in the streets, the opportunities for choosing routes and the conditions for movement and social integration.



Figure 7. Example of reports. Prepared by the authors based on Jornal Cruzeiro do Sul, 2024.

In the diagnosis of the road network plan for Campolim Park (Figure 08), the observation of the road hierarchy and the constitution of the urban fabric of the area is unsatisfactory. Figure 08 shows the classifications of the streets, road networks and divisions of lots of the study perimeters, these shown on the same scale. The road hierarchy maps indicate that the predominantly residential area of Campolim Park lacks local streets and is made up of few connections, most of which are made up of collector streets. The contrast between the existence of short and unconnected streets, the scarcity of appropriate local streets and the consolidation of very long streets that play the role of collecting access to the interior of the area from the arterial road axis to the east is striking. The low occurrence of road intersections demonstrates the precariousness of land division and urban permeability in the

area. Furthermore, an analysis of the road network maps shows that, except for the blocks to the northeast (originating from the initial subdivision project for the neighbourhood), the Parque Campolim area consists of huge blocks, without adequate subdivision and road intersections. Reading the maps with the divisions of lots (Figure 08) suggests that the consolidation of the urban network is subject to the insertion movements of vertical developments, starting from the arterial road connection to the east, from the backs of industrial lots to the north and from the walls of condominiums to the south, up to the core of the contour – where urban voids with characteristics of farm lands can still be seen and, to the west, the border with the Permanent Preservation Area can be seen.

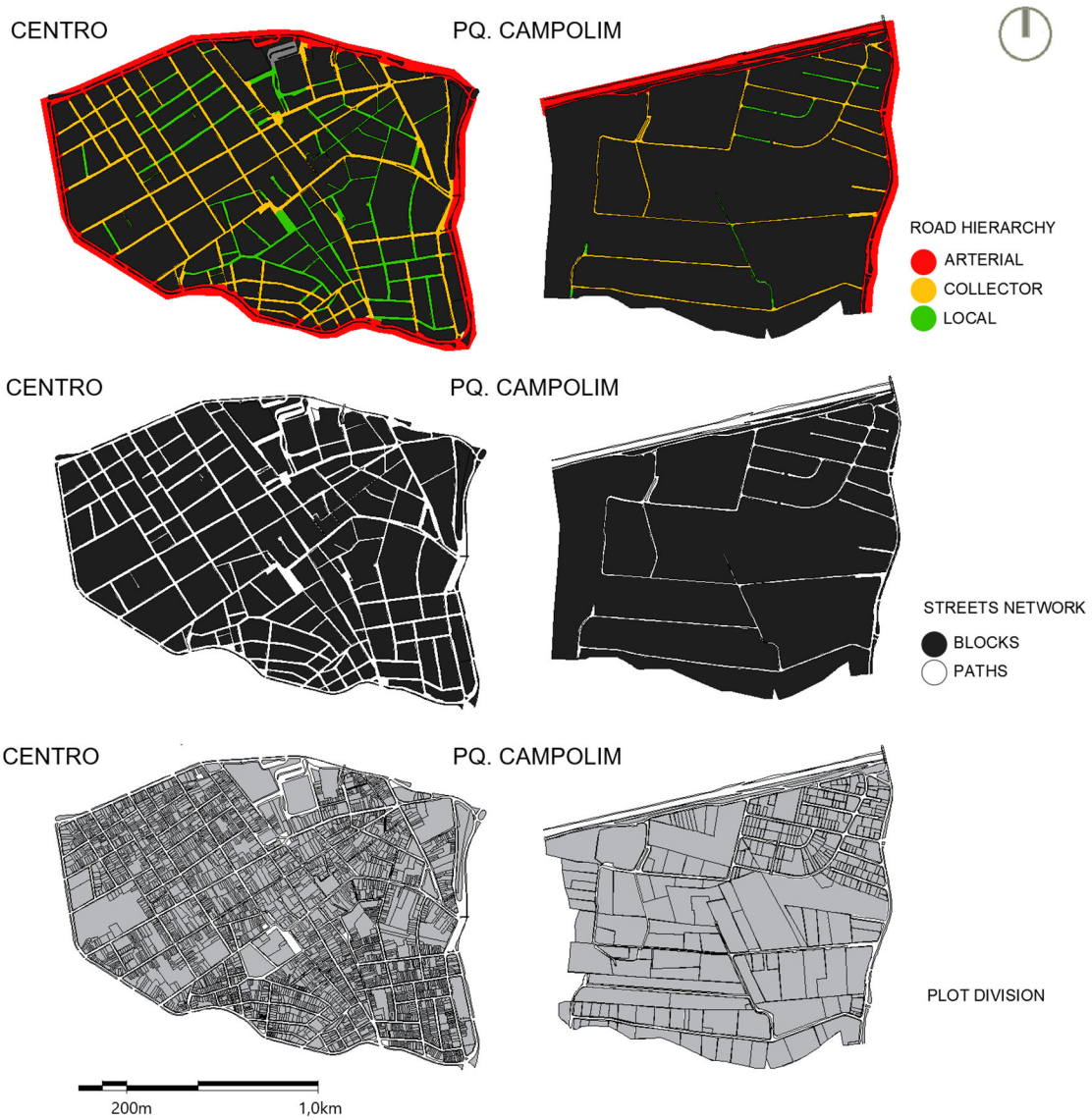


Figure 8. Analysis maps.

Long streets and blocks with high land use constitute oppressive spaces, while a more permeable network can encourage connections with parks and squares, different uses and a variety of housing typologies in the constitution of an adequate density (Jacobs, 2000). The lack of variety in block sizes or arrangements and few road intersections generate low levels of permeability and urban

connectivity, hindering motorized travel and, mainly, walkability. The northeast portion of Campolim Park (Figure 09), because it has smaller block lengths, demonstrates, through the interpretation of its paths, that the arrangements of the fabric indicate a certain oversizing of blocks, since, even so, it consists of blocks larger than those indicated in the literature.

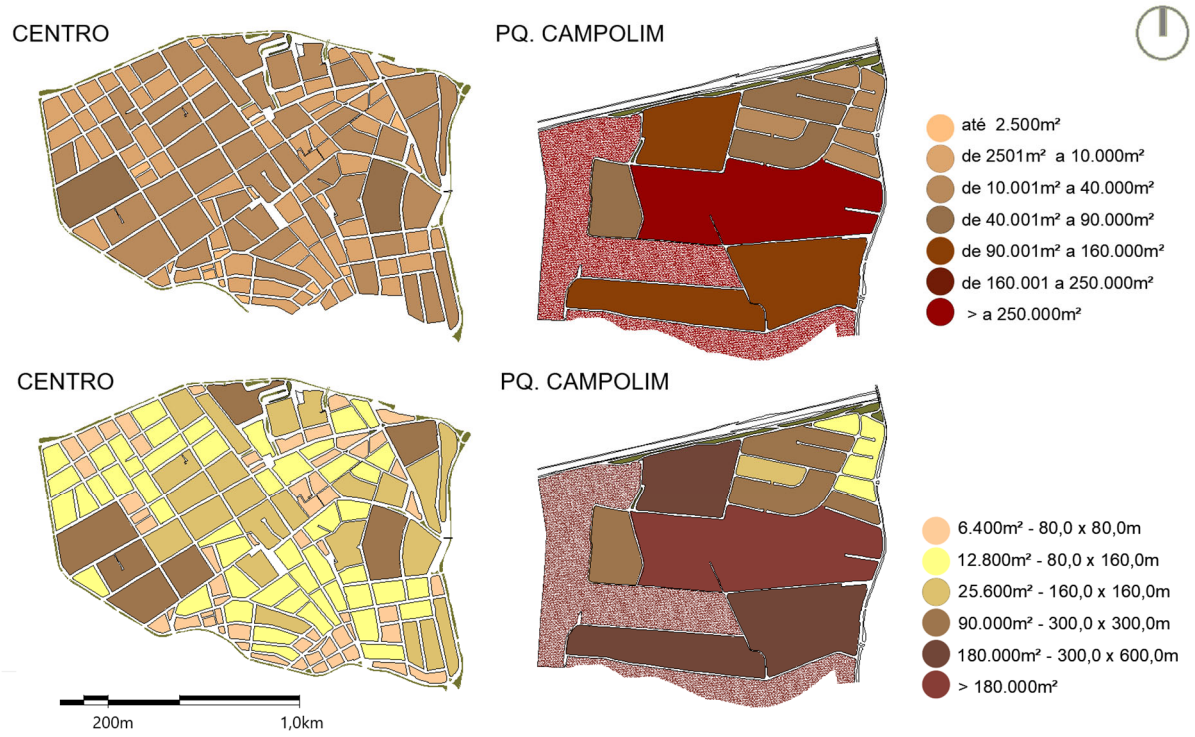


Figure 9. Analysis maps.

The dimensions of the blocks are related to the aspect of road permeability, since the smaller the blocks, the greater the alternative routes (Bentley et al, 1999). The arrangement of blocks can determine the quality of the urban form but does not necessarily define the architectural forms. Street patterns are more resilient in relation to infrastructure and must present measures that allow for transformations, as well as sufficient areas for commercial development, circulation and social space (Carmona et al, 2021)

CONCLUSIONS

It is possible to point, through this examination, that the process of consolidating vertical areas has generated public spaces without urban quality, despite being seen as positive in the absorption of an expanding housing demand by the local press. These spaces are the result from practices that prioritize the real estate market to the detriment of urbanity, in other words, the narrative presented to the population does not serve the collective sphere of the city.

Current patterns of urban verticalization are far from the sustainability needed for the future of cities in terms of mitigating and adapting, for example, to avoid the continued harmful effects of climate change. In the case studied, housing production is evidently disconnected from the urban and humanistic context – unfortunately, there is no assessment by the government or any pressure from the press, given the problematic prognosis for the region, which could imply the precariousness of the

already non-existent environmental quality, as well as requiring high investments from the municipality to, at the very least, solve problems that could have been avoided at practically no cost.

The morphological analysis points to situations that may be irreversible, since much of the occupation of this territory occurs in the absence of a block division project. Verticalized concentration can be a powerful instrument for meeting the population's demands for more compact growth, but this is not what has been done. Marketing strategies aimed at high exchange value define other values for architecture and urban landscape. It also highlights the effectiveness in shaping a narrative that, instead of providing citizens with access to information, resigns itself to being another advertising tool for the real estate market.

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Quantitative analysis of walking accessibility and convenience of metro stations based on isochronous fields

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ABSTRACT

Over the past two decades, China has maintained a high rate of urbanization, with high levels and rates of urban expansion and the formation of large urban suburbs. China's urban suburbs have an extremely large total amount of residential areas, accommodating a large number of people. The imbalance of jobs-housing has also led to extreme congestion on major arterial roads connecting the city center to the suburbs during peak commuting hours. Metros have become the preferred mode of transport for most people. However, in most Chinese cities, the city expanded first and the metro was built later, resulting in a high degree of disparity in the accessibility and convenience of metro stations, as well as a failure to maximize their public service performance. Thus, many studies have attempted to distinguish their morphological characteristics, accessibility, and convenience. However, most of these studies are directly based on the circular area with a certain radius from the center of the station, ignoring the specificity of the real accessible area due to the road network. In this study, based on the walking navigation function provided by mobile phone apps, the real walking isochronous fields of metro stations are obtained through big data acquisition and analysis. A series of isochronous fields are also mapped to deeply analyze and evaluate the accessibility and service convenience of metro stations. The study selected a set of metro stations in the suburbs of Nanjing, China as the cases for isochronous fields mapping. The quantitative analyses included not only the morphological features and service facilities within different isochronous fields, but also the characteristics of the isochronous field's own shape, such as area, compactness, and directionality. The results presented a more accurate and refined understanding of the accessibility and convenience of these stations, and provided a more targeted strategy for optimizing their public service performance.

Keywords: Isochronous field; Urban morphology; TOD; Walking accessibility; Convenience

INTRODUCTION

Over the past two decades, China has maintained a high rate of urbanization, with high levels and rates of urban expansion and the formation of large urban suburbs. China's urban suburbs have an extremely large total amount of residential areas, accommodating a large number of people. The imbalance of jobs-housing has also led to extreme congestion on major arterial roads connecting the city center to the suburbs during peak commuting hours (Ta et al., 2017). Metros have become the

preferred mode of transport for most people. However, the delayed construction of metro systems in many Chinese cities—following urban expansion—has resulted in disparities in station accessibility and convenience. This misalignment has prevented metro systems from fully optimizing their public service capacity.

Many studies have attempted to distinguish their morphological characteristics, accessibility and convenience (Liao and Scheuer, 2022; Wu and Zhou, 2023; Stojanovski, 2015). However, these studies have often relied on simplified circular zones around stations, failing to account for the specific road networks that influence real-world accessibility (Zhang et al., 2023; Sun et al., 2016). Zacharias and Zhao (2018) used tracking data of metro users to generate walking service areas of the metro stations. Although the results are more accurate, they are time-consuming and difficult to replicate. In contrast, the walking navigation data provided by mobile phone apps offers a more efficient and cost-effective method for delineating real walking isochronous fields (Shen and Tong, 2022).

In this study, a series of isochronous fields are calculated to deeply analyze and evaluate the accessibility and service convenience of metro stations. The study selected a set of metro stations in the suburbs of Nanjing, China as the cases for isochronous fields mapping. The quantitative analyses included not only the morphological features and service facilities within different isochronous fields, but also the characteristics of the isochronous field's own shape, such as area, compactness, and directionality. The results presented a more accurate and refined understanding of the accessibility and convenience of these stations, and also provided a more targeted strategy for optimizing their public service performance.

METHOD TO CALCULATE 15 MINUTES WALKING ISOCHRONOUS FIELD

Existing studies on isochronous field divisions have several limitations, often failing to account for the complexity of the urban road network. To address these issues, Shen and Tong (2022) developed a method based on walking navigation data from mobile phone APP, applying big data to capture real-time walking paths. For the selected start point, a point array is generated around each station (with a 40m interval and a range of 3000m), as in the left image of Figure 1. Then the navigation APP is used to calculate actual walking times from the start point to each destination point in the array. This process visualizes walking times as point attributes (middle image of Figure 1). Using the interpolation algorithm of the GIS platform, the point arrays are rasterized to generate isochronous fields for different time ranges (right image of Figure 1).

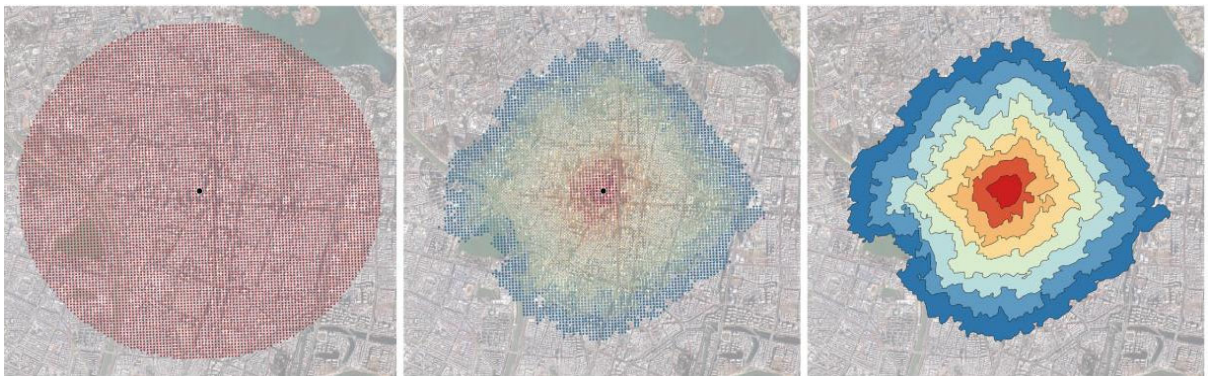

Figure 1. Process to calculate the isochronous field with navigation function of mobile phone APP (Shen and Tong, 2022).

Compared to traditional methods—such as using circular "buffer zones" to delineate living areas—this approach offers a more localized and precise analysis. The Baidu Maps data provides real-time updates of the road network, offering a more comprehensive view of the actual walking paths. This

method is more efficient and cost-effective than other models, such as GPS or cell phone signal-based approaches. Additionally, compared to ArcGIS road network models, which are static and often outdated, Baidu Maps' real-time road data allows for more accurate calculations.

Given that metro stations typically have multiple entrances and exits, and each entrance may be separated by considerable distances, the isochronous field for each entrance is calculated individually. The final isochronous field for each station is obtained by superimposing the results for all entrances, providing a comprehensive overview of the station's accessibility.

CASE STUDIES

Located in the east of China, Nanjing is the capital of Jiangsu Province and is a typical large city. It covers an area of 6,587 km2 and has a population of approximately 9.5 million. The city currently has 13 metro lines and 226 stations, with a total metro line length of about 473 km, in addition to 12 metro lines under construction or extension. The Nanjing metro serves an average of more than 3 million passengers daily, making it the primary mode of transportation for most residents. Based on the population density, this study divides the Nanjing urban area into five zones: the core area, the main urban area, the near-suburban area, the middle-suburban area, and the far-suburban area. As shown in Figure 2, the selected cases are located in the red dashed circle. Figure 3 shows the four station cases selected for this study and the lines they belong to.

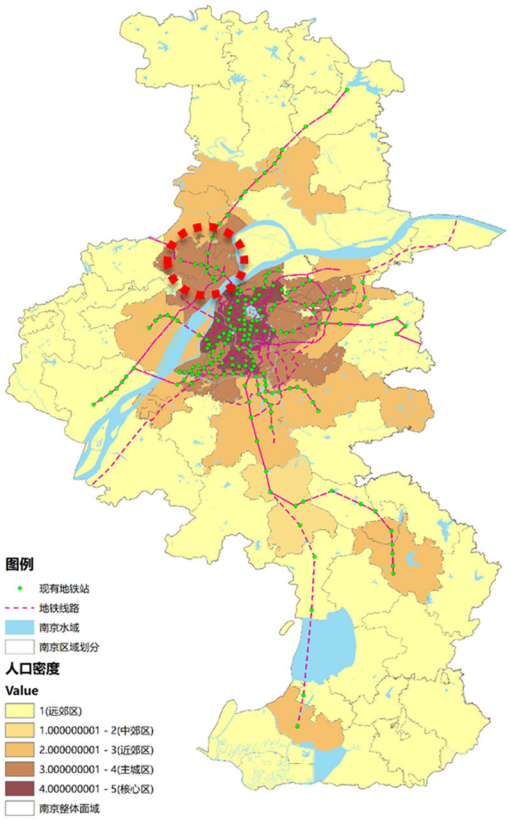

Figure 2. Metro lines and stations of Nanjing. The selected cases are located in the red dashed circle.

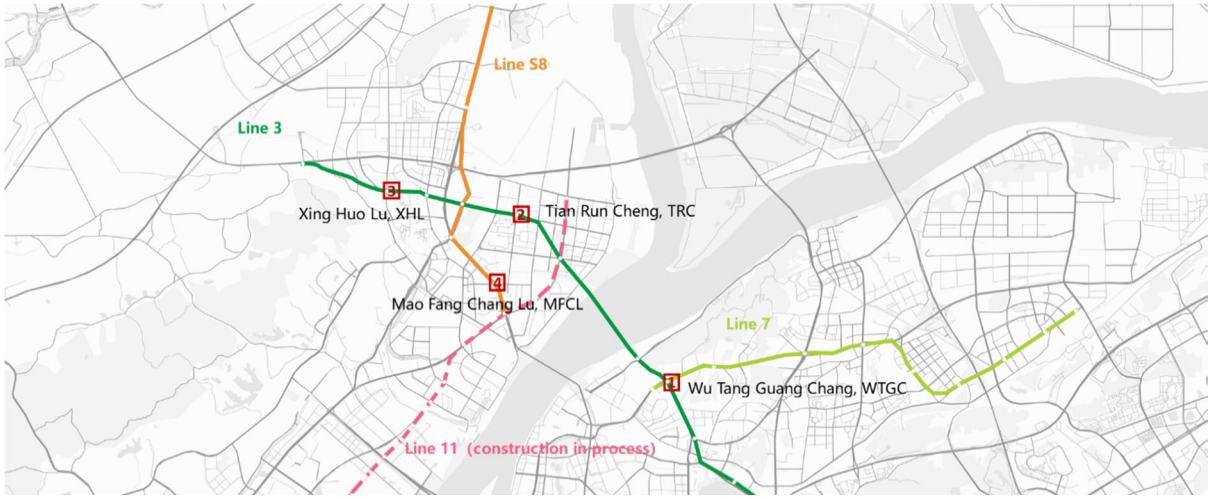

Figure 3. The locations of the selected 4 metro stations and the lines they belong to.

Figure 4 shows the satellite map of these four stations and the actual photographs of the station entrances. From the figure, it can be seen that each of these stations has its own typical characteristics. Wutangguangchang (WTGC) Station is an interchange station with five entrances and is surrounded by mostly old settlements. Tianruncheng (TRC) Station is surrounded by high-density large-scale emerging residential areas and has 3 entrances. Xinghuolu (XHL) Station is surrounded by low-density mixed functional areas and some natural hills, with 4 entrances. In addition to the high-density residential area around the Maofangchanglu (MFCL) station, there are also large commercial complexes, with a total of four entrances. The first three stations are located on Metro Line 3, and the last one is located on Metro Line S8. The urban form around the four stations basically represents the morphological characteristics of urban suburbs: a large number of high-density residential, large commercial complex nodes, some old neighborhoods, and integration of the natural environment. The analysis of these stations can better cognize the characteristics and limitations of urban metro stations and their surrounding urban construction.



Figure 4. Satellite maps and street photos of the 4 metro stations. (From left to right: WTGC station, TRC station, XHL station, MFCL station.)

MORPHOLOGICAL ANALYSIS OF 15 MINUTES ISOCHRONOUS FIELD

Applying the isochronous field calculation method, we generate a point array with a spacing of 40m around each of the four stations, and calculate the walking time for different entrances of each station

to reach these point arrays, and then get the 15-minute walking isochronous field ranges of the four study stations by taking the minimum value of each. The resulting 15-minute walking isochronous fields are shown in Figure 5, revealing significant variations in size and shape between the stations. Most stations have an isochronous field area of around 200 ha, but XHL Station has a smaller field, covering only 164 ha.



Figure 5. The isochronous fields of the 4 metro stations. (From left to right: WTGC station, TRC station, XHL station, MFCL station.)

Correspondingly, the total area of buildings covered by the 15-minute isochronous fields also caries significantly (Figure 6). The XHL station has a lower density of buildings in the surrounding area, and its 15-minute isochronous field area is also small, covering a total building area of only 1.29km2, and the Floor Area Ratio (FAR) calculated by the isochronous field area is only 0.79, of which the residential FAR is only 0.25. The other three stations have similar 15-minute isochronous field areas, but the WTGC Station covers a total building area of 1.97km2, with a FAR of 0.98, of which the FAR of residential is 0.78. The TRC Station covers a total building area of 2.65km2, with a FAR of 1.27, of which the FAR of residential reaches 1.2. And under the influence of the neighboring large-scale commercial complex, the MFCL Station covers a total building area of up to 5.46km2, with a FAR as high as 2.77, of which the FAR of residential is 1.38. Differences in building FAR and function across the isochronous fields reflect the diverse range of people served by each metro station (Table 1).

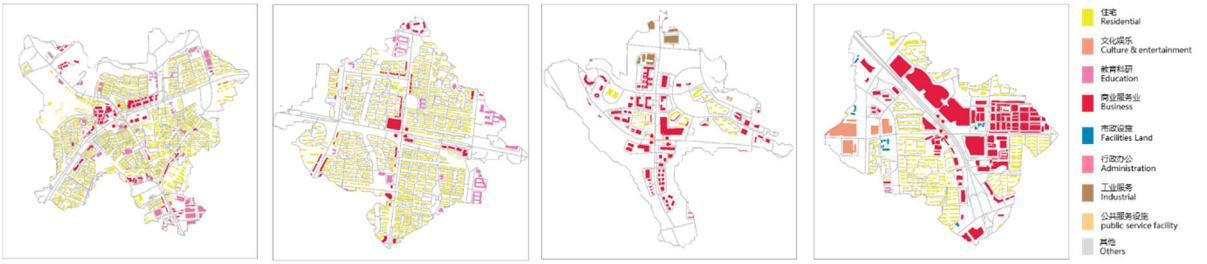

Figure 6. The buildings inside the isochronous fields of the 4 metro stations. (From left to right: WTGC station, TRC station, XHL station, MFCL station.)

Table 1. The areas of buildings inside the isochronous fields of the 4 metro stations.

Metro stations	Area of 15min isochronous field (ha)	Area of buildings (km^2)	FAR	FAR of residential
WTGC station	200.53	1.97	0.98	0.78
TRC station	208.07	2.65	1.27	1.20
XHL station	164.02	1.29	0.79	0.25
MFCL station	197.36	5.46	2.77	1.38

Similarly, once the isochronous fields were defined, we analyzed the roads, bus stops, points of interest (POIs), and some other elements within each field (Figure 7). These elements illustrate the real-world influence of the metro stations within a 15-minute walking distance. The roads reflect the

accessibility of the area around the metro station. The bus stops and lines reflect the convenience of metro and bus transfer. The number of POI classification reflects the convenience of life around the metro station. As shown in Table 2, the statistics for the WTGC station and TRC station are largely similar, reflecting the residential neighbourhood. However, the number of POIs at the WTGC station is more than that at the TRC station, indicating that the former, as an old neighbourhood with some history, has a greater abundance of amenities than a new neighbourhood such as the latter. The XHL Station has the lowest statistical values for all indicators except for the POIs, which is related to its special topography. However, the office facilities represented by the large number of red dots in its POI indicator also reflect the work attributes of the area. The MFCL station has low values for total road length and density, but has the most bus lines, suggesting that the area has more major roads but few minor streets. In addition, the MFCL station has the highest number of POIs around it, implying the most convenient amenities.



Figure 7. From top to bottom are roads, bus stops, and POIs inside the isochronous fields of the 4 metro stations. (From left to right: WTGC station, TRC station, XHL station, MFCL station.)

Table 2. The statistical data of roads, bus stops, and POIs inside the isochronous fields of the 4 metro stations.

Metro stations	Total length of roads (km)	Density of roads (km/ha)	Number of bus stops	Number of bus lines	Number of POIs
WTGC station	62.03	0.31	15	13	1496
TRC station	69.34	0.33	17	15	1242
XHL station	23.66	0.14	11	13	1322
MFCL station	39.37	0.20	14	37	3573

ANALYSIS BASED ON MULTIPLE ISOCHRONOUS FIELDS

By employing this new isochronous field calculation method, we can easily determine the walking range for various durations, allowing for a more nuanced analysis of metro station accessibility and convenience. In this study, we subdivided the isochronous fields into 5-minute, 10-minute, and 15-minute intervals for each station, and deepened the analysis of these fields.

Figure 8 presents the isochronous fields for different time intervals at the four stations, while Table 3 shows the change in area for each station across time. These subdivided isochronous fields highlight how the walking range coverage differs from station to station as walking time increases. For instance, although XHL Station has the smallest 15-minute field, it covers the largest area in the 5-minute range. In contrast, TRC Station has the smallest 5-minute isochronous field, covering only half the area of XHL Station. These differences have practical implications. It can imply that there is a significant difference in the accessibility of different stations for different age groups. In the case of the TRC station, for example, it may be more suitable for younger people, while the accessibility of the station is poorer for older people who are not conducive to longer walks. For the WTGC station, it shows a more consistent increase in area coverage across time intervals, suggesting better accessibility for all age groups.

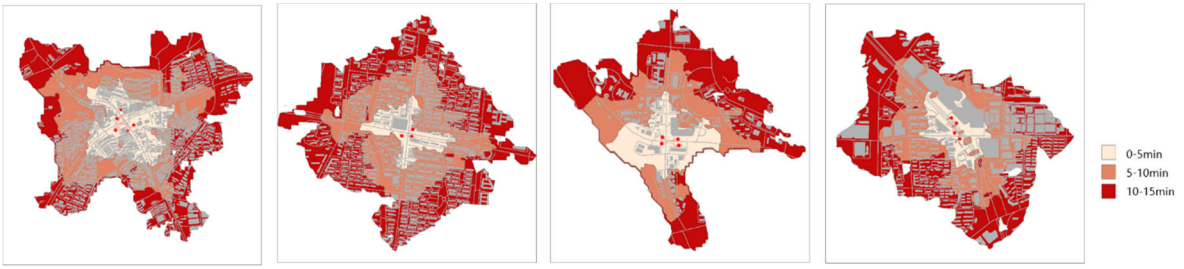

Figure 8. The isochronous fields of different time intervals at the 4 metro stations. (From left to right: WTGC station, TRC station, XHL station, MFCL station.)

Table 3. The areas of the isochronous fields of different time intervals at the 4 metro stations. (IF: Isochronous Field)

Metro stations	Area of 0-5min IF (ha)	Area of 5-10min IF (ha)	Area of 10-15min IF (ha)	Area of 15min IF (ha)
WTGC station	32.51	72.97	95.05	200.53
TRC station	17.81	68.99	121.27	208.07
XHL station	32.96	51.75	79.31	164.02
MFCL station	24.09	63.66	109.61	197.36

Figure 9 shows the buildings located within the isochronous fields of different durations, i.e., we can directly identify the walking time for each building to reach the metro station. This analysis offers a detailed perspective on the station's coverage and its convenience for residents. As shown in Table 4, the MFCL stations have the most buildings area in every isochronous field. With the exception of the MFCL station, the data for the other 3 stations were relatively even. Among them, the WTGC station has the most buildings area in 5-minute and 5-10-minute isochronous fields. The TRC station has the least buildings area in 5-minute isochronous field, but has the most buildings area in 10-15-minute isochronous field.

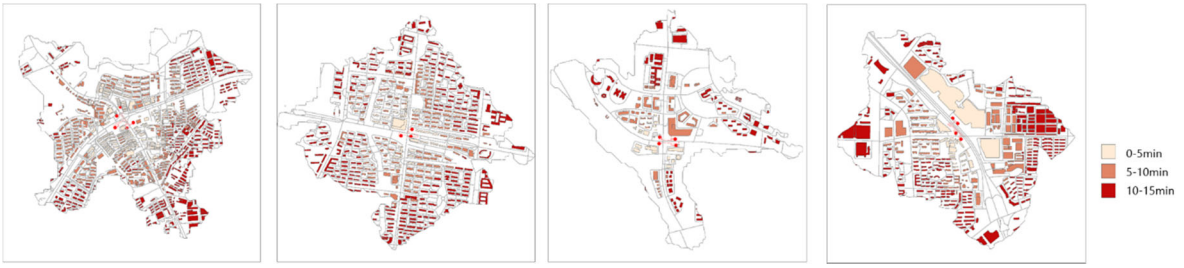

Figure 9. Walking duration of the buildings of the 4 metro stations. (From left to right: WTGC station, TRC station, XHL station, MFCL station.)

Table 4. The buildings area in the isochronous fields of different time intervals at the 4 metro stations. (IF: Isochronous Field)

Metro stations	Buildings Area in 0-5min IF (10000 m^2)	Buildings Area in 5-10min IF (10000 m^2)	Buildings Area in 10-15min IF (10000 m^2)
WTGC station	43.29	75.19	78.87
TRC station	21.42	66.44	97.60
XHL station	39.89	46.15	49.09
MFCL station	118.57	156.48	274.21

We also examined the relationship between metro stations and bus stops, as the distance between these can significantly affect metro-bus transfers (Figure 10). And Table 5 shows that the WTGC, TRC, and XHL Stations have several bus stops within the 5-minute isochronous field, enhancing the convenience of transfers. However, most of the bus stops near the MFCL Station are located within the 10-15 minute range, making transfers less convenient at this station.



Figure 10. Walking duration of the bus stops of the 4 metro stations. (From left to right: WTGC station, TRC station, XHL station, MFCL station.)

Table 5. The number of bus stops in the isochronous fields of different time intervals at the 4 metro stations. (IF: Isochronous Field)

Metro stations	Number of bus stops in 0-5min IF	Number of bus stops in 5-10min IF	Number of bus stops in 10-15min IF
WTGC station	3	2	10
TRC station	4	6	7
XHL station	3	2	6
MFCL station	1	3	10

Finally, Figure 11 illustrates the distribution of POIs within different isochronous fields. As shows in Table 6, the WTGC and TRC Stations have a relatively even distribution of POIs, while POIs at the XHL Station are concentrated within the 10-minute walking range, with a sharp drop beyond that. In

contrast, the MFCL Station has more POIs in the 10-15 minute range, indicating better accessibility to amenities further from the station.



Figure 11. Walking duration of the POIs of the 4 metro stations. (From left to right: WTGC station, TRC station, XHL station, MFCL station.)

Table 6. The number of POIs in the isochronous fields of different time intervals at the 4 metro stations. (IF: Isochronous Field)

Metro stations	Number of POIs in 0-5min IF	Number of POIs in 5-10min IF	Number of POIs in 10-15min IF
WTGC station	406	535	555
TRC station	344	492	406
XHL station	503	629	190
MFCL station	583	1240	1750

Through this detailed analysis of multiple isochronous fields, we can gain a deeper understanding of the accessibility and convenience of metro stations, as well as the significance of the surrounding road network.

ANALYSIS OF ISOCHRONOUS FIELD SHAPE

While most of the previous analysis focuses on area coverage, the shape of the isochronous field itself also provides important insights. In addition, the unconventional shape of the isochronous field reflects its unique characteristics from another dimension after we abandon the traditional circular calculation range (Figure 12). This feature is closely related to the morphology of the road network around the metro station, and thus can express the structural characteristics of the road network. This study further analyzes the shapes of isochronous fields with different time lengths in an attempt to explore the features embedded in them.

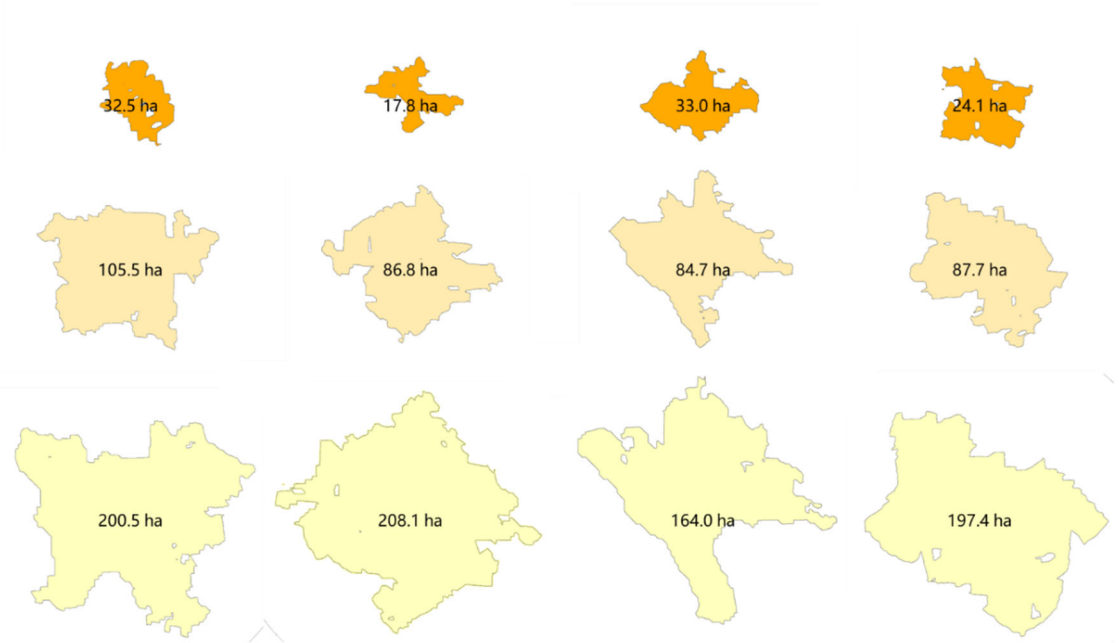

Figure 12. The shape and area of the multiple isochronous fields of the 4 metro stations. (From left to right: WTGC station, TRC station, XHL station, MFCL station.)

Compactness is a commonly used indicator to characterize shapes, and is generally used to express the relationship between the shape and the circle. Among the many public notices for compactness calculation, the formula proposed by Prof. Stephen Marshall can describe the shape from the Elongation, Convolution, and Dispersal, which can better reflect the shape characteristics (Marshall et al., 2019). Therefore, this study adopts this calculation formula to calculate the compactness of the shape of the isochronous field. The calculation formula is:

$$C=4A/DP$$

where C is the compactness, A is the area of the shape, D is the diameter of its outer circle, and P is its perimeter. Based on this formula, the maximum value of C is 1, which corresponds to a perfect circle. A smaller value of C indicates more fragmented, irregular shapes.

Applying this formula, we calculated the compactness of the isochronous fields at the four stations for 5, 10, and 15-minute walking intervals (Table 7). The results reveal that TRC Station has the smallest compactness value for the 5-minute isochronous field, while the MFCL Station has the highest compactness for the 15-minute isochronous field. The highest compactness value observed is less than 0.5, indicating that none of the fields closely resembles a circular shape. It reflects that the overall road network structure has a strong directionality, resulting in the isochronous fields appearing a distinctly finger-like, especially the 5-minute isochronous field at the TRC Station and the 15-minute isochronous field at the XHL Station, which are also the two smallest compactness among all the isochronous fields. Even the most compact ones have shapes that are just close to rectangular.

The table 7 also shows that there is a correlation between the compactness and the area of the isochronous fields. The smaller fields tend to have lower compactness, as seen with the 5-minute field at the TRC Station, the 10-minute and 15-minute fields at the XHL Station. However, the reverse is not always true, as fields with larger compactness do not necessarily have larger areas, such as the 15-

minute field at the MFCL Station, which, despite its high compactness, ranks third in terms of area size.

Table 7. The areas and compactness of the multiple isochronous fields of the 4 metro stations. (IF: Isochronous Field)

Metro stations	5min IF		10min IF		15min IF	
	Area (ha)	Compactness	Area (ha)	Compactness	Area (ha)	Compactness
WTGC station	32.5	0.350	105.5	0.387	200.5	0.336
TRC station	17.8	0.269	86.8	0.338	208.1	0.355
XHL station	33.0	0.353	84.7	0.323	164.0	0.289
MFCL station	24.1	0.336	87.7	0.366	197.4	0.410

Figure 13 plots the compactness trends for the four stations over different walking intervals. The line diagrams show that the four stations do not have the same trend of isochronous field compactness as the walking time increases. The trends of the TRC station and the MFCL station exhibit increasing compactness as walking time increases, indicating that their road networks are more suited for longer walks. On the other hand, the compactness of the XHL Station decreases with walking time increases. Upon our own inspection we found that the perimeter of the station is surrounded by natural hills in the southeast corner and southwest side. Due to its obstruction, the road network has large gaps in both areas, thus creating a significant reduction in compactness. In addition, the WTGC Station shows a more irregular trend, with compactness initially increasing at 10 minutes, then decreasing again at 15 minutes. A close examination of its road network reveals that, due to the large area of old settlements around the station, its road network structure is characterized by an obvious patchwork of different groups. The lack of sufficient connections between different groups results in a compactness that is greater at the 10-minute isochronous field than at the 15-minute field.

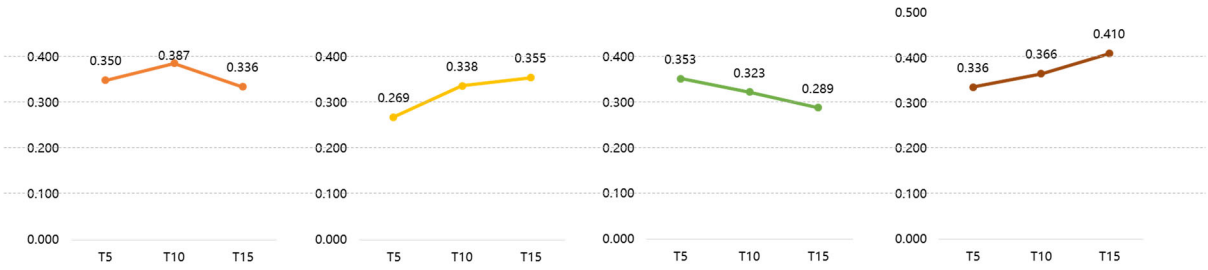

Figure 13. The compactness of the multiple isochronous fields of the 4 metro stations.

This compactness analysis provides insights beyond simple area coverage, highlighting the road network's influence on station accessibility and offering a deeper understanding of the structural characteristics that shape isochronous fields.

CONCLUSIONS AND DISCUSSION

The paper should be completed with your conclusions. Future research directions may also be mentioned. Please note that every reference cited in the text should also be present in the reference

list and vice versa. Citations should follow the Harvard referencing style, which is also used in the Journal of Urban Morphology. References in the reference list section should be arranged first alphabetically and then further sorted chronologically, using the appropriate pre-defined paragraph style.

Acknowledgements

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Rapid urbanization urban form - a theoretical study of chinese megablock urbanism

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ABSTRACT

As the most extensive urbanization in human history, rapid development in China has led to the proliferation of the megablock urban form—a distinctive approach to managing the spatial dynamics of burgeoning populations and their demands. Existing theories on Chinese urbanization have failed to provide a clear understanding of megablock development, given its exceptional context and spatial characteristics. Understanding and assessing this unique urban phenomenon requires a morphological matrix with a comprehensive framework critically derived from urbanism theories, with Chinese urbanism characteristics. This study investigates the theoretical underpinnings from an international perspective, for instance, the garden city, new town movement, new urbanism, suburbia, urban sprawl, compact city, and communist planning, by studying their context, factors, cases, and urban forms. It further connects and restructures the theoretical framework with the Chinese context and conditions of megablock urbanism, seeking to understand its role in shaping the urban landscape. The aim is to critically assess the spatial characteristics of this urban form with representative factors and variables. Utilizing a qualitative research methodology, the study synthesizes findings from theoretical and historical interpretations, policy reviews, case studies, and factor analyses. The findings reveal that Chinese megablocks differ from existing urbanisms, from their theoretical content to analytical tools. The study concludes that while the megablock urbanism model offers a rapid response to urban expansion, it necessitates careful consideration of its development mechanism. The implications of this research are significant for understanding the Chinese urban form and for future practice that should be consciously aligned with the need for sustainable and inclusive urban environments.

Keywords: Urbanism Theories, Megablock Research Framework, Morphological Metrix

INTRODUCTION

Chinese modern rapid urbanization is unprecedented and exceptional in urban development history. It is characterized by the largest population, the fastest pace, and a publicly owned land system. This unique combination sets China apart from other urbanization processes observed globally.

The sheer scale of urbanization in China is staggering. Over the past few decades, hundreds of millions of people have migrated from rural areas to urban centers, transforming the demographic landscape. This massive influx has resulted in the rapid construction of cities, infrastructure, and housing, often at a pace that far exceeds historical precedents in other countries.

Moreover, the speed of urban development in China is unparalleled. While many countries have experienced gradual urbanization over centuries, China's transformation has occurred in just a few decades. This accelerated growth poses significant challenges and opportunities, influencing economic, social, and environmental dimensions of urban life.

The publicly owned land system in China further complicates the urbanization narrative. Unlike many Western countries where land is privately owned and market-driven, China's land is primarily owned by the state. This system allows for swift decision-making and implementation of large-scale projects but can also lead to issues such as displacement and social inequality.

Given these distinctive features, applying existing Western urban theory to explain Chinese urbanization would be inadequate and potentially misleading. Western theories often rely on assumptions rooted in individual property rights, market dynamics, and incremental growth patterns, which do not fully capture the complexities of China's urban transformation. A more nuanced approach is required, one that recognizes the unique social, political, and economic contexts shaping Chinese cities.

This study explores three pivotal concepts—speed, scale, and form—in relation to contemporary Chinese urbanization. Speed refers to the rapid expansion of urban areas in China, characterized by a swift migration of populations and the quick construction of infrastructure. Scale addresses the massive scope of urban development, with entire cities designed to accommodate millions of residents within a remarkably short timeframe. Form pertains to the physical layout and architectural design of these large-scale urban areas, particularly at the community level.

The research originated from a keen observation of these unique aspects of Chinese urbanization, prompting questions about how speed, scale, and form intersect to shape the morphologies of Chinese mega-block developments. The introductory chapter establishes the research background, underscoring the rapid rate of urbanization in China and the emergence of mega-block developments as a response to this growth.

This introduction contextualizes the genesis of the research questions and theoretical framework, situating them within China's unprecedented urban transformation. By reviewing key concepts and laying the analytical groundwork, the introduction prepares the study for a critical investigation of its research queries and clearly articulates the research objectives and expected outcomes.

Gaubatz (1995) characterized post-reform urbanization in China as a transition from traditional work-unit structures to expansive commodity housing compounds, largely developed by a mix of private and state-owned real estate companies. Despite this shift, the designs of these developments often maintain an enclosed, amenity-rich environment. Guillaume elaborates that many of Beijing’s current gated communities originated as work-unit compounds (danwei dayuan, 单位大院) during the socialist era, which have since been commercialized and commodified following housing reforms.

Some of these extensive compounds feature dozens of towers, capable of housing over 100,000 residents, essentially functioning as self-contained miniature cities.

Huang (2006) details how Chinese commodity housing estates often act as self-sufficient mega-communities. This design approach reflects the communist ideal of self-sufficiency, minimizing the necessity for residents to venture outside their community. From a governance perspective, this model fosters social cohesion and cultivates a sense of collective identity. Features such as unified façades, strategic branding, professional property management, and active homeowner associations work together to dictate the community's operations and aesthetics. At its core, the People's Republic of China (PRC) implements a publicly owned land system, evolving from the traditional communist danwei (单位) model into modern capitalist mega-compounds. Nevertheless, the foundational principles of creating large-scale, collective communities continue to permeate the narrative of China's rapid urbanization.

However, the real estate-driven commodity housing model diverges significantly from both Western urbanism and the Chinese communist work-unit system. Its distinctive characteristics of speed, scale, and form have generated a unique urban model that this study seeks to investigate. By examining relevant urban theories—including their definitions, descriptions, influencing factors, and case studies—the research aims to construct a theoretical framework specifically tailored to the rapid urban forms emerging in China. This framework will facilitate a deeper understanding of the complexities and implications of Chinese urbanization in a global context.

CRITICAL LITERATURE REVIEW FOR THEORETICAL FRAMEWORK

Urbanism encompasses the study of how urban inhabitants interact with their built environment, capturing the essence of urban life, organization, and challenges (CTI Reviews, 2016; Jacobs, 1961). It is characterized by density, diversity, and intricate social structures (Gottdiener et al., 2016; Florida, 2002). One of the most influential definitions comes from Louis Wirth (1938), who outlined four key features of urban experience: population heterogeneity, functional specialization, anonymity, and standardized behavior. His ideas were expanded by scholars like Herbert Gans (1962) and Manuel Castells (1977), who examined the nuances of urban experiences and the significance of space.

Since World War II, urban challenges in the U.S. have been analyzed by scholars such as Thomas Sugrue (1996) and Robert Putnam (2000), while post-war European urban development has often focused on restoring historical identity (Hall, 1998). The boundaries between urbanism and suburbanism have blurred, with subcultures permeating various regions and a high-consumption lifestyle becoming prevalent (Gottdiener et al., 2016; Baudrillard, 1981).

The emergence of urbanism in the early 20th century was tied to centralized manufacturing, mixed-use neighborhoods (Leyden, 2003; Jacobs, 1961), and social networks (Dupuy et al., 2008; Castells, 1989). Savage and Blokland (2008) describe this convergence of political, social, and economic citizenship as a reflection of collective urban life (Park et al., 1925). Dupuy et al. (2008) applied network theory to urbanism, identifying its networked nature as a dominant characteristic that challenges traditional spatial concepts.

Stephen Graham and Simon Marvin (2001) argue we are entering a post-urban environment, where decentralized neighborhoods replace traditional urban spaces, leading to "splintering urbanism." This fragmentation results in enclaves of global connectivity alongside network ghettos (Graham & Marvin, 2001). Dominique Lorrain suggests that this splintering began in the late 20th century with the rise of gigacities, characterized by network density and blurred boundaries (Brenner & Schmid, 2015).

Manuel Castells (2002) posits that premium infrastructure networks selectively connect favored users while bypassing others. Graham and Marvin (2008) argue that attention to infrastructure is often reactive rather than systematic, highlighting a disconnect between urban life and infrastructure networks (Fainstein, 2000).

Additionally, Douglas Kelbaugh (2001) identifies three paradigms within urbanism: New Urbanism, Everyday Urbanism, and Post-Urbanism. Paul L. Knox (2010) discusses the “aestheticization of everyday life” (Zukin, 1995), while Krieger & Saunders (2009) contend that urban design is more a mindset than a technical discipline (Cuthbert, 2006).

For this research on Chinese megablocks, we can consider scale, speed, and form as technologies of urbanization. Urban morphology theory posits that space itself is a form of technology, intricately linked to how spatial elements connect (Hillier, 2007; Rapoport, 1977). Thus, understanding urbanity necessitates examining space and scale (Lefebvre, 1991). Figure 1 illustrates the relevant urbanism theories contributing to the phenomenon of Chinese megablocks.



Figure 1. Framework of relevant urbanism theory that contributes to the phenomenon of Chinese megablock

New Town

The Garden City concept significantly influenced modern urban planning, representing a shift from historical city centers to planned satellite towns. While not directly part of the New Town Movement, early designs like Versailles set a precedent for comprehensive urban planning, and cities like Amsterdam integrated garden city principles into their suburbs (Mumford, 1961). The New Town Movement emerged as a response to urban overcrowding, exemplified by Letchworth, the first Garden City, and developments like Crawley and Toa Payoh aimed at alleviating housing crises (Howard, 1902; Cullingworth, 1997).

Pioneered by Ebenezer Howard in the late 19th century, the Garden City Movement sought alternatives to the chaotic industrial cities of Britain, emphasizing ecological balance and functional land use (Ward, 2002). Patrick Geddes critiqued urban living conditions, while the rise of modernist

thought—spurred by planners from the Soviet Union, the Bauhaus Group, and figures like Le Corbusier—focused on functional land allocation and high-density designs (Choay, 1965). Le Corbusier's "Towers in the Park" concept proposed high-rise structures surrounded by greenery, promoting urban density management and sustainability (Kostof, 1991). Planners influenced by the Athens Charter played crucial roles in orchestrating urban expansion, acquiring peripheral lands in advance to mitigate congestion (Merlin, 1980). The postwar era saw the garden city and neighbourhood unit principles guiding societal cohesion (Wakeman, 2016). The New Town Movement's principles spread to British colonial territories, laying the groundwork for contemporary urban planning (Home, 2013; Hall & Ward, 1998).

Garden City and New Town Movement illustrates a paradigm shift toward ecological balance and managed density in urban planning. Key concepts of scale, functional land use, and community design have evolved from Howard's vision, influencing modernist interventions and fostering a collective vision for sustainable urban growth.

New Urbanism

The New Urbanism movement emerged in the 1990s as a response to regional sprawl, advocating for human-scaled urban environments (Gottdiener et al., 2016). Unlike the holistic concepts of modernist designs like La Ville Radieuse, New Urbanism promotes limitless and open-ended territorial expansion. A defining feature of this movement, especially in American cities, is the prominence of highways, which shape urban planning and contribute to sprawling development.

Key figures, such as Elizabeth Plater-Zyberk and Andres Duany, exemplified New Urbanism through their design of Seaside, Florida, emphasizing grid layouts and identifiable town centers (Grant, 2001). This approach is further illustrated in transit-oriented developments like Chatswood in Sydney and Del Mar Station in Los Angeles, which integrate residential, commercial, and recreational spaces to promote walkability.

The movement draws on Clarence Perry's concept of the Neighborhood Unit, which emphasizes schools as central nodes surrounded by accessible services to foster community and reduce car dependency. Doug Farr's Sustainable Neighborhood Unit updates these principles by incorporating green infrastructure and addressing climate change (Farr, 2010). Peter Calthorpe and William Fulton advocated for a holistic approach to urban planning, where all components interact effectively, as seen in projects like Laguna West in California (Tabb et al., 2013). Andrés Duany's Urban to Rural Transect concept further informs New Urbanism by recognizing the spectrum of environments from dense urban centers to natural landscapes, promoting context-sensitive planning.

New Urbanism counters car-centric planning by emphasizing walkability, connectivity, and diverse land use. Its principles, as articulated by the Congress for the New Urbanism, advocate for sustainable transport, increased density, and a traditional neighborhood structure that fosters community. Collectively, these elements aim to create cohesive, inclusive communities that balance urban growth with environmental sustainability.

Urban Sprawl

Suburbs serve as transitional spaces between urban and rural areas, often contrasting with the compact city movement that advocates for higher urban density. Gottdiener et al. (2015) define suburbs as residential areas outside large central cities, characterized by lower population densities

than urban centers but higher than rural areas. The rise of suburbs was facilitated by the expansion of railway services to cities like London and the development of streetcar lines in North America, which enabled middle-class migration to picturesque residential zones (Ward, 1968; Gilfoyle, 1998).

Rapid suburban growth, exemplified by areas like Milton, Ontario (Bunting & Filion, 2010), and Arden Park, Sacramento (Jividen, 2005), was driven by economic prosperity and infrastructure investments. Suburban areas often cater to diverse needs with retail, recreational, and residential spaces, while zoning laws have shaped their landscapes, typically designating areas for residential use on larger plots (Hirt, 2015). The suburbanization process has also been marked by racial dynamics, with historically white-dominated regions increasingly welcoming minority groups seeking better opportunities (Fichman & Fowler, 2003; Yen, 2010). Cities like Portland, Oregon, have implemented urban growth boundaries to manage suburban expansion (Nelson & Dawkins, 2004), while post-war developments like Panorama City, California, exemplify self-contained suburban communities (Fogelson, 2005). Despite criticisms of suburbanization, including higher maintenance costs and the homogenizing effects of megablocks, suburbs have increasingly become centers of innovation and economic activity, as seen in Silicon Valley (Gottdiener et al., 2015).

Suburbanization trends have also spread globally, with countries like China experiencing rapid suburban development characterized by Western-style residential blocks (Lang, 2012). Scholars like McManus & Ethington (2007) and Mary Corbin Sies (2001) emphasize the need to redefine suburbs by considering geographical and economic contexts, moving beyond traditional stereotypes. In summary, suburbanization has transformed human settlement patterns, creating distinct landscapes that bridge urban and rural areas. Driven by mobility, economic forces, and evolving planning policies, suburbs strive for self-sufficiency while navigating challenges related to identity, autonomy, and integration with urban centers.

Compact City

The compact city model has become essential in sustainable urban planning, tracing its origins to Dantzig and Saaty's work in 1973, which emphasized high-density designs to enhance residents' quality of life while minimizing environmental impacts. Their framework included architectural, geographical, and socio-economic elements.

Following this, the European Commission's 1990 Green Paper on the Urban Environment advocated for denser urban forms and mixed land use, aligning with Burton's (2002) definition of a compact city as one that promotes efficient public transport and encourages walking and cycling. Subsequent scholars, including Jabareen (2006) and Dempsey et al. (2010), expanded the concept by stressing social diversity and the need to avoid urban sprawl through strategies like infill and redevelopment. Practical examples like Melbourne and Ballston in Virginia illustrate successful compact city implementations, focusing on walkable neighborhoods that integrate residential and commercial spaces. In contrast, critics like Breheny (1992) question the model's effectiveness, suggesting that higher densities may not yield the desired outcomes, as supported by studies from Stead and Marshall (2001). The compact city also intersects with the concept of megablocks, which may homogenize urban landscapes and reduce spatial diversity. The lack of a universally accepted definition complicates discussions around compact cities, leading to potential misapplications. Neuman (2005)

identifies key characteristics of compact cities, including high residential densities, mixed land uses, and multimodal transportation systems.

Ultimately, while the compact city model aims for efficient, livable environments, the integration of megablocks necessitates localized and nuanced strategies to ensure social equity and adaptability, reflecting the complexities of individual urban contexts. This evolution underscores the balance between fostering sustainable urban growth and maintaining community diversity and resilience.

Communist Planning

The urbanization of Soviet Bloc countries, particularly Russia, unfolded during the Cold War, characterized by a blend of ideological rigor and practical needs. In Moscow, state-controlled land facilitated large-scale housing and industrial projects, leading to uniform high-rise developments inspired by Modernist architects (Colton, 1995; Wybieralski & Mikulec, 2009). This approach resulted in mass housing on city outskirts, neglecting historical centers (Churakov, 2021). Notable examples include Yaroslavl's compact city complex, which centralized public services in a dense urban core (Ruble, 1995).

China adopted Soviet planning principles from the 1950s, prioritizing rapid industrialization and urban development, often at the expense of historical preservation (Xie & Costa, 1993; Tang, 2000). The establishment of self-contained "danwei" units reflected a collectivist vision under Mao, while post-1978 reforms under Deng Xiaoping catalyzed extensive urban reconstruction, blending socialist ideals with market dynamics (Wu, 2009; Ma, 2002).

Overall, the evolution of urban planning in Soviet Bloc countries and China illustrates a complex interplay of ideological dictates and practical necessities, shaping their urban landscapes and the function of megablocks in contemporary development.

METHODOLOGY

This study employs a systematic approach to develop a theoretical framework for Chinese Modern Urbanization (CMU) through an extensive literature review of urban theories. The initial phase involves a comprehensive examination of existing urban theories, particularly those rooted in Western urbanism, to identify relevant concepts and factors applicable to the study of megablocks in China.

Following the literature review, the methodology incorporates collaborative group discussions and Delphi analysis. These discussions aim to build a consensus among experts in the field, synthesizing insights from their academic work to refine the theoretical frameworks. This iterative process ensures that the revised frameworks are grounded in a broad spectrum of urban theories, reflecting both Western perspectives and the unique characteristics of the Chinese urban landscape.

To further enhance the theoretical framework, factor analysis is utilized to categorize significant variables identified from Western urbanism theories into comprehensive factors. This analytical approach allows for a structured evaluation of how these factors manifest within the Chinese context, ensuring that the framework is both relevant and adaptable to local conditions.

The literature review also leads to the selection of 50 pilot cases from various global regions, each representing distinct categories of urbanism that form the theoretical framework. These international cases are paired with 50 corresponding Chinese cases that exhibit characteristics of megablocks or

show influences from Western urban theories. The compilation of these 100 case studies provides a robust empirical foundation for the subsequent investigation into the urban morphology of megablocks in China, facilitating a comparative analysis that illuminates the intersections of local and global urbanization trends.

The methodology integrates literature review, expert consensus, factor analysis, and case study comparison to construct a comprehensive theoretical framework for understanding megablocks within the CMU context. This multifaceted approach ensures a thorough exploration of urban morphology, enabling the study to contribute valuable insights to the field of urban planning and development.

THEORETICAL FRAMEWORK OF CHINESE MEGABLOCK URBANISM (CMU)

In exploring the concept of Chinese Megablock Urbanism (CMU), a comprehensive theoretical framework has been established through a meticulous literature review and analysis of urban development models. This framework serves as a structured lens through which to examine the unique characteristics and dynamics of megablock developments in China. By identifying and synthesizing key factors and variables that influence these urban forms, the framework aims to illuminate the complexities of CMU. It encompasses various dimensions, including scale, density, accessibility, and livability, allowing for a nuanced understanding of how these elements interact within the broader context of rapid urbanization. This systematic approach not only highlights the significance of these factors in shaping urban experiences but also facilitates a rigorous analysis of megablock configurations in both domestic and international settings.

Development Process

The development of the CMU framework follows a structured methodology:

Variable Extraction: The initial phase involves gathering a diverse range of variables and factors from various urbanism models discussed in the earlier sections of the thesis, particularly focusing on the concepts of Megablock and relevant urban forms. This extraction process is documented in summary figure, which highlight the potential variables pertinent to CMU.

Relevance Filtering: In the second phase, the identified variables are meticulously filtered to ensure they are specifically relevant to the characteristics and nuances of Chinese megablocks. This step guarantees that the variables selected for the framework are contextually applicable to the phenomenon of CMU.

Factor Grouping: The filtered variables are subsequently organized into five core factors, reflecting their interrelations:

Radicalness: This factor includes critical variables such as scale and construction speed, key elements that define the rapid and extensive nature of megablock development in China.

Intensity: This encompasses variables like density, collectivity, and sustainability, which are essential for evaluating the compactness and operational efficiency of megablocks.

Morphology: Variables under this factor, such as urban form quality, architectural design, boundary definition, and public spaces, facilitate the analysis of the physical attributes and spatial organization of the megablocks.

Accessibility: This factor addresses transportation, walkability, and proximity, which are vital for assessing how well the megablocks connect with the surrounding urban environment.

Livability: This includes variables such as mixed-use diversity, quality of life, and self-sufficiency, which help gauge the comfort and convenience provided to residents within the megablocks.

Validation and Refinement

To ensure the robustness of the theoretical framework, the researcher engaged in group discussions and expert interviews, applying a Delphi method for feedback collection. This iterative process allowed for refinement and enhancement of the framework based on expert insights. The selected factors were also chosen for their capacity to be evaluated through morphological measurements, facilitating a more objective and quantifiable analysis of the CMU concept.

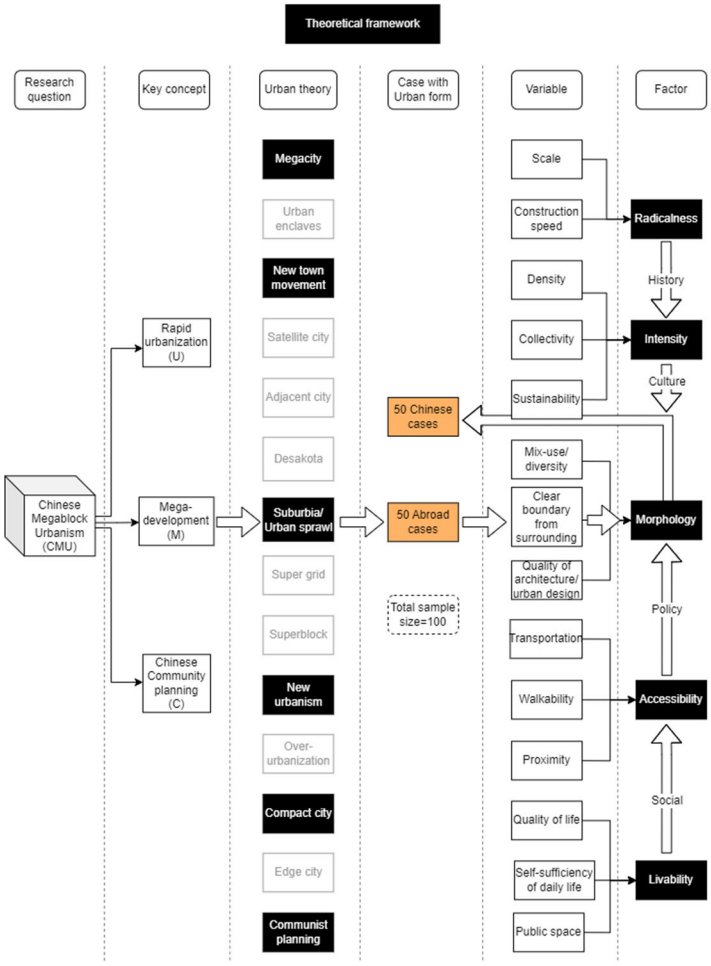

Figure 2 Theoretical Framework

Analytical Structure

The framework is designed to facilitate a hierarchical analysis, wherein broader factors are examined through extensive case studies, while specific variables are scrutinized in detailed case analyses. This

dual approach enables a comprehensive exploration of Chinese Megablock Urbanism (CMU) at both theoretical and analytical levels. The cases utilized in developing the theoretical framework have been assessed using morphological measurements tailored to the research objectives. Figure 3 presents examples of the analytical results. For each case, visualizations depict block scale and form, road density, network connectivity, and proximity in cartographic representations. In total, this study has assessed 100 cases using the same methodology, thereby providing an objective analysis of the morphological characteristics of CMU.

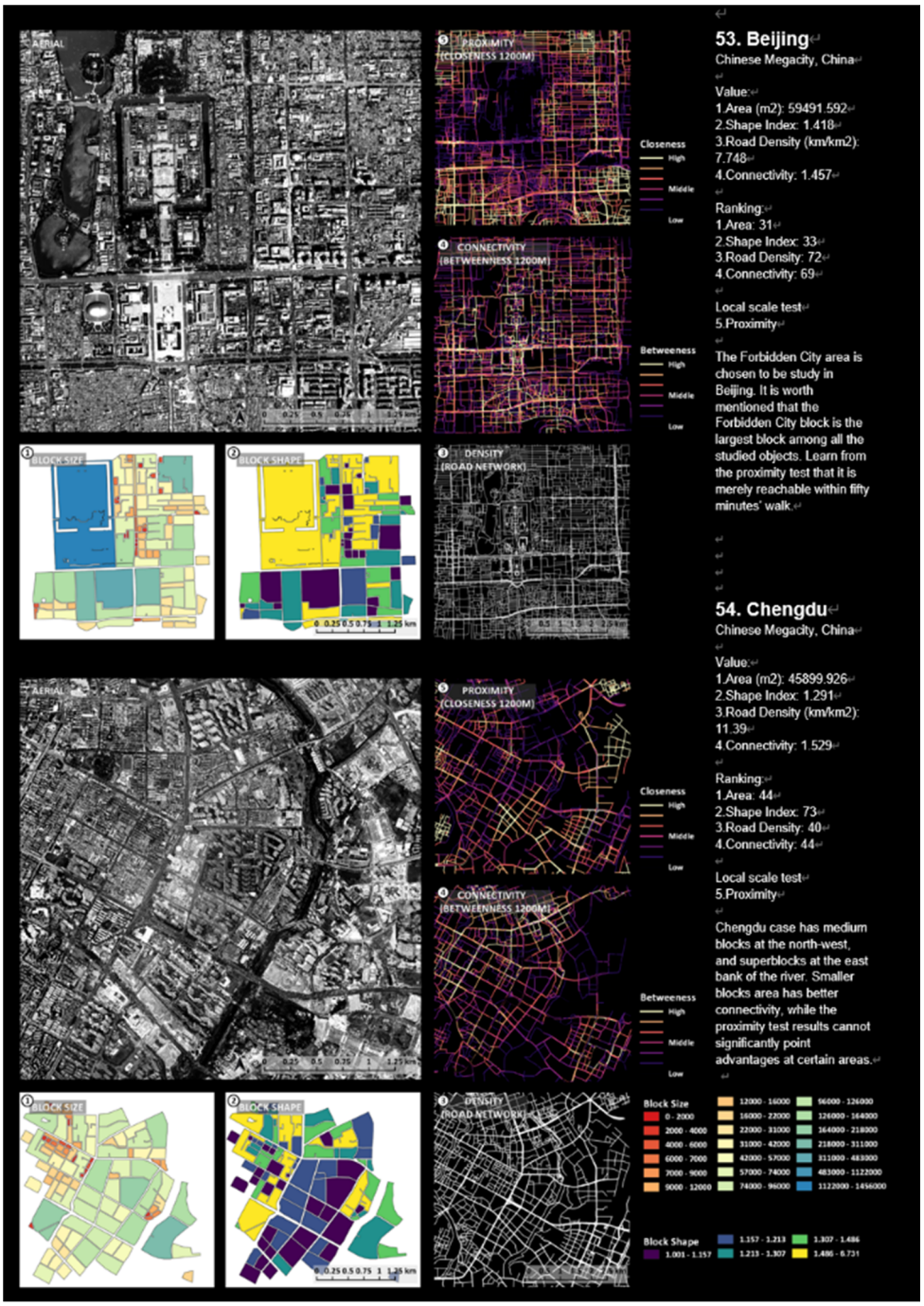

Figure 3. Examples of CMU morphological analysis results.

In conclusion, the theoretical framework established in this research provides a systematic and thorough lens through which to understand the dynamics of Chinese Megablock Urbanism (CMU). The framework facilitates a hierarchical analysis, wherein broader factors are examined through extensive case studies, while specific variables are scrutinized in detailed case analyses. This dual approach enables a comprehensive exploration of CMU at both macro and micro levels. The cases utilized in developing the framework have been assessed using morphological measurements tailored to the research objectives. Figure 3 presents examples of the analytical results, with visualizations depicting block scale and form, road density, network connectivity, and proximity in cartographic representations. In total, this study has assessed 100 cases using the same methodology, providing an objective analysis of the morphological characteristics of CMU. The logical interconnections between the identified factors and variables, as derived from the critical literature review, are visually represented in a diagram (FIG 2), offering a clear overview of the framework's structure and relationships. This comprehensive approach not only elucidates the complexities of CMU but also serves as a robust foundation for further research in this evolving field.

CONCLUSIONS

The rapid urbanization occurring in China represents an unprecedented phenomenon in human history, necessitating a reevaluation of existing Western urban theories. These theories often fail to adequately interpret the complexities and unique characteristics of Chinese urbanization, which is shaped by distinct socio-economic, cultural, and political contexts. As such, it is imperative that urban studies and planning frameworks evolve to better account for these factors, leading to the development of a theoretical model specifically tailored to Chinese conditions.

Chinese megablock urbanism (CMU) should be recognized not only as a case study but as a foundational theory in urban planning that can inform practices in other countries or regions experiencing similar urbanization processes. By examining CMU, planners and policymakers worldwide can gain insights into the dynamics of rapid urban growth, the interplay between urban morphology and social characteristics, and the implications for sustainable development.

The preliminary findings suggest that the analysis of CMU cannot be confined to a singular focus on context or morphology. Instead, it necessitates a hybrid approach that integrates context, morphology, and characteristic descriptions. This multifaceted perspective allows for a more comprehensive understanding of urbanization in China, facilitating the formulation of a robust CMU model that can serve as a reference for other urban contexts facing rapid transformation.

In conclusion, as global urbanization intensifies, the lessons derived from CMU are invaluable. By acknowledging the distinctive elements of Chinese urbanization and developing tailored theoretical frameworks, scholars and practitioners can enhance their understanding of urban dynamics. This approach not only enriches the academic discourse but also provides practical strategies for managing urbanization effectively in diverse global contexts.

DISCUSSION

This study aims to initiate a critical dialogue regarding Chinese modern urbanization (CMU), an area that has not received sufficient scholarly attention from either Western or Chinese academics. Given the context of significant national strategies such as the "Belt and Road Initiative," the "Asian

Infrastructure Investment Bank," and the Greater Bay Area (GBA) development, the implications of CMU extend beyond national borders and warrant a more profound investigation into its potential impacts both domestically and internationally.

Understanding the interplay among scale, density, and morphology within the framework of CMU is crucial for revealing urban spatial characteristics that define this unique urbanization process. These elements not only shape the physical landscape but also influence socio-economic dynamics, necessitating a comprehensive approach to developing an instructional guideline for CMU. By elucidating these relationships, researchers can better understand how urban forms evolve and how they can be optimized for future urban planning initiatives.

Future research should focus on deepening our understanding of CMU through the lens of urban morphology, aiming to direct urban development toward higher quality and sustainability. This perspective emphasizes the need to analyze urban forms and their interactions, which can lead to more effective strategies for managing urban growth and enhancing livability.

Moreover, adapting and refining analytical tools specifically tailored for the study of CMU is essential. Traditional urban analysis methods may not adequately capture the complexities of rapid urbanization in the Chinese context. Thus, there is a pressing need to develop innovative frameworks that can more accurately assess the spatial, social, and economic dimensions of CMU.

As Chinese rapid urbanization approaches a saturation point, we must consider the implications of entering a Post-CMU era. This transition presents an opportunity to explore urban regeneration strategies that can revitalize existing urban areas while addressing challenges such as environmental degradation and social inequity. Investigating how to effectively conduct urban regeneration within the CMU context will be critical for fostering sustainable urban environments that can adapt to evolving socio-economic conditions.

In summary, the study of CMU not only contributes to a richer understanding of urbanization in China but also offers valuable lessons for global urban planning practices. By focusing on scale, density, and morphology, adapting analytical tools, and exploring regeneration strategies, we can better navigate the complexities of urban growth in a rapidly changing world.

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Research on 3-dimensional pedestrian accessibility based on sDNA from time cost perspective: A case study of 5 rail transit station areas in Shanghai, China

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ABSTRACT

Rail transit is a pivotal mode of transport in high-density cities, and time sensitivity is of paramount importance, particularly for passengers walking to stations. Prior pedestrian accessibility measuring approaches have concentrated on space-based obstacles, thereby neglecting the temporal challenges encountered by pedestrians. The present study proposes a novel method that incorporates time obstacle parameters, including traffic light waiting time, elevator speed and stair climbing speed, via the use of Spatial Design Network Analysis (sDNA). This method is designed to evaluate 3-dimensional pedestrian accessibility in rail transit station areas utilizing precise time cost, which is reflective of the need for pedestrians to conserve travel time. Using this method, 5 typical rail transit station areas in Shanghai central district are analyzed and compared the 500m radius accessibility, whilst exploring its influencing factors. The results indicate that, multilayer walkways are effective in replacing pedestrian crossings thus save the walking time of rail transit station and improve travel efficiency, while reducing the number of vertical traffic conversion in the path is also necessary; network morphology can influence the distribution of accessibility of station area, the benefit on accessibility descend from circular network, chain network to isolate network.

Keywords: pedestrian accessibility, travel time, rail transit station area, sDNA

INTRODUCTION

As a pivotal mode of transportation in high-density cities, time sensitivity of rail transit is of paramount importance, and its travellers have a significant demand for time efficiency on commuting. Walking is the basic way to travel by rail transit, and it is also connects rail transit to other modes of transportation. The pedestrian accessibility of rail transit station area is of great importance on improving the efficiency of rail transit travel and attract passengers. Therefore, it is necessary to

evaluate the pedestrian accessibility of rail transit station area from the perspective of travel time cost.

The concept of Accessibility originated in the 1920s, which is generally regarded as the convenience in getting from one location to another via a specific transportation mode. In the current urban form studies on rail transit station area, the road network morphology is often regarded as the key influence factor on accessibility (Morris et al., 1978). Evaluation methods include: (1) The global quantitative evaluation based on the overall connectivity of the network; (2) the evaluation of network structure characteristics based on the calculation of indicators for specific paths (Xu et al., 2020). These evaluation methods mainly focus on spatial distance, converting walking time into walking distance by multiplying average walking speed, but neglect the importance of time cost as a fundamental travel characteristic of rail transit, and the walking experience of pedestrians. Moreover, rail transit station areas in Chinese cities are often high-density in construction with multiple layers of walking path, and the complexity of built environment leads to more waiting and speed changes during walking rather than exactly uniform movement. Therefore, the evaluation of pedestrian accessibility based on time and spatial distance perspective differs.

Though there were studies discussing the impact of obstructive factors on walking time in rail transit station area, such as trunk road and viaduct (Gao et al., 2021), waiting at signalized intersection (Jiao et al., 2017), standstill (Ando and Ujihara, 2019; Gehl, 2009), etc., current studies are qualitative analysis, and lack of solid quantitative analysis. Therefore, this study intends to quantify different types of spatial barrier factors into accurate walking time cost index, and use analytical software sDNA to objectively evaluate the pedestrian accessibility of the station area from the perspective of time.

METHOD

Research object

Rail transit station area

The research scope in the rail transit station area is set according to the comfortable walking distance for pedestrians, and 500m is widely used as the radius of analysis in existing studies. Therefore, the research area in this study is set as a buffer zone formed by a radius of 500m centered on the entrance-exits of the rail transit station (Figure 1).

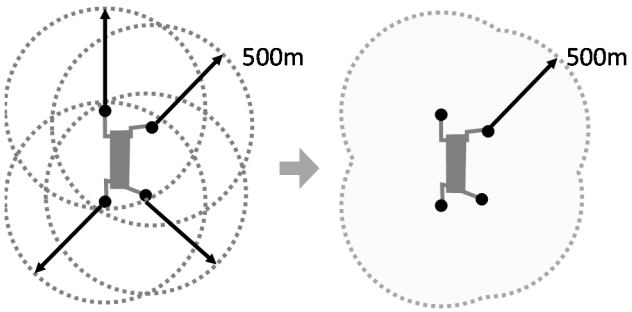


Figure 1. Research scope of rail transit station area.

Research cases

Five rail transit stations in Shanghai, China were selected as research cases: Xujiahui (S1), Wujiaochang- Jiangwan Stadium (S2), Jing'an Temple (S3), Zhongshan Park (S4), and Hongkou Football Stadium (S5). They are all located in the central city within the Outer Ring Road in Shanghai, surrounded by large business districts, as transfer stations of multiple rail transit lines, and have high intensity of construction and development, and their multilayer walking systems provide rich choice of walking paths.

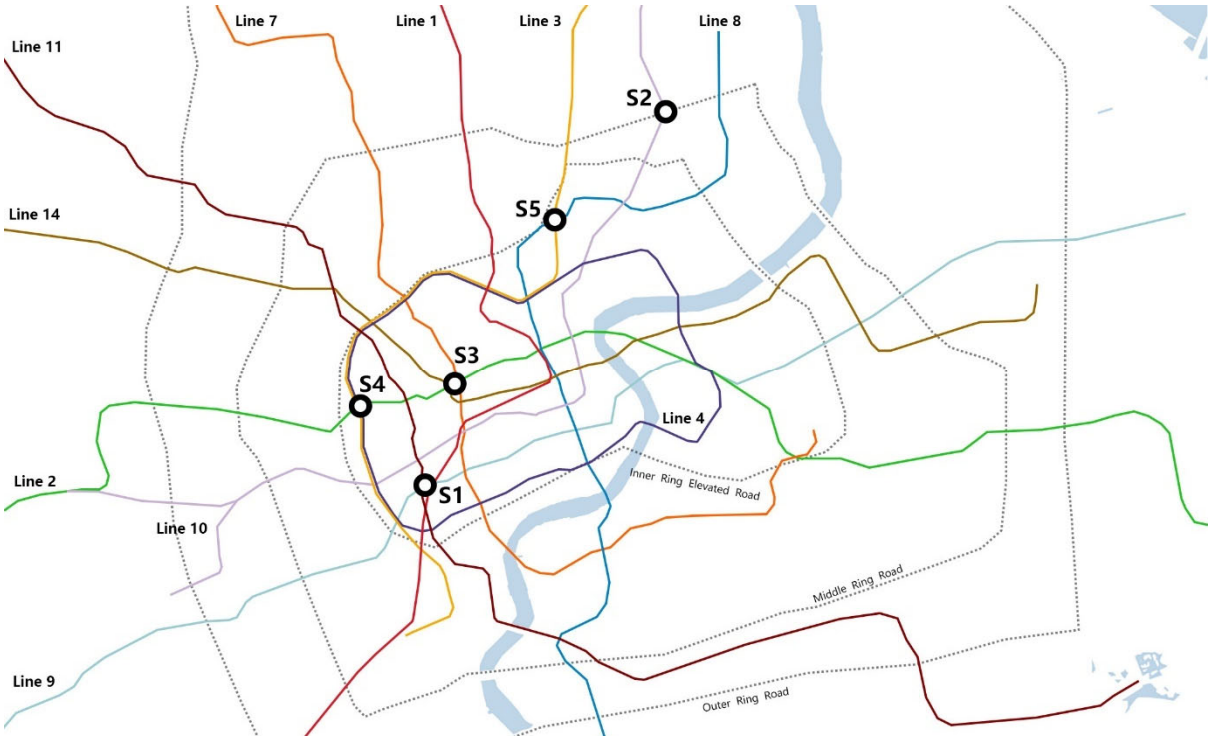


Figure 2. Location of 5 stations.



Figure 3. satellite image and street view photograph of 5 stations.

sDNA and the application

Spatial Design Network Analysis (sDNA) is an analysis tool developed in recent years based on ArcGIS platform and 3-dimensional perspective, which can achieve the goal of computing accessibility and analyzing the rationality of road network structure in a 3-dimensional environment (Cooper and Chiaradia, 2020). Compared with traditional network analysis, sDNA is able to objectively measure the difference of paths in the vertical direction by calculating the changes of distance, Angle or direction

equally on the X, Y and Z axes, and better simulate the path selection in multilayer walking system. In addition, sDNA also provides a custom measurement calculation method to adapt to diverse research scenarios. The application of sDNA has developed rapidly in recent years. Scholars such as Zhang (2019; 2021), Chen (2022) have applied this tool to the analysis and optimization of pedestrian networks in high-density cities, indicating that the tool is effective in analyzing the accessibility of 3-dimensional pedestrian network in high-density cities, and the application is highly flexible. Therefore, sDNA was selected as the calculation tool for the pedestrian accessibility of rail transit station area in this study.

sDNA uses Betweenness and Closeness to measure the "centrality" of a network (Bavelas, 1950; Freeman, 1977). Betweenness can be used to analyse the importance of individuals in a social network (Cooper, 2024). The potential of each street segment x as a through-movement channel is reflected by calculating the number of times each street segment x is crossed by the shortest path between any two other street segments y and z within a particular analytical radius.

$$Betweenness(x) = \sum_{y \in N} \sum_{z \in R_y} W(y)W(z)P(z)OD(y,z,x) \quad (1)$$

Where

N = The set of polylines in the global spatial system,
R_x = The set of polylines in the network radius from link x,
P_y = The proportion of any polyline y within the radius,
$W(y)$ = Weight of a polyline y.

sDNA parameter setting

In existing studies of pedestrian accessibility, Euclidean distance measurement and angular measurement are commonly used, while the composition of metric of angular and Euclidean (hybrid distance) measurement is widely used in sDNA analysis. In this study, the scenarios of standstill (waiting for red lights at the crossroads, waiting for the elevators, etc.) and speed changes (going up and down stairs, using escalators and elevators, etc.) are taken into account. By adjusting the parameters of different types of road sections, the time cost of travelling is accurately calculated by assigning the metric values of each road section based on the Euclidean distance in the sDNA calculation.

The time cost measurement parameter (N_t) denotes time-cost coefficient per unit length in the sDNA calculation, which represents the ratio of the actual walking time-cost of the road section to the time on a common walkway section the same length.

$$N_t = \frac{T}{T_0} = \frac{v_0}{v} = \begin{cases} \frac{L}{v_0 \times T_{cros}} & \text{(pedestrian crossings)} \\ \frac{2 \times v_0}{v_{up} + v_{dn}} & \text{(stairs)} \\ \frac{v_0}{v_{\text{esca}}} & \text{(escalators)} \\ \frac{v_0}{v_{\text{elev}}} & \text{(elevators)} \end{cases} \quad (2)$$

Where

T_{cros} = time span of whole street crossing process (s),
v_0 = walking speed at common walkways (m/s),
L = length of the path (m).

Common walkways

Existing studies have shown that pedestrian walking speed is generally within the range of 0.9 to 1.5m/s. Among them, Henderson's (1971) study in Sydney, Australia found that the average speed of pedestrian was 1.34m/s. Compared with other countries, the pedestrian walking speed in China is relatively low. Dai's (2009) study adopted 4km/h (1.11m/s) as the average pedestrian walking speed, and results of some surveys in Shanghai and Beijing show that the average walking speed of pedestrians is 1.21 to 1.24 m/s. Walking scene and crowd characteristics have a great influence on the walking speed. The walking speed inside rail transit station is higher than that in streets, passages and shopping malls, the walking speed of young and middle-aged people is higher than that of the elderly and children, and men's speed is higher than that of women. Based on the above research, this paper defines the average walking speed of common walkways (v_0) = 1.2m/s in the rail transit station area.

pedestrian crossings

Due to the high volume of motor vehicle traffic on urban arterial roads, vehicle efficiency is a higher priority when organising traffic at the crossroads, which is ensured by the use of a long-period signal control scheme, which interrupts pedestrian walking at intersections and causes an increase in travel time costs.

In this study, pedestrians are considered to be affected by two parts of delay when crossing the street at signalised intersections: the waiting time for the red light and the walking speed for crossing the street. Congestion due to the large number of pedestrians and the interference caused by right-turning vehicles at intersections are ignored.

$$T_{cros} = T_{pass} + T_{wait} \tag{3}$$

Where

T_{cros} = time span of whole street crossing process (s),
T_{pass} = time span of walking crossing the street (s),
T_{wait} = time span of waiting for a red light (s).

According to existing studies on pedestrian crossing walks at signalised intersections, and considering the age ratio of Shanghai's population, a speed of walking crossing the street of 1.4m/s is used in calculation.

When people pass through the intersection according to the signal, the waiting status can be divided into two categories: (1) if the light is green at arrival, and the remaining time of green light is long enough to pass the crossing, there is no need to wait; (2) if the light is red at arrival, or the remaining green light is not long enough to pass the crossing, then pedestrians need to wait until the next green light comes on.

$$\mathrm{F}_{\mathrm{wait}}(t) = \begin{cases} 0, \ 0 \le t \le T_1 - T_{pass} \\ T_2 + T_{pass} - t, \ T_1 - T_{pass} < t < T_1 + T_2 \end{cases} \tag{4}$$

Where

$\mathrm{F}_{\mathrm{wait}}(t)$ = The function of waiting time with respect to t (s),
t = time variable when pedestrian arrive at the crossroad (s),
T_1 = time duration of a green light (s),
T_2 = time duration of a red light (s).

Since the calculation involves the data of traffic light duration at each intersection, we recorded and counted the traffic light duration at 33 intersections in the research area, and calculated the average waiting time to cross the road according to formula (3). The results show that the waiting time to cross the road is significantly correlated with the number of motor vehicle lanes in the road section. After regression analysis of the data, formula (5) is obtained.

$$T_{wait} = 10.03 + 8.66 \times N_{dw} \quad (5)$$

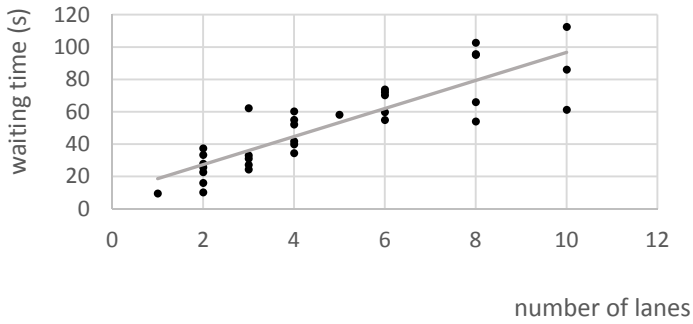


Figure 4. scatter diagram of average waiting time versus the number of lanes.

Therefore, crossing waiting times are estimated according to formula (5) based on the number of lanes in each road section. Then the time cost measurement parameter of pedestrian crossings can be calculated according to formula (6).

$$N_{tCros} = \frac{\frac{L}{1.4}+10.03+8.66\times N_{dw}}{\frac{L}{1.2}} = \frac{6L+18.43+72.744\times N_{dw}}{7L} \quad (6)$$

Where

N_{tCros} = Time index of pedestrian crossings,
L = length of the path (m),
N_{dw} = number of lanes.

Stairs

In the investigation of Beijing's pedestrian 3-dimensional crossing facilities, it is shown that the vertical speed of pedestrians going up the stairs is 0.21m/s, the inclined speed is 0.47m/s. Walking speed in the metro station is faster, and in the investigations of metro stations in Shanghai, Beijing, and Nanjing, the pedestrians go up the stairs at a speed of about 0.69 to 0.79m/s, and go down the stairs at a speed of about 0.81m/s to 0.92m/s. Based on the above investigation data, this paper adopts the

average speed of pedestrians going up the stairs (inclined speed) v_up=0.60m/s, and the average speed of going down the stairs v_dn=0.70m/s, then:

$$N_{tStair} = \frac{2 \times v_0}{v_{up} + v_{dn}} \approx 1.85 \quad (7)$$

Escalators

According to the relevant norms, the rated operating speed of escalator inclination angle α ≤ 30° is not more than 0.75m/s; the rated operating speed of escalator inclination angle α < α < 35° is not more than 0.50m/s. Field research is carried out on the escalators within the scope of this study, and the inclined speed of the escalator operation is calculated by measuring the length of time pedestrians use to pass through the escalator, the number of stair steps with the same height difference and the inclined angle of the escalator. The results show that the running speed of the escalators at the entrances and exits of the rail transit stations and that inside the commercial complexes are all about 0.5m/s, thus obtains:

$$N_{tEsca} = \frac{v_0}{v_{esca}} \approx 2.4 \quad (8)$$

Elevators

The elevators within the scope of this paper are mainly divided into two categories: accessible elevators in public facilities (underground stations, footbridges and underpasses) and passenger elevators in commercial complexes. Field measurement results show that the underground and public facilities configured barrier-free elevator has height of 1 to 2 floors, time of riding the elevator and waiting for the elevator length is roughly equal, the average speed is about 0.45m/s after entering the car, including the operation and operation of the buffer time; for the passenger elevator of the commercial complex, due to the number of floors, waiting time is about two times the time spend of the ride, the speed of about 0.3m/s. Therefore obtaining the following formula:

$$N_{tElev} = \frac{v_{esca}}{v_0} \approx \begin{cases} 8.0 & \text{(public facilities)} \\ 12.0 & \text{(commercial area)} \end{cases} \quad (9)$$

Modelling

The road network data was obtained through the open-source map (OSM), and on its basis, the correctness of the road network information was verified by combining satellite maps, street views and field research, and then the pedestrian network was mapped in Autodesk AutoCAD Map 3D. The pedestrian network included in the study consists of the following three categories: (1) at-grade public pedestrian paths; (2) 3-dimensional public pedestrian walkways; and (3) urban public space accessing the public pedestrian system.

According to range of the 500m research radius plus 500m analytic radius, the road network within 1000m radius of the rail station entrances and exits was modelled (Figure 5).

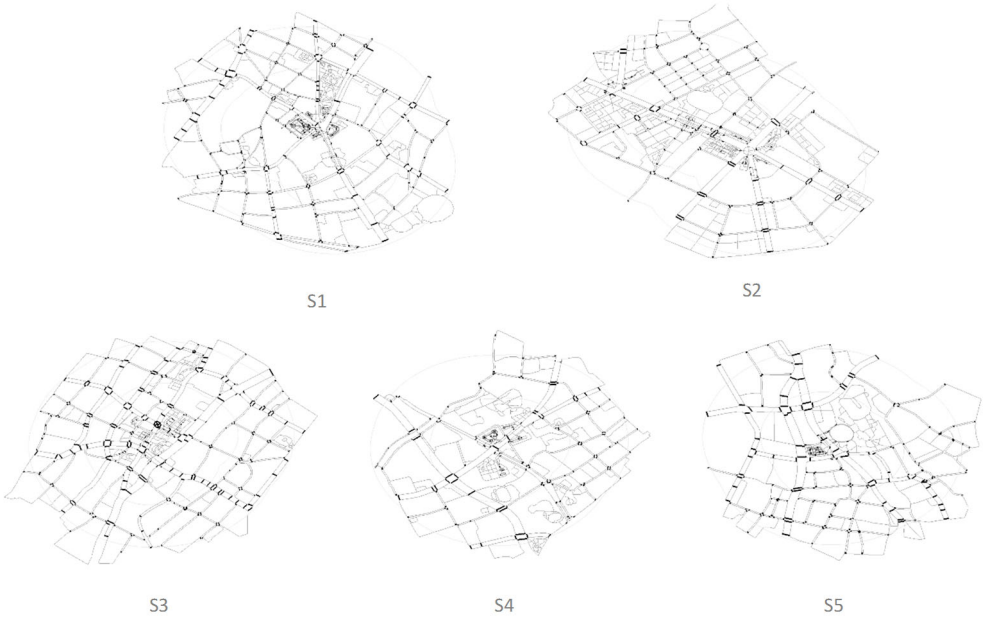


Figure 5. Illustration of pedestrian network modelling and N_t value of each sections.

The 3-dimensional structure of the pedestrian network is shown in Figure 6. The rail transit station hall, shopping malls and public pedestrian walkways in the station areas of S1 and S2 are connected to each other to form circular 3d walkways and extend outward; the network of S3 and S4 are mainly based on the station passage as the skeleton and extend in the form of a chain; and the network of S5 are more introverted, congregated on the interior of the station and the stadium ring road, and less extended and diffused to the outside.

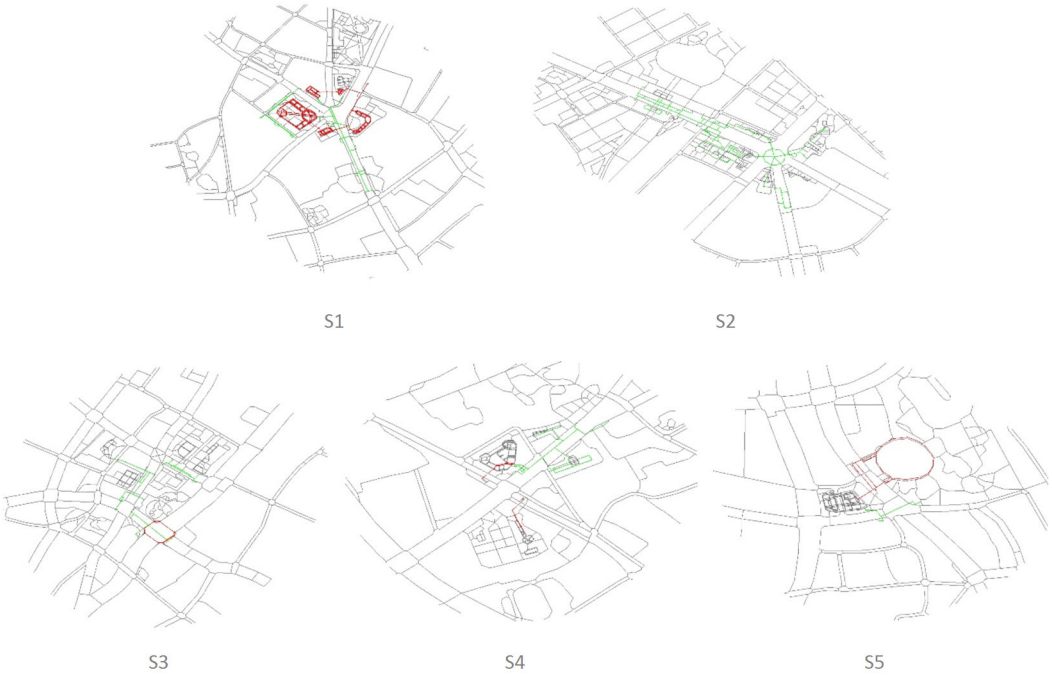


Figure 6. Composition of 3d walkways of each station area.

After the sDNA analysis, the calculation result of Betweenness in 500m analysis radius measured by time cost (BtC500) of each station areas are shown in Figure 7.

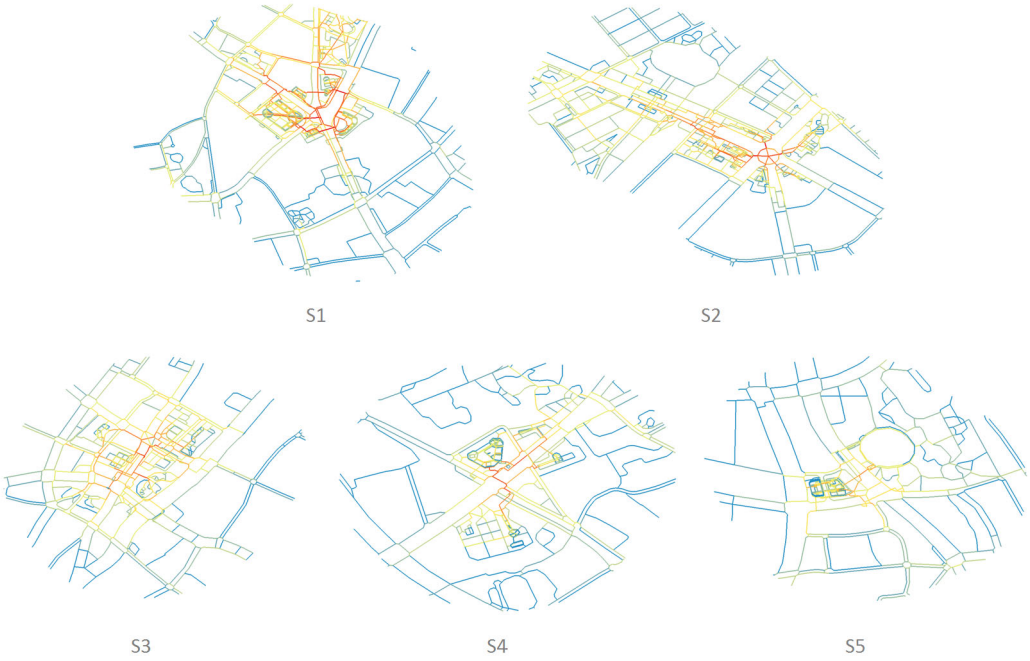


Figure 7. Calculation result of Betweenness in 500m analysis radius measured by time cost (BtC500).

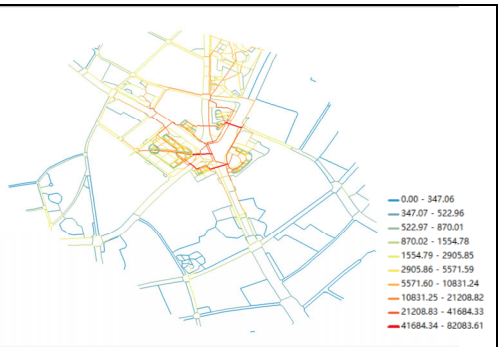
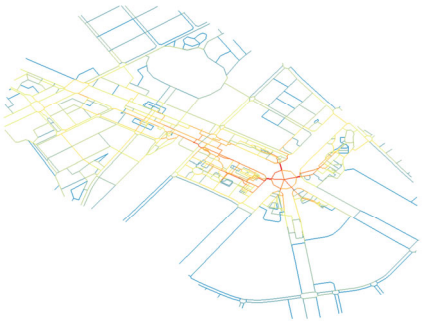
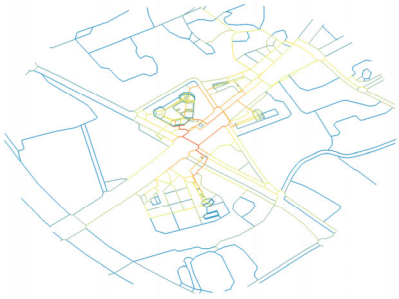
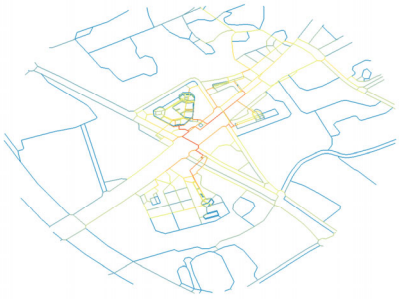
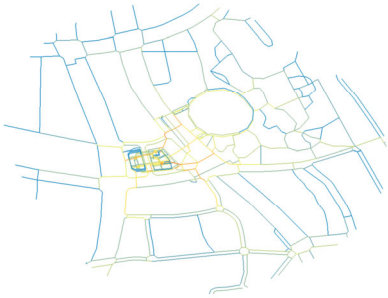
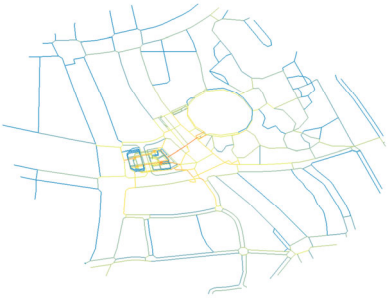
ANALYSIS

Comparison of accessibility from the perspective of distance and time cost

The betweenness of 3-dimensional pedestrian network in each station area is calculated based on traditional measurement of Euclidean distance and the time cost measurement (Table 1). It is found that the sections with the highest betweenness in the former are mostly at-grade walkways and contain many pedestrian crossings, while the sections with the highest betweenness in the latter are mostly aerial and underground paths for crossing streets. This shows that the time cost of vertical traffic and detour through three-dimensional path is shorter than the average time cost of waiting for traffic lights. Therefore, compared with the at-grade pedestrian crossings, the multilayer walkways connecting land blocks can help save the walking time of the rail transit station area and improve the travel efficiency, though it takes a longer spatial distance. At the same time, this also reduces the potential for pedestrian-vehicle conflicts and safety hazards associated with crossing motorways.

Table 1. Comparison of Betweenness measured by Euclidean distance and time cost.

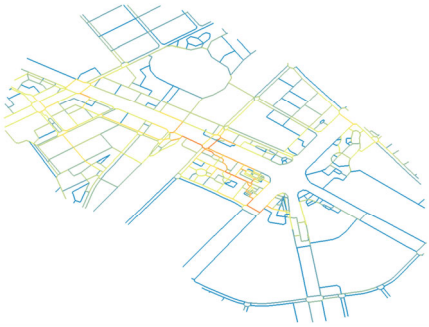
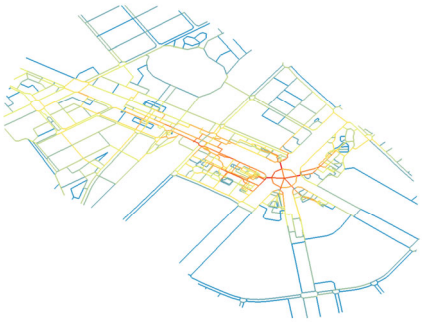
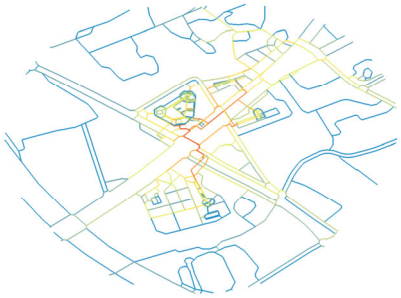
Station	BtE500（Measured by Euclidean distance）	BtC500（Measured by time cost）

S1		 0.00 - 347.06 347.07 - 522.96 522.97 - 870.01 870.02 - 1554.78 1554.79 - 2905.85 2905.86 - 5571.59 5571.60 - 10831.24 10831.25 - 21208.82 21208.83 - 41684.33 41684.34 - 82083.61
S2		
S3		
S4		
S5		

From time cost perspective: how 3D paths influence accessibility

The above studies show that under the consideration of time efficiency, people are more inclined to choose the 3d walkways in rail transit station area, which is consistent with the pedestrian activities observed on site. Therefore, the following studies all adopt the measurement from the perspective of time cost. In order to further explore the impact of 3d walkways on pedestrian accessibility, accessibility of the basic at-grade pedestrian network of the station area and the network containing 3d walkways (including the public walkways in the commercial complex) were further calculated and compared (Table 2 and Table 3).

Table 2. Comparison on BtC500 of different pedestrian network.

Station	basic network	3d network
S1		
S2		
S3		
S4		

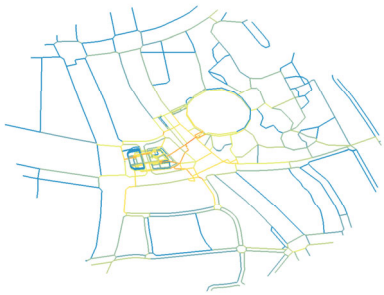
S5		

Table 3. Pedestrian network data and accessibility of each station area.

Station	length percentage of 3d walkways	Average equivalent distance of pedestrian crossings (m)	Average BtC500 of station area		
			basic network	3d network	rate of increase
S1	13.18%	62.65	2679.68	5477.19	**104.40%**
S2	12.42%	86.04	1814.43	3825.85	**110.86%**
S3	7.55%	110.32	2491.73	3362.11	**34.93%**
S4	12.91%	95.09	1399.79	2682.07	**91.61%**
S5	14.02%	117.20	836.44	1985.68	**137.40%**

The results show that the pedestrian accessibility of the station area after adding the 3d walkways is substantially improved. This is mainly influenced by the rail transit station construction mode. Constrained by development timing, engineering difficulty and other practical conditions, the layout of rail transit lines and stations in Chinese cities is often combined with the arterial traffic road for motor vehicles, resulting in generally long pedestrian crossing distances in the station area. From the time perspective, the equivalent crossing distance is about 3-4 times of the actual spatial distance on average, resulting in a large amount of time-consuming and negative influence on the station area pedestrian accessibility. Setting of 3d walkways can effectively reduce the negative impacts of the excessive time spent on crossing the street.

From time cost perspective: how 3D path morphology influences accessibility

According the above analysis, it is clear that the 3d walkways has a significant effect on increasing pedestrian accessibility from time cost perspective, but the effect varies from station to station, which is presumed to be related not only to the length of the 3d walkways, but also to the morphology of the network (Figure 8). Most of the 3d walkways in the rail transit station area are closely integrated with the station entrances, which enhances the accessibility of the rail transit station to the urban road network, so the effect of the 3d walkways on the accessibility of the station entrances and exits is included in the analysis. (Table 4).

Table 4. Comparison on Betweenness of station areas and entrance-exits.

Station	Average BtC500 of entrance-exits			Average BtC500 of station area		
	basic network	3d network	rate of increase	basic network	3d network	rate of increase
S1	3756.86	6719.32	78.85%	2679.68	5477.19	104.40%

S2	883.20	4229.43	378.88%	1814.43	3825.85	110.86%
S3	4201.82	6639.22	58.01%	2491.73	3362.11	34.93%
S4	1975.31	5090.77	157.72%	1399.79	2682.07	91.61%
S5	1021.35	4183.82	309.64%	836.44	1985.68	137.40%

The 3d walkways of S1 and S2 appear to be circular structure with outward extension, which closely connects multiple land blocks cut by the motorway, so that the rail transit station and the surrounding land blocks form a good connection, and the high-accessibility area radiates outward with the circular 3d walkways as the centre, so that the overall accessibility of the station area is increased exponentially. In addition, the circular 3d walkways are highly coupled with commercial complexes, and the high-accessibility areas of the station area are concentrated between commercial complexes, thus bringing in more consumer crowds. At the same time, 3d walkway of these two stations are set at the same level with the entrance-exits of station or commercial complex, avoiding the increase of walking time cost brought by complicated conversion in vertical circulation. For example, corridors on the first floor of S1 connects five shopping malls together, improving the accessibility of the commercial area; north side of the S2 station hall is closely combined with underground commercial street, which brings a very large increase on accessibility of entrance-exits of station.

In contrast, the morphology of the 3d walkways in S3 and S4 are in the form of catenate structure, and their high-accessibility area concentrate in the catenate space connected by the metro passage, which extends outward in the form of fishbone through the entrances and exits. Although these extension passages make sense in connecting the land blocks, their ability to radiate outward is relatively weak. The addition of the catenate 3d walkways to pedestrian network enhances the accessibility of the station entrances-exits more than that of the whole station area, so the scope of influence is relatively limited. In addition, the high-accessibility area of the rail transit station area is concentrated in the metro passage itself, and the connection between the neighbouring land blocks relies on the rail transit station hall to a large extent, which fails to better enhance the accessibility of the surrounding urban public space, and is prone to cause congestion in the metro station.

It should be noted that the pedestrian network structure of 3d walkway in S5 is an isolated one, with the worst degree of road network connectivity in general, and the 3d walkway is weakly connected to the surrounding urban space. The two rail transit station halls are located on the second floor and the basement floor, which leads to a complicated vertical circulation transfer and add to the walking time cost to a large extent, and it is also difficult to replace the at-grade walkway for quick connection among the land blocks. Although the interchange between the two station halls is spatially via the interior of the shopping mall, it is managed independently of the mall and cannot attract more consumers; on the other hand, the aerial walkway connecting the football stadium on the east side is also relatively isolated and does not have a good connection with the surrounding commercial and urban public spaces, resulting in a low efficiency of the 3d walkway and poor accessibility to the station area in general.

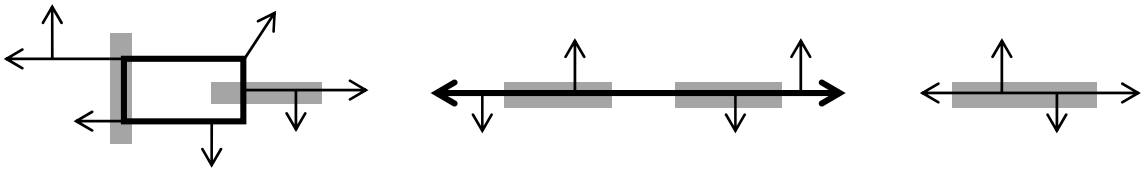


Figure 8. Different structure of 3d walkway in rail transit station area.

CONCLUSIONS

In this paper, the sDNA method is innovatively applied through the calculation of pedestrian accessibility in rail transit station areas. According to the actual situation of urban pedestrian network, the road section characteristics are quantified as time cost measurement parameters, making the sDNA accessibility calculation result more relevant to the travel efficiency needs of rail transit passengers and surrounding residents.

Through the case study of Shanghai rail transit station area, the following conclusions are drawn: (1) compared with the at-grade crossing pedestrian path, 3d walkways, although longer in spatial distance, is more conducive to saving the walking time of the rail transit station area to improve the efficiency of travelling; (2) the existence of 3d walkway in the rail transit station area can improve the pedestrian accessibility of the station area under the time cost perspective to a large extent; (3) circular 3d walkways, catenate 3d walkways and isolated 3d walkways, plays a descending role of improving pedestrian accessibility and consumption potential in the order, so future planning of pedestrian network in rail transit station area should give priority to the morphological consideration and reduce the complexity of vertical traffic transitions.

Acknowledgements

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Research on satisfaction evaluation and influencing factors of pedestrian environment around subway station: A case study of Shanghai, China

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ABSTRACT

The combination of urban rail transit and walking has been widely used to solve different transportation problems as well as being catalyst for sustainable urban development. However, most previous studies and practices have focused on residential areas, neglecting that the characteristics of the built environment around subway stations in different functional zones may be different. This paper aims to explore the influence of pedestrian environment details around different functional types of stations on pedestrian walking psychology and satisfaction.

In this study, 11 evaluation indexes were extracted from five dimensions which include walking convenience, traffic safety, indication guidance, sidewalk quality and environmental facilities, and the framework of pedestrian environment assessment in station area was established. In addition, 15 typical subway station areas in Shanghai were selected and categorized into three functional types: residential area, commercial service area and business office area. At each survey station, the investigators were asked to collect 30 questionnaires, a total of 446 questionnaires were collected and the response rate was 99.1% (446 /450).

The results show that: (1) the interviewees are generally but not excessively satisfied with the pedestrian environments around three types of stations; (2) the convenience of crossing the street intersection has a major impact on pedestrian overall satisfaction, and the smooth and clean sidewalk, less vehicle traffic interference are also highly correlated with pedestrian overall satisfaction; (3) the influence factors of pedestrian satisfaction evaluation are different among the three types of station areas, among which, the pedestrian satisfaction of business office area is higher than that of other types of station area, but it has higher requirements for bus transfer, street commercial facilities and climate shelter facilities, while the pedestrian satisfaction in residential station areas is generally low, especially in terms of traffic safety and sidewalk quality.

Keywords: subway station area, pedestrian environment, satisfaction evaluation, functional zone

BACKGROUND

With the popularization of green travel and low-carbon development, the construction of pedestrian-friendly environments around metro stations has become a common concern in urban transportation planning and urban design fields (Xu, Liu and Lu, 2015; Jiao, Chen and He, 2017; Houston et al., 2015). A high-quality pedestrian environment in station areas is crucial for attracting citizens to choose public transportation and fostering diverse public activities such as social interactions and leisure (Freeman et al., 2013). Previous studies have mostly focused on the environmental walkability of specific functional types of station areas (Shen et al., 2020; Zhang et al., 2020; Guo, 2009), lacking analysis of the pedestrian environment needs of different functional types of station areas. However, the functional types of metro stations are influenced by the types of urban land use and urban forms around the stations (Duan and Zhang, 2020). For example, land use dominated by commercial services, residential living, and office employment will have different planning layouts, resulting in different built environments (Lu et al., 2023). Additionally, passengers traveling to and from different functional types of station areas may have varying requirements for the performance of the pedestrian environment in these areas due to different travel purposes.

Shanghai, China, is experiencing a rapid development period in its rail construction. Currently, there are 20 operational lines with a total of 508 stations and an operating mileage of 831 kilometres, ranking first in the world. The fast and convenient urban rail transit construction has attracted nearly half of Shanghai's citizens, with an average daily passenger flow exceeding 10 million, presenting new opportunities and challenges for the pedestrian-friendly environment in station areas. Taking the central urban area of Shanghai as an example, this paper evaluates the pedestrian-friendly environment of 15 station areas, analyses the differences in pedestrian environment needs of station areas with three dominant functions: commercial services, residential living, and office employment, and explores corresponding environmental improvement and optimization design strategies. The aim is to provide ideas and references for the planning and design of pedestrian environments around metro stations, promoting green travel and low-carbon development in the city.

RESEARCH DESIGN

Evaluation Indicators

Referring to Maslow's hierarchy of needs theory and the TOD (Transit-Oriented Development) walkability evaluation system (Jiao, Chen and He, 2017), the evaluation of pedestrian-friendly environment performance in station areas is summarized into five major performance indicators: convenience and continuity, pedestrian and vehicle safety, signage and guidance, sidewalk quality, and environmental facilities. These are further subdivided into 11 specific individual indicators (Table 1).

Among them, convenience and continuity refer to the accessibility of rail transit stations perceived by walkers, involving the street network, bus stops, and street crossing facilities around the station area. Pedestrian and vehicle safety refers to the interference of pedestrians by motor vehicles when walking, which is related to mixed traffic, disorderly parking, and occupying lanes. Signage and guidance refer to the signage and guidance of the site, mainly related to the signage guidance system of the surrounding streets. Sidewalk quality refers to the quality and width of the pavement foundation, including flatness, cleanliness, footpath width, etc. Environmental facilities are designed to meet the daily basic needs of walkers, including sufficient commercial facilities along the street, recreational facilities for public communication, shelter facilities for bad climates, and so on.

Table 1: Pedestrian environment indicators for metro station areas

Performance Dimension	Element Code	Element Indicator
Convenience and Continuity	A1	Convenient and direct walking paths
	A2	Easy access to bus stops
	A3	Convenient pedestrian crossings
Pedestrian and Vehicle Safety	B1	Low interference from motor vehicle traffic
	B2	Sidewalks free from vehicles or obstructions
Signage and Guidance	C1	Clear signage for the metro station
Sidewalk Quality	D1	Smooth and clean sidewalks
	D2	Spacious sidewalks
Environmental Facilities	E1	Numerous commercial facilities along the road
	E2	Enough green spaces and plazas along the road
	E3	Ample shaded areas along the road

Case Selection

The jobs-housing ratio is a key indicator for evaluating the balance between employment and housing, revealing the land use patterns around the station area (Woo, 2021). The definition of this ratio involves specific factors depending on local demands, economic structure, and commuting patterns (Wu, Zhang and Yang, 2015). Considering Shanghai's large urban scale and high-density built environment, along with the measure of walkability, this study defines the service coverage area of each station by taking the station exit as the centre and a radius of 500 meters. The jobs-housing ratio within this defined area is calculated to categorize metro stations into three dominant functional types: commercial, residential, and office (Table 2).

Table 2: Indicators of dominant functional types in metro station areas

Type	Index
Commercial Type（I）	0.6 < jobs-housing ratio (building area) < 1.5
Residential Type（II）	jobs-housing ratio (building area) < 0.6
Office Type（III）	jobs-housing ratio (building area) > 1.5

Based on the above three main function types, 5 typical rail interchange site areas are selected (Figure 1, Table 3). The above 15 stations are transfer stations, with an average daily passenger flow ranging from 56,000 to 154,000, and their large number of people can ensure the diverse social attributes of passengers, and have the urgency of improving the walking environment.



Figure 1: Location distribution of railway interchange stations

Table 3: The selected rail transit station number

Type	Code	Station Name	Metro Line	Passenger Amount
Commercial Type（I）	I-1	Caobao Rd	1+12	63157
	I-2	Dongan Rd	4+7	57519
	I-3	Jiangwan Stadium	4+8+10	80314
	I-4	Nanjing Rd.(W)	2+12+13	153760
	I-5	Yishan Rd	3+4+9	90065
Residential Type（II）	II-1	Caoyang Rd	3+4+11	64432
	II-2	Changshu Rd	1+7	61358
	II-3	Hongqiao Rd	3+4+10	56385
	II-4	Jiangsu Rd	10	87497
	II-5	Jinshajiang Rd	3+4+13	71532
Office Type（III）	III-1	Hanzhong Rd	1+12+13	73512
	III-2	Hongkou Football Stadium	3+8	73584
	III-3	Jinke Rd	2	66934
	III-4	Lujiazui	2	153701
	III-5	Zhaojiabang Rd	7+9	58098

Data Source

Information about the pedestrian environment in the three types of functionally dominant station areas was collected through questionnaires. The questionnaire comprised three main sections: the first part collected the respondents' basic social attributes, the second part ranked the importance of different pedestrian environment performance indicators according to the respondents, and the third part evaluated the respondents' satisfaction with the pedestrian environment. In the second part, the importance ranking of each indicator by the respondents was assigned corresponding scores: 3, 2, and

1, and the importance scores of each single indicator were weighted and normalized to obtain the demand degree of the corresponding indicators. The third part evaluated the respondents' satisfaction with the environment using a Likert scale, with five levels: "Very Satisfied," "Satisfied," "Neutral," "Dissatisfied," and "Very Dissatisfied," corresponding to scores of 5, 4, 3, 2, and 1. The data were then statistically analysed using Excel and SPSS software.

Data collection was conducted from May 2023 to April 2024. Thirty questionnaires were distributed to pedestrians using the metro at each survey station, with a total of 446 valid questionnaires collected, resulting in a response rate of 99.1%. According to statistics, the overall situation of the respondents is as follows: males accounted for 44.62%, less than females; the age range was mainly concentrated between 18 and 60 years, accounting for 81.61%; more than half of the respondents used the metro at least three days a week, ensuring the validity of the questionnaire information. During the survey, additional methods such as spatial environment annotation analysis, semi-structured interviews, and behavioural activity observations were also used for cross-verification of the survey results.

DATA ANALYSIS

Demand degree of Pedestrian Environment

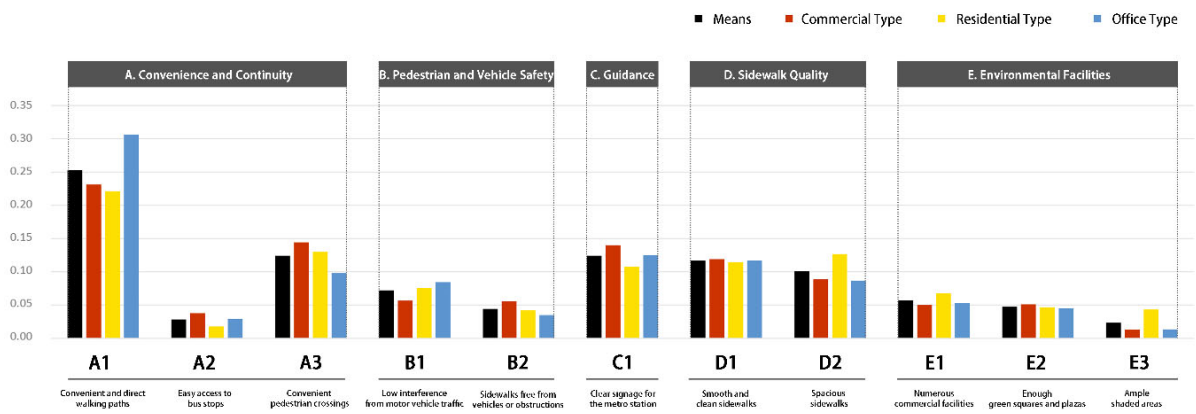

Figure 2: The demand degree of pedestrian environment dominated by different functions

From the performance indicators of respondents' demands for the pedestrian environment in station areas (Figure 2), "A: Convenience and continuity", "C: Signage and guidance", and "D: Sidewalk quality" have generally higher demand levels, indicating significant concern from pedestrians. Among the individual indicators, "A1: Convenient and direct walking paths" has the highest demand level (25.26), followed by "A3: Convenient pedestrian crossings" (12.43), suggesting that the convenience of reaching the station should be a primary consideration in design.

As for the dominant functional types of the station areas, there are significant differences in pedestrian demands. Residential dominant stations have a significantly higher demand for "D2: spacious sidewalks", "E1: Numerous commercial facilities", and "E3: Ample shaded areas" compared to the average. Office dominant stations have a significantly higher demand for "A1: Convenient and direct walking paths" and "B1: Low interference from motor vehicle traffic" compared to the average. Commercial dominant stations have a significantly higher demand for "A3: Convenient pedestrian crossings", "A2: Easy access to bus stops", "B2: Sidewalks free from vehicles or obstructions", and "C1:

Clear signage for the metro station" compared to the average. Overall, residential areas focus more on the comfort and convenience of the pedestrian environment, office areas emphasize the efficiency and safety of pedestrian access, while commercial areas prioritize the convenience and continuity of walking paths. These differences in demand can provide a basis for targeted optimization of the pedestrian environment around metro stations.

Satisfaction Evaluation of Pedestrian Environment

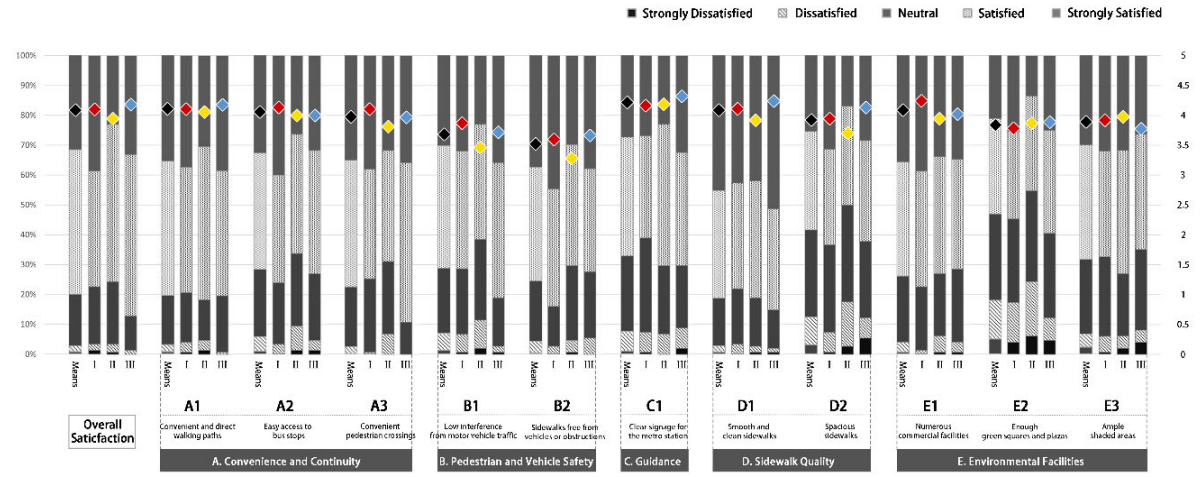

Figure 3: The satisfaction evaluation of pedestrian environment dominated by different functions

Based on respondents' overall satisfaction with the pedestrian environment around station areas (Figure 3), the average score is 4.08, indicating a generally high level of satisfaction with the pedestrian environment around the case study stations. From the perspective of the performance dimensions of the pedestrian environment, the rank is that "C: Signage and guidance" (4.24) > "A: Convenience and continuity" (4.05) > "D: Sidewalk quality" (4.02) > "E: Environmental facilities" (3.94) > "B: Pedestrian safety" (3.60). Among the individual indicators, "C1: Clear metro station signage" has the highest satisfaction score (4.24), while "B2: Sidewalks free from vehicles or obstructions" has the lowest satisfaction score (3.51), indicating that illegal occupation of sidewalks by non-motorized vehicles, motor vehicles, and other facilities affects the smooth passage of pedestrians around the stations.

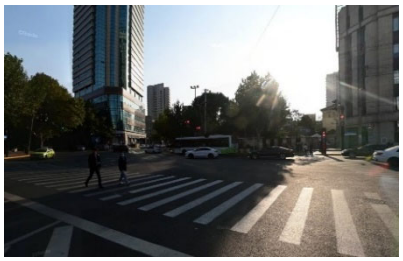

Figure 4:
Problem of intersection crossing (A2) around residential type (Station Code ：II-2)



Figure 5:
Problem of walking path width (D2) around residential type (Station Code ：II-1)



Figure 6:
Problem of vehicle interference (B1) around residential type (Station Code ：II-3)

Further comparison of the satisfaction indicators for the pedestrian environment in station areas with different functional types reveals that residential stations have the lowest overall satisfaction (3.94) and generally lower satisfaction across various performance dimensions. Pedestrians rate "A:

Convenience and continuity", "B: Pedestrian safety", and "D: Sidewalk quality" relatively low (Figures 4-6). However, some individual indicators, such as "E2: Numerous green spaces along the road" and "E3: Ample shaded areas" are rated higher than average, indicating that the construction of recreational facilities in the pedestrian environment around residential dominant stations is relatively complete. Office stations have the highest overall satisfaction (4.19), with generally high individual satisfaction scores, although "A2: Easy access to bus stops", "E1: Numerous commercial facilities along the road", and "E3: Ample shaded areas" are below average (Figures 7-8). Commercial stations have slightly above-average overall satisfaction (4.11), with individual satisfaction scores fluctuating around the average, and all elements are rated well.



Figure 7:
Lack of commercial facilities (E1) around office type (Station Code ：III-3)



Figure 8:
Lack of shade space (E3) around office type (Station Code ：III-2)

Differences in Satisfaction of Stations with Different Functional Types

Table 4: One-way Anova Analysis of Different Functional Station

Dimension	Code	Element	F
	—	Overall Satisfaction	3.792*
Convenience and Continuity	A1	Convenient and direct walking paths	
	A2	Easy access to bus stops	
	A3	Convenient pedestrian crossings	4.526*
Pedestrian and Vehicle Safety	B1	Low interference from motor vehicle traffic	5.483**
	B2	Sidewalks free from vehicles or obstructions	5.067**
Signage and Guidance	C1	Clear signage for the metro station	
Sidewalk Quality	D1	Smooth and clean sidewalks	5.814**
	D2	Spacious sidewalks	7.944**
Environmental Facilities	E1	Numerous commercial facilities along the road	5.341**
	E2	Enough green spaces and plazas along the road	
	E3	Ample shaded areas along the road	

Note: The significance test value of ** is less than 0.01, and the significance test value of * is less than 0.05.

Using the One-way ANOVA method, the between-group and within-group variances of each influencing factor for the three types of functional stations were calculated. This quantified whether the differences in observed variables (satisfaction with various indicators) were due to random errors or controlled variables (station functional types), thereby identifying the influencing factors of pedestrian environment satisfaction (Table 4). The results indicate that under the null hypothesis of

no difference in overall pedestrian environment satisfaction among the functional types of stations, the significance level P-value is less than 0.05, meaning there are significant differences in overall pedestrian environment satisfaction among pedestrians at different functional types of stations.

Among the individual indicators, at the significance level of $P < 0.01$, there are significant differences in pedestrian satisfaction among different functional types of stations regarding "B1: Low interference from motor vehicle traffic", "B2: Sidewalks free from vehicles or obstructions", "D1: Sidewalks smooth and clean", "D2: Spacious Sidewalks", and "E1: Numerous commercial facilities along the road." Among these, "D2: Spacious sidewalks" has the highest F-value (7.944). Combined with the demand analysis in Figure 2 and the satisfaction evaluation in Figure 3, it is found that there is a correlation between demand and satisfaction of this indicator. Specifically, elements with high demand have relatively low satisfaction scores, indicating that the improvement of "D2: Spacious sidewalks" should be prioritized in the pedestrian environment around residential stations. For the remaining four indicators, the satisfaction scores for residential types are lower than those for other dominant functional types, indicating that these are the primary reasons for the lowest overall satisfaction in residential types and are important factors affecting overall pedestrian environment satisfaction.

Additionally, "A1: Convenient and direct walking paths" has the smallest F-value (0.670). In Figure 2, it is shown that the demand for this indicator is very high in the areas surrounding office-dominant functional stations, while in Figure 3, the satisfaction is higher than that of other types of stations. This indicates that the construction of the pedestrian environment in terms of "A1: Convenient and direct walking paths" performs well in Shanghai, with little room for optimization, and can be considered for slower improvement.

CONCLUSIONS AND DISCUSSIONS

Based on the empirical research of pedestrian demand and satisfaction in 15 metro station areas in downtown Shanghai, this study finds that the overall evaluation of the pedestrian environment around metro stations results from the aggregation and reorganization of different aspects of pedestrian environment perception, but it is more closely related to the functional types of the stations. Key factors influencing overall satisfaction include low motor vehicle traffic interference (B1), sidewalks free from vehicle or facility obstructions (B2), clean and smooth sidewalks (D1), spacious sidewalks (D2), and numerous commercial facilities along the road (E1). This suggests that a safe and continuous pedestrian environment, spacious and smooth sidewalks, and a variety of street-level commercial establishments all contribute to enhancing the overall pedestrian environment of metro stations.

From the survey results, it is evident that residential dominant stations face significant pedestrian environment issues that need to be prioritized by the government and relevant departments in urban planning and management. On one hand, the road rights distribution around residential stations often prioritizes vehicles, leading to problems such as insufficient sidewalk width and pedestrian-vehicle traffic accidents. On the other hand, the residential population around these stations has diverse characteristics in terms of age, health, and occupation, which may result in different needs for the pedestrian environment. It should be noted that commercial and office-dominant station areas also have their own pedestrian environment issues to varying degrees, which need to be addressed by

considering the pedestrian environment needs specific to different functional types, and adopting a multi-faceted and multi-level approach to achieve overall environmental quality improvements.

Advice for stations dominated by residential function

Typically located in densely populated areas, these stations have a high demand for pedestrian space. It is necessary to rationally adjust the distribution of road rights to ensure a safe and spacious pedestrian environment and reduce vehicle interference. Additionally, the diverse characteristics of the residential population—reflected in age, occupation, and family structure—mean that inclusive design for the pedestrian environment is also important. Accessibility features should be improved, unnecessary steps or height differences should be minimized, and road surfaces should be kept smooth. Furthermore, a safe and well-equipped activity space and various service facilities should be provided, particularly considering amenities for the elderly, such as fitness and rest facilities, and children's play areas, to enhance the walking experience for different users.

Advice for stations dominated by office function

The population around these stations primarily consists of working professionals in their young and middle years, who have a fixed walking pattern during weekdays, with peak times in the morning and evening. Due to high work pressure and time constraints, they require a convenient and accessible pedestrian environment. Based on this survey's conclusions, there are common issues in such areas related to convenient access to bus stops (A2), commercial facilities along the route (E1), and shaded areas along the route (E3). These issues need to be addressed by considering convenient transfers between various transportation modes and providing a more comfortable walking environment through appropriate urban greening, architectural design, and road layout.

Advice for stations dominated by commercial function

These stations are typically well-connected and emphasize the convenience and diversity of commercial facilities, attracting a large number of shoppers and tourists. The characteristics of the crowd are dense and varied, including local residents and visitors. As the population is not fixed and may include many first-time visitors, improving the signage system (C) should be a primary focus to assist pedestrians who are unfamiliar with the area. Additionally, the surrounding areas of comprehensive stations should be designed with a focus on commercial characteristics, incorporating commercial facilities, cultural facilities, and recreational spaces into the pedestrian environment, such as cafes, small shops, and public art spaces. Adding artistic elements and distinctive pavings can enhance the artistic effect of the station area, boost the attractiveness and vitality of commercial activities, and promote the prosperity of the commercial district

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Research on the organization and performance of motor traffic in hub-type railway station areas of China

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ABSTRACT

In the past decade, large railway stations have emerged in urban areas with the rapid development of high-speed railways in China, significantly impacting urban form and transportation patterns of surrounding areas due to their scale and functions. The construction of large railway stations, in particular, alters the block scale of the surrounding areas and introduces substantial traffic flows, often leading to these areas becoming traffic bottlenecks within urban regions. Consequently, the in-depth analysis of traffic problem in the hub-type railway station areas has become a crucial issue, including their types, causes, and the strategies of improvement. This study focused on 84 hub-type railway station areas in China, investigating the characteristics of station-area traffic through spatial organization and traffic flow configuration. This paper proposed a classification method for the traffic organization around hub-type railway station areas. Then, the study analyzed traffic performance indicators at three scales: within the station, station area, and the urban context. By quantitative analysis, the research summarized the traffic performance characteristics of station areas with different types of organization. The results of this study revealed that block morphology and scale significantly influence the traffic performance within the station area. In conclusion, this research identified the causes of traffic problems, and suggested traffic improvement strategies tailored to different organization types.

Keywords: Railway station area; traffic organization; traffic performance

INTRODUCTION

As railways have developed as a medium- to long-distance transportation mode, research on the planning and construction of railway stations began to emerge at the end of the last century, with a marked increase in studies after 2000. Foundational theories on the urban spatial development of station areas have also continuously emerged, including Urban Catalysts, Smart Growth, Transit-Oriented Development (TOD), and Holistic Design on Urban Architecture (Gui, 2018). Under the guidance of these foundational theories, scholars from various countries, in light of their national contexts, have conducted extensive research on the urban development of station areas.

Since the beginning of the 21st century, Chinese scholars have also, based on the country's specific circumstances, conducted numerous studies on the urban development of railway station areas. During the early stages of the development of China's high-speed rail network, researchers proposed the "Node-Place" model and used it to study the development of railway station areas in China. The studies suggested that these hubs will become new key nodes in national spatial policy, and the transportation node value and urban functional value of these hubs should be considered together. Both values have marginal effects and require balanced development (Zheng and Du, 2007). Following the rapid expansion of the railway network after 2008, issues surrounding the urban development of station areas have drawn more attention from scholars. During this period, station areas have increasingly been regarded as integrated entities, with spatial issues dissected into three interconnected levels: surfaces, lines, and points, all of which must function together (Gui, 2018). The mechanism by which station-city integration promotes urban development has also become a major focus of research, encompassing areas such as passenger flow forecasting models, optimization techniques for connecting transport systems, commercial development models, and collaborative management mechanisms under the station-city synergy framework. These studies have contributed to forming a comprehensive set of organizational methods for station area of high-speed railways (Zhou, 2021).

In response to the challenges facing the urban development of railway station areas in China, relevant studies have also reflected on the station-city synergy development and compared domestic and international development models, offering recommendations for domestic station-city synergy. These studies have put forward views such as "diversified travel purposes and demands," "significant differences in time and cost sensitivity among different passenger groups," and "station-city synergy is not synonymous with TOD." They argued that the current main issue facing station-city synergy was the relatively weak demand for "the station as a destination." (Li, 2022).

Traffic issues in station areas primarily involve the disciplines of traffic engineering and urban planning. Both disciplines have conducted research on topics such as traffic demand, characteristics, configuration, and efficiency within station areas, though their research methods and objectives vary.

Traffic engineering research on internal station area traffic can be divided into studies on traffic demand and traffic characteristics. The former includes various types of traffic flows such as pedestrians and vehicles, while the latter focuses on the organizational characteristics of different traffic elements within the station area. Studies on traffic demand start with analyzing passenger flow and activity characteristics, proposing optimization strategies for spatial organization in station areas that meet the needs of travelers (Kang, et al., 2019; Sun, et al., 2012). Research on traffic characteristics, on the other hand, aims to study layout and capacity calculation methods for station area components such as station forecourts, bus terminals, and taxi stands. Some scholars also use analysis tools like VISSIM and space syntax to model and simulate station area traffic spaces, with the simulation results providing quantitative reflections of existing problems in the station area traffic space.(Li, 2018; Fu, et al., 2009)

Since the traffic organization within station areas often impacts the traffic pattern of an entire district or even a metropolitan area, in addition to the internal traffic issues, the connectivity of station area traffic has become a key research topic. In the early stages of China's high-speed rail development, some scholars attempted to establish predictive models for passenger transfer demand and focused

on evaluating the connection between railways and urban transit systems (Zhang, 2006). As China's high-speed rail network matured, the research became more segmented and in-depth, and the ring-layer model began to be widely accepted as a spatial model in railway station research (Niu and Wang, 2016).

Research in the field of urban planning, on the other hand, has focused more on the spatial ontology of station area traffic organization, particularly on the characteristics of spatial ontology and how to organize station areas within the context of rapid high-speed rail development. In the early stages, scholars in the field of urban planning were concerned with clarifying the relationships between the complex functional spaces within high-speed rail hubs and designing station spaces that would be sustainable for China's long-term railway planning. As China's high-speed rail network and station development matured, there was an increase in case studies and analyses of station areas. Scholars have classified China's high-speed rail stations according to spatial form and scale, with a consensus emerging on dividing the development of these stations into four eras. (Sheng, 2019)

Evaluation studies on station and station areas have focused more on quantitative evaluation methods, establishing indicator models to evaluate space performance, vitality, and sustainability. Depending on the research direction and objectives, scholars have used different methods to build evaluation models. Based on existing research results, we can summarize several primary objectives of station area space evaluation: space performance, space vitality, and transportation connectivity. The "Node-Place" model, a significant model in this research area, suggests that the node and place characteristics of station areas should be adjusted according to factors such as the geographic location and traffic characteristics of the cities where they are located. Achieving a balanced state among these factors represents an ideal development model for railway station areas (Yang and Zhuang, 2023).

This study attempts to address railway station traffic issues from a "configuration" perspective. First, it quantitatively analyzes the current traffic configuration types in station areas across China to clarify spatial characteristics. Then, using open online map traffic data, the study analyzes station area traffic performance. The research seeks to answer the question: "What types of configurations can achieve better vehicular traffic performance in station areas?" and proposes strategies for future station area traffic design and optimization.

RESEARCH OBJECT AND DATA SOURCE

Research Objects

This study classified railway stations in Chinese cities into four categories based on traffic and functional characteristics: traffic node type, traffic hub type, specific function area type, and public activity area type. The focus of this study is on the traffic organization and efficiency of traffic hub type railway stations. These stations serve as important nodes for urban and intercity traffic conversion, often at the intersections of two or more main railway lines, and frequently handle multiple other transportation modes such as highway, air, and water transport. These station areas feature complex functions and traffic characteristics. In selecting research objects, this study first filtered out cities by grade, selecting 41 provincial capitals and major non-provincial capital cities. For each city, data on railway line configurations and public transport facilities were collected and filtered, ultimately identifying 84 traffic hub-type railway passenger stations as the research objects.

Station	City	City Tier	Platform (Line)	Station	City	City Tier	Platform (Line)	Station	City	City Tier	Platform (Line)
Hongqiao	Shanghai	Tier 1	16 (30)	Xi'an N	Xi'an	New Tier 1	18 (34)	Dalian N	Dalian	Tier 2	10 (20)
Shanghai	Shanghai	Tier 1	7 (15)	Xi'an E	Xi'an	New Tier 1	3 (7)	Suzhou	Suzhou	New Tier 1	7 (16)
Shanghai N	Shanghai	Tier 1	6 (13)	Hangzhou	Hangzhou	New Tier 1	5 (14)	Suzhou N	Suzhou	New Tier 1	2 (6)
Beijing	Beijing	Tier 1	14 (16)	Hangzhou S	Hangzhou	New Tier 1	7 (21)	Suzhou Campus	Suzhou	New Tier 1	2 (4)
Beijing W	Beijing	Tier 1	18 (20)	Hangzhou E	Hangzhou	New Tier 1	15 (30)	Ningbo	Ningbo	New Tier 1	8 (16)
Beijing S	Beijing	Tier 1	13 (24)	Hangzhou W	Hangzhou	New Tier 1	11 (20)	Fuzhou	Fuzhou	Tier 2	7 (14)
Guangzhou E	Guangzhou	Tier 1	7 (14)	Foshan	Foshan	Tier 2	2 (5)	Fuzhou S	Fuzhou	Tier 2	15 (30)
Guangzhou S	Guangzhou	Tier 1	15 (28)	Foshan W	Foshan	Tier 2	10 (23)	Xiamen	Xiamen	Tier 2	5 (9)
Guangzhou	Guangzhou	Tier 1	4 (7)	Nanjing	Nanjing	New Tier 1	8 (16)	Xiamen N	Xiamen	Tier 2	13 (27)
Shenzhen	Shenzhen	Tier 1	4 (8)	Nanjing S	Nanjing	New Tier 1	15 (28)	Hefei	Hefei	New Tier 1	5 (12)
Shenzhen N	Shenzhen	Tier 1	11 (20)	Shenyang	Shenyang	Tier 2	10 (19)	Hefei S	Hefei	New Tier 1	12 (26)
Futian	Shenzhen	Tier 1	4 (8)	Shenyang N	Shenyang	Tier 2	8 (16)	Wuxi	Wuxi	New Tier 1	7 (12)
Chongqing N	Chongqing	New Tier 1	14 (29)	Qingdao	Qingdao	New Tier 1	6 (10)	Wuxi E	Wuxi	New Tier 1	2 (6)
Chongqing W	Chongqing	New Tier 1	15 (31)	Qingdao N	Qingdao	New Tier 1	14 (18)	Shijiazhuang	Shijiazhuang	Tier 2	13 (30)
Shapinba	Chongqing	New Tier 1	4 (9)	Qingdao W	Qingdao	New Tier 1	4 (11)	Taiyuan	Taiyuan	Tier 2	5 (12)
Chengdu	Chengdu	New Tier 1	6 (12)	Jinan	Jinan	Tier 2	7 (10)	Hohhot	Hohhot	Tier 3	4 (20)
Chengdu E	Chengdu	New Tier 1	14 (26)	Jinan E	Jinan	Tier 2	13 (27)	Changchun	Changchun	Tier 2	9 (16)
Tianjin	Tianjin	New Tier 1	10 (18)	Jinan W	Jinan	Tier 2	8 (17)	Nanchang	Nanchang	Tier 2	7 (16)
Tianjin W	Tianjin	New Tier 1	13 (26)	Changsha	Changsha	New Tier 1	7 (16)	Urumqi	Urumchi	Tier 3	9 (18)
Tianjin S	Tianjin	New Tier 1	2 (6)	Changsha S	Changsha	New Tier 1	13 (28)	Nanning	Nanning	Tier 2	7 (13)
Binhai	Tianjin	New Tier 1	3 (6)	Harbin	Harbin	Tier 2	8 (14)	Haikou	Haikou	Tier 3	5 (9)
Wuhan	Wuhan	New Tier 1	11 (20)	Harbin E	Harbin	Tier 2	3 (12)	Guiyang	Guiyang	Tier 2	6 (10)
Wuchang	Wuhan	New Tier 1	5 (12)	Zhengzhou	Zhengzhou	New Tier 1	7 (13)	Guiyang N	Guiyang	Tier 2	15 (32)
Hankou	Wuhan	New Tier 1	10 (20)	Zhengzhou W	Zhengzhou	New Tier 1	16 (32)	Lhasa	Lhasa	Tier 4	6 (10)
Dongguan	Dongguan	New Tier 1	3 (8)	Hangkong Gang	Zhengzhou	New Tier 1	16 (32)	Xining	Xining	Tier 4	9 (21)
Humen	Dongguan	New Tier 1	2 (6)	Kunming	Kunming	Tier 2	9 (14)	Lanzhou	Lanzhou	Tier 2	6 (12)
Dongguan E	Dongguan	New Tier 1	3 (8)	Kunming S	Kunming	Tier 2	16 (30)	Lanzhou W	Lanzhou	Tier 2	13 (28)
Xi'an	Xi'an	New Tier 1	9 (18)	Dalian	Dalian	Tier 2	5 (9)	Yinchuan	Yinchuan	Tier 3	7 (15)

Table 1. List of Stations selected in this research

Data Sources

To conduct a study on the spatial morphology and traffic performance of railway stations, we acquired relevant data for each station area from open data platforms. The study area was defined as a core study area with rectangular regions measuring 2 kilometers diagonally . Building outlines and road network information within the study area were obtained from the OpenStreetMap website. Due to potential data delays on this platform, the latest satellite imagery of the station areas was also sourced from Google Maps, alongside road network information, to serve as the foundational geographic data for this research.

In addition to examining the urban morphology and spatial organization of station areas, this study also focuses on the efficiency of motor traffic under different spatial configurations. Accordingly, we collected real-time traffic data for the station areas and their surrounding areas at different times. This data was sourced from the Area Traffic Query Application Programming Interface (API) provided by the Baidu Maps Open Platform. The API service offers real-time traffic information for areas with a maximum diagonal length of 2 km, including overall traffic conditions, names of congested segments, lengths of congested segments, and average vehicle speeds on these segments. This information enables us to calculate congestion index.

The core study area was defined as a rectangular zone with a diagonal length of 2 km centered on each station. Additionally, the extended study area was expanded to a rectangular zone with a diagonal length of 6 km centered on the station. This supplementary area includes eight 1-square-kilometer grid zones surrounding the primary study area. By obtaining time-based traffic condition data for the nine grid zones of each station, we can assess and analyze the traffic efficiency of the station areas.

ORGANIZATION OF MOTOR TRAFFIC

The spatial organization of station-area motor traffic represents the tangible structural configuration that accommodates transportation, while the urban motor traffic mix serves as the functional element

configuration that engages with the traffic system. In this study, these two components collectively form the framework of motor traffic configuration.

Organization of Space

The history of station area (generation of China railway stations)

The development of China's railways can be traced back to the early 20th century. In the early stages, railway stations did not distinguish clearly between passenger and freight services, often providing a single railway transport function and typically adopting a side platform layout (where the railway lines and waiting areas are on the same level). The early Dalian Railway Station is a typical example of this. Since the 1980s, China has gradually implemented a separation of passenger and freight services, leading to the specialized definition of "railway passenger station." From this stage onward, the design of railway stations began to focus on passenger experience and needs.

The Shanghai Railway Station, completed in 1987, represents a new type of railway passenger station. It was the first to adopt a "north-south entry, elevated waiting" format and constructed dual-level motor vehicle circulation routes, both on the ground and underground, enhancing the efficiency of passenger flow at the station as an urban transportation hub. Since 2008, with China entering the "high-speed railway era," the organization of motor traffic at railway passenger stations has become increasingly complex and more focused on circulation efficiency. The main factors driving these changes include the following:

Rapid Increase in Passenger Volume: China's railway passenger volume increased from 1.46 billion in 2008 to 3.66 billion in 2019, a 2.5-fold increase. The passenger volume growth at central stations in first-tier cities has been even more rapid. For example, Beijing West Railway Station saw its passenger volume in 2016 reach 3.7 times that of ten years earlier. Station areas have increasingly borne the heavy burden of passenger circulation.

Diversification of Urban Transfer Demands: Over the past two decades, the development of urban public transportation in China has accelerated continuously. By 2018, the operating mileage of subway in China had reached 5581.6 kilometers. Subway, as a transition between urban and intercity transportation, has played a crucial role in connecting cities and railway hubs. However, with the construction of subway, many railway stations have undergone expansion and renovation of their underground spaces. The emergence of new transportation modes such as trams, ride-hailing services, and maglev trains has also made the organization of motor traffic at railway stations increasingly complex.

Emergence of Station-City Integration Demands: On one hand, the development of urban planning theories has emphasized the connection between transportation spaces and surrounding urban functions. On the other hand, with the rapid expansion of Chinese cities, railway stations originally located in suburban areas have gradually become surrounded by urban built-up areas. The combination of urban traffic and access traffic for passenger pick-up and drop-off in station areas has pushed the hierarchy of motor traffic networks in these areas to continuously increase.

In summary, the diversity of transfer modes, emphasis on circulation efficiency, and the diversification of traffic demands have become important characteristics of the motor traffic organization at contemporary traffic hub-type railway stations.

The influence to nearby the "giga-scale" railway stations

Over the past few years, the construction of large railway stations in China has significantly altered the regional dynamics of their surrounding areas, leading to changes in urban form, urban functions, and traffic organization. In many cases, a previously open urban block has been transformed into a closed precinct, often served by urban expressways, fundamentally changing the existing urban fabric. The roads within these station precincts are typically designed to cater exclusively to the traffic demands of the station, often neglecting the transportation needs of local residents. This can result in increased traffic pressure, and in cases where traffic organization is poorly managed, the station area may become an "isolated entity" within the urban context.

By comparing satellite images and urban data of several typical railway stations before and after their construction, we have identified the following impacts on the surrounding urban areas:

Significant Changes in Block Scale and Increased Difficulty in Block Permeability: On one hand, railway platforms, stations, and forecourts need to accommodate passenger flow and allow for future expansion. On the other hand, domestic railway stations in China are subject to strict security measures, including dual-ticket checks, which prevent the possibility of “walk-through” access. Consequently, stations are often equipped with large-scale waiting halls. These factors combine to create urban blocks that are significantly larger than the surrounding areas, with many facilities being enclosed, thereby limiting pedestrian and vehicular permeability across the block.

Complex Traffic Networks and Increased Traffic Pressure: A comparison of urban traffic networks before and after the construction of railway stations reveals an overlap of arrival/departure traffic and through-traffic, as well as a mix of private cars, taxis and buses. This overlapping of traffic flows not only complicates the traffic network but also necessitates the allocation of more space within the station precinct to accommodate the various types of vehicles, thereby increasing overall traffic pressure.

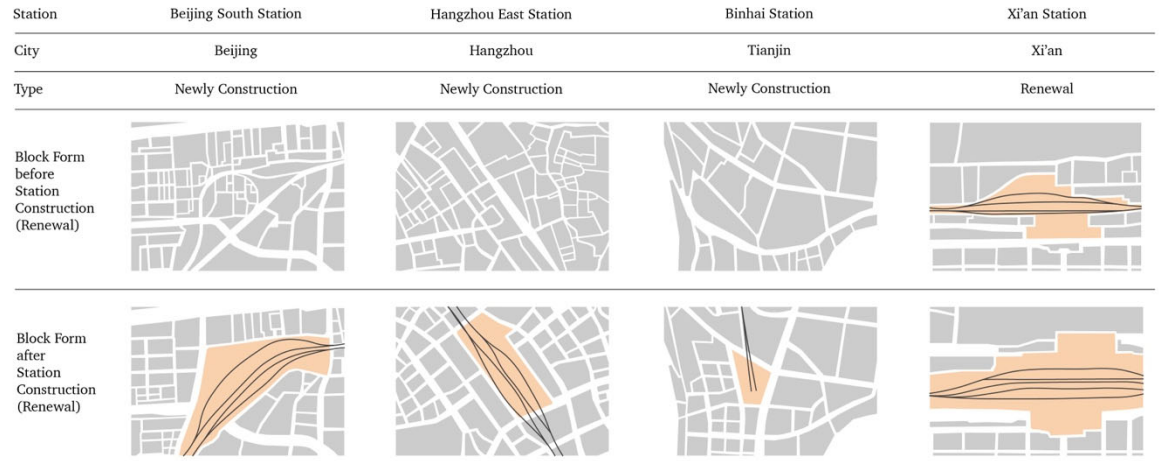

Figure 1. A comparison of the urban morphology in the areas surrounding four typical stations before and after the construction of the station

The spatial organization of motor traffic in the station areas

First, we define the concept of station-area motor traffic organization configuration. This refers to the spatial organization pattern of motor traffic roads within a specific area surrounding a railway station. The configuration of station-area motor traffic reflects the unique urban spatial morphology of the station area. The primary function of motor traffic in the station area is to facilitate passenger arrivals, departures, and transfers, while also accommodating the city's through traffic. Through observation, it has been found that most stations separate station-bound traffic from city through-traffic on urban roads at a certain distance from the drop-off platform. This separation occurs within a designated block area, forming dedicated roads within the station area. In this study, we refer to such block areas as "station-area motor traffic units." City through-traffic is typically routed onto urban expressways, passing through the periphery of the station area without overlapping with the internal station-area traffic.

The internal organization and scale of station-area motor traffic units are key factors in our configuration research. The internal organization reflects the different urban morphologies of station areas. Typological research on organization methods aids in understanding the spatial forms of station-area traffic. We categorize the motor traffic organization methods in station areas into four types:

Adjacent Type (Surface/Elevated): The adjacent type refers to a configuration where the drop-off platform and the station entrance/exit are seamlessly connected. The station square and entrance/exit are located on either side of the drop-off platform, with parking lots and taxi stands located adjacent to the station building. A typical example is Wuhan Station.

Remote Type (Surface/Elevated): The remote type describes a configuration where the drop-off platform and station entrance/exit are separated by a certain distance. This often results from a restricted area in the station plaza located between the drop-off zone and the station entrance, preventing seamless connection between the station hall and the drop-off zone. A typical example is Hankou Station.

Interleaved Type: The interleaved type is a traffic organization method adopted by many newly constructed large railway stations. In traditional railway stations, the access roads and drop-off areas are aligned parallel to the tracks, with no roads crossing the tracks. However, in the interleaved type, the drop-off platform is arranged perpendicular to the tracks, and the access roads cross the tracks. A typical example is Beijing South Station.

Hybrid Type: The hybrid type often includes two or more of the above-mentioned organization methods. Some stations employ different strategies on either side of the station for organizing ingress and egress traffic, resulting in a hybrid traffic configuration. A typical example is Shanghai Station.

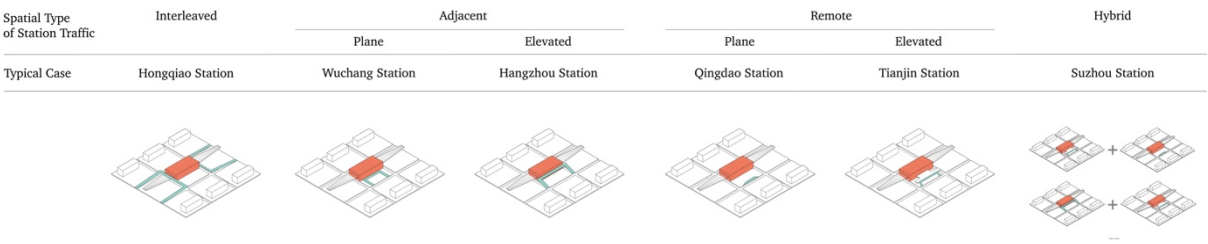

Figure 2. Four types of station-area traffic configuration

Traffic share

The spatial configuration of motor traffic in the station area serves as the physical structure that accommodates traffic flow. Another factor influencing the traffic performance in the station area is the share of motor traffic among all traffic modes. Before conducting data analysis, we hypothesize that cities with a higher motor traffic share will have more railway passengers choosing to travel to or from the railway station by car, which in turn increases the traffic pressure within the station area.

In this study, we use the modal share of public transport, non-motor transport, and private cars as our research data to represent the motor traffic share configuration in the cities where the stations are located.

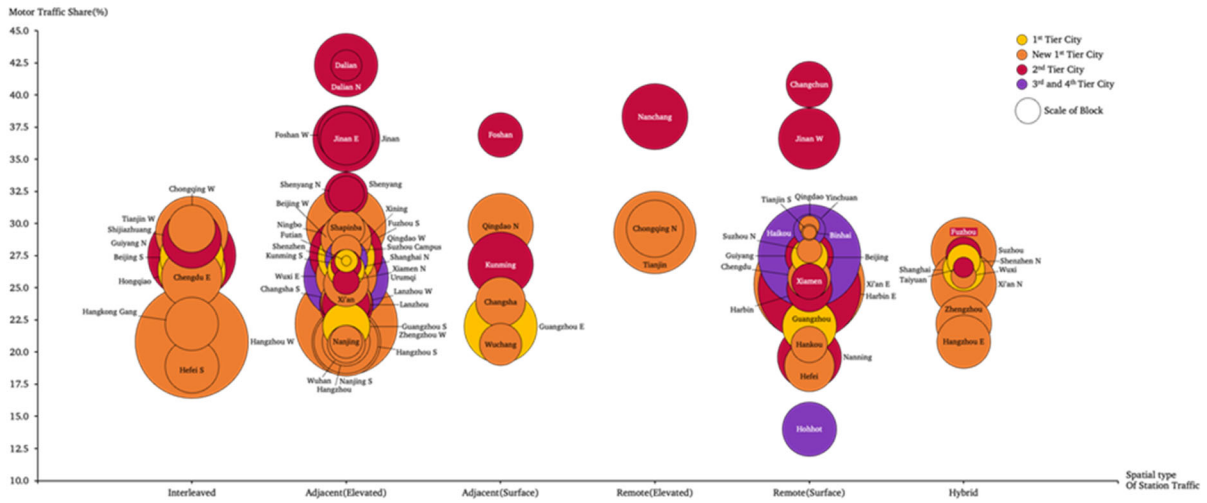

Figure 3. Spatial organization, Traffic share and Scale of block of 84 selected stations

From a spatial organization perspective, among the stations we studied, the Adjacent Type (Elevated) configuration is the most prevalent, accounting for 39.3% of the cases. This mode, where elevated roads lead directly to the station platforms, has become the most mainstream organization model for

station-area motor traffic. The next most common configuration is the Remote Type (Surface), representing 26.2% of the cases. This type is often found in railway hubs built before the high-speed rail era, where large station squares were designed between the station roadways and the station halls to accommodate crowd dispersal needs. Consequently, the roadways are located at a distance from the station entrances and exits.

The scale of the station-area motor traffic units represents the urban area influenced by station-area vehicle flows and the distance from the station to the traffic diversion point between station and city flows. In our study of 84 cases, the average scale of the station-area motor traffic units is 1.43 square kilometers. The smallest is Futian Station, with its unit covering only 0.04 square kilometers, while the largest is Hangzhou West Station, with a unit covering 5.78 square kilometers. First-tier cities, due to land constraints and early station-area developments that have often undergone multiple redevelopment cycles, generally have the smallest average unit scales. In contrast, new first-tier cities, driven by high-speed rail development, have established large railway hubs in suburban areas, resulting in larger traffic unit scales for these hubs.

From the perspective of traffic share configuration, across the 40 cities encompassing the 84 stations, the average motor traffic share is 27.2%. First-tier cities have the lowest average motor traffic share, primarily due to their extensive public transportation networks and higher public transit shares. On the other hand, second-tier cities have the highest average motor traffic share.

PERFORMANCE OF MOTOR TRAFFIC

Ideally, the motor traffic within the station area should efficiently accommodate the inflow and outflow of vehicles related to the station area. We define the capacity of the station area's motor traffic system to handle traffic volume as its performance. When the performance of the station area’s traffic system is inadequate to manage the traffic volume, congestion occurs, indicating that the design performance does not meet the actual demand. To analyze and compare the motor traffic performance of station areas, we gathered real-time traffic data from the Baidu Maps Open Platform across multiple time periods.

To ensure comprehensive and reliable data, we selected several weekdays and weekends, collecting real-time traffic data for the core station area every hour from 8:00 AM to 11:00 PM. The analysis revealed that peak motor traffic periods in station areas differ from the typical "urban rush hour." For many station areas, the peak traffic period occurs between 1:00 PM and 4:00 PM. This is because the traffic volume in these areas is primarily driven by train arrivals and departures. By examining the timetables of various stations, it becomes apparent that the afternoon often marks the peak period for train activity, leading to the highest motor traffic volume of the day.

At certain stations located at the terminal points of the rail network, such as Harbin Station and Guangzhou Station, train arrivals and departures are concentrated during early morning and late evening hours, causing congestion around 11:00 AM and 7:00–8:00 PM. However, the traffic pressure during these times is generally lower compared to the afternoon peak.

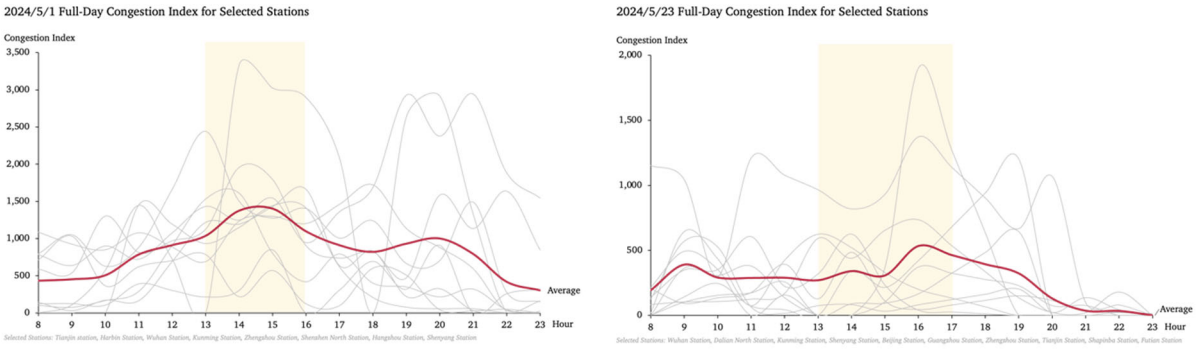

Figure 4. Full-day Congestion Index of selected stations

From a city tier perspective, second-tier city are more prone to experiencing congestion in station areas compared to first-tier and new first-tier cities. In contrast, lower-tier cities (third-tier and below) generally do not experience congestion in station areas.

When comparing the average congestion index between core areas and expanded areas, it is evident that in both first-tier and second-tier cities, the reduction in congestion from the core to the expanded area is minimal, with little difference in average congestion index between these areas. However, in new first-tier cities, congestion decreases more significantly as one moves outward from the core area. This suggests that the impact of station-related congestion in new first-tier cities is relatively limited in scope, exerting less influence on the surrounding urban traffic.

DISCUSSION OF CONGESTION PHENOMENON

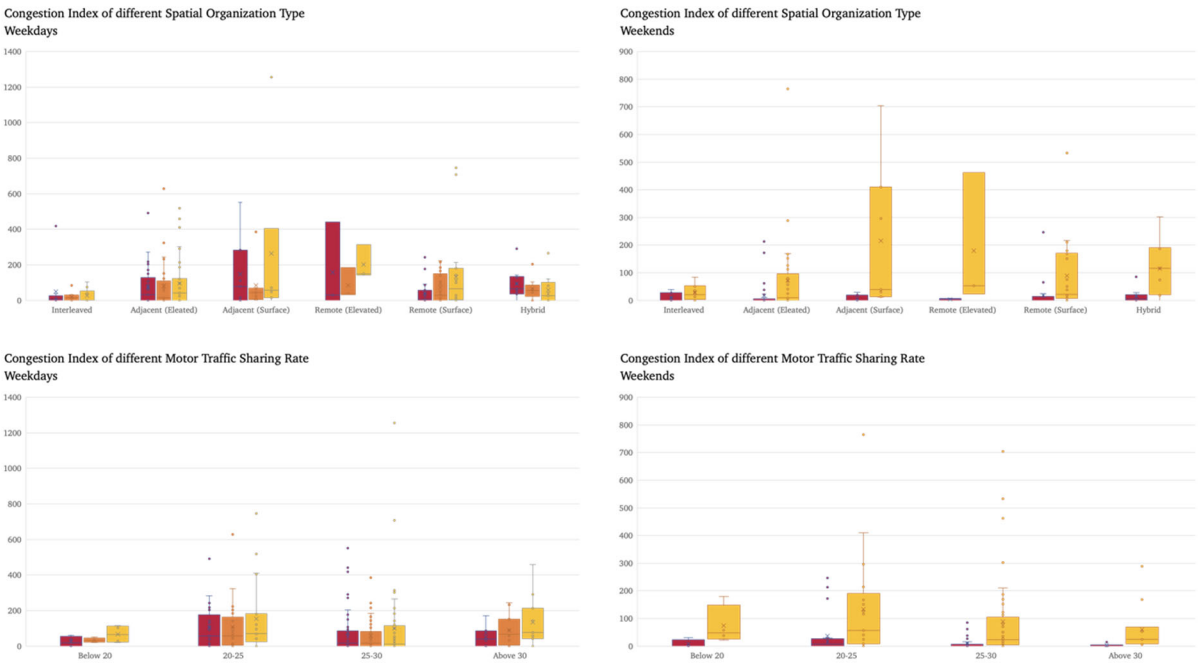

Figure 5. Motor traffic performance under different configurations and different motor traffic share

Performance and Configuration of Station-Area Motor Traffic

In our study, we first divided the congestion data for station-area motor traffic into two groups: weekdays and weekends, to represent the traffic flow characteristics of different time periods. Next, we classified each station into one of the four spatial configuration types identified earlier in the study. By comparing the congestion index of station areas with different spatial configurations, we found

that stations with an Adjacent Type (Surface) configuration exhibited poorer motor traffic performance and were more prone to severe and widespread traffic congestion.

Detailed observation of the traffic conditions in these specific stations revealed that such stations typically organize their forecourt spaces sequentially as square, drop-off platform, and station hall. This layout causes large numbers of pedestrians entering the station from the square to cross the roads in the drop-off platform, reducing the efficiency of motor vehicle passage. Additionally, vehicles dropping off passengers also need to pause in the drop-off platform, further compounding the congestion. The combination of these factors makes stations with this configuration more susceptible to traffic jams. Furthermore, the surface configuration is less effective than the elevated configuration at separating station-area traffic from urban traffic, making it easier for increased station traffic volumes to spread congestion into surrounding areas, leading to more extensive traffic issues.

Among the six types of station-area motor traffic configurations, stations with the Interleaved type configuration showed the best motor traffic performance, with the least likelihood of congestion in the surrounding areas. Observation of real-time traffic conditions in these stations suggests that their superior motor traffic performance can be attributed to two main factors. First, this configuration has been implemented more recently, with some stations only recently completed and operational, meaning they were planned with sufficient capacity reserves. Second, unlike traditional configurations where roadways run parallel to the railway tracks and are located on both sides of the station building, the Interleaved type configuration allows roadways to cross the railway, with drop-off platforms situated above the tracks. This design avoids the isolation effect caused by the railway dividing urban traffic on either side, resulting in smoother traffic dispersal in all directions.

When attempting to analyze the correlation between urban motor traffic share and station-area congestion, we found that the overall correlation was weak. In some cities with a higher motor traffic share, congestion was actually less severe. Upon reviewing the data, we speculate that this result may not be entirely due to motor traffic share alone. Cities with a higher motor traffic share are often lower-tier cities, where overall travel demand and railway passenger volumes are lower, meaning that station areas do not frequently experience high motor traffic pressures.

Distribution characteristics of Station-Area Congestion

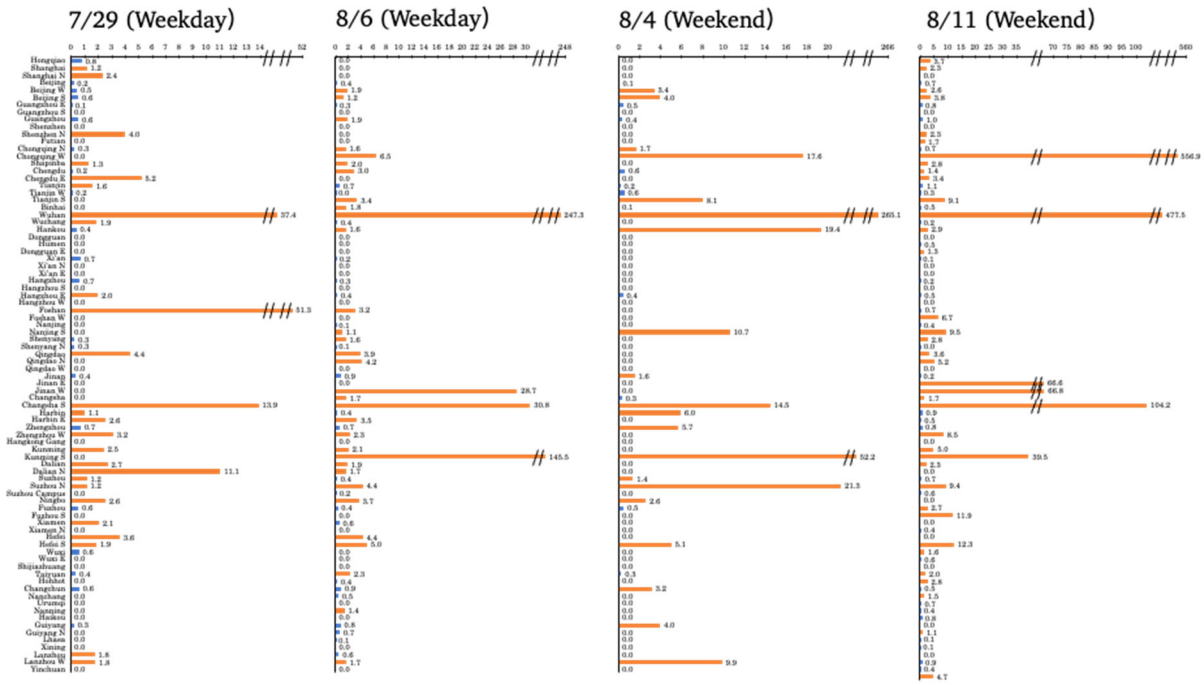

Figure 6. Ratio of congestion Index between core study area and extended study area

In our research, we delineated a core study area (a rectangular region with a 2 km diagonal centered on the station) and an extended study area (a rectangular region with a 6 km diagonal centered on the station). We compared congestion Index between the station's core area and its surrounding area. This comparison helps us further understand whether congestion in the station-area space is primarily due to the station's own low traffic performance or if it originates from the inherent congestion-prone nature of the surrounding urban area. For these two scenarios, we should propose different strategies in future traffic improvement plans.

For stations where congestion in the core area is significantly higher than in the surrounding region, we hypothesize that this congestion is mostly attributable to the station itself. Typical examples include Wuhan Station, Changsha South Station, and Kunming South Station. Improving the motor traffic performance of these stations will require optimizing their internal traffic systems.

Conversely, for stations where congestion levels in the core area are similar to or even lower than those in the surrounding area, it indicates that the broader urban area is already under high traffic pressure. Examples of this include Guangzhou Station, Xi'an Station, and Hangzhou Station. For these stations, enhancing passenger dispersal capacity in the future will likely be constrained by the limited potential to improve the station's motor traffic performance. Therefore, the focus should shift toward developing high-capacity public transit options (such as subways and BRT systems) to reduce the demand for motor vehicles entering and exiting the station area.

CONCLUSIONS

Based on urban traffic big data platforms and open map platforms, this study conducted a comparative analysis of the motor traffic configurations and motor traffic efficiency across 84 railway stations in 41 cities. In the study of motor traffic configurations, we conducted a typological analysis of the spatial organization models of station-area motor traffic and analyzed quantitative information

such as the block scale of the station areas and the motor traffic share of the cities where these stations are located. This allowed us to derive a dataset that encapsulates the characteristics of each station.

In the study of motor traffic performance, we collected and processed real-time traffic data for the 84 stations at different time intervals. By analyzing congestion index, we assessed the gap between the motor traffic performance of the station areas and the actual demand. From this data, we conducted an overall analysis of congestion patterns for stations with different spatial configurations. The findings indicate that interleaved type can enhance traffic performance in station areas and mitigate the barrier effect of railways on the adjacent urban areas. By delineating different study areas, we analyzed the distribution of congestion in station areas and proposed various traffic optimization strategies for different types of stations. For stations that predominantly experience endogenous congestion, improving their performance will require optimizing their internal traffic organization and management models. In contrast, for stations where exogenous congestion is more prevalent, a more developed public transport network will be necessary to alleviate the pressure on motor traffic.

However, this study also has some limitations. First, due to time and data resource constraints, we only obtained real-time traffic congestion data for a limited period. While this data provides a general overview of the traffic conditions in the station areas, more comprehensive real-time traffic data will be needed for more precise research and analysis in future studies. Secondly, the "congestion index" calculated in this study was based on two parameters: the length of congested road segments and the average vehicle speed on these segments. In subsequent research, incorporating additional parameters could yield more accurate results. Finally, there is room for further exploration in improving the traffic performance of station areas. Future work will involve utilizing traffic simulation tools to evaluate the effectiveness of proposed traffic improvement plans.

Through this research on the traffic configurations and performance of station areas, we aim to provide data support and basic conclusions that can inform urban design for station-city synergy, ultimately contributing to the development of high-performance station-area traffic systems that meet the needs of Chinese cities. This research will continue, with two key directions for further deepening in the next phase. First, there will be an effort to obtain a broader range of real-time traffic data to provide stronger data support for the conclusions drawn in the traffic performance section. Second, after completing the analysis of traffic configurations and performance in station areas, the research plans to propose optimized traffic configurations for specific station areas. These optimized designs will be evaluated through traffic simulations to compare their impact on traffic performance. This approach will allow the qualitative and quantitative conclusions derived from this study to be translated into concrete urban design strategies.

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Resilient neighbourhood transformation in Cape Town, South Africa

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ABSTRACT

Urban morphology in Southern African cities reveals expanding, incremental, auto-constructed, and resilient neighbourhood transformation. The study aims to demonstrate peripheral patterns in the changing urban form in Cape Town, South Africa. Local meanings and urban processes are interpreted through a succession of deliberate, engaged and change-orientated design teaching studios, called Studio Hope, and ongoing research in the neighbourhood of Gugulethu. The design research methodology is multi-scalar, practical, affordable, participatory, and relevant to the context. 'Off-grid' data is collected using multiple, innovative ways of discovery and exchange through real and virtual urban walks and urban talks with local agents and youth. Findings plot three patterns of interrelated, underrepresented, yet emerging urban morphology in a local neighbourhood: 1) Incremental expansion and peripheral transformation occurring within and beyond unrecognised, self-built settlements, post-apartheid (neighbourhood/block); 2) Informal urban infill and dynamic change within an established apartheid-built 'township' neighbourhood (block/street); and 3) Urgent, everyday occupation and the flux of urban space (street/plot), including micro urban forms or social infrastructure, such as spaza shops, taverns, hair salons, community gardens, informal markets, public walkways, and waterways. The translation of expanding 'township transformation' enables a deeper understanding of spatial co-production, socio-economic practice, and everyday culture that influence Gugulethu's changing plot, street, block, and neighbourhood. Meaningful interpretation of diverse urban forms guides a working concept of a resilience framework. Design strategies and planning scenarios reveal an approach to urban morphology with purpose, value, and local agency, but also consciously rupture the methods of understanding unhealthy patterns of fragmented and deeply divided spaces inherited from colonial, modernist and apartheid spatial planning.

Keywords: urban transformation, peripheral neighbourhoods, South Africa, emerging network.

INTRODUCTION

Urban morphology in the urban Global South reveals interrelated processes and diverse practices of expanding, incremental, auto-constructed and informal neighbourhood transformation (Arefi, 2011; Caldeira, 2017; Roy, 2011). The rate of urbanisation and rapid, dynamic urban change expose the various spatial patterns and typologies of adaptive and informal built form in African territories. However, the fine-grain and fragile nature of the built urban fabric influenced by socio-cultural practice and the increasing informal density, mix, micro adaptation and rapid increments of change

remain underrepresented and largely undocumented in Southern African cities (Ewing, 2023; Mottelson and Venerandi, 2020).

There is a need to consider the study of the form of settlements over time (Scheer, 2016). Dovey (2012) argues informal morphologies or the forms of informality remain "…under-researched and under-theorised at micro-spatial scales" (p.351). The intention here is to grapple with the complexity of emerging informal neighbourhoods, across sizes, scales, densities and heritages (Larkham, 2022). However, there is an urgency to interpret urban transformation to provide guides to urban upgrading versus the 'slow' and singular approach to measuring the city. We, therefore, require new ways of understanding urban morphology in Southern Africa that are relevant, practical and usable beyond the spatial disciplines. The study aims to explore alternate methods and emerging patterns of peripheral urban form in a township territory, Gugulethu, in Cape Town, South Africa.

Outcomes from ongoing design research and the University of Cape Town's (UCT) Master of Urban Design (MUD) programme's teaching studio, Studio Hope, are translated into lessons on urban morphology to design relevant urban design frameworks and interventions.

Three key findings are gathered from five years of teaching and fifteen years of action research in Gugulethu. First, peripheral transformation within settled auto-constructed informal settlements illustrates the expanding neighbourhood beyond boundaries and town transformation in processes of peripheral urbanisation. Second, incremental, urban infill and dynamic change inserted within formal housing are presented. Third, spontaneous, socio-economic occupation of urban space reveals a fine-grain, adaptable, underestimated, and attached micro-urban form. The micro-morphology shows a distinctive form of local agency where spaces are incomplete or constantly in the process of evolution.

Although not within the scope of this paper, the findings ignite a meaningful interpretation of diverse urban forms that surface a resilience framework. Further, student-led design strategies and planning scenarios show an approach to urban morphology with purpose, value and local agency. A guiding principle is to "rupture" (Scheer, 2013) and deliberately break the unhealthy pattern of apartheid and modernist spatial planning thinking in the South East Cape Metro territory.

The paper is part of a working journal article on urban design pedagogy in the Global South. It presents four interrelated sections. First, the methodology, approach and intentions are briefly described. Second, three key findings on peripheral urban form are presented and interpreted in the context of Gugulethu. This forms the key focus of the paper. Third, reflections on creative student work and ongoing research facilitate an emerging resilience framework to understand urban morphology in the global south. Last, recommendations for further research are discussed in the conclusion. Theoretical perspectives on urban morphology and peripheral urbanisation in the Global South are interwoven throughout the paper.

STUDIO HOPE, GUGLETHU: APPROACH AND METHODOLOGY

Although this paper will not detail a teaching and learning pedagogy per se, nor an overarching research methodology, the focus is on urban form (Scheer, 2016). However, the research and teaching methodology is action-based, multi-scalar, practical, affordable, participatory, and relevant to the emergent southern territory.

In our South African context, a decolonised design studio course curriculum intentionally prepares students to deal with socio-spatial inequality caused by apartheid spatial planning (Dewar, 2019). The research actively engages a transdisciplinary approach through practice, research and teaching.

Studio Hope is a situated pedagogy, grounded in design research. The studio course takes a transformative and collaborative learning framework including urban design and landscape architecture students. The studio is taught over a 12-week series of four progressions from site analysis (to explore), co-design workshops (to disrupt) to design interventions (to transform) and concludes in a summative oral presentation (to represent). A blended approach has been developed that seeks experiential learning, utilising digital tools and active learning activities in the field and the studio.

Deliberate and engaged scholarship (Longo, 2013) forms the foundation for the work. This gives rise to the inclusion of local agents to support a flexible methodology to study urban morphology in a "critical neighbourhood" (McFarlane, 2011; Moreira, 2022) or critical urban form in Cape Town. This has been constant over 5 years of teaching. One of the local agents, Xolile Ndzoyi, has been involved in research since 2015 with the author in practice with the Violence Prevention through Urban Upgrading (VPUU) programme and as a fieldworker on research projects with UCT from 2020. Opening the studio and research to different disciplines, local agents and design practitioners allows multiple voices to be heard and translated. Participants in our studio are encouraged to take authentic responsibility for the co-production of knowledge as an active community of practice (CoP).

Data collection through walks and talks

Spatial data collection is considered a basic form of knowledge to interpret urban form (Scheer, 2016). Basic GIS and aerial photography are gathered from the local municipality. However, conventional methods make 'off-grid' urban data difficult to access. We, therefore, acquire unrecognised, informal or undocumented data using multiple, innovative ways of seeing, being, and knowing. Alongside Google Earth time-lapse maps, historical analysis, and the layering of information, real-time and virtual urban talks and urban walks are conducted. The urban talks include youth exchange co-design workshops and focus group discussions on campus and in the field, with online conversations and digital stories via What's App diaries. Guided urban walks involve strategic and engaged fieldwork combined with virtual site visits via Zoom online and WhatsApp App live and recorded videography, photo stories and context discoveries of place-making in Gugulethu (Ewing, 2022b). A large-scale neighbourhood working model (1:1000) is used yearly to situate Gugulethu as a neighbourhood. Rough, mobile, urban block models (1:500) are developed to allow for quick, participatory approaches for data collection with local agents and rapid interpretation, rather than long and expensive fieldwork. Section models (1:25) investigate streets and public space.



Figure 1. A large-scale neighbourhood model (1:1000) was used to collect data through three co-design workshops with local agents, youth and students in 2022. Cape Town, photo credit: Candice Lowin, 2022



Figure 2. Urban block models (1:500) were used to collect data in a rapid-fire co-design workshop with a local agent, researchers and students in 2024. Cape Town, photo credit: Kathryn Ewing, 2024

Pattern recognition and local agency

A local archive and e-library of 'otherwise invisible' maps have been co-produced over the years which guide pattern recognition. Digital GIS information has been used on open-source QGIS and geo-located AutoCAD drawings for group sharing. Services, streets, housing and urban economic space typologies are labelled as specific layers. Each year students add to the 'base layers' and find emerging patterns dependent on the areas of investigation or theoretical application.



Figure 3. Creative mapping of cultural practice and everyday practice in Gugulethu, image credit: Lizelle Jackson, MUD, 2024

Photo stories of ordinary places from local agents and author research since 2010 are themed and stored under blue-green infrastructure (waterways and community gardens), informality, including block (urban infill) and street transformation (dwelling interface), social infrastructure (communal taps, toilets, walkways, public space and facilities), and fixed and temporal spaces of exchange (jazz venues, meat markets, hair salons, furniture repair, fruit stalls and so on).

The outcomes from pattern recognition are further 'plotted' onto exploratory social, emotional and memory maps. The drawings reveal the ordinary and everyday urban spaces across the scales (neighbourhood, block, street, plot) in Gugulethu. The processes surface hidden socio-cultural and economic and spatial practices, gendered identities in place-making and spatial transformation.

Towards a theory of change

Current urban scholars note the rising interest in peri-urban spaces in the African context (Buire, 2014; Chirisa and Matamanda, 2019; Mabin et al., 2013; Meth et al., 2021). Buire (2014) notes, "…accelerated urbanisation in Africa has led to an unprecedented variety of urban forms that reach beyond and reconfigure these centre-periphery dualities… and South Africa… shows rapid reconfigurations of their local and regional urban patterns."

The design research and teaching approach purposely infiltrate Southern theory, expanding the conventional vocabulary of urban morphology to deal with the urgent, changing nature of the African urban fabric. The process of the production of space (Lefebvre and Nicholson-Smith, 1991) is reframed through the concept of *peripheral urbanisation* (Caldeira, 2017), combined with concepts from *subaltern* (Roy, 2011), *critical* (McFarlane, 2011) and *incremental urbanisms* where "urban informality produces a range of different morphologies" (Kamalipour and Dovey, 2018).

FINDINGS ON PATTERNS OF PERIPHERAL URBAN FORM: THE CASE OF GUGULETHU

Aligned with Scheer's (2013) viewpoint on the death of the master plan in an era of limited resources and the need for sustainability, the developing design solutions are "utterly dependent on urban morphology" (p.170) as an essential lens to unravel the inner workings of deeply troubled and peripheral cities. However, the combination of working with local agents in plotting critical urban forms, and working through exploratory, co-designed activities and multi-dimensional approaches to informal urban morphologies become more attractive and relatable to younger, 'woke' students engaged in transformation and spatial justice (Soja, 2010). The implications of including themes on social and blue-green infrastructure, informality, everyday culture, safety, and temporality add extra dimensions, upsetting a more scientific measured approach to urban form.

'Expanding': situating the Southern territory of Gugulethu

In the past 30 years, urban neighbourhoods have transformed in South Africa due to mainly, increasing urbanisation, poverty, migration and informality (du Plessis et al., 2015). Extreme territorial violence and inequality continue to impact the quality of life in many low-income areas. At a city scale, the fragmented regions remain embedded in outdated regulations and stubborn, separated urban form inherited from colonial and modernist, apartheid spatial planning (Dewar, 2016). Policy, albeit well-meaning, struggles to shift or implement an appropriate urban form. Informality continues and post-apartheid formal development follows established patterns of socio-economic division. Further, the delivery of basic infrastructure and state housing appears sluggish, restless, and unsuitable to the needs and practice of urban residents.

However, resilient connections and social networks are prevalent, albeit ambiguous at a local neighbourhood, street and micro scale. Dynamic spatial occupation, socio-economic activities and everyday culture are constantly disrupting the landscape through a "silent encroachment" (Bayat, 1997) of urban space, allowing cities to adapt and persist over time (du Plessis et al., 2015). Further, giving local meanings and the ability for urban citizens to participate in a form of peripheral or fractional urbanism (Ewing, 2021) by expanding the city horizontally (sometimes vertically) and filling the gaps in open space.

Gugulethu is a contraction of *igugu lethu*, meaning 'our pride'. Although Gugulethu is centrally located 20 km from the Cape Town central business district, access to resources, infrastructure and services remains economically peripheral. Historically, it was established in 1958 as a black residential area or 'township' on the Cape Flats under apartheid spatial planning through the Group Areas Act of 1950.

The original township or 'suburban' peripheral settlement remains racially divided from the coloured neighbourhood of Manenburg to the west by the Central railway line. To the east, Gugulethu merges seamlessly with Nyanga township, displaying the connection with the original name of Nyanga West. The rapidly evolving Philippi East area, including Siyahlala, Sweet Home and other informal settlements in Browns Farms, lies across Govan Mbeki Road to the south. The N2 national highway separates the Cape Town International Airport and the north of Gugulethu. The peripheral informal settlements of Lotus Park, Waterfront, and Phola Park are situated in the southern portion of Gugulethu with the informal settlements of Barcelona, Kanana, KTC and Europe edging the northern portion of the township.

However, throughout Gugulethu, formal and informal systems are inextricably entangled. Building on the concept of incremental adaptive processes (Kamalipour and Dovey, 2018) and King and Dovey's (2011) typology of informal settlements, the following three findings on expanded patterns of urban form are presented as *settling, inserting* and *attaching (action words)*. In some cases, overlaps are seen as a hybrid mix of many processes and spatial outcomes and are difficult to define as one pattern.

'Settling': urban informality and township transformation (neighbourhood/block)

Auto-constructed or informal settlements illustrate the expanding neighbourhood within and beyond the territory of Gugulethu. The focus of the pattern is on the urban morphologies of spatial evolution, and within informal settlements, "Spatial boundaries are inscribed and erased…" where "Territorialisation is a synthetic process wherein wholes form from parts, identities form differences" (Dovey, 2012, 353). Informality is considered as a site of critical analysis (Banks et al., 2020).

Using aerial photography over 20 years shows a process of 'settling' on underutilised land in the southern portion of Gugulethu including Lotus Park, Waterfront, and Pholla Park Informal Settlements and the more formal housing environment of KwaKhikhi and southwards to Philippi East. The analysis transcends the boundaries of paths and plots and questions the scales of recognition at the neighbourhood scale, including housing typologies, forms of tenure and land occupation.

Settlements are sometimes built on unclaimed land. This results in contested and confusing ownership debates within governance structures, communities and the local municipality and further influences the basic delivery of services and future upgrading possibilities.

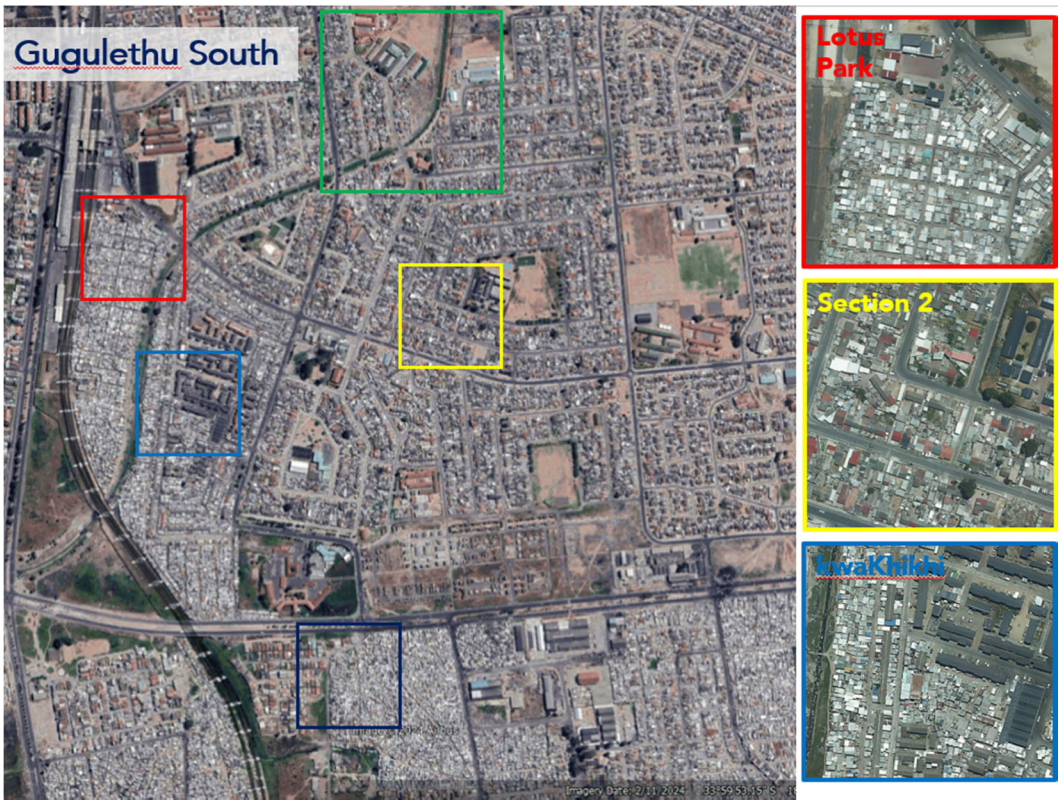

Figure 4. Southern Gugulethu, illustrating the focus areas of Lotus Park (red), Kwakhikhi (bright blue) and Section 2 (yellow) in 2024. The area in green represents a central sports and education precinct adjacent to the Lotus River. The area in dark blue is Siyahlala Informal Settlement in Browns Farm, which is outside of Gugulethu.

The study area zooms in on the informal settlement of Lotus Park. The spatial informal patterns of Lotus Park include detailed data collection of basic services and enumeration of informal dwellings since 2010, as part of the Violence Prevention through Urban Upgrading (VPUU) programme. The Lotus Park case reveals no formalised, individual plots, rather illustrated as a series of urban blocks, defined by shared streets and social and basic infrastructure (sanitation, water and waste collection points). The informal structures are never considered fixed to a plot or completed, sometimes extending into the public street or urban space as an attachment or extension into common space for household gain. The internal space of Lotus Park remains largely constant or settled. Yet, the informal edges have expanded, occupying unclaimed land south and west along the railway line. Physical barriers, such as the railway line and the Lotus River, limit further growth. The ability of the settlement to change and remain settled, yet still unrecognised in the municipality, speaks of adaptive resilience.

Student fieldwork in 2015, 2016 and 2022, mapped and re-mapped the local economic built form (containers, stand-alone structures, markets) and social infrastructure. The data and spatial pattern of land occupation and economic activity have guided the urban design of a spatial reconfiguration plan for incrementally upgrading an informal settlement through a live participatory approach through the VPUU programme. Further mapping of the urban transformation between 2010 and 2020 of a shared public space and community facilities of the VPUU Lotus Park Neighbourhood Centre (NHC) and Oliver Kahn Safe Hub© have developed a public investment framework and design approach to precinct development (Ewing, 2021). Urban imaginations by students build on practice-based work.

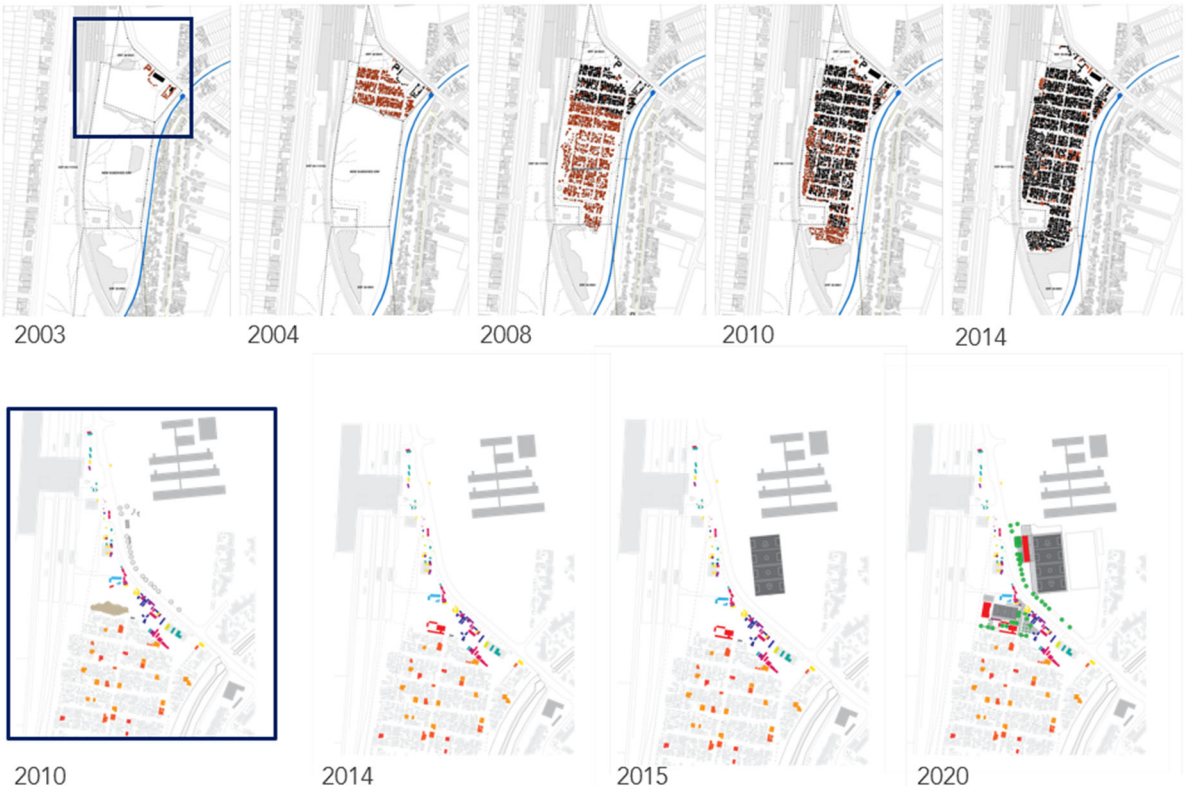

Figure 5. Lotus Park (LP) informal settlement historical expansion from 2003; and the mapping of an urban precinct over 10 years of the LP Neighbourhood Centre and Oliver Khan Safe Hub urban township transformation.

‘Inserting’: Urban infill and plot or housing transformation (block/plot)

Incremental, urban infill and dynamic change inserted within formal housing plots are illustrated within an established apartheid-built township neighbourhood in an area known as Section 2 (the original name given to the Sections in the inception of the township) in the south of Gugulethu. The block-to-street interface and the changing layout of the urban form on the individual recognised formal plot, including undocumented back-yard informal rental housing and front-yard extensions, illustrate a changing urban form to the original brick government semi-detached housing (4 and 2 row-housing typology, each with two rooms and total area of about 50m²).

It is well known that self-constructed, secondary dwellings on formal plots are common in South African townships from previous research and current investigation (Harris et al., 2023). However, there is minimal recorded spatial documentation of plot transformation in internal residential blocks of former black townships such as Gugulethu. The pattern reveals block and plot-by-plot transformation that can inform alternative and recognised forms of suitable mixed-use housing and active street typologies through auto-constructed township transformation.

Backyard spaces are often used for rental accommodation in secondary dwellings, commonly referred to as ‘back-yard shacks’ and more recently, ‘back-yard flats’. These dwellings are rarely inspected for health and safety, nor do they comply with building regulations or have approved building plans. The secondary dwellings may consist of a series of rooms, approximately 25m², built from informal materials. The flats are more stable, masonry double-storey apartment blocks divided into multiple rental flats, some with ablutions adjacent to the room and some with communal shared services in the back yard. They are generally inserted onto the edge and back of the 250m² plot.

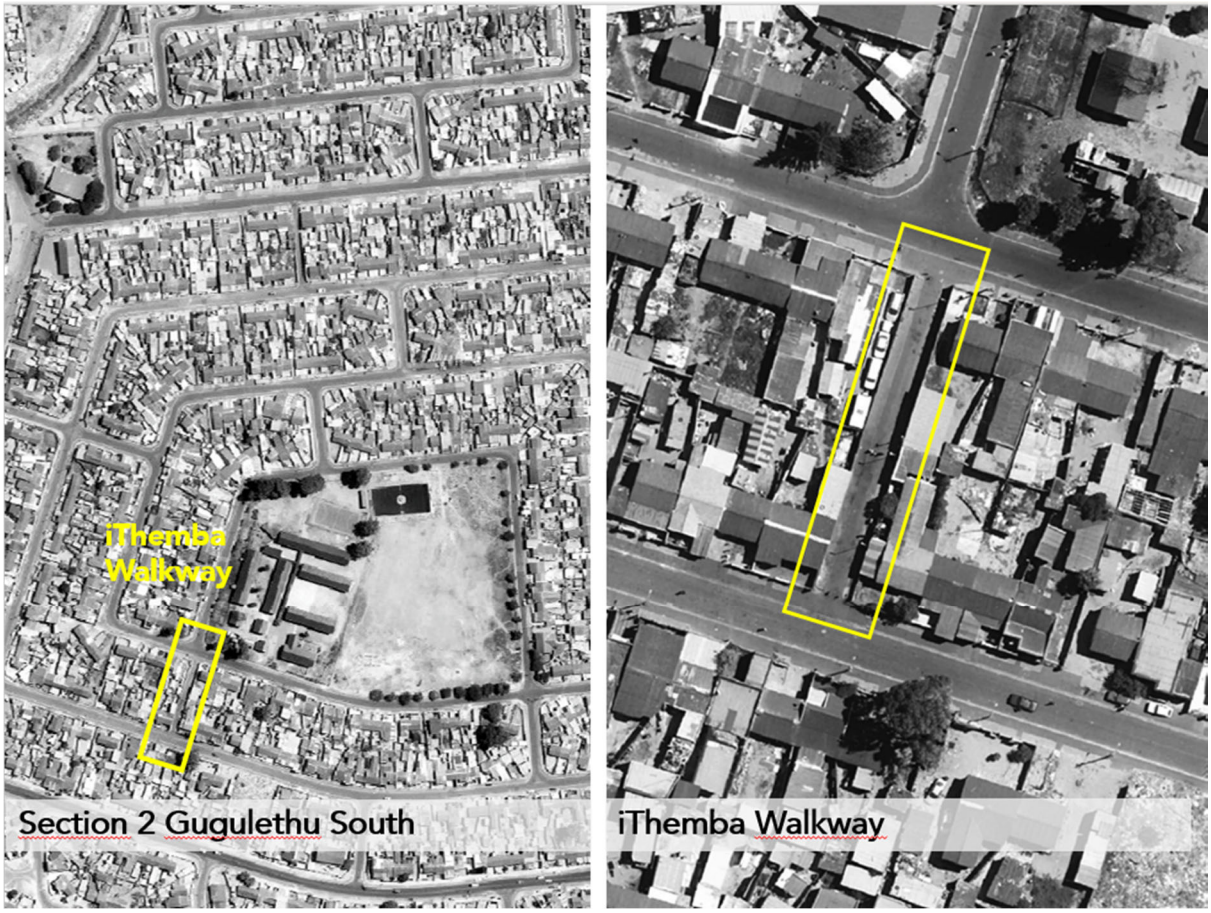

Figure 6. Section 2, Gugulethu South and urban block formation shown on the left and the image on the right shows the path through the urban block showing incremental plot transformation in inserted urban form.

Informal and formal extensions to the front yard generally reveal a pattern of economic urban form as an extension of the dwelling and access to the street. These include spaza shops, beer halls and so on. The adaptations from the original home provide additional income or expanded space through incremental architecture. They illustrate blurred boundaries of public and private use. Further, they display a range of densities and functional mixes of the plots with changing street access networks. Section 2 in Gugulethu is also undergoing a more recent and unfortunate phenomenon around the street transformation and the emergence of patterns of solid high walls, ornate gates and concrete columns, signifying a sense of permanence and an emerging identity of the adapting Gugulethu street interface. This requires further investigation to understand the social and cultural meaning. Stories from local agents suggest the interface conditions are a sign of wealth, but so a demand for safety.



Figure 7. Section 2, Gugulethu South (from left to right): 1) Back-yard flat above and local shop below; 2) front yard spaza shop on NY89; 3) ornate street interface on NY3; and 4) original two-room, 50m² 'township' house.

‘Attaching’: Micro-urban form as soft infrastructure (street)

Spontaneous, socio-economic occupation or use of urban space reveals a fine-grain, adaptable and informal micro-urban form, that co-develops with the buildings and attaches to the formal city structure. This is a vastly unrepresented pattern of urban form, mostly as it changes so quickly or is merely invisible to state regulations, design frameworks and municipal budgets.

The micro-urban form focuses on the everyday practices of the ordinary citizen. It can be temporal or permanent or may only be occupied at certain times of the day, week or month. Complex connections and diverse functions are understood through the evolution (and eradication) of small-scale built elements across scales and systems (du Plessis et al., 2015).

Patterns of adaptable micro-morphologies in Gugulethu include stand-alone spaza shops, tuckshops, taverns or shabeens (drinking bar), hair salons, barber shops, community gardens, self-made street furniture, informal meat markets, transitory street spaces, bridges, crossings and urban walkways.

Three specific examples that reveal the micro-urban form are, first, spaces of exchange (Ewing, 2022a, 2021), including the smiley (raw and cooked sheep heads) corner, located by the Lotus Park entrance along the street of NY3 (native yard from the original township naming). The space was largely unused in 2010. With the development of the VPUU Lotus Park NHC and surrounding public space, the area has attracted small-scale meat traders in the mid to late afternoon. Mobile ‘braais’ (BBQs), umbrellas, and fold-up tables allow traders to actively occupy the space, almost like shadows of urban form.

Second, blue-green infrastructure (BGI) is often neglected as a pattern of urban form. Self-constructed bridges, communal water taps and engineered formally implemented infrastructure are scattered along the Lotus River that runs 3,5km through the centre of Gugulethu. The edges to the river are cut off from the rest of the neighbourhood, making the space unsafe and vulnerable. The BGI forms an important element that has resulted in students developing a kit of parts and using components towards design toolkit for upgrading spaces along the river.

Third, a small-scale project called iThemba Walkway illustrates the impact of social infrastructure and public space transformation. The walkway is located within Section 2 of Gugulethu and is a 50m long and 6m wide passageway. Locally, it is called iRhanga, a space where people are connected. Since 2021, the space has been incrementally upgraded through strategic interventions along the edges through a timeline, tree planting and mural painting. Students are involved in a design-build process.



Figure 8. Gugulethu micro-morphologies (from left to right): 1) LP entrance ‘smiley corner’; 2) children play on an infrastructure pipe as a temporary bridge across the Lotus River; and 3) iThemba Walkway in 2024

REFLECTIONS TOWARDS A RESILIENCE FRAMEWORK

Through Studio Hope and constant research in Gugulethu over the years, it was clear that an expanded vocabulary and typology are required in the southern context to interpret urban form, particularly the intricacies of micro-urban morphologies. The translation of 'township transformation' enables a deeper understanding of spatial co-production, socio-economic practice, and everyday culture that influence and adapt Gugulethu's changing plot, street, block, and neighbourhood evolution. The spatial arrangements and patterns of urban form were investigated through the typology of *expanding* informality and further concepts adapted from Kamalipor and Dovey (2018) of *settling, inserting* and *attaching*.

Although not discussed in detail within the scope of this paper, meaningful interpretation of diverse urban forms guides a working concept of a *resilience framework as a humanising approach*. This sets up a potential framework concurrent with a more inclusive and compassionate perspective to direct appropriate and affordable urban design interventions, both real (practice and design-build implementation) and imaginary (student learning), including concepts of *justice, participation,* and *care* (Gachago et al., 2022).

Spatial justice as the desired goal: The scales of recognition and access acknowledge the role of the urban designer and the influence of the historical context, including power, politics, positionality and place (4 P's) forward-thinking and backwards-looking. History analysis of urban form is critical in understand the goal of justice.

Participation as a process: There is a desire to understand and develop alternative forms of cooperation and social agency, involving critical engagement *with* multiple stakeholders to uncover hidden meanings in the urban form, past, present and for the future.

Care as a key principle: Democratic access to information, critical deep analysis and interpretation of urban patterns enable an inclusive design towards transformative action, within the studio and the context. This allows participants to have a say in both the translation and the decision-making processes of urban design and trauma healing in critical neighbourhood transformation.

By reviewing the urban form of Gugulethu, students make informed decisions towards design interventions using different methods and understandings. Design strategies and planning scenarios further reveal an approach to urban morphology with purpose, value, and local agency, but also consciously rupture the methods of understanding unhealthy patterns of fragmented and deeply divided spaces inherited from colonial, modernist and apartheid spatial planning.

In 2022 the spatial outcomes of Studio Hope were co-presented by students, local agents and academics to the Mayor of the City of Cape Town as part of a project called The Walkway Project. Further, researchers and local agents co-presented their research at an Innovation Indaba in 2023 hosted by the City of Cape Town. A representative from the municipality attended the student's summative assessment exam in 2024, showing a commitment to the outcomes of the studio.

The intention is to add to an ongoing toolkit of urban elements for BGI implementation and urban design intervention projects. Interpretation and translation of student work is continuing. The student design-build and the relationship of academia and community through the iThemba Walkway project are important creative works towards rethinking urban form as the intersection between the ordinary and the extraordinary complex patterning of change post-apartheid (Harrison and Zack, 2014).

CONCLUSION

The paper focused on an approach and method to understand patterns of urban form in a township territory. There are concerns about the growing informality, rapid transformation and peripheral urbanism in South Africa (Kovacic and Giampietro, 2017). As the neighbourhood of Gugulethu expands, local agents argue that it remains economically marginal in Cape Town, entangled in insecurity, extreme violence and social inequality with little hope of integrating into the city. However, the patterns described reveal a certain level of resistance and resilient township transformation that transcends multiple scales, dimensions and critical sites.

In conclusion, data collection, pattern recognition, design approaches and Southern theory are used as clues to disrupt and 'plot' spatial design scenarios with local agents to reframe a theory of change for peripheral urban morphology in Cape Town.

Du Plessis, Landman, Nel and Peres (2015) note that "Urban form aids (and hinders) urban resilience in several ways." (p.183). Adaptive strategies in certain focus areas of Gugulethu are most prevalent at the complex, yet successful and robust micro-scale, albeit almost invisible at the network, policy and municipal level. Micro-urban morphologies are perhaps the most unrepresented type of urban form in Gugulethu with the most potential towards resilient *township transformation*. Further research is underway on micro-urban forms aligned with a research project on social infrastructure and underground networks (Gehl, 2024), entitled *Spaces of Exchange,* aligned with *The Walkway Project* on the urban upgrading of public space in Gugulethu.

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Study on the evaluation of spatial quality of sunken plazas in rail transit station areas — an empirical analysis of Shanghai's central urban area based on the entropy method

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ABSTRACT

As the Transit-Oriented Development (TOD) model matures, rail transit stations have evolved beyond their original function as transportation nodes to become key nodes of urban public life. Sunken plazas, as important types of connecting spaces between transit stations and urban environments, have advantages such as improving pedestrian experience, increasing property value, and promoting effective integration of stations with urban spaces, and their construction and development are receiving increasing attention. This paper reviews the spatial form indicators and evaluation framework of sunken plazas at transit stations in Shanghai's central urban area, using the entropy method to quantify the relative importance of various evaluation indicators and establishes a corresponding quality assessment model. It evaluates the sunken plazas of transit stations in Shanghai's central urban area in three dimensions: path walkability, transfer convenience, and activity comfort, and analyses the reasons for these evaluations. The results indicate that evaluating the spatial quality of sunken plazas is a multi-dimensional, multi-path process influenced by the three dimensions, with the complete configuration of accessibility facilities, the number and layout of entrances, and the density of facilities in sunken plazas being representative indicators of these dimensions. The development of most sunken plazas in Shanghai is inconsistent, indicating significant room for improvement.

Keywords: sunken plaza, rail transit station area, spatial quality, Entropy Value Method

INTRODUCTION

As the Transit Oriented Development (TOD) model matures, compact development centred around rail transit stations has become an important type of construction in high-density large cities. Consequently, rail transit stations are no longer confined to their original function as transportation nodes but are gradually becoming key nodes of urban public life, possessing the dual attributes of "node" and "place." In large cities in China, an increasing number of rail transit stations are integrating their entrances and exits with the open space of sunken plazas, making them intermediary spaces that

connect urban surface space with surrounding commercial spaces. This integration helps improve pedestrian experience, increase property value, and promote the effective integration of stations with urban spaces.

Currently, there is limited research related to the spatial form and usage conditions of sunken plazas within rail transit station areas. Among the few existing studies, some analyse the important role of sunken plazas in improving the pedestrian environment, enhancing the land use value around stations, and creating urban public spaces (Wu Jun, 2020); others explore the coordination relationship between sunken plazas, urban construction, and the behavioural activities of users based on the current usage of existing sunken plazas (Cooper Marcus, 2001). These studies have relatively narrow perspectives and lack comprehensiveness, failing to propose a systematic framework and methodology for evaluating the spatial quality of sunken plazas. This paper reviews the spatial form indicators and evaluation framework of sunken plazas in rail transit station areas, utilizing the Entropy Value Method to quantitatively analyse the relative importance of various evaluation indicators, and establishes a corresponding quality assessment model, aiming to provide objective evidence and theoretical reference for the planning and design of sunken plazas in future rail transit station areas.

Research Design

Evaluation Indicators

Based on relevant studies such as the Node-Place (N-P) model of transit stations (Bertolini 1996), the Five Levels of Walking Needs model (Alfonzo 2005), and the Public Space Design Evaluation Table (Cooper Marcus 2017), this paper analyzes the spatial quality and form indicators of sunken plazas from three dimensions: path walkability, transfer convenience, and activity comfort (Table 1).

Path Walkability

Path walkability refers to the degree of accessibility of sunken plazas as basic infrastructure at the entrances and exits of transit stations for different groups of people. It mainly includes evaluating the condition of the plaza's surface and the completeness of accessibility facilities. Good surface conditions are characterized by flatness, slope, walkable area, and the ability to remain dry and non-slip in adverse weather (Han et al. 2022). In this paper, Walkability of the site is used as a measure; the completeness of accessibility facilities reflects the service conditions of the sunken plaza for people with mobility difficulties (including the elderly, children, parents with strollers, and people with disabilities) (Purnamasari et al. 2022). This is measured by the coverage rate of accessible elevators and escalators at the entrances and exits of the plaza.

Transfer Convenience Dimension

Transfer convenience refers to the ease with which users switch between different functional spaces within the sunken plaza. This includes the evaluation of the convenience of transport transfers and the optimization of walking paths. The convenience of transportation transfers is mainly reflected in the scale and number of transfer facilities, measured by the density of staircases and entrance and exit facilities used for transportation transfers in the sunken plaza. The optimization of walking paths is mainly reflected in the convenience of walking from station entrances to various travel destinations, measured by three indicators: walking distance from the sunken plaza to nearby residential, office, and commercial facilities, detour factor, and the Betweenness Centrality (BtH) of the sunken plaza path in the neighbourhood walking path. In calculating the average value of multiple paths, the building scale of destination facilities is used as the weight in calculating the average value of walking distance and detour factor.

Activity Comfort Dimension

Activity comfort refers to the degree of humanized convenience and aesthetic pleasure users experience in the sunken plaza, primarily including the evaluation of spatial attributes and facility operations. In terms of spatial attributes, this is mainly reflected in the scale, shape, enclosure, and proportion of grey space of the sunken plaza. Regarding facility operations, it is mainly reflected in the attraction and support for diverse walking activities, with relevant evaluation indicators including the proportion of commercial interface, the proportion of service facility area, and the diversity of operations.

Table 1. Calculation methods for each indicator.

Dimension	Indicator	Code	Formula	Description
Path Walkability	Accessibility Completeness of Facilities [-]	ACF	$\frac{N_{acc}}{N_t} \times a$	Where N_{acc} is the number of accessible facilities and N_t is the number of total entries. When an accessible direct elevator is present,$a = 2$; otherwise,$a = 1$.
	Walkability of the Site [-]	WS	$\frac{A_w}{A_t} \times \mu$	Where A_w is the walkable area of the square, μ is the friction coefficient of the ground material, and A_t is the total area of the square.
Transfer Convenience	Entrance and Exit Density [X/m²]	EED	$\frac{N_t}{A_t}$	Where N_t is the number of entries and A_t is the total area of the square.
	Escalators and Stairs Density [-]	ESD	$\frac{\sum_{i=1}^{n} A_i}{A_t}$	Where A_i is the area of elevators and escalators in the square and A_t is the total area of the square.
	Betweenness (R=400) [-]	BtE400	$\sum_{s \neq v \neq t} \frac{\sigma_{st}(v)}{\sigma_{st}}$	The *s* and *t* are any two distinct nodes in the network. Where σ_{st} represents the total number of shortest paths from node s to node t.
	Walking Distance to Amenities [m]	WDA	$\sum_{i=1}^{n} L_i \times \frac{S_i}{S_t}$	Where L_i is the walking distance to each facility, S_i is the building area of that facility, and S_t is the total building area of all facilities within the station area.
	Detour Coefficient of Amenities [-]	DCA	$\sum_{i=1}^{n} \frac{L_i}{D_i} \times \frac{S_i}{S_t}$	Where L_i is the walking distance to each facility and D_i is the straight-line distance to each facility.
Activity Comfort	Scale[m²]	SCA	A_t	Where A_t is the total area of the square.
	Shape[-]	SHP	$\frac{4\pi A_t}{{P_t}^2}$	Where P_t is the total perimeter of the square.
	Enclosure[-]	ECL	$\frac{H}{median(D)}$	Where H is the depth of the sunken area and $median(D)$ is the median width of the square.
	Commercial Interface Rate [-]	CIR	$\frac{\sum_{i=1}^{n} L_i}{P_t}$	Where L_i is the length of commercial interfaces and P_t is the perimeter of the square.
	Grey Space Ratio [-]	TSR	$\frac{\sum_{i=1}^{n} A_i}{A_t}$	Where $A_i$is the area of grey space and A_t is the total area of the square.
	Rest Facility Area Ratio [-]	RFAR	$\frac{\sum_{i=1}^{n} A_i}{A_t}$	Where A_i is the area occupied by rest facilities and A_t is the total area of the square.
	Diversity of Facilities in the Square [-]	DFS	$-\sum_{i=1}^{n} \frac{n_i}{N} \log_2(\frac{n_i}{N})$	Where n_i is the number of individuals in the *i*-th category, and *N* is the total number of individuals across all categories.
	Diversity of Facilities in the Station Area [-]	DFA	$-\sum_{i=1}^{n} \frac{n_i}{N} \log_2(\frac{n_i}{N})$	Where n_i is the number of individuals in the *i*-th category, and *N* is the total number of individuals across all categories.

Case Selection and Data Sources

Shanghai now holds the top spot in the world for rail transit operation mileage, which is distinguished by a dense network, heavy passenger volume, and a wide range of traveller uses. This paper selects 16 sunken plazas across 13 rail transit stations in Shanghai's central urban area as the research objects (Table 2, Figure 1), noting that some transit stations have multiple sunken plazas connected to them. These plazas feature diverse spatial forms, functional types, and current usage conditions, providing reliable case support for studying the spatial quality of rail transit station area sunken plazas. Data collection for the research samples is conducted at two spatial levels: the internal environment of the sunken plazas and the surrounding neighbourhood environment. The internal plaza environment's characteristics are derived from field measurements, surveys, and building drawings. Open Street Map is the original source of the data on the features of the neighbourhood environment, and a GIS platform is used to integrate and calculate the raw data to create the indicators. (Figure 2).

Table 2. Sunken Plaza Codes.

Research Object	Object Code
Jiangwan Stadium	A
Wujiaochang	B
Zhenru	C
Zhenbei Road	D
Loushanguan Road	E
Jinshajiang Road	F
Daduhe Road	G
Changshou Road	H
Jing'an Temple	I
South Shaanxi Road	J
South Huangpi Road	K
Century Avenue (Exit2)	L1
Century Avenue (Exit5)	L2
Century Avenue (Exit8)	L3
Oriental Sports Center (Exit2)	M1
Oriental Sports Center (Exit5)	M2

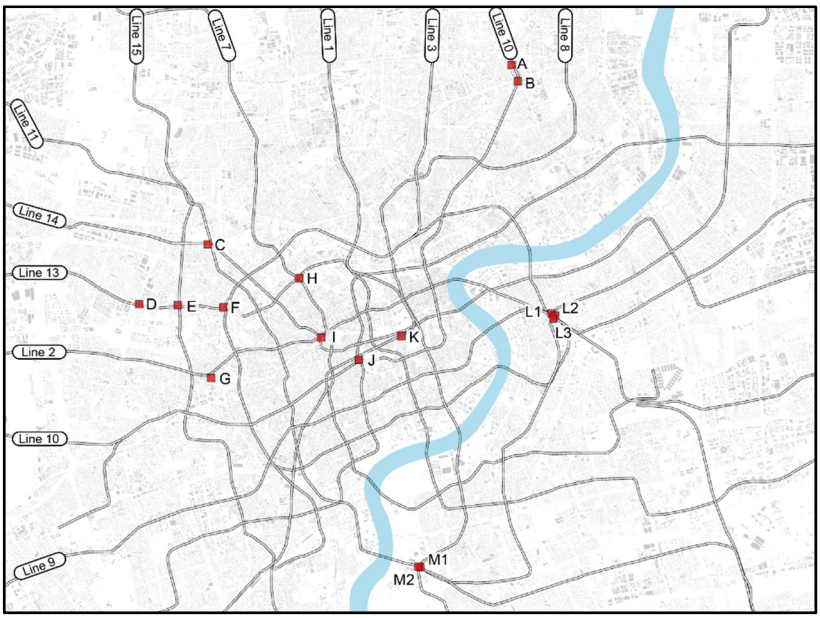

Figure 1. Distribution of Sunken Plazas in the Study

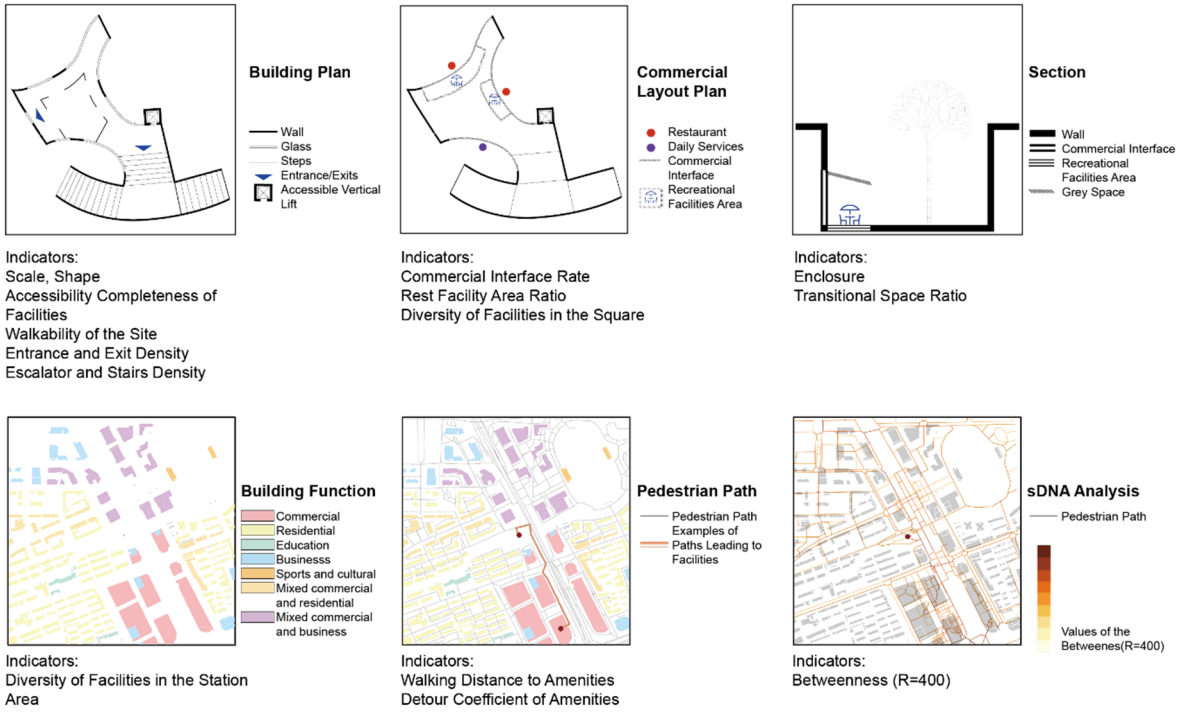

Figure 2. Distribution of Sunken Plazas in the Study

Research Methodology

The evaluation process of the spatial quality of sunken plazas in rail transit station areas is complex, with various built environment elements interacting in a complex manner to collectively influence the final spatial quality of the sunken plazas. The entropy method, as an objective weighting method (Zhang et al., 2023), determines the weights of indicators based on the amount of information provided by the observed values of each indicator, thereby avoiding errors caused by human factors. This paper uses an improved entropy method for evaluation, with the following steps: Firstly, the collected data of 15 indicators from 16 sunken plazas are used to construct the original data matrix x_ij, indicating the observed value of the sample i on the indicator j. To eliminate the impact of the original indicator dimensions and absolute value size, the raw data are standardized after

distinguishing between positive and negative indicators. Based on this standardization, the proportion p_ij of each sample on each indicator is calculated, reflecting the importance of the sample's performance on this indicator relative to other indicators. Subsequently, the entropy value e_j for each indicator is calculated based on this proportion to assess the degree of dispersion of the indicator. If all sample values for an indicator are very close, it indicates low uncertainty of the indicator, meaning it contributes less to the overall evaluation. Finally, the weights of each indicator are allocated according to the entropy value, ensuring that indicators with higher variability have a greater weight in the evaluation, while those with less variability have a correspondingly smaller weight.

RESULTS AND DISCUSSIONS [Heading 1]

Indicator Weight Analysis Using the Entropy Method

Using the entropy method, the 15 morphological feature indicators of 16 plaza samples are ranked by weight(Figure 3). The results show that the spatial scale indicator of sunken plazas has the highest weight, indicating significant differences in spatial scale among the case samples. The size of a plaza largely influences the number of service facilities and the types of public activities it can support; larger sunken plazas can accommodate more diverse service facilities and activities. The weight of accessibility facilities is second, indicating that some sunken plazas still lack adequate accessibility facilities. The ability of people with disabilities, the elderly, and children to use transit and other facilities within the station area safely and conveniently is directly impacted by the presence of accessibility facilities, including accessible elevators, which is still a critical factor in evaluating the spatial quality of sunken plazas. The weights of entrance density and elevator density under the dimension of transfer convenience rank third and fourth, indicating that the number of entrances connecting urban spaces and commercial areas, as well as the number of vertical pathways, play important roles in the efficient organization of pedestrian flow at stations. The weights of plaza spatial shape and ratio of facility area under the dimension of activity comfort rank fifth and sixth, respectively, indicating that the spatial form and recreational facilities play important roles in increasing the use rate, comfort, and attractiveness of sunken plazas. The increase in the number of people lingering not only enhances the vitality of the plaza but also promotes the development of surrounding businesses, fostering a positive cycle.

Additionally, other characteristic indicators also have varying degrees of impact on the spatial quality evaluation of sunken plazas. However, because the differences in these indicators among samples are small, they do not show a significant role in distinguishing the spatial quality of sunken plazas. Nevertheless, this does not negate the value of these evaluation indicators. For example, the degree of enclosure of a sunken plaza is also important for creating the atmosphere of a spatial place. A highly enclosed sunken plaza helps create a private and quiet rest environment in a high-density neighbourhood and aids in shaping a commercial atmosphere. A design with low enclosure is suitable for sunken plazas that frequently host performances, exhibitions, and other public activities, as it helps provide larger open spaces for crowd gatherings and activities.

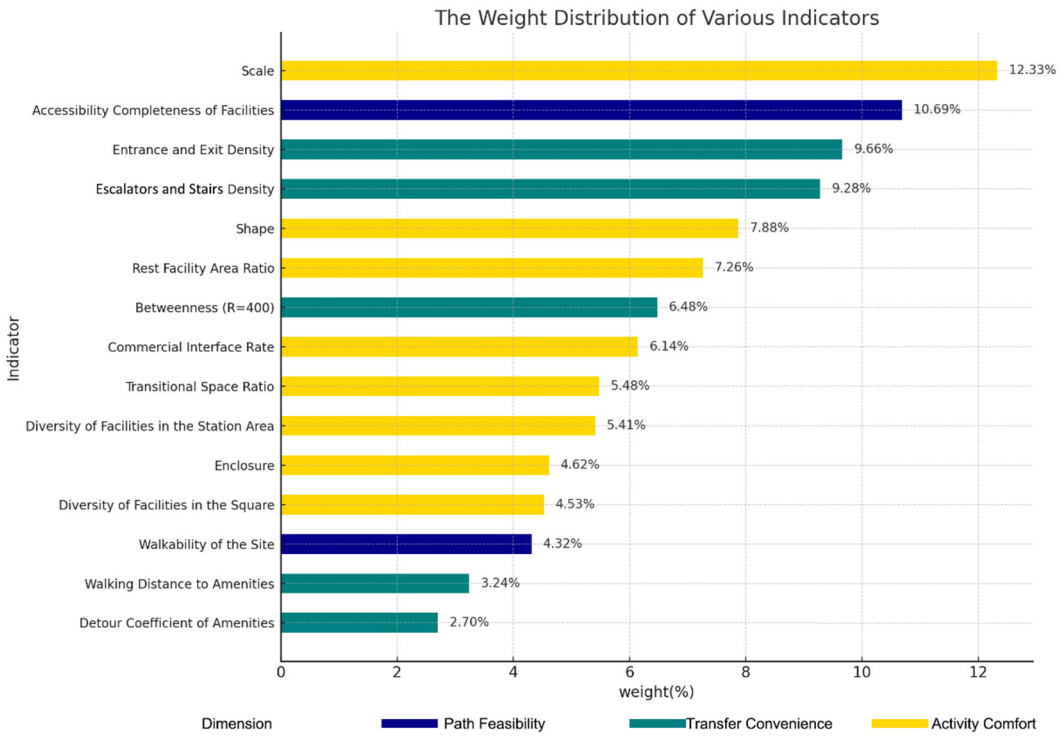

Figure 3. Weights of Indicators

Spatial Quality Characteristics of Sunken Plazas

The comprehensive spatial quality scores for the 16 plazas were calculated using the entropy method model. Additionally, individual scores in the three research dimensions—path walkability, transfer convenience, and activity comfort—were acquired. (Figure 4, Figure 5). In terms of comprehensive scores, plazas F, B, and K ranked in the top three. Analysing the site conditions of these three plazas, both plaza F and plaza K are sunken plazas integrated with commercial complexes above transit stations within the plots, while plaza B is a sunken plaza located below a major intersection. The urban morphology of the station areas for plazas F and K is different.

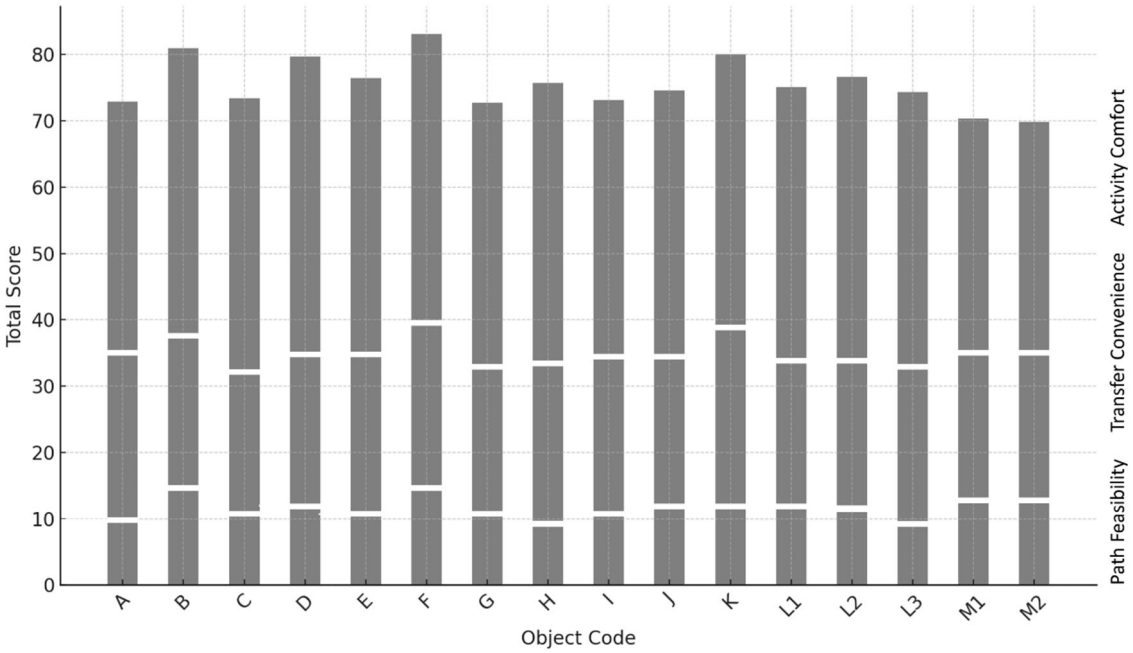

Figure 4. Scores of Spatial Quality for Plazas

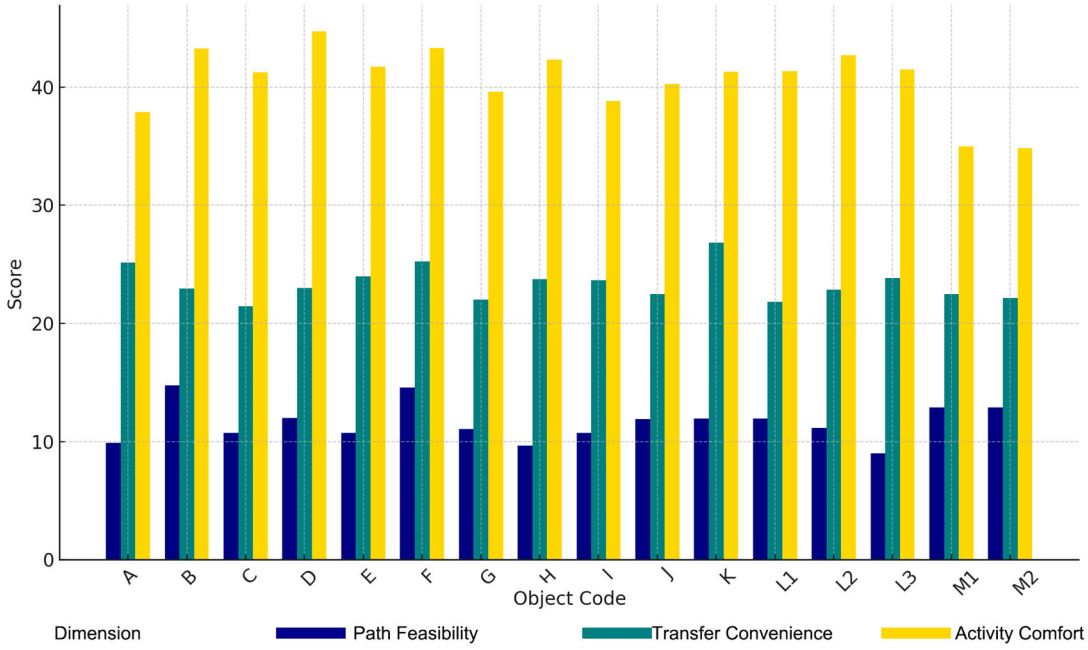

Figure 5. Scores on Three Dimensions for Plazas

Plaza K is in Shanghai's ancient city center, where the extensive road network and compact urban layout facilitate easy transport transfer and good access to business, residential, and office spaces. However, the size of the sunken plaza is tiny, lacking accessible elevators and having unidirectional escalators due to early construction and the requirement to keep existing buildings on the site. This leads to less notable assessments for path walkability and activity comfort. Plaza F is in a new urban area of Shanghai, with the notable advantage of tightly integrated planning and design of the sunken plaza with the transit station area, fully equipped with accessible elevators and bidirectional escalators. Additionally, the sunken plaza is closely linked to a large commercial complex, allowing

commercial activities to effectively extend into the plaza. The 500m² space scale supports coffee, fast food businesses, and brand pop-up events within the sunken plaza. However, due to the influence of wide vehicular lanes and low road network density within the station area, it shows relative weakness in the accessibility of surrounding facilities. The original design intention of plaza B is to serve as a hub for the underground transportation system, alleviating conflicts between pedestrians and vehicles at the intersection of major roads and enhancing public transportation and walking accessibility to commercial facilities adjacent to the main roads. The surface of plaza B uses flat, non-slip permeable stone paving, with accessible elevators set up at each entrance, demonstrating good inclusivity for all user groups, achieving the highest score in path walkability. By setting up multiple entrances directly connecting to surrounding facilities and ground entrances leading to various roads, effective reductions in walking distance and detour factors within the station area facilities are achieved. Plaza B has the largest land area, providing efficient paths for pedestrians traveling to and from the transit station. At the same time, open spaces, sitting landscapes, and temporary commercial facilities are integrated into the site edges, enriching its function as a hub of underground space within the station area. Ultimately, as a multifunctional public activity space that integrates commerce, sports, and leisure, it is well-received by the public(Table 3, Figure 6).

Table 3. Key Indicators of Plazas K F B.

Object Code	ACF[-]	BtE400[-]	DCA[-]	SCA[m²]	RFAR[-]
K	1.00	18702.79	1.23	380.23	0.08
F	2.00	22637.84	1.35	522	0.30
B	2.00	44443.00	1.38	5942	0.13

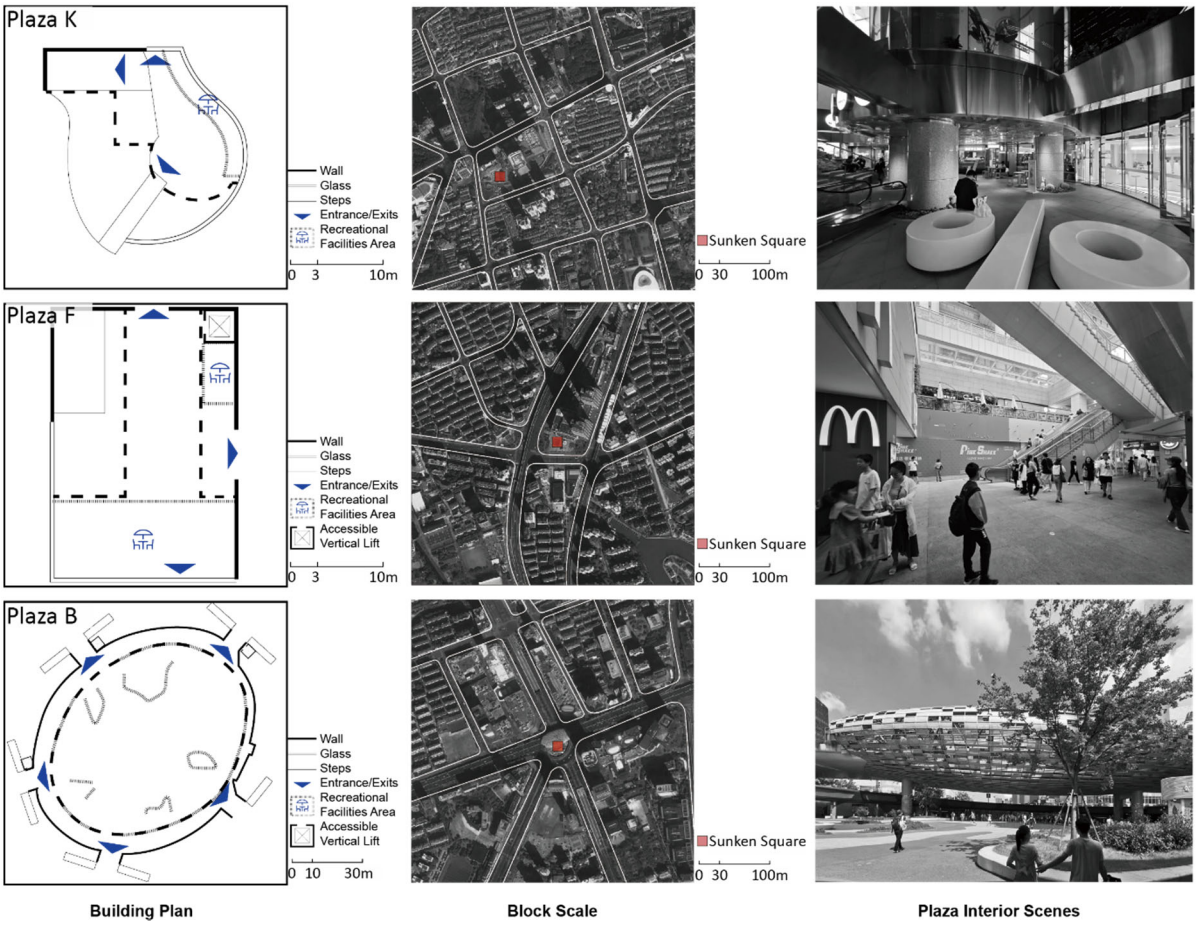

Figure 6.Diagram of Key Indicators of Plazas K F B.

In terms of path walkability, the presence of accessible elevators significantly affects the score differences among the samples. Only plazas B and F have accessible elevators installed, resulting in these two samples having outstanding scores in path walkability. The score differences among other samples are mainly influenced by the configuration rate of escalators and the walkability of the site. Accessible elevators serve people sensitive to walking distance and detours. For sunken plazas, which have unique visual appeal and can effectively function as pedestrian thoroughfares, the installation of accessible elevators should be more widespread.

In terms of transfer convenience, the score differences among the samples are mainly influenced by entrance density and elevator density. Plazas C and D are both large, elongated sunken plazas adjacent to large commercial complexes, yet they show significant differences in transfer convenience scores. Plaza C has entrances to the complex only at the ends, with staircases and escalators sparsely arranged along the long side. In contrast, plaza D has multiple entrances connecting to the complex on one side of the plaza and two additional passages on the other side connecting to the rail transit station. Therefore, in terms of accessibility to surrounding facilities, plaza D has a significant advantage and scores higher in transfer convenience. However, from the perspective of block layout, both samples are arranged along the long side of the complex, aligning with the pedestrian paths of the surface streets, without leveraging the unique advantages of underground pedestrian paths. As a result, both have relatively low scores in BtH within a 400m range(Table 4, Figure 7).

Table 4. Key Indicators of Plazas C D.

Object Code	EED[X/m²]	ESD[-]	BtE400[-]	SCA[m²]	SHP[-]
C	2.15	0.15	29196.26	2326.48	0.24
D	3.26	0.21	21334.65	3005.83	0.23

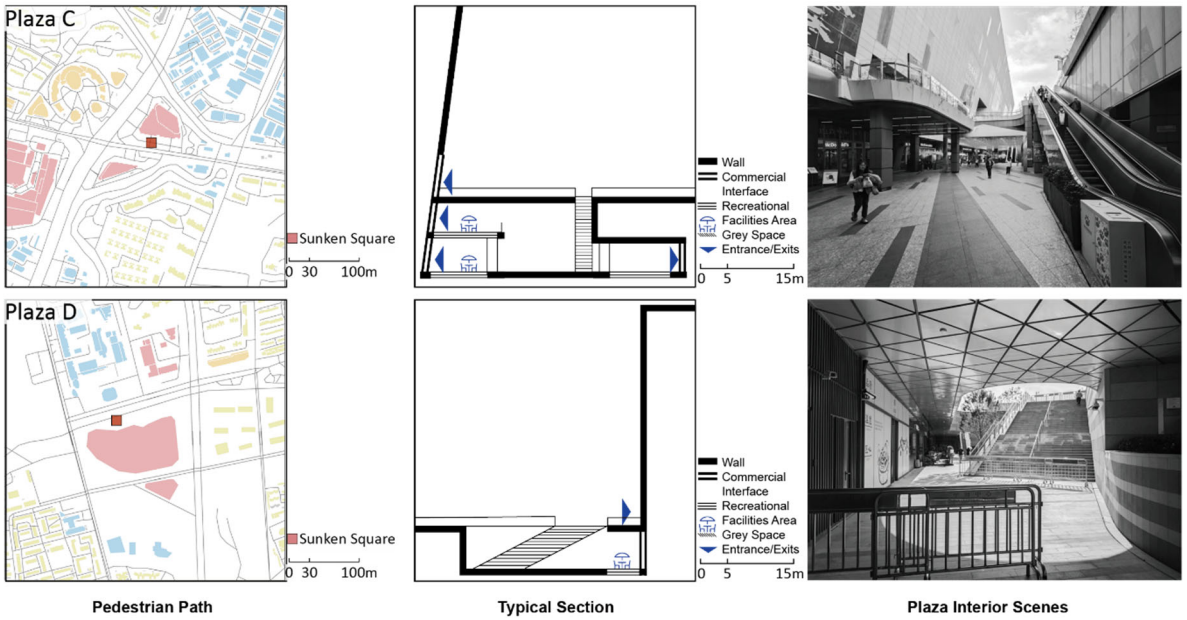

Figure 7.Diagram of Key Indicators of Plazas K F B.

In terms of activity comfort, plazas M1 and M2 score low and show significant gaps compared to other samples, primarily due to the lack of service facilities on site. These two sunken plazas are located in newly developed urban areas, with large areas connected to commercial districts and sports parks, offering good environmental resources that have not been fully utilized. M1 does not extend the business patterns of the adjacent mature commercial district, and M2 does not tap into the potential commercial vitality of the sports park's clientele. The interfaces within both plazas are monotonous and enclosed, lacking seating and commercial facilities, which diminishes their appeal as places for people to linger. As a result, instead of developing into lively urban public areas, they only function as transit buffer spaces for reaching rail transit stations. (Figure 9).



Figure 9 Interior Scenes of Plazas K F B.

Spatial Quality Evaluation Model for Sunken Plazas

The overall spatial quality of sunken plazas in rail transit station areas is calculated by multiplying the scores of various research factors by their respective weights. Based on the natural breaks method, all indicators are classified into two categories by weight, with the more important category including six indicators, leading to the following spatial quality evaluation model for sunken plazas in transit station areas.

$$Y=0.123\times X1+0.107\times X2+0.097\times X3+0.093\times X4+0.079\times X5+0.07\times X6+0.072\times X7$$

Where Y is the spatial quality score of a particular sunken plaza, and X1,X2,X3,X4,X5,X6,X7 are the standardized values of spatial scale, accessibility facilities completeness, entrance density, elevator density, spatial shape, and ratio of recreational facilities area, respectively.

CONCLUSIONS

This study applies the entropy method to empirically analyze the spatial quality of sunken plazas in rail transit station areas in Shanghai's central urban area. It concludes that sunken plazas, as elements of urban public space, are important for boosting the overall coherence of urban space, making the area around rail transportation stations more walkable, and boosting the area's commercial activity above the stations. Through indicator analysis of the spatial quality evaluation model, it is shown that evaluating the spatial quality of sunken plazas is a multidimensional and multi-path process, influenced by dimensions such as path walkability, transfer convenience, and activity comfort. The complete configuration of accessibility facilities, the layout of entrances and exits, and the density of facilities in sunken plazas are representative indicators of these dimensions.

To improve the spatial quality of sunken plazas in rail transit station areas in Shanghai's central urban area, the following recommendations are proposed: (1) Fully configure accessibility facilities to promote inclusive design in the vertical spatial direction of the city, ensuring the basic transit needs

of users with mobility difficulties; (2) Increase the multi-path and multi-directional pedestrian connections of the sunken base surface, using underground passages to mend urban spaces fragmented by vehicular traffic, thus stimulating commercial vitality in the entire area; (3) Diversify the functional types and recreational facilities as much as possible to create a comfortable and pleasant public space environment that meets the needs of different groups.

The paper has limitations such as a relatively singular analysis method and indicator selection mainly derived from literature without perception surveys of sunken plaza users. To provide more thorough and scientific theoretical support as well as useful guidance for the construction of urban transit-oriented development (TOD), future research can broaden the sample range to include more cities, perform comparative analyses of various types of sunken plazas, and delve deeper into the study of the spatial quality of sunken plazas in areas surrounding rail transit stations.

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The urban form of peripheral springs: the case of the Lageado watershed, São Paulo/ SP

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ABSTRACT

This study aims to analyze the twenty springs that make up the Ribeirão Lageado watershed, in the Itaim Paulista region, East Zone of the Municipality of São Paulo, and to analyze the characteristics of their amphitheaters, which should be Permanent Preservation Areas with a minimum Non Aedificandi distance of fifteen meters, but which, in practice, are occupied by disadvantaged segments of the population, which generally constitute a framework of socio-environmental vulnerability and socio-spatial segregation. Thus, it is understood that a clearer definition of what constitutes the set of urban elements of these springs in peripheral regions can help in the implementation of future urban plans that aim to mitigate environmental problems and adapt these areas in terms of a minimally adequate supply of infrastructure, mainly basic sanitation, but also combined – green, blue and gray (GBGI). Furthermore, this study revisits the theme of neighborhood units, precisely from an environmental perspective, where each sub-basin of the system can be understood and qualified as a minimum unit of urban planning. As methodological procedures, a specific theoretical framework was established to support the analysis of local tissues, which was carried out by recording in-person and virtual routes. As a result, twenty springs were named, based on prominent elements of the road tracing, and categorized according to the environmental requalification potential of each one, whether high, medium or low. Thus, this research proves to be relevant in light of the Sustainable Development Goals, especially SDG 11, to make cities inclusive, safe, resilient and sustainable, and contributes to the characterization carried out, since these smaller watercourses are embryonic, so to speak, of the water structure of São Paulo as a whole.

Keywords: environmental requalification, rhizome, green blue and gray infrastructures, urban resilience, SDG 11

INTRODUCTION

This paper aims to analyze the twenty springs that make up the Ribeirão Lageado watershed, in the Itaim Paulista region, East Zone of the city of São Paulo (Figure 1). More specifically, it aims to characterize these springs based on the urban elements that make up their surrounding areas, namely, buildings, open areas, lots, blocks and road layout. The aim of this preliminary characterization is to categorize them according to a greater or lesser possibility of future requalification.

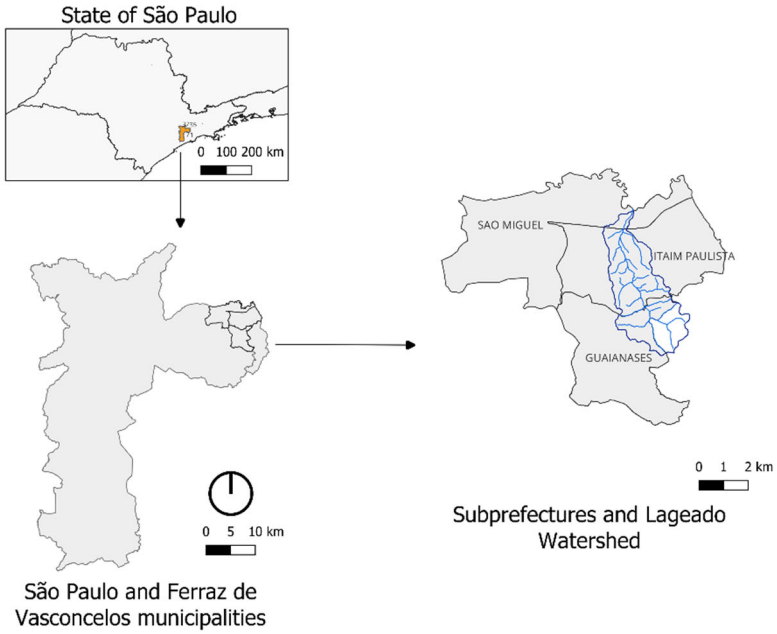


Figure 1 – Urban insertion of the Lageado Watershed. Source: prepared by the authors, 2024.

The typological study that will be carried out is based on the theoretical assumptions of three schools: English (CONZEN, 2022), Italian (MURATORI, 1959) and Portuguese (DIAS COELHO, 2013), which establish distinct methods, but which can be understood as complementary, especially with regard to the characterization of European cities. In contrast, this study proves to be relevant because it seeks to analyze peripheral landscapes, whose spring amphitheaters should be Permanent Preservation Areas with a minimum Non Aedificandi distance of fifteen meters, but which, in practice, are occupied by disadvantaged strata of the population.

Therefore, in general, this is a dual scenario of socio-spatial segregation (VILLAÇA, 2012) and socio-environmental vulnerability (ALVES, 2006; CANIL, LAMPIS and SANTOS, 2020), which can be observed in the insufficiency of the domestic sewage quota network, which implies that it is discharged directly into these same sources. Added to this is a symptom of quite severe underdevelopment, which is the cartographic lag that such urban fabrics present, since areas delimited as favelas, for example, are simply not designed by the Government. This issue was the subject of a previous stage of this research (FIRMINO, KOURY and SILVA, 2023), and demonstrated the importance, for future urban planning actions, of addressing this gap.

Thus, it is understood that a clearer definition of what constitutes the set of urban elements of these springs in peripheral regions can help in the development of future urban plans that aim to mitigate environmental problems and adapt such areas in terms of a minimally adequate supply of infrastructure. Furthermore, this study revisits the theme of neighborhood units, which was also previously addressed from a historical perspective (CESARINO and SILVA, 2015). Therefore, an environmental lens will now be applied, where each sub-basin of the system can be understood and qualified as a minimum unit of urban planning.

It is important to highlight a technical report that was recently published, on August 1, 2024, by the City of São Paulo, organized by the Hydraulics Technological Center Foundation (FCTH) and the Secretariat of Urban Infrastructure and Public Works (SIURB), in this case the Wartershed Notebook:

basins of the Água Vermelha, Lajeado and the São Martinho streams. A previous study of this research is directly cited in this Notebook, related to a hydrological modeling of the Lageado watershed (SILVA and KOURY, 2023), with compensatory drainage devices distributed throughout the basin, in this case small parallel reservoirs with potential for public use for leisure, sports and recreation. From now on, it will be necessary to carry out another future study to discuss the contents of this Notebook in relation to the research that has been carried out. In any case, one of its maps was used as a reference base for the analysis of the springs (Figure 2), even though there is a considerable difference – and insufficiency – in the number of springs identified in the Notebook and the thalwegs traced in this research, as can be seen by comparing them with the GeoSampa base (Figure 3).

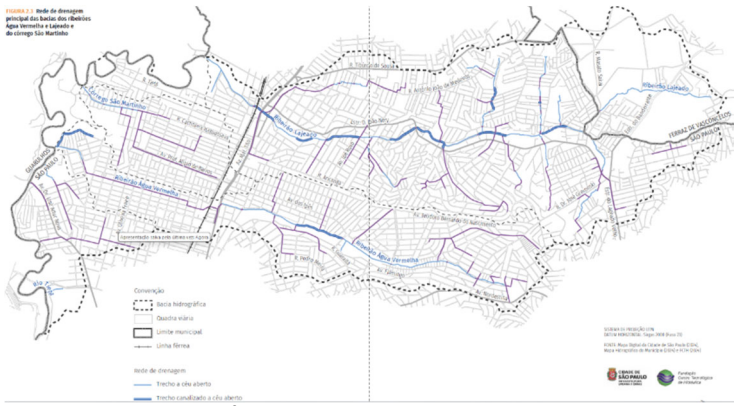


Figure 2 – Main drainage network of the Água Vermelha, Lajeado and the São Martinho streams watersheds. Source: SÃO PAULO (MUNICIPALITY), 2024, p. 30-31.

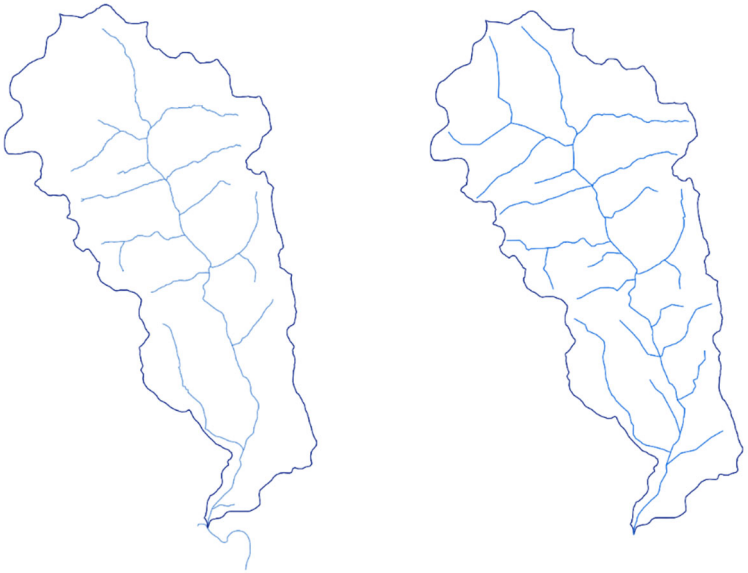


Figure 3 – Comparison between hydrography according to GeoSampa (left) and thalwegs as produced in this research (right). Source: prepared by the authors, 2024.

Henceforth, it is understood here that the set of sub-basins of Ribeirão Lageado can and should be the object of future interventions, mainly in the provision of environmental sanitation infrastructures. Therefore, these interventions can and should be articulated with combined urban projects, which combine functionality with the enhancement of the landscape and environments. In particular, the combined typologies of green, blue and grey infrastructures constitute important instruments of

urban resilience and climate adaptation (KUMAR et al., 2024), since they can contribute to the mitigation of heat waves by creating islands of coolness.

In short, this research is relevant to the Sustainable Development Goals, especially SDG 11, which aims to make cities inclusive, safe, resilient and sustainable, due to the characterization it proposes, since these smaller watercourses are embryonic, so to speak, of the water network as a whole. This network, which in the case of São Paulo consists of a myriad of springs (Figure 4), is, in most cases, apparently banal and invisible. However, as observed in this study, they present many peculiarities and a very complex formal variation.

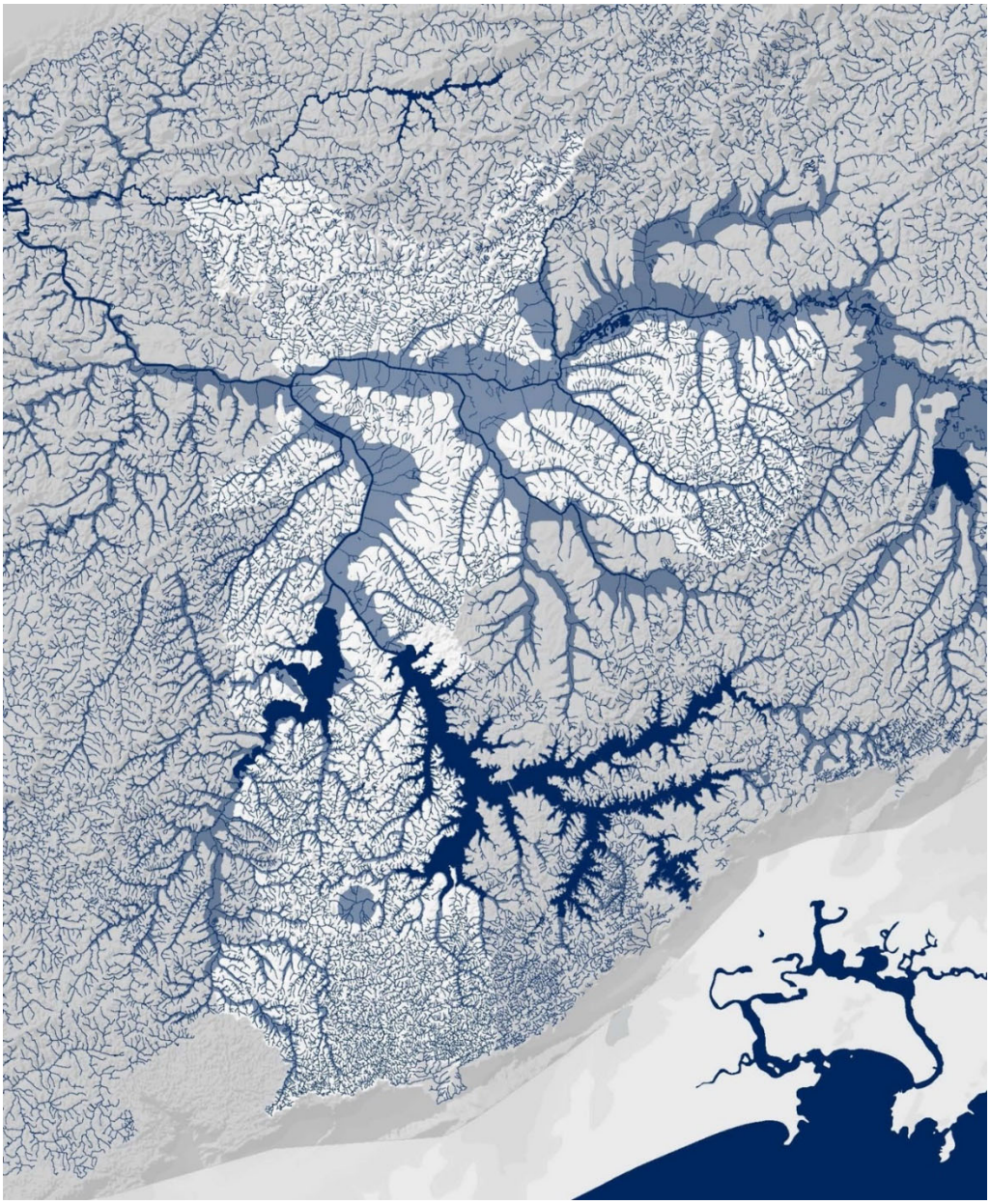


Figure 4 – Hydrography of São Paulo. Source: São Paulo (Municipality), 2016, p. 41.

OBJECTIVES

From a broader perspective, the objective of this study is to deepen the understanding of what constitutes, in terms of urban form, the set of springs that make up the Ribeirão Lageado watershed, making its constitution clearer. The aim is to define a quick but effective methodology – a how-to – that will enable more detailed guidelines for future urban projects. More specifically, the study seeks to:

List a theoretical framework that supports an understanding of the complexity of the set of "frameworks" that make up the object of study, in order to enable its characterization;

Characterize each spring based on environmental variations – or constancy – along its axis, from upstream to downstream;

Appoint, then, each spring based on an element of the surrounding road layout, be it a street, lane or avenue, so that such names are significant of local characteristics, for example, a word of indigenous origin possibly designates some previous characteristic of the natural site;

Identify, based on the characterization carried out, in which springs it is possible to prioritize an urban requalification project, environmental recovery and landscape enhancement;

Complement, in terms of a dialogue and a technical proposal, the Watershed Notebook of the Água Vermelha, Lajeado and São Martinho streams;

Demonstrate, therefore, that it is necessary to advance not only in terms of a more detailed formal understanding of the object of study, in order to increase the resolution of the scale of analysis of the water network, but, above all, of a cultural appreciation of peripheral landscapes, in addition to the criticism that can – and should – be made of the framework of socio-spatial segregation and socio-environmental vulnerability.

METHOD

This study combines different methodological procedures, constituting an empirical process that intersperses diverse and complementary activities, mainly in-person and virtual field visits. These procedures have constituted a platform for sequential and uninterrupted actions, constituting step-by-step advances in the process of a research that focuses on a trans-scale plan, from the river basin to various local situations.

Theoretical framework

Some works were listed as strategic to support the analysis that was carried out. In both, the similarity in the way in which the territory is unveiled stands out, mainly due to a continuous movement. A "fleet in being" – as proposed by the philosopher Paul Virilio, who discusses the place of fluidity in a completely scrutinized territory, where, according to Deleuze and Guattari: "one no longer goes from one point to another, but dominates the entire space from any point: instead of striating the space, it is occupied with a vector of deterritorialization in perpetual movement" (1980, vol. 5, p. 161).

It is no coincidence that Deleuze and Guattari are the main references for "Aesthetics of ginga: the architecture of favelas through the work of Hélio Oiticica", by Paola Bereinstein Jacques (2003). In this work, the author proposes three conceptual figures to explain the urban fabric of favelas – fragment, labyrinth and rhizome. These are distinct and complementary scales of approach, which draw a parallel with the artistic projects developed by Hélio Oiticica, which, according to his biography, incorporated themes originating from the culture of these places, especially the Favela da Mangueira.

Another work that provides a timely approach to urban form is the books “A Rua da Estrada” (2009) and “A Vida no Campo” (2011), by Álvaro Domingues, whose analyses of rural and peri-urban landscapes in Portugal are conducted through absolutely economic aphorisms. Using simply photographs, the author defines the main themes of the landscapes observed, as well as typologies, which are evident, mainly, in the character of a dispersed economy, be it agricultural, commercial or industrial. In this way, he outlines a panorama of what the urban form of these parts of Portuguese territory would be.

Finally, another work deserves to be highlighted, which was not conceived to be organized as such. It is a collection of letters from the writer Anton Chekhov to his publisher, on the occasion of his reconnaissance trip to what would become the penitentiary colony of Sakhalin, located on the coast of Russian territory. In “A Good Pair of Shoes and a Notebook: How to Write a Report” (2008), Thekhov makes an on-site observation of the territory, seeking to understand the way of life of the population there, a place that was the object of an “official discourse” by the Russian government, but which had its own rules, as he himself observed.

Thus, this set of works allows us to consider an integrated but, above all, rapid approach, so that planning actions can be carried out in parts of the territory that are largely unassisted, whether in terms of cartography or in terms of available infrastructure, especially basic sanitation. This agility in diagnosis is nothing new, and already appeared as a prerogative in 1969, as discussed by Jorge Wilheim in “Urbanism in underdevelopment”. However, there would be a shortage not only of technical teams, but, rather, of portions of territory that are produced, yes, by an arrangement of absolutely marginal and relatively anonymous techniques.

From field visits to Google's database

The in-person visit to the territory makes it possible to observe details that cannot be perceived in any other way, whether through cartography or other data formats. Several visits have been made in the context of this research, driven by different, albeit complementary, motivations. However, a river basin such as the one studied here makes it impossible, due to its size, to undertake long walks. Therefore, the conceptual figures of the fragment and the labyrinth become palpable and understandable, since such routes necessarily need to be undertaken by motorized transport, whose speed is incompatible with any consideration of the landscape.

Conversely, when using the virtual route tool provided by the Google platform, in this case Google Street, this same motorized transport now assumes the time of “slow pace”. It then becomes feasible to make a detailed observation of the areas surrounding the road layout, moving frame by frame, with the possibility of 360° rotation. This is a formidable database that makes it possible to fill many of the gaps between the fragments observed in the maze of field visits.

One of the uses of this tool is the direct comparison between an aerial photo and a ground-level perspective, as if the observer were parachuting into the desired location. In the case of Spring 11, for example, what in the aerial photo appeared as a large vacant lot (Figure 5) turned out to be a large housing development in perspective, even allowing the identification of very detailed information through the construction sign (Figure 6). This example demonstrates how much progress is needed in terms of cartographic updating for accelerated urbanization processes such as those occurring in the outskirts of São Paulo. It also demonstrates that it is necessary to take advantage of alternative procedures to those considered more traditional in the scope of urban form studies, which should not simply be dispensed with, but rather contextualized in terms of the relevance of their application.



Figure 5 – Aerial photo of the area surrounding Spring 7, highlighting the terrain upstream (right). Source: Google Maps, 2024.



Figure 6 – Construction sign for the land upstream of Spring 7. Source: Google Street, 2024.

The "notebook"

In order to characterize the springs analyzed here, this study opted to create a mosaic of images for each case, constituting the notebook where the rhizomatic route itself is recorded, through the way in which the movement between points in the territory is conducted. In an earlier stage of this research, the special nature of the creation of a route was already discussed, as well as the trajectories and tracking intrinsic to field visits, which can be observed, for example, in the paths taken by cats at night, recorded by Global Positioning System – GPS (Figure 7). In this way, the design of the form is carried out through the collage of images, and the notebook, with a card for each of the twenty springs, is created as a set of assemblages (Figures 8 and 9).



Figure 7 – Nighttime path of a cat recorded by GPS. Source: Central Tablelands LLS.

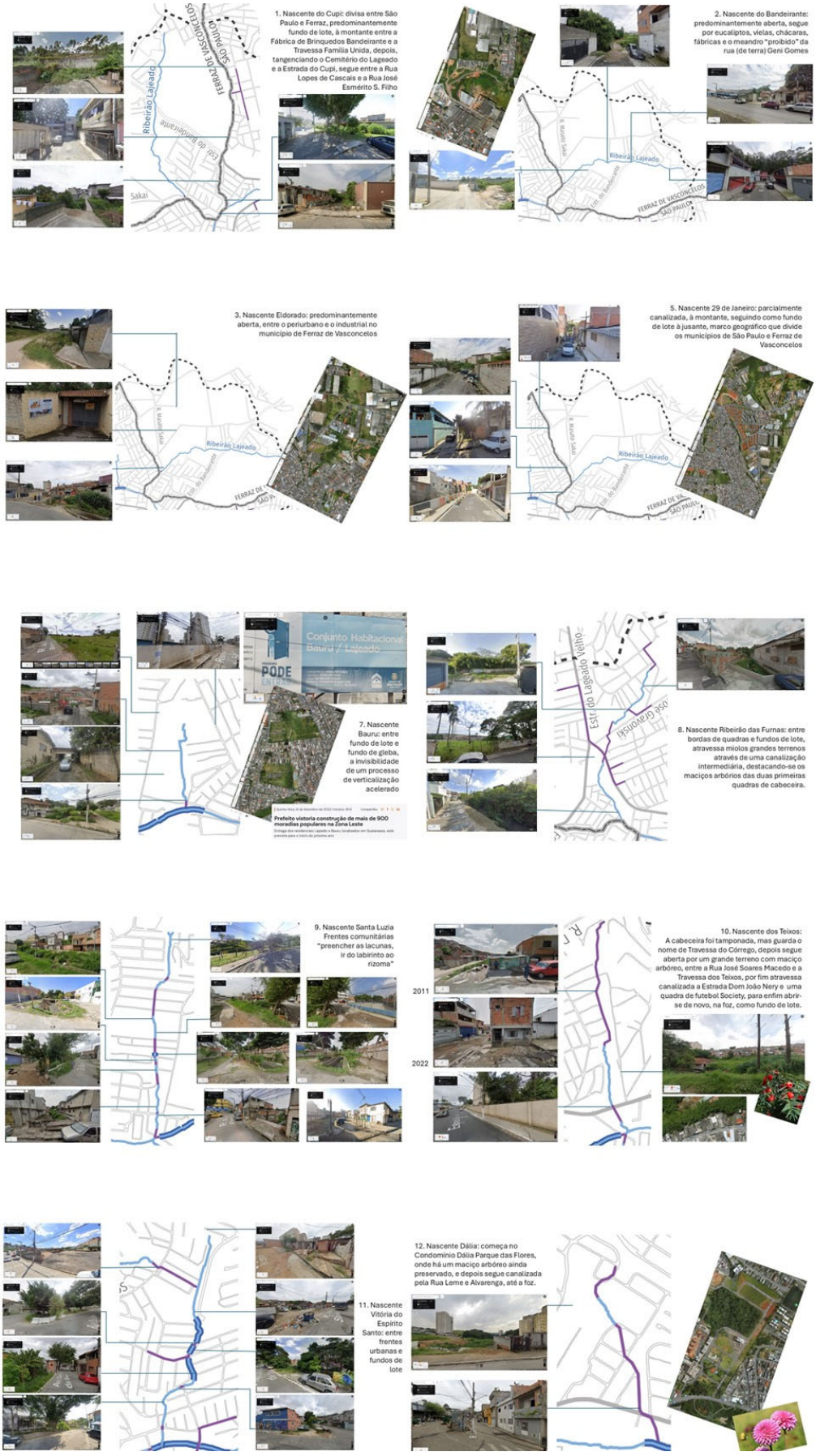


Figure 8 – Analysis sheets for Springs 1 to 11. Source: prepared by the authors, 2024.

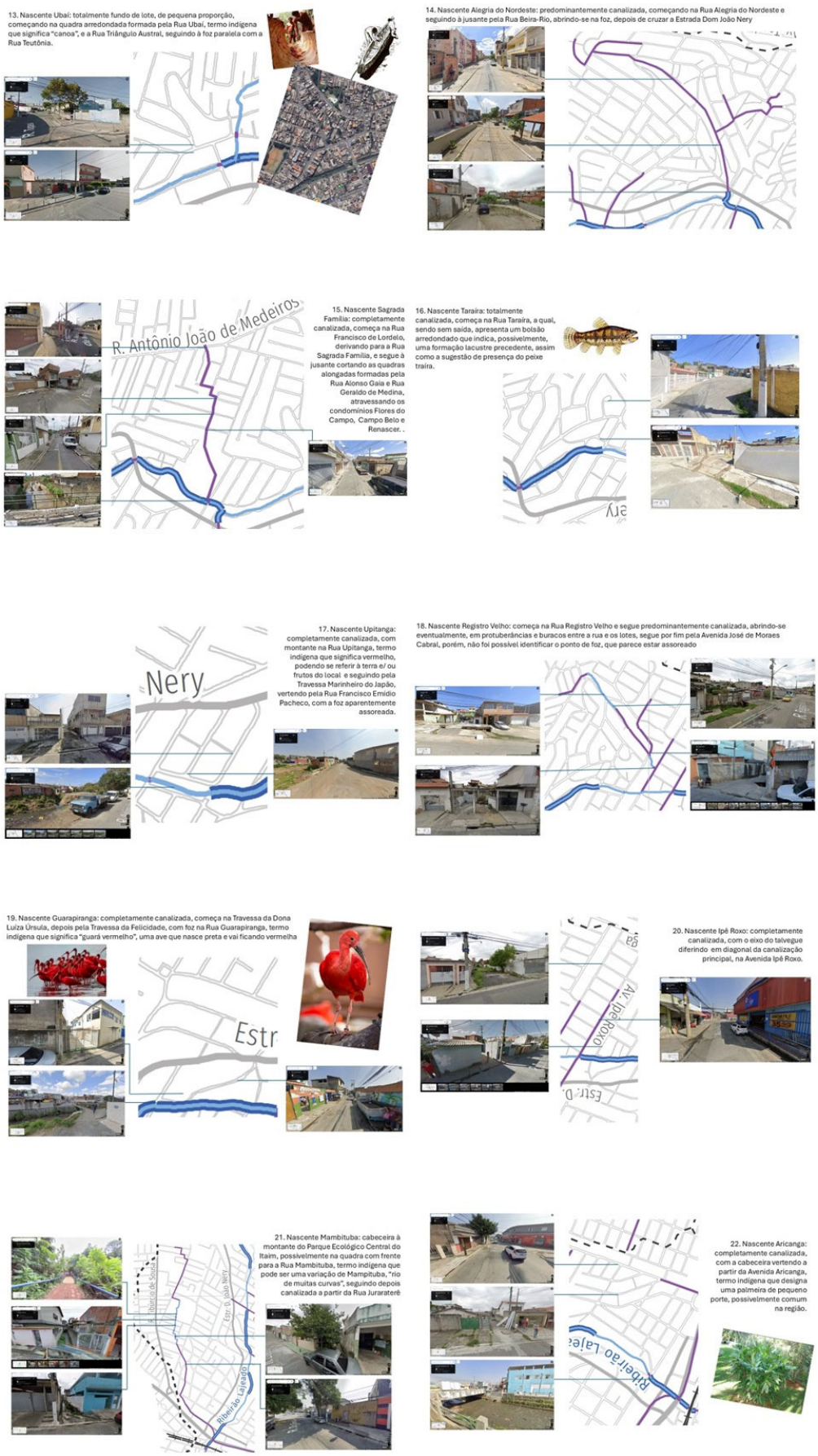


Figure 9 – Analysis sheets for Springs 12 to 22. Source: prepared by the authors, 2024.

Each of the sheets has its own proportions, but in all of them, a stratum of the cartography of the Notebook was used to frame the spring under analysis, directing all of them vertically, with upstream above and downstream below, except for Spring 2. In this way, the collage of images would also follow a pattern in terms of organizing the analytical path. As these strata were explored, we sought to identify a prominent name in one of the elements of the road layout, be it a street, an alley or an avenue, in order to give the name to the spring under analysis. Some of these names stand out as indigenous expressions – such as Spring 13 – Ubaí (Figure 10), and others as names of trees and flowers – such as Spring 20 – Ipê Roxo (Figure 11), revealing a potential to support environmental education actions and the valorization of local culture.



Figure 10 – Sheet of Spring 13 – Ubaí. Source: prepared by the authors, 2024.



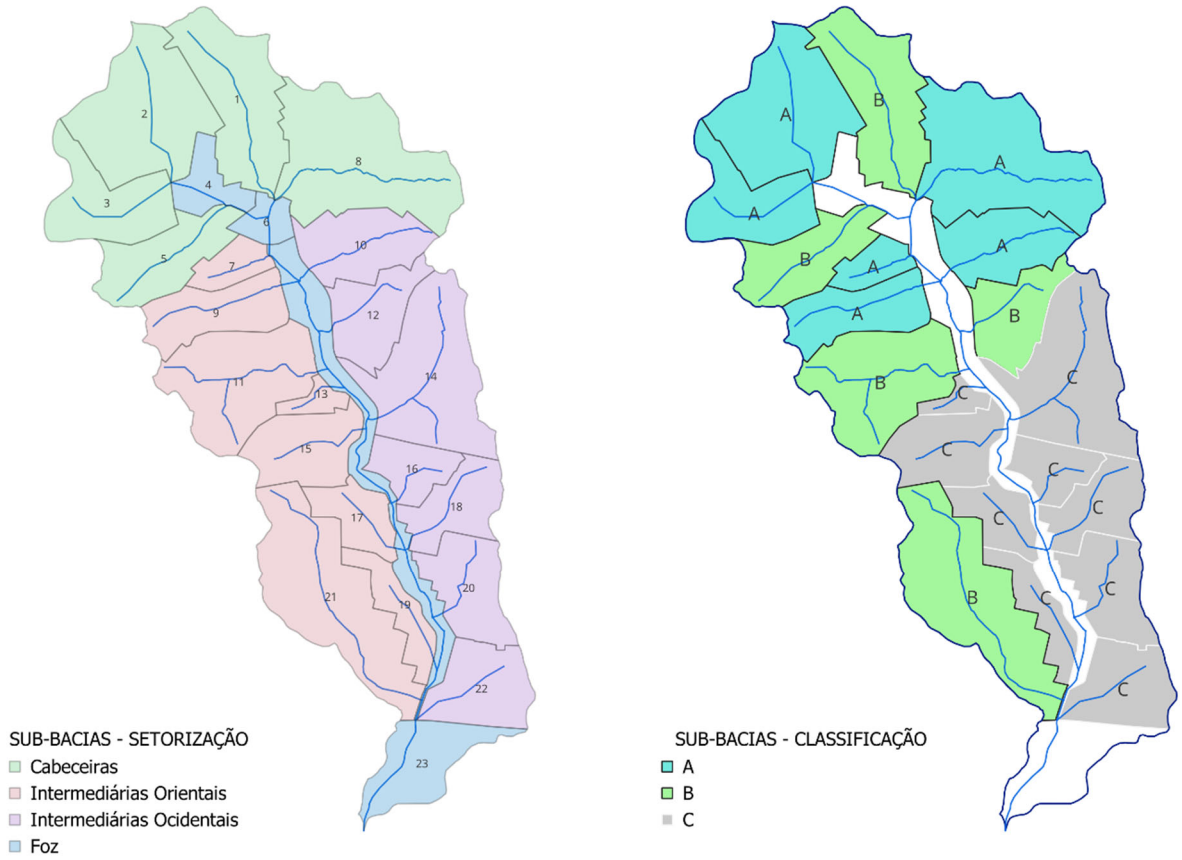
Figure 11 – Sheet of Spring 20 – Ipê-roxo. Source: prepared by the authors, 2024.

RESULTS AND DISCUSSIONS

This study resulted in two distinct but complementary products: one was the naming of the springs, creating a link between the observed landscapes – "fragments" – and the characteristic "labyrinthine" complex of the peripheral layout analyzed that constitutes each amphitheater of springs (Table 1). The other product consists of the categorization of each spring according to its potential for environmental requalification – high, medium and low. The research then progressed from a generic topological sectorization – headboards, eastern and western springs (Figure 12), to a specific classification according to their potential for environmental requalification (Figure 13).

Table 1. Naming and classification of the twenty springs of Ribeirão Lageado. Source: prepared by the authors, 2024.

Number	Name	Classification
1	Cupi Spring	B
2	Bandeirante Spring	A
3	Eldorado Spring	A
5	29 de Janeiro Spring	B
7	Bauru Spring	A
8	Ribeirão das Furnas Spring	A
9	Santa Luzia Spring	A
10	Teixos Spring	A
11	Vitória do Espírito Santo Spring	B
12	Dália Spring	B
13	Ubaí Spring	C
14	Alegria do Nordeste Spring	C
15	Sagrada Família Spring	C
16	Taraíra Spring	C
17	Upitanga Spring	C
18	Registro Velho Spring	C
19	Guarapiranga Spring	C
20	Ipê-Roxo Spring	C
21	Mambituba Spring	B
22	Aricanga Spring	C



Figures 12 and 13 – Sectorization and classification of the Ribeirão Lageado sub-basins. Source: prepared by the authors, 2024.

Regarding categorization, those springs that are predominantly open, such as more or less preserved shores, and that cross land with significant vegetation, even if they are partially channeled or cross the back of lots, were considered to have high potential for requalification. Those springs that are predominantly open, but cross the back of lots, were considered to have medium potential for requalification, which implies both a land limitation and a health problem, due to the discharge of domestic sewage directly into the watercourse, as can be seen at the mouth of the Spring 29 de Janeiro (Figure 14). However, in these springs with medium potential, significant masses of vegetation were observed, as is the case of the Spring Mambituba, which crosses the Itaim Central Ecological Park. The springs defined as having low potential for environmental requalification are those that are predominantly plugged, thus becoming alleys, streets and avenues.



Figure 14 – Discharge of domestic sewage directly into the mouth of Nascente 29 de Janeiro. Source: Google Street, 2024.

CONCLUSIONS

This study presents important advances in the field of urban studies applied to its construction form in contact with environmental aspects, such as the more or less "hollowed" sites of the amphitheaters or the more or less sinuous design of the watercourses. In addition, it allowed the collection of a series of evidence that demonstrates how an accelerated urbanization process is taking place in the outskirts of São Paulo, whose interventions, in their rapid advancement, seem to escape official records. In a comprehensive manner, it allowed an understanding of the main problem identified in this portion of the territory, in addition to the variations in form: the lack of basic sanitation infrastructure, and in all the open springs it was possible to identify the discharge of domestic sewage directly into the watercourses.

Acknowledgements

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Urban expansion on the edge of Avenida Brasil highway, Rio de Janeiro

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ABSTRACT

Avenida Brasil is a major highway in Rio de Janeiro, Brazil, which serves as a vital artery for the traffic flow of the metropolitan region. Crossing the city from east to west and intersecting 29 neighborhoods, its 58 kilometers have had a huge impact on urban mobility and form, and have been a vector of urban expansion since its construction in the 1940s. This article seeks to investigate how Avenida Brasil has structured the adjacent urban tissue, and to understand how the urban growth on its border has developed and expanded the city, creating new peripheral districts until today. Using historical morphological cartography, the research examines the evolution of urban forms and segregation patterns around the highway. It adopts a comparative historical approach, analyzing maps and satellite images to show how urbanization has evolved in response to the highway. The findings suggest that while Avenida Brasil facilitated urban expansion, it also contributed to spatial fragmentation and segregation. The study identifies three distinct categories of urban tissue: plot subdivisions, self-built settlements, and large residential or industrial complexes, each reflecting different phases of urban development and contributing to the morphological segregation of the city. This analysis highlights the complex relationship between urban mobility infrastructure and urban form, and provides insights into the spatial dynamics and segregation patterns influenced by major mobility vectors on the peripheries of metropolitan regions in the Global South. Such phenomena can generate and perpetuate higher levels of dependency and urban segregation, particularly in economically disadvantaged areas.

Keywords: Avenida Brasil, Highway, Urban expansion, Urban Mobility Infrastructure, Urban form

INTRODUCTION

This article is part of the development of the thesis on the segregation of urban form, following the work of the Master's thesis entitled "The dimension of segregation of mobility infrastructures: the case of Avenida Brasil", presented by the author in 2020. Exploring the intersection between infrastructure and urbanization, the research focuses on the influence of major roads on the organization of urban space. This particular investigation focuses on the urban expansion along the Avenida Brasil highway, a study that presents the issues through historical morphological cartography. Located in the city of Rio de Janeiro, Avenida Brasil is approximately 58 kilometers long and crosses 29 neighborhoods, and is one of Rio's most important urban mobility infrastructures. Avenida Brasil

is an icon in the history of Rio de Janeiro's urban expansion. Crossing the city from east to west, it links the central area with metropolitan peripheral regions, playing a crucial role as a structuring axis in the growth of the urban fabric and the occupation of the Western Zone. As part of the urban section of the BR-101 in the city, Avenida Brasil is responsible for the largest traffic flow in Rio de Janeiro, with more than 300 thousand vehicles a day, according to estimates by the City Hall.

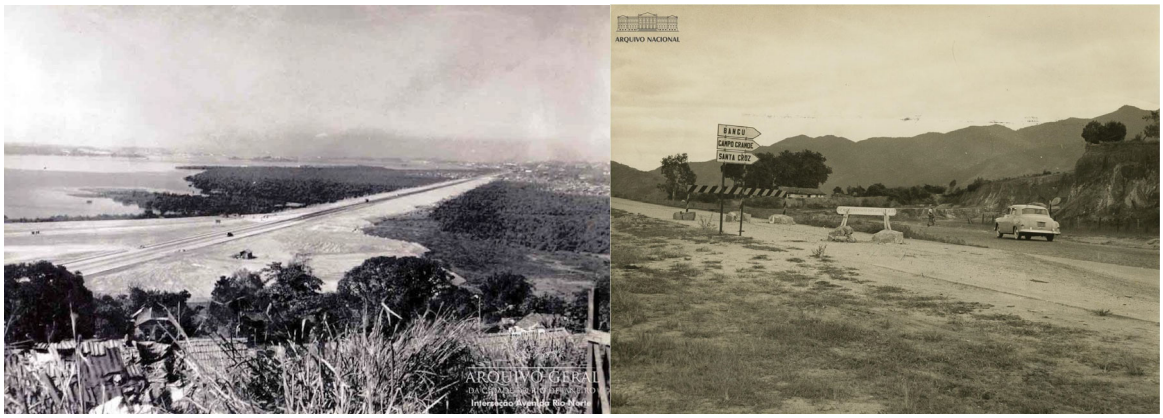

Figure 1. Historical photos of the construction of Avenida Brasil, respectively, between 1940 and 1957. Sources: General Archive and National Archive.

Built in the 1940s, it became a visible landmark in the urban transformations resulting from the emergence of the automobile as the main modern urban transport of the time. The highway project aimed to expand the Brazilian industrial field, thus becoming an axis for urban expansion. The images provide a glimpse of the initial conditions around Avenida Brasil in the 1940s and 1950s. The first image, from 1940, shows Avenida Brasil at the height of the Maré region. The absence of buildings and the large green areas indicate that the road was in a very early stage of development, serving as a transport axis through an area that was still sparsely populated. The second image, taken in 1957, shows the current Avenida Brasil (formerly Avenida das Bandeiras) in the area of Realengo. It is still partly rural, with vegetation and uninhabited land. Due to its importance, Avenida Brasil has been a recurrent object of study for the scientific community in the fields of urbanism, history and other social sciences. The importance of the highway for the development of the city and its role as a highway, as an expressway or even as a "street" (GAMA-ROSA, 2006), as well as its role as one of the main vectors of urban expansion in the metropolitan periphery (TORRES, 2017). More specifically, in the field of morphological urban studies, the important work of Pedro Barreto de Moraes stands out, which deepens the discussion on "urban spaces defined by large road infrastructure works" (MORAES, 2021) and uses Avenida Brasil as a case study, proposing the concept of "metropolitan highway".

Mobility Infrastructure and segregation

Urban mobility infrastructures are often considered as vectors of urban growth, enabling urban expansion and constituting an interface between urban mobility systems and landscape landmarks. Cases of highways in the urban realm are significant as they can represent forms of interpretation of urban phenomena at different scales. David Harvey (2008), in his concept of 'space-time compression', argues that technological innovations, particularly in transport and communication, have changed perceptions of space and time over the centuries. This process illustrates how changes in transport have not only reduced distances, but also radically changed the organization and shape of urban spaces over time. In the twentieth century, innovation in transport focused on urban mobility

infrastructure, and the reduction in travel time was accompanied by an expansion of urban space. Cities began to be adapted, shaped and planned to respond to the increase in the distances that could be traveled. This led to the emergence of suburbs, settlements outside central areas and dispersed urbanization, which has been criticized for its dependence on motorways. This research argues that the current Avenida Brasil, despite being a link between the western periphery and other regions of the city, shows patterns of urban fragmentation and dispersion at a local scale. In its extension, there are different morphological patterns of occupation: continuous and discontinuous settlements; associated and fragmented; concentrated and dispersed, of different scales and urban tissues.

In addition to transport innovation, the study of urban segregation took on particular contours during the 20th century, reflecting the complex social, economic and spatial dynamics of Brazilian cities. Among the major contributions to the understanding of this phenomenon, Roberto Lobato Corrêa, Flávio Villaça and Maurício de Abreu stand out for their analysis and interpretation of the configuration of urban space and the segregation processes that occur within it. Corrêa (1989) offers a detailed analysis of the formation of urban spaces, highlighting the dichotomy between self-segregation and imposed segregation. Villaça (2001) works on the issue of urban segregation, defining it as any form of exclusion that is spatially manifested in the city. Abreu (1987) is a major contributor to studies on the history of urbanism in Rio de Janeiro and the transformations of its urban landscape. In his work "Urban Evolution of Rio de Janeiro", he points out that the difficulty of importing manufactured goods led the municipal government to allow the indiscriminate location of industries on the outskirts of the city. The project that characterized the industrial growth of the city at that time was the effective occupation of a new axis of industrial expansion recently implemented by the State: Avenida Brasil.

New nuances, layers, faces or distinct dimensions of urban segregation are currently emerging in urban studies. Albert Pope (2014) identifies significant changes in the way cities are structured and experienced, particularly through the process of suburbanization, and introduces the concept of 'ladders'. These represent discontinuous and hierarchical connections that contrast with the traditional continuous grid, reflecting a shift towards a less integrated and more focused urban organization. This phenomenon is described as 'network erosion', where the introduction of vehicular circulation systems and the priority given to the convenience of travel ultimately undermines the integrity and quality of the network. In his studies, Pope (2014) points to a direct correlation between socio-spatial residential segregation and morphological or physical or purely spatial segregation. Morphological segregation can therefore reflect processes of fragmentation, dispersion, discontinuity and isolation in the urban form by dividing spaces and, consequently, populations. This phenomenon occurs when groups are separated by large distances and physical barriers. The result is a fragmented city, where the continuity of the urban network is interrupted and whole areas are cut off from each other. This spatial dispersal makes social and economic integration more difficult and is characterized by islands and urban enclaves, creating greater isolation, reinforcing inequalities and limiting access to resources.

Hipotesis and article structure

This article seeks to understand how urban growth around Avenida Brasil has developed and expanded the city, creating new peripheral neighborhoods and structuring the adjacent urban tissue. When mobility infrastructures enable urban expansion, does it result in a more integrated or segregated city? In order to answer this question, this introduction is followed by a cartographic

methodology that focuses on the immediate surroundings of the urban tissue at the edge of the highway. Historical maps at both metropolitan and local scale are used, covering almost 40 of the 58 km of highway built. In addition to the description of the historical material used, the methods of analysis are presented, which include the temporal and morphological classification of the urban tissue at the local scale. Next, we present the results of our mapping and classification methodology. These results include two main aspects: firstly, a metropolitan scale analysis that illustrates the process of urban occupation along the edges of Avenida Brasil over several decades; and secondly, an analysis based on 15 aerial photogrammetric maps from Rio City Hall at a scale of 1:2000. These maps provide a detailed view of urban growth and the development of the urban fabric along the highway. By comparing these maps with historical data, we show changes in the urban landscape before and after the construction of the highway. Finally, we deepen the discussion of these results through the comparison and analysis of the tissues classified along the highway in the 15 maps and discuss the organization of this analysis by sections of the highway, which, in the end, leads us to final considerations based on this morphological analysis in relation to spatial segregation on the edges of Avenida Brasil.

METHOD

Using a comparative historical approach, we have analyzed documents and maps from different periods, comparing maps from the beginning of the highway in the 1940s with contemporary satellite images. This analysis aims to reveal different characteristics along the areas of Avenida Brasil: where the urban tissue is continuous or fragmented, where there is a morphological difference between the left and right sides of the road, and where there are variations in the scale of urban elements. The tools used to analyze urban development have become increasingly sophisticated, allowing a deeper understanding of spatial transformations over time. Geographic Information Systems (GIS) allow historical and contemporary data to be overlaid, facilitating detailed temporal analysis. In addition, the digitalization and georeferencing of old maps improves the accuracy of comparisons with current data, providing a clearer picture of the changes that have occurred in cities over the years.

Firstly, in order to analyze the occupation around Avenida Brasil at a metropolitan scale, the existence of "urban tissue" (PANERAI, 1983), illustrated by old maps on the edges of the highway over the decades, is identified, using the ImagineRio application as a basis. The elements represented on the website have approximate locations, which corresponds to the proposed objective, since the development of this stage takes place on a large scale. As a result, it is possible to map, decade by decade, which parts of the edges of the highways, divided into right and left sides (always taking into account the movement away from the city center), were urbanized at each time.

Secondly, in order to analyze the expansion on the edges at a local scale that allows us to classify the urban tissue into categories, a comparative approach has been used on documents and maps from different periods, comparing historical images from the beginning of the highway in the 1950s with contemporary satellite images. It is possible to observe the existing buildings, plots and streets on the historical maps as well as on the contemporary cadastral plans. The satellite images allow us to analyze other layers of information, such as the materiality of the ground (green, sandy or asphalt areas) and the roofs. The selected maps refer to the documents available at the IPP (Pereira Passos Institute) from the 1950s and 1960s, as a result of an aerial photogrammetric survey carried out by the

Municipality of the Federal District of Rio de Janeiro at that time. Among the cadastral maps found in the survey, all those that were in good condition and that framed the location relative to the current position of the highway were selected. In some cases, for example, a projection of the construction of the highway can be seen with dashed lines, while in others contour lines indicate the earthworks prior to construction. It was not possible to include all the regions of Avenida Brasil, due to the lack of maps available under these conditions, as in the case of the Santa Cruz neighborhood, but in general, with the 15 maps studied, it is possible to have a good illustration of the urban condition of the city at times prior to the construction of Avenida Brasil.

Historical cartography is the study and creation of maps that represent geographical space in different historical periods. These maps are used to analyze how cities have grown, changed shape and adapted to different circumstances. The development of transport infrastructure over time has a direct impact on the form and functionality of cities. Analyzing a specific case study such as Avenida Brasil in different historical periods can show how local and global factors influence its development. By using time as a category of analysis, we can observe changes over the years, understand urbanization processes and visualize the impact of historical events. The analysis of urban morphology from a historical-geographical perspective is based on the work of Conzen, who seeks to understand the character and structure of cities over time through a systematic evaluation of their constituent elements. In this approach, structures are analyzed according to the time intervals that define morphological periods. When analyzing urban evolution, it is important to define time in significant periods, developed by synthesizing historical periods with evolutionary periods. As a result of these analyses, we have the process of evolution of the urban landscape. (CONZEN, 2004 apud NETO et al. 2014)

This analysis allows us to visualize the occupation of the different sections of Avenida Brasil that occurred over time, compared to what was maintained, erased and added after its implementation. In addition to the historical record of the urban tissue over time, we used a method to classify the tissues based on their morphological characteristics. In this way, we crossed two axes of information for each category of tissue: the historical period (prior or post construction of Avenida Brasil) and the morphological classification (Fig. 2). Considering the study of urban form as the study of the processes that define the city and its unique physical characteristics, distinguishing it from the concept of "form" (AURELLI, 2011), this morphological analysis aimed to deepen the understanding of these processes in order to systematically organize the urban tissues into different categories. Based on three fundamental elements: the building, the plot and the urbanization (SOLÀ-MORALES, 1973), how they relate to the processes (what comes before and what comes after) and their physical dimensions, it was possible to group them into unique conditions that define a specific category of urban tissue.

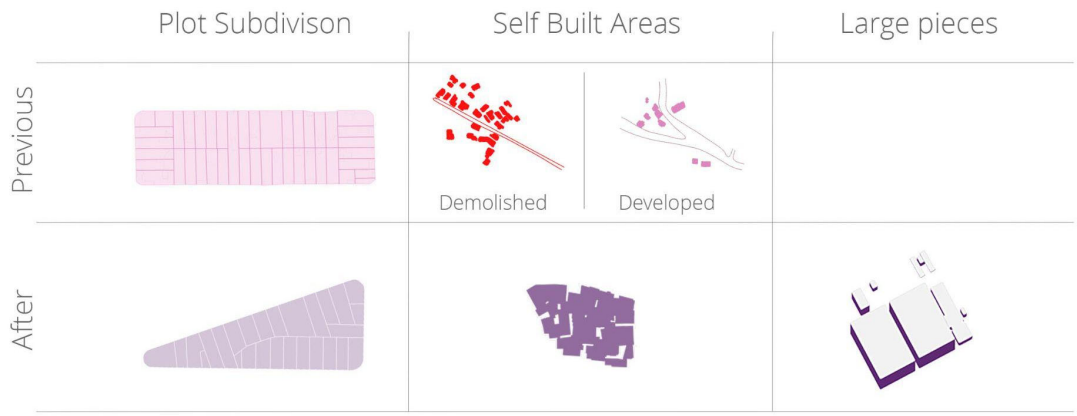

Figure 2. Scheme for categorisation of urban tissues according to historical period and morphological characteristics. Developed by the authors.

We have identified three categories of urban tissues that we consider significant in the structuring of the city of Rio de Janeiro, especially along the Avenida Brasil: plot subdivisions, self-built occupation areas, and large residential or industrial pieces. It is worth noting that these categories may evolve, subdivide or be replaced in the course of ongoing research, as new relationships and processes of construction and expansion of the city are analyzed. The peripheral expansion of Rio de Janeiro was initially marked by the subdivision of land, both private and public, promoted by companies that transformed large areas into urbanized lots for the sale of single-family homes. In these cases, the urbanization of the roads and the legalization of the subdivisions are carried out simultaneously, while the construction of the buildings takes place later. The plots have typical dimensions of between 300 and 600 m², and the blocks are generally rectangular, long and narrow, with a width equivalent to two plots, placed back to back. Although these areas become denser over time, with many changes in building and land use, the street structure and plot configuration remain relatively constant. However, as a result of isolated and independent initiatives, the design of these subdivisions usually does not create continuity in the road network between them, despite maintaining orthogonality and a certain standard of lot and block sizes.

From the 1970s and 1980s, self-constructed settlements became more widespread, characterized by the construction of buildings without prior demarcation of plots or implementation of roads and infrastructure (urbanization). These settlements emerged in undervalued areas, such as hills and riverbeds, and over time developed an irregular road network that followed the curves of the local topography, resulting in a homogeneous density, albeit detached from urban formality. The large residential or industrial buildings typical of contemporary expansion are characterized by complexes built in isolated blocks with specific functions, where the building, the plot and the urbanization occur simultaneously. In contrast to self-constructed settlements, polygons are often self-segregating, surrounded by walls that clearly demarcate public and private space and do not contribute to the continuity of the urban tissue. The plots are generally large, occupying the entire block (with dimensions ranging from 20 to 100 thousand m2), and the buildings are centralized, with a considerable distance from the street and higher heights than in other categories. Examples include classic mass construction initiatives such as the “Banco Nacional de Habitação” (BNH), the industrial parks and the “Minha Casa Minha Vida” (MCMV) programme.

RESULTS AND DISCUSSIONS

Since the analysis was carried out first on a broader scale, covering the entire length of the highway, we seek to understand its role as a metropolitan axis and a structuring factor in the urban expansion of Rio de Janeiro in recent decades. This approach has generated insights that relate the occupation of the margins of Avenida Brasil to the history of the city, offering a deeper understanding of the impact of the construction of the highway, especially through a "before and after" classification that underpins the subsequent categorization of urban tissues. This view of the highway as a unique structuring element of the city serves as the basis and starting point for the detailed analysis of the maps of each section of the study that follows.

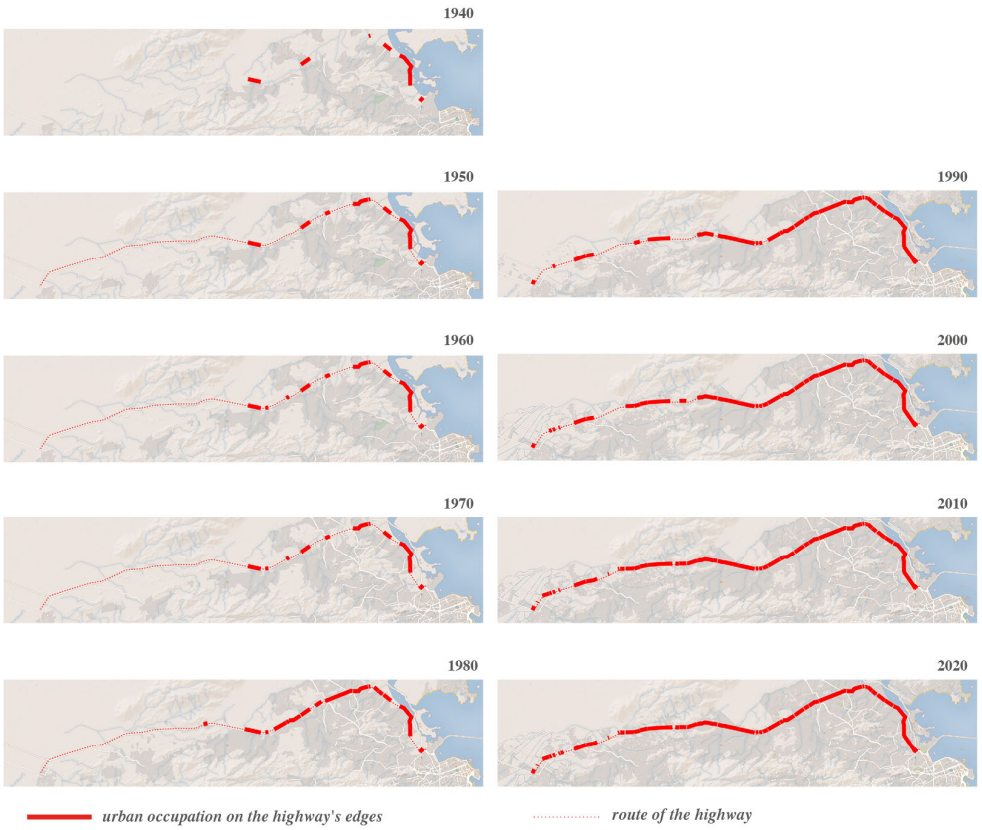

Figure 3. Maps showing the occupation of the "edges" since the implementation of Avenida Brasil, based on the Imagine Rio app. From 1940 - 2020. Source: Adapted, by the authors, 2020.

In the 1940s, when the Avenida Brasil was in its initial phase of construction, urban occupation along the highway's edges was sparse and limited, reflecting the initial nature of the road's development and its function of connecting existing and growing areas (Fig. 3). Between the 1950s and 1970s, with the completion of the highway, urban occupation along its banks began to increase, driven by the development of new infrastructure and the national migration of workers to Rio de Janeiro. The 1980s saw a consolidation of urbanization, with the area around Avenida Brasil being largely occupied. This increase in urban occupation can be linked to economic growth and the intensification of land use for commercial and industrial activities. Occupation in the 1990s followed the occupation trend of previous years, leaving little space for new urban development. Occupation along Avenida Brasil became more dispersed, especially due to the significant expansion of occupation in the part corresponding to the western zone.

Between 1990 and 2000, this movement towards the periphery illustrates the significant urban 'diffusion' that took place in the city of Rio de Janeiro. During this period, the population density fell from 15,000 inhabitants/km2 to 10,000 inhabitants/km2. Although the city's population almost doubled (from 3 million to 5.8 million), the occupied urban area tripled. The dynamics of urban expansion and its correlation with density show a change in urban models in the mid-20th century, based on road construction (MAGALHÃES et al., 2012). At the beginning of the 2000s, urbanization along Avenida Brasil was practically complete, leaving little space for new development. In the 2010s, urban development continued, with a focus on the modernization and restructuring of previously integrated areas. There has also been investment in infrastructure to support the high levels of traffic and demand for urban services in the region. In 2020, urban occupation along Avenida Brasil is characterized by extensive occupation. The thick red line on the map indicates consolidated occupation, although it shows some empty spaces at the western end.

In recent years, from 2000 to the present, diffusion has continued in the city of Rio de Janeiro: land occupation increased by 44.5%, while the population grew by 24%. (MAGALHÃES et al., 2012). The phenomenon of expansion with a decrease in population density observed in Rio de Janeiro, especially along Avenida Brasil, reflects a trend towards dispersed urbanization, where new areas are occupied without a corresponding increase in population density. This phenomenon results in dependence on urban mobility infrastructure, socio-spatial fragmentation and areas with few services and economic opportunities for the population living in their vicinity. The transformation of Avenida Brasil from a sparsely populated peripheral road into a vital urban corridor is an example of the profound impact of mobility infrastructure on urban development. As can be seen in both the historical images and the maps (Figure 3), this highway facilitated the physical expansion of Rio de Janeiro. In order to examine the spatial morphology resulting from this urbanization process, we carried out an analysis of the impact of this highway on the expansion of the urban area, by collecting before and after urban patterns on some historical maps, geographically indicated in the following figure:

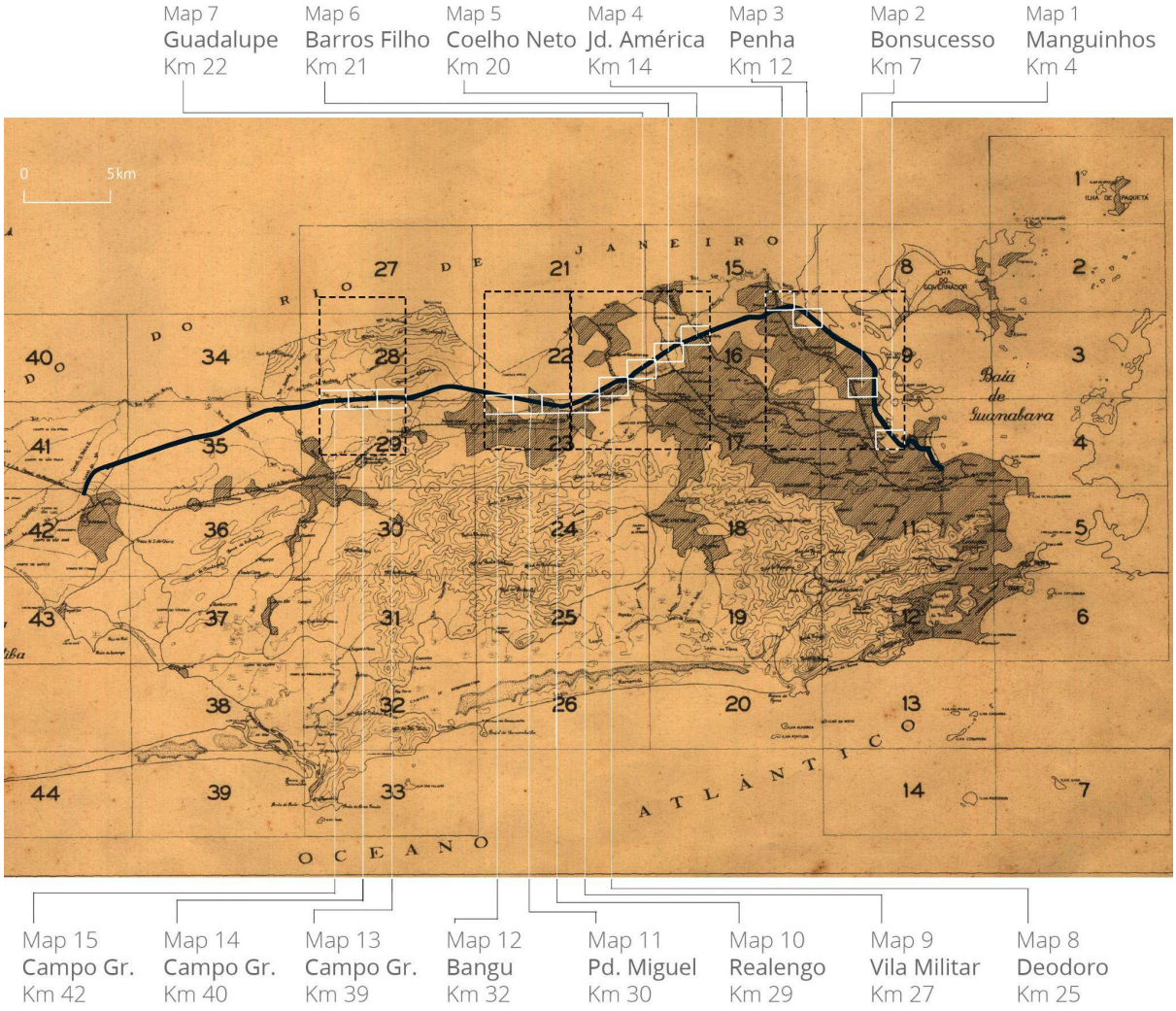

Figure 4. Location of the studied aerial photogrammetric maps in relation to the 1942 Federal District Charter. Source: IPP Imagine Rio

The superimposition of the location of the aerial photogrammetric survey maps studied in this article with the current layout of Avenida Brasil and the 1942 urban area of the city allows a deeper understanding of the relationship between the period before and after the construction of the highway and its impact on the urban expansion of the city (Figure 4). Firstly, a section (maps 1 to 4) is considered where the highway runs along the bay of Guanabara, crossing a previously inhabited area, such as Manguinhos, Ramos and Bonsucesso, until it reaches Penha, where it changes course to the west. In a second section (maps 5 to 9), the highway crosses the main railway branches to the north, passing through areas that are not yet inhabited but have great potential for public transport connections (maps 5 to 7). Deodoro and Vila Militar (maps 8 and 9), neighborhoods with large military installations, represent an important landmark in the city's urban structure and act as an important divider in the expansion area.

The third section (maps 10 to 12) is notable for crossing the still rural areas of important neighborhoods in the western zone, such as Realengo and Bangu. Finally, the fourth section (maps 13 to 15) marks the end of the section studied in this article and represents the occupation of rural areas isolated from the consolidated urban area of the city before the construction of the highway.

Compared study cases: Penha and Campo Grande



Figure 5. Case study maps and comparisons between historical maps, current satellite imagery and morphological classification of urban tissues. Sources: IPP Data Rio, City Hall, Google Earth.

This in-depth study of the urban fabric and the dimensions of blocks, plots and buildings allowed for a differentiated understanding of the characteristics of each category. The categorisation of the maps according to the previously presented legend allowed a deeper understanding of each case and facilitated their comparison. Of particular note are maps 4 and 14, which show parts of the Penha and Campo Grande neighborhoods, respectively (Fig. 5). In Map 4, the presence of the three classified types of urban tissue can be observed: subdivisions, self-constructed settlements and polygons. After the construction of the highway, there was no additional development of subdivisions; only large pieces (whether industrial or residential) and self-built occupations occupied the edges of Avenida Brasil. These filled "gaps" represent the spaces between the new infrastructure and the old urban fabric of the early 20th century. The fact that they were not occupied by a continuous expansion of the existing may indicate the catalytic potential of a mobility infrastructure such as Avenida Brasil, which stimulates the expansion of the network created by specific initiatives that generate new forms. Another relevant point is the demolition of a small self-built settlement to create a ring road for the highway, highlighting the impact and strength of a metropolitan scale infrastructure such as Avenida Brasil. In contrast, Map 14, which shows part of the Campo Grande neighborhood, illustrates a situation that is the opposite of Penha's. At the time the highway was built, this was a rural area, not yet integrated into the urban area of Rio de Janeiro.

In the years that followed, urban expansion, driven by easy access to the highway, took place in a catalyzed and radiocentric manner from the old center of the Campo Grande district towards the new highway, gradually occupying the rural areas of the region. The result of this expansion is a mosaic of disconnected and independent pieces, with little diversity. Self-built settlements predominate, with some isolated subdivisions. The road network is based on the old rural roads of the region, resulting in main axes that connect each of these isolated areas to the main road.

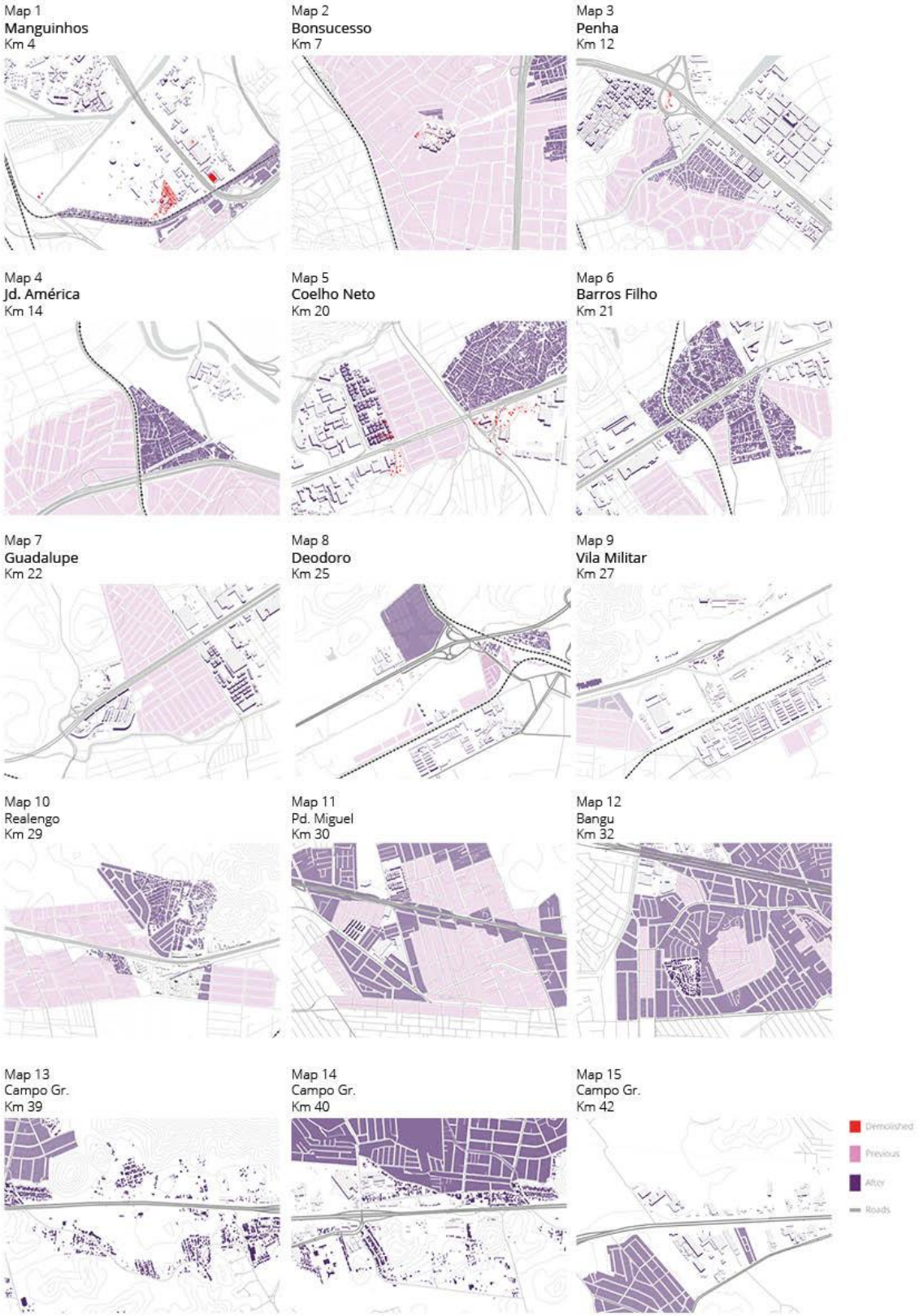

Figure 6. General Analysis of the 15 maps and the urban tissue categories. Sources: IPP Data Rio, City Hall, Google Earth.

Putting all 15 maps into perspective, we can see some convergence. Maps 1 to 7 show that the new settlements created after the construction of the highway are mainly characterized by

industrial/residential complexes and self-built settlements. Maps 5 and 7 in particular show the continuity of the road structure in the subdivisions, rare cases where the subdivisions were approved and sold at the same time as the construction of Avenida Brasil. Maps 8 and 9 show specific cases where the low density is due to the presence of the large military complex in Deodoro, which creates very specific conditions that are difficult to compare with other areas. From map 10 onwards, there are cases of subdivisions built after the construction of the highway. Some of these are configured as urban enclaves, such as gated communities, while others are extensions of subdivisions that predate the construction of the highway.

Maps 10, 11 and 12 show the greater presence of subdivisions along the edges of the road, highlighting settlements that emerged after the construction of the highway, with the exception of map 10. These maps, belonging to the Realengo neighborhood, are the best examples of the continuity of the urban form between the two sides of the highway and between themselves. A strong presence of the alignment of the road network crossing the highway can be observed, with few empty spaces occupied by informal constructions. Finally, maps 13, 14 and 15, which also represent the Campo Grande neighborhood, show a lack of continuity in the urban fabric, characterized by low population density, low road connectivity and the predominant presence of isolated pieces of urban fabric. There is a typical spread of rural and self-built settlements, linked to structuring roads, as well as a mosaic of disconnected subdivisions and the scattered presence of industrial areas along the highway.

CONCLUSIONS

This case study explores the implications of new morphologies that emerge with the implementation of urban mobility infrastructures in the peripheries of metropolitan regions in the Global South. These phenomena can reinforce urban dependency and segregation, especially in economically disadvantaged areas. The analysis of the current maps reveals different characteristics along different areas of the Avenida Brasil, noting where the urban fabric is continuous or fragmented, where there are morphological differences between the sides of the highway, and where there are variations in the scale of urban elements. Based on this methodological principle of classifying urban tissues, and using the concept of segregation as an interruption of the continuity of the street network or urban form, it is possible to identify four distinct stretches in the relationship between the construction of Avenida Brasil and its proximity to previously consolidated urban areas:

In the first section, the highway crosses previously inhabited areas, replacing the old Avenida dos Bandeirantes. Here, new settlements concentrate on filling empty spaces with industrial/residential polygons and self-constructed settlements. The second section is characterized by the "bundling" of the highway with large housing estates and polygons, such as Fazenda Botafogo, attracting new residents, including in large favela complexes, such as Acari. In the third section, the highway crosses rural areas in expanding neighborhoods, such as Bangu and Realengo, where it acts as a catalyst for an ongoing process (the concentric radio expansion of neighborhood centers), being the least segregated section in relation to the urban fabric along its edges. Finally, in the fourth section, the highway crosses rural areas very far from the urban area or any connective structure. In this case, the occupation driven by the highway is more segregating, generating autonomous forms of isolated subdivisions, scattered self-built occupations and little continuity in the road structure between the edges. The spatial segregation in the urban fabric of the edges of the highway depends on their

proximity to other connective elements of the consolidated city. When the Avenida Brasil crosses previously urbanized areas, there is some continuity in the urban fabric, with the highway itself acting as a catalyst for ongoing expansion. However, when it crosses rural and isolated areas, the highway stimulates the development of a new urban tissue, which does not present continuity, creating a difference between the sides of the highway and creating urban fragments separated from each other. In short, the further the construction of the highway is from any urban infrastructure or previous occupation, the more disconnected and segregated the urban tissue should be.

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Urban morphology, transit-oriented development (TOD), and planning: A case study from Aotearoa New Zealand

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ABSTRACT

Geographical urban morphology provides a systematic framework for urban form research. In particular, it has been applied in planning, architecture, and urban design towards seeking economically efficient, environmentally sustainable, and socially inclusive future built environments. Despite growing interest in transforming the intellectual ideas of urban morphology into operational tools, practical bases are yet to be fully achieved. In connection with an investigation in Auckland, New Zealand, where transit-oriented development (TOD) has been promoted as a planning response to excessive automobile travel and associated urban problems, this paper reports the use of urban morphology to reveal the development process of Auckland's railway station catchment areas. Clarifying the developmental or evolutionary process provides a foundation for future development to build upon, enhancing place identity and meeting future needs. Alongside global morphological and TOD studies, this research contributes to innovative sustainable development in New Zealand and enhances the practicality of morphological methods.

Keywords: urban morphology, sustainable urban form, transit-oriented development, New Zealand.

INTRODUCTION

First established in central Europe in the late 19th century, geographical urban morphology (Conzen, 1960; Gauthiez, 2004; Whitehand, 1981) was later consolidated as an approach for studying urban form in research conducted by M.R.G. Conzen. Beginning in the 1950s, Conzen used town-plan analysis to clarify the geographical arrangement and distinctiveness of towns by systematically examining their constituent elements and tracing their evolution over time (Kropf, 2009). The framework not only enables a critical analysis of buildings and urban fabrics but also informs and shapes the design process (Strappa, 2023). Not surprisingly, it has since been applied in planning, architecture and urban design (Whitehand, 1981).

Despite the increasing interest in transforming the intellectual ideas of geographical urban morphology into operational tools (Gu *et al*., 2019; Whitehand, 2009), its full potential is yet to be realised. In particular, traditional morphological data collection and analysis require greater clarity. There is a need to improve urban morphology to enable reproducibility and methodological

compatibility across disciplines (Zhang *et al*., 2023) and establish a dependable methodology for measuring and classifying urban forms (Dibble *et al*., 2019), thus widening its applicability.

The morphological approach strives to disclose the 'genesis' or 'engendering process' of landscape forms as a developmental or evolutionary process. Alexander (2004) claims that in order for people to create a sustainable world and maintain its uniqueness, they need to recognise that the living environment transforms in a holistic and sequential unfolding process, inheriting and strengthening the good qualities of systems and rectifying their flaws. This 'structure-preserving (and enhancing) transformation' maintains and improves a place's existing structure or essence, the streets, squares, or urban neighbourhoods, even as they evolve and develop (Alexander, 2002). The morphological process uncovers what will emerge and is always informed by the form at the moment just before (Tan *et al*., 2024). City planning thus seldom begins with a blank canvas and existing land uses play a crucial role in shaping future development (Atkinson-Palombo and Kuby, 2011).

It is argued that the challenges facing urban morphology frequently relate to ignorance of the dynamics of spatial-temporal processes. Seeking to address this gap, this paper explores the challenges facing urban morphology through the exploration of transit-oriented development (TOD). TOD offers a promising approach to achieving carbon neutrality, which remains an important priority for both local and central government. However, practical strategies and methods for TOD implementation are underdeveloped in New Zealand. Based on the 50% benchmark (Hale, 2014), many of the railway station catchment areas in Auckland show low usage of sustainable modes of transport (public transport, walking and cycling). Furthermore, according to analysis of data from the 2018 New Zealand Census, 28 of the city's 39 railway station catchment areas score below 30% in terms of travel by sustainable modes (Li, 2024). This underutilisation of rail transport is an obvious problem, and there has been no investigation of the causes from a morphological perspective. Geographical urban morphology provides a systematic approach to revealing the complex process of TOD development and redevelopment. Specifically, the morphological approach is used in this study to analyse the relationship between the urban development process and current underutilisation of railway stations in Auckland, and thereby provide suggestions for future TOD development.

Morphological periods, fixation lines and plan units are Conzenian terminology (Larkham and Jones, 1991). Urban development can be conceptualised as a series of morphological periods (Conzen, 1960). Each morphological period represents a portion of history that has distinctive forms based on socio-economic conditions. These forms leave varying degrees of residue in the urban landscape depending on the requirements of the societies that follow (Conzen, 1988). The idea of fixation lines has been applied in various planning and design research. For example, the city walls of Pingyao are a fixation line that can be traced from historical maps as well as on the ground now, reflecting the influence of historical structure on built form (Conzen *et al*., 2012). While city walls and mountain ranges have been explored as fixation lines, there has been no research into railways as fixation lines in TOD.

The railway line has a significant influence on urban form and urban development, dividing the land into parts and forming a frame or barrier for development. The ever-changing relationship between the railway and urban form is therefore worth investigating to ensure new development can be continuous and respond to problems left historically by prior development. The plan unit, or areas with similar development qualities, can be recognised from a town plan in terms of distinctive

combinations of streets, plots and buildings formed in the development process (Conzen, 1960). It takes on various sizes, ranging from a single plot to a large portion of a town (Gu, 2014).

This paper therefore addresses the following questions: 1) In what way and to what extent can morphological concepts support explanations of the development process of railway station catchment areas?; and 2) Given the available qualitative and quantitative data for historical development, how can urban morphology be applied to help reveal the changing morphological process of TOD? Answers to these questions are provided by means of a critical examination of urban development and other changes in the area around the Panmure railway station in Auckland. The case study area has a rich history and has been deeply influenced by Auckland's complex transportation evolution and urban development. This paper reports an in-depth study of its 15-minute walkable catchment area. The transition to mobility in urban environments can start with these railway station catchment areas, which are still in operation and have greater potential for TOD than other areas of the city.

The paper is organised into two parts. First, the morphological periods of the study area are described in connection with the concept of fixations lines. This complex layering of the spatial-temporal landscape then forms the basis for urban landscape assessment using historical maps and documents. The second part reports the morphological units based on data collected for each morphological period. The resulting plan units will support the continuity of future development.

METHOD

The methods used to explore the evolving relationship between the Panmure railway station and its surrounding area mainly derive from town-plan analysis, notably reconstruction of the urban development process through analyses of historical series of ground plans and documentary records. The systematic survey conducted for this study used multiple sources including historical maps, property data, Auckland Council Geomap, and field surveys to explore patterns of development (Gu, 2014). Plans and maps of Panmure are widely available, beginning with cadastral maps from 1860 (Auckland Libraries Heritage Collections, 1860a, 1860b). These historical maps play a crucial role in reconstructing the development history of the urban landscape (Gu, 2014). Additionally, Property Guru offers a comprehensive collection of New Zealand property-related information. This dataset includes details such as the names of occupants and owners and the ages of most buildings. A plot-by-plot field survey allows land uses to be identified.

The use of geospatial technology, particularly an integrated GIS system, is increasingly important for analysing and synthesising morphological data. It enables multi-source data to be assembled into a single database for analysis. More importantly, it can spatially relate data from different sources and produce new or missing variables in separate datasets. In this research, the plans and maps of the study area were georeferenced in GIS (Tümtürk *et al*., 2024), and the ground plan information then digitised in ArcGIS Pro.

Panmure and its morphological periods

With 170 years of European history, Auckland is the largest urban area in New Zealand (Gu, 2010). The evolution of society since early colonial days has affected the building types and ground plan,

influencing the development and transformation of building forms, which often leave marks on the ground. About 18 per cent of Auckland's total urban land area lies within the 15-minute walkable zones around its 39 railway stations. The railway station area in Panmure provides an ideal case study, with its historical development and current form representative of many urban railway station areas. The study area was delineated as the surface included within a 15-minute walkable distance of the railway station.

Located in East Auckland, the Panmure station is close to the Auckland CBD and Manukau central business districts. The suburb of Panmure lies between Mount Wellington and Panmure Basin, offering a mountain view and water connections to the Hauraki Gulf and Waitematā Harbour. Throughout the years, key changes in planning, infrastructure, and policies have greatly shaped the development of Panmure and its adjacent urban areas (Beharrell, 2024).

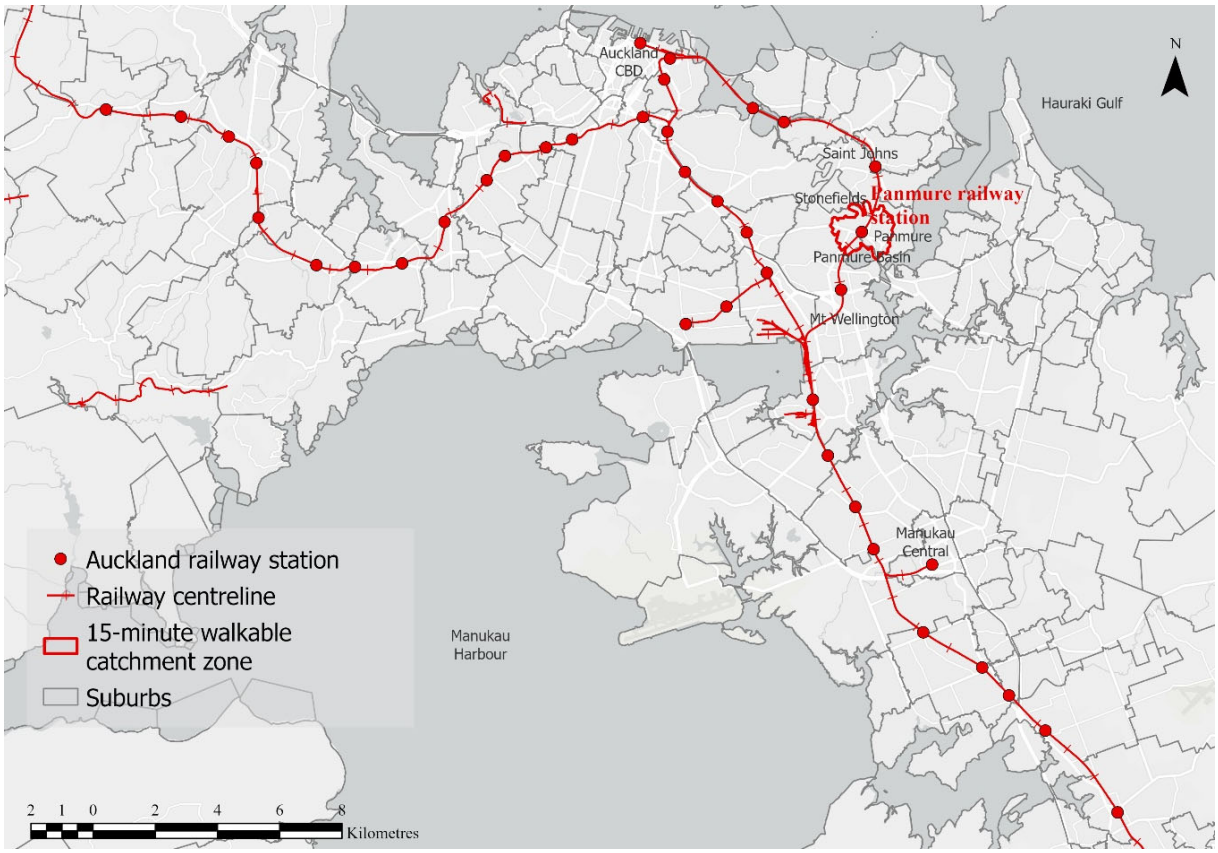


Figure 1. Railway stations in Auckland and Panmure railway station's 15min walkable zone.

Based on a review of the historical records of Panmure, its development can be categorised into four morphological periods of growth and change: pre-urban development (1840s–1880s), railway colonisation and expansion (1890s–1930s), segregation and fragmentation (1940s–1990s), and urban redevelopment and revitalisation (2000s–now).

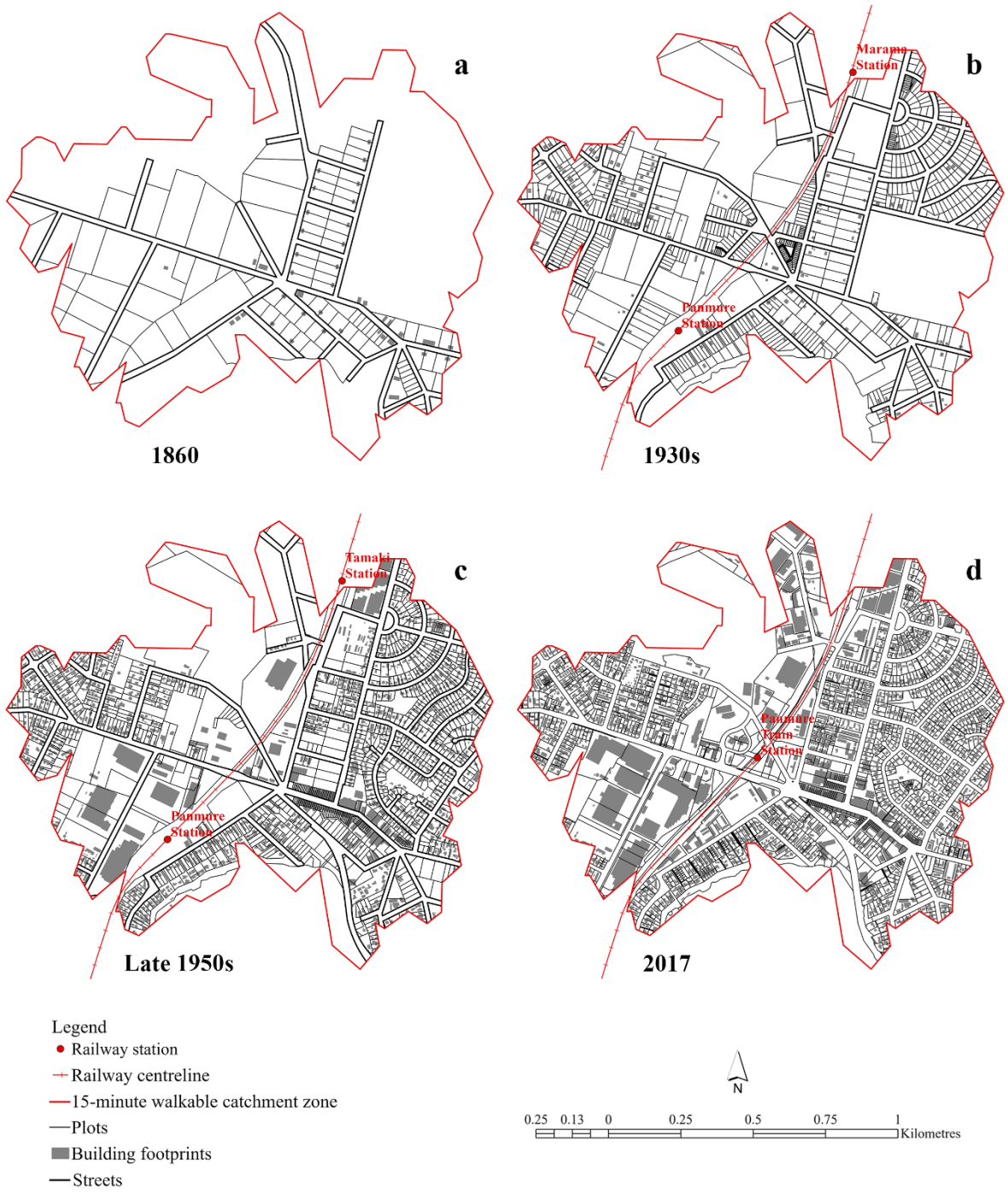


Figure 2. Streets, plots and buildings in the 15min walkable catchment area of Panmure in (a) 1860, (b) 1931–1940, (c) late 1950s and (d) 2017 (based on Auckland Council, 1958, 1959, 2024; Auckland Libraries Heritage Collections, 1860b; Auckland Libraries Heritage Collections Map 71, 1931).

Pre-urban development (1840s–1880s)

Panmure started as a defence post in the 1840s, when it was established as one of Auckland's fencible settlements (Hoffman, 2019) on divided farmlands. Situated along feared potential Maori invasion routes to Auckland after the outbreak of hostilities between Maori and the Crown in the north, Howick, Panmure, Otahuhu and Onehunga were the locations chosen to provide places for 2,500 Fencibles and their family members (almost double the population of Auckland at that time), who

travelled from the UK to New Zealand between 1847 and 1952 (Howick Historical Village, n.d.). The word Fencible comes from ‘defencible’, meaning ‘capable of defence’. The Fencibles had served as soldiers in the wars of Britain in the 1830s and 1840s. To emigrate to New Zealand under the Fencible scheme, retired soldiers were required to be under 48 years of age and of ‘good character and industrious habits’ (Howick Historical Village, n.d.). These retired soldiers were enlisted to serve for seven years in exchange for a cottage and one acre of land (Howick Historical Village, n.d.).

Panmure became a busy place in the mid 19th century, partly because of its location near the narrowest part of the isthmus, on the route between Auckland and the largest fencible settlement of Howick. People and goods were transported across the water by ferry at the narrow point below Mokoia Pa (Auckland Transport, 2018).





Figure 3. Fencible cottage and Panmure ferry in the 1860s (Auckland Libraries Heritage Collections 1031-P619-06, 589-0426)

Railway colonisation and expansion (1890s–1940s)

Railway construction in Auckland dates back to 1863, with the railway system starting to take definite shape in the 1870s (Davidson, 1931). Upon the arrival of railway to Auckland to carry not only goods but also passengers (Lowe, 1973), Panmure became a busy transport hub (NZ Herald, 2010). Steamers from Auckland stopped there on their way to the goldfields in the Coromandel and Firth of Thames. New developments and plans for land around the railway line also started during this period. The original Panmure Station opened on 16 November 1930, shown in Figure 2 (b), on a site to the south of the current station.

After World War I (1914–1918), the newly established profession of town planning and its advocates aimed to provide solutions for the challenges of postwar resettlement in both urban and rural areas, and showcase the effectiveness of town planning (Miller and Roche, 2003). Town planners in New Zealand adopted town planning concepts from Britain, and were especially influenced by the Garden Suburb model when accommodating soldier settlements (Miller and Roche, 2003).

Starting from the beginning of the 20th century, the garden suburb movement gained popularity, with the Tamaki Heights Garden Suburb designed by E. V. Blake (see Figure 4) showing marked garden suburb appeal. The subdivision shown in Figure 4 was marketed by brochures and newspaper advertisements from 1926 to 1928 (Miller, 2004). However, the garden suburb experienced slow development and was eventually incorporated into the State Housing programme, which led to changes in its layout (Miller, 2004).

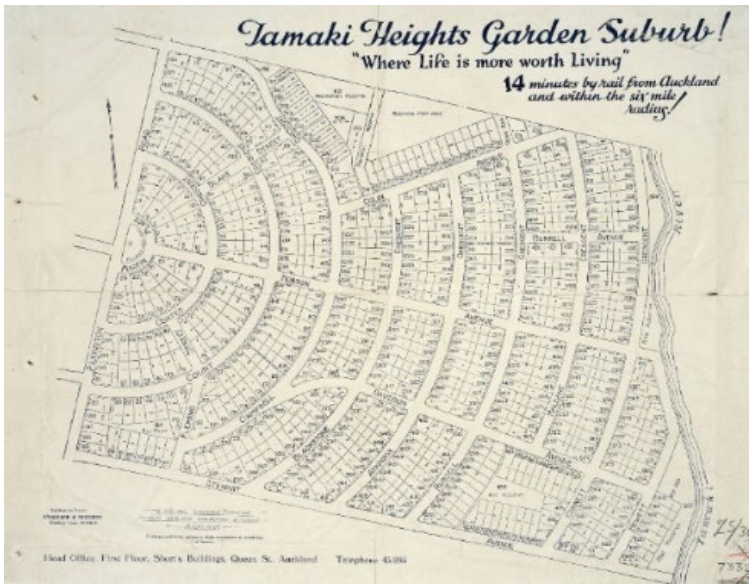


Figure 4. Panmure store and sales advertisement of Tamaki Heights Garden Suburb development allotments (Auckland Libraries Heritage Collections, 1920).

Segregation and fragmentation (1950s–1990s)

Up until the mid-20th century, Panmure remained a prosperous but predominantly pastoral area (NZ Herald, 2010). It was only after the explosive suburban development that occurred around Panmure following World War II (1939−1945) and the construction of better bridges to Pakuranga (NZ Herald, 2010) that the suburb grew significantly and transformed into a commercial centre. During the period 1950−1955, Panmure grew from a small village with a few shops and a hotel into a busy suburban shopping hub with the development of the West Tamaki housing estate (Hoffman, 2019).



Figure 5. State houses on Pilkington Road and Main road (Queens Road) in the 1960s (Auckland Libraries Heritage Collections 895-A62539, Auckland Libraries Heritage Collections 786-A18-03).

In 1948, there was initial discussion about an eastern motorway to cater for Auckland's future growth (Cayford, 2011). In 1955 as part of a Master Transportation Plan, a South Eastern Motorway was proposed to link the central business area to eastern areas of Auckland, Mt Wellington Highway and the existing SH1 Motorway at Mt Wellington via Tamaki (Cayford, 2011). In the 1960s, the Eastern Corridor was part of the regional highway plan (1965 Report on a Comprehensive Transportation Plan for the Auckland Regional Authority), with land designated for a motorway. The intended motorway was changed to a limited access (arterial) road in 1967 (Cayford, 2011). In 1974, the Eastern Corridor was incorporated into the Auckland Regional Planning Scheme, with the Auckland Regional Authority

revisiting the idea of a four-lane arterial road in 1975 (Cayford, 2011). In 1993, the Auckland City Council designated the corridor route under the title Proposed Limited Access Road – Eastern Highway. Effective until 2004, the designation was then extended in August 2004 for ten years to 2014 (Cayford, 2011). The development of highways has meant urban development in the area no longer centres on the railway. As a result, superblock types have formed with through roads for private cars and more cul-de-sacs (Figure 2 (c)).

The creation of the Auckland Regional Planning Scheme in 1988 established a framework for managing coordinated growth in the Auckland region, setting rules to manage expansion and development (Hoffman, 2019). It helped address the previous segmentation and fragmentation.

Urban redevelopment and revitalisation (2000s-now)

Since the beginning of the 2000s, there have been efforts to seek collaborative solutions for urban development and infrastructure improvements around railways. In 2004, the Hobson Bay, Purewa Creek, Glen Innes/Panmure, SH1 and Tamaki River corridors were recommended as the preferred routes between Auckland's CBD and the Tamaki River (Cayford, 2011). Local elections in October 2004 led to a reconsideration of the project by the Auckland City and Manukau City Councils and Transit New Zealand, with more emphasis on passenger transport and improving roads to carry passenger transport. Auckland City subsequently resolved there would be no highway component for the project north of Glen Innes. The Auckland-Manukau Eastern Transport Initiative (AMETI), which originated from the Eastern Highway project, is a package of transport improvements along the Glen Innes – Panmure – Pakuranga –Botany corridor. The project aims to provide a high-quality strategic transport link between Auckland City and Manukau City via the eastern suburbs. Requiring major public investment, AMETI includes land use zoning changes and an urban design approach, providing bus lanes and other bus priority measures, an improved road network, improved walking and cycling facilities, and travel demand measures (Cayford, 2011). Still ongoing, the Auckland Manukau Eastern Transport Initiative (AMETI) involves major public investment (Cayford, 2011). The area's transport infrastructure developments highlight its important role as a transport node and crucial interchange.

Panmure is also the focus of large public investment as part of the Tāmaki urban transformation led by the Tamaki Regeneration Company, a government-council joint venture. The project was set up with the aim of building 7,500 new homes and community facilities over the next 15−20 years. The area has seen a high level of local board planning, with strong political and community backing for change. Launched in 2012, the Tamaki Transformation Programme is the country's first urban regeneration programme. As described in the project plan for Panmure, many of Panmure's facilities and natural assets are underutilised due to poor local connections. The town centre needs to maximise the benefit of transport investments, including through AMETI, greenways, and improvements in walking and cycling. The area offers a wide range of local services, leisure and recreational facilities, including council amenities, that can be enhanced to support future growth (Panuku Development Auckland, 2018). Panmure's town centre is strategically located, featuring infrastructure and access to public transport. The area has the potential to meet the pressing need for sustainable and quality urban development.

The town centre regeneration plan by Panuku Development was approved by Auckland Council's Planning Committee in 2018. It seeks to strengthen links between Panmure Station and the town centre (Panuku Development Auckland, 2018). The Unlock Panmure Project includes planning for new

precincts and new projects within the precincts to create a thriving town centre, upgraded public spaces and more (Eke Panuku Development Auckland, 2023).

The Panmure railway station was relocated to its current site in 2007. Since the opening of the upgraded station in 2014, there has been significant growth in train boardings in Panmure. Based on 2018−2019 data, Panmure station has become the third busiest station, following Britomart and New Market station (Greater Auckland, 2019).

The morphological structure of the Panmure railway station area

Panmure in 1860 was characterised by large plots and empty land as shown in Figure 2 (a), which the railway line later cut through creating a divide (Figure 2 (b)). Large plots were subdivided, resulting in many smaller plots. The two sides of the divide subsequently experienced different types of development, in part related to the location of the train station. The original garden suburb development is still evident on the northeast side of the study area. Seeking to reverse this trend, efforts are now being made to recover a coherent urban form through reconnecting the separate developments.

The plan units

Examination of change in the ground plan has been an important basis for the identification of six plan units in the 15-minute walkable catchment area of Panmure railway station (Figure 6 and Table 1). The area with the longest development history is identified as the first plan unit. Subsequent development occurred as the Garden Suburb unit. The railway station unit, suburban expansion unit and residential unit developed over similar periods. Notably, the railway station unit is completely different from the other two residential units in terms of form and uses; the fixation line of the railway has had a major influence on the result.

Fixation lines in the form of natural and artificial features, such as city walls, rivers, mountain ranges and railways, are often seen as a barrier to development (Conzen, 1960). They have a major influence on the formation and changing direction of urban development and expansion. The spaces around fixation lines have many things in common. For example, these areas often act as corridors and they are low density, exerting less pressure on land. A trend can be identified whereby socio-economic factors influence fixation lines, in this case the railway line. On one hand, the railway station site brings new development and commercial opportunities for the area, and it prospers. On the other hand, the railway track attracts freight yards, industry and housing nearby (Bertolini, 1996). It is important to recognise the long-standing influence of the railway line on the surrounding development as part of the history and identity of the place.

Under certain conditions, urban development can continue beyond the barrier created by a fixation line (Gu *et al*., 2022). In the case of the railway line, the resulting divided environment has been an obstacle in station redevelopment projects. Methods of dealing with this constraint include vertical crossings or having the railway line below or above the ground (Bertolini, 1996). Even once the physical barrier is removed, the characteristics of the developed area brought about by the fixation line will remain unique features on the ground (Gu *et al*., 2022).

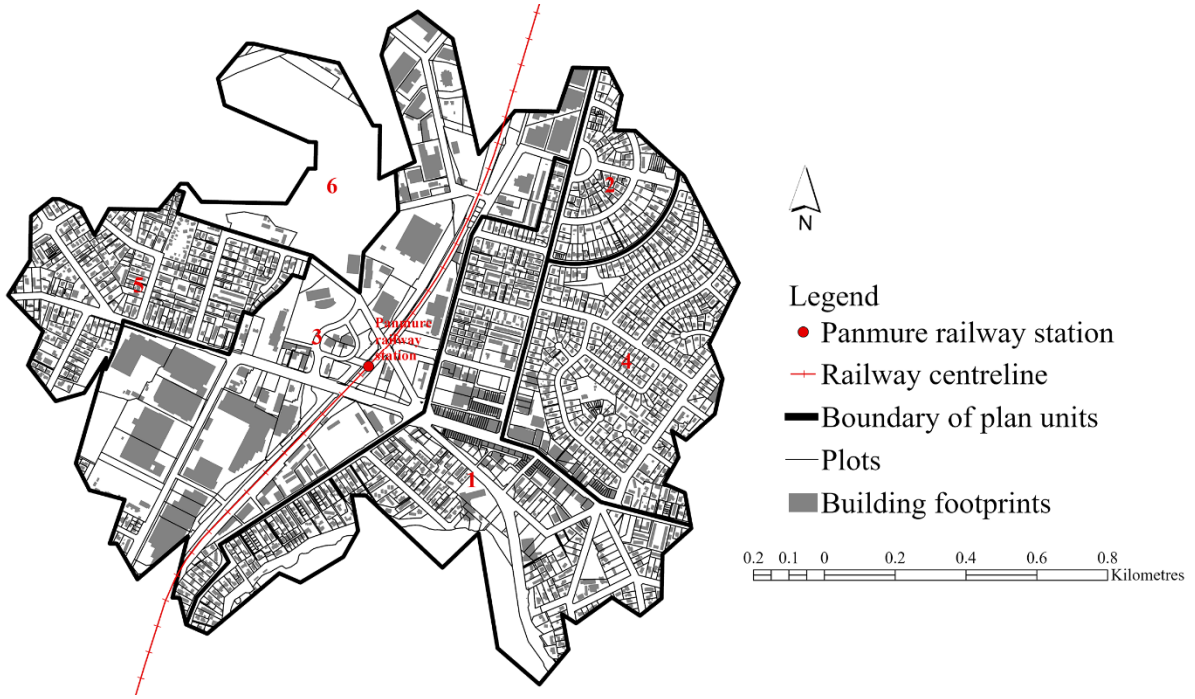
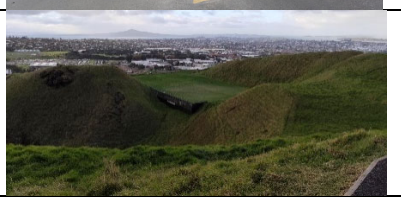


Figure 6. Plan units in the 15min walkable catchment area of Panmure railway station. (1) Historical development, (2) Garden suburb unit, (3) Railway line unit, (4) Suburban expansion unit, (5) Western residential unit, (6) Mt Wellington Domain unit

Table 1. Plots and their metamorphosis and buildings and their block plan in the plan units (Authors own photo 2024).

Plan units	Plot	Building	Image
1.Historical development unit	Mainly small- and medium-sized plots mostly in the form of 1950s	Mixture of commercial, residential and recreational buildings	
2.Garden suburb unit	Planned layout with regular plots	Residential buildings and local commercial stores	
3.Railway line unit	Mainly large plots for industrial purposes resulting from plot subdivision and amalgamation	Industrial, public transport and commercial buildings	
4.Suburban expansion unit	Mainly small plots	Mainly residential buildings, with small portion of commercial and institutional buildings	

5.Western residential unit	Mainly small plots	Mainly residential buildings	
6.Mt Wellington Domain unit	Single large plot	Natural landscape, horticulture yard and recreational buildings	

TOD planning and design

Auckland Council's Plan Change 78 regarding intensification is underway and expected to be finalised by 2025. Prioritising rapid transit, it recognises that strategic planning and development around train station areas are urgently needed (Auckland Council, 2023). The provisions of the plan change have the potential to impact the Panmure station area. There is provision for six-storey buildings within the 800-metre walking catchments of rapid transit network stations (RTNs) through rezoning residential land to Residential – Terrace Housing and Apartment Building, and rezoning all other existing urban residential land to the revised Residential – Mixed Housing Urban category, unless there are valid reasons not to (Auckland Council, 2022). The provisions of Plan Change 78 will likely increase the speed and scale of development in Panmure as the market responds to the new planning regime. As a result, residential intensification and population growth in Panmure will probably be faster and higher than projected in the Auckland Plan 2050 (Auckland Council, 2024b). The spatial distribution of future populations will change as a result.

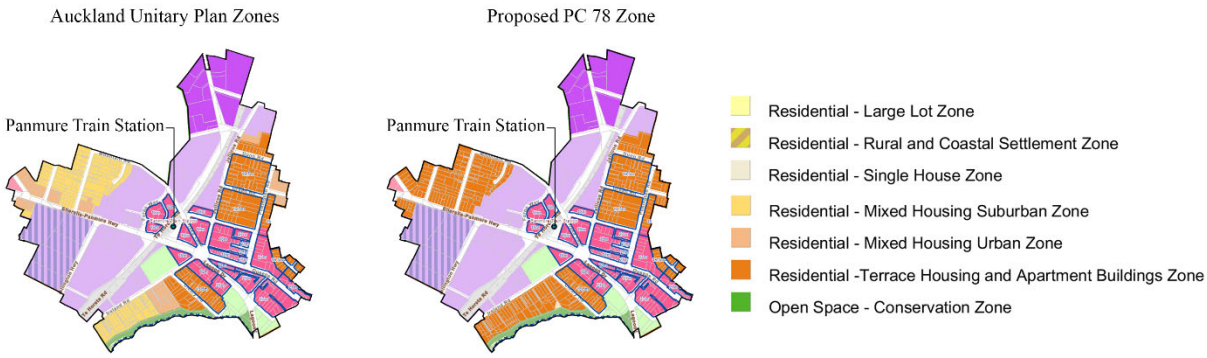


Figure 7. Auckland Unitary Plan Zones and Proposed PC 78 Zones – propose changing residential-mixed housing suburban zone and residential-mixed housing urban zone to residential-terrace housing and apartment buildings zone (Auckland Council, 2022).

However, the PC 78 zones fail to consider the spatial-temporal processes of the areas and acknowledge little of the differing characteristics relating to their development process (Gu, 2014). This will potentially lead to a fragmented landscape. To create a coherant landscape, unit-specific (Gu, 2014) and place and form-based design is recommended. In this way, 'pull factors' including improved

accessibility, walkability, and proximity to public facilities (Gehrke *et al*., 2019; Zondag and Pieters, 2005) will be integrated in the different units.

For the historical development unit, the town centre, the emphasis should be on the historical connection with the railway line, improving public space and roads for easy access, and ensuring a pedestrian-friendly environment. In the Garden suburb unit, which has a historical connection with the previous Tamaki station, work could be done to enhance pedestrian-friendly travel to the railway station. Finally, the western residential and suburban expansion units should be the focus of intensification.

Based on the PC78, there are changes proposed to the railway line unit. However, this area could become the focus for denser mixed-use development around the railway station as there is a lot of publicly owned land available, much of which is currently used for open-air parking. As a result, homes, employment, and supporting retail as well as other services would develop immediately adjacent to, if not directly above the railway station. The roads need to be improved for easy pedestrian and cycle use to connect to the other units in this walkable catchment area, thereby creating a highly connected spatial layout to supplement TOD. This would minimise the negative effect of the rail tracks and maximise the development of TOD neighbourhoods to accommodate the desire of people of various socioeconomic status to live in a TOD neighbourhood (Olaru *et al*., 2011).

CONCLUSIONS

Applying a morphological perspective to TOD study is important, as the physical form of TOD greatly influences its success. Through this approach, continuity can be retained and enhanced, and local characteristics preserved, leading to more successful development around railway stations. This paper has examined the evolutionary process of Panmure railway station's 15-minute walkable catchment area. The distinct characteristics of each morphological period were identified by reconstructing the historical ground plan and analysing how the past influences the present. By tracking the continuous transformation of form from one period to another, factors that should be considered in future planning can be determined.

The identification of morphological units can therefore support future planning and design decisions, ensuring that the development process incorporates morphological research as a planning and design guide (Gu, 2014). The findings and recommended strategies for each unit type identified in this study contribute to research and planning practices aimed at recovering a sustainable urban form in the railway station catchment area.

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A study on street space evaluation method based on depth perception

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ABSTRACT

Evaluating the perceptual quality of urban street spaces has always been a significant goal in morphological analysis. Among these methods, analyzing street view photos is particularly important. This analysis primarily focuses on the feature analysis of physical elements in the photos, such as fractal calculations of street view images and the proportion of street view area occupied by elements like the sky and vegetation based on semantic segmentation. It examines their correlation with human perceptual experiences, such as pleasantness and cleanliness. However, the "depth perception" information in visual perception has not yet received attention in street view photo analysis. Depth perception refers to the perception of the distance between the perceived object and oneself, as well as the distance and positional relationship between perceived objects. It significantly impacts people's experience of the richness of urban street spaces. This study first classifies streets based on morphological elements such as street width, intersection distance, the number of along-street building interfaces, their lengths and heights, and the number of along-street plots to establish an ideal analysis model. Then, through the three dimensions of forward level, lateral level, and perspective vanishing point, an evaluation index system is established to distinguish the differences in "depth perception" among different types of street models. Finally, through a perceptual evaluation scale study, the most critical indicators and characteristic thresholds of street morphological elements affecting depth perception are identified.

Keywords: street space, depth perception, morphological analysis, street view photos

INTRODUCTION

Urban street spaces are one of the most important types of public spaces in cities, and their perceptual quality evaluation has long been a significant focus in urban morphology analysis (Chen, ST & Biljecki, F, 2023; Li, XJ, Zhang, CR, et al., 2015). One approach is to directly analyze the spatial elements within two-dimensional street view scenes. Street view images have become widely used data types (Fang-Ying Gong et al., 2018; Tang Jingxian et al., 2016). For example, fractal calculations of street view images and the proportion of street view area occupied by elements such as the sky and vegetation based on semantic segmentation are analyzed to examine their correlation with human perceptual experiences, such as pleasantness and cleanliness (Xu Lei-qing et al., 2017; Jon Cooper & Reza Oskrochi, 2008; C.S.B. Grimmond et al., 2001).

Another approach is to analyze perceptual quality using three-dimensional spatial elements and their indicators of streets. Commonly mentioned morphological characteristics of street three-dimensional space in relevant studies include street width, length, height, aspect ratio (height-to-width ratio), street wall continuity, number of buildings along the street, standard deviation of building heights on both sides, proportion of building intrusions into the street view, and street curvature. These indicators can affect the visual complexity of the street view and may imply perceptions of content and order (Harvey et al., 2015). For example, high-rise buildings can create a sense of "oppression" for citizens, with a critical height for this oppressive feeling being 45 meters. Changing the aspect ratio from 3 to 4 is less effective in reducing or increasing oppression compared to changing the aspect ratio from 2 to 3, depending on whether the width or height is fixed (Esmaeil Zarghami et al., 2019).

In addition to affecting the subjective emotions emphasized in the aforementioned studies, the geometric characteristics of street space have a more direct impact on people, namely depth perception. Depth perception is the ability of humans and other sighted animals to perceive objects as having volume (rather than seeing only planar outlines) and to recognize the relative positions of objects in a three-dimensional environment (rather than in a two-dimensional image). The main influencing factors can be divided into binocular cues and monocular cues. Binocular cues include binocular disparity and binocular convergence, while monocular depth cues include relative position, relative height, relative size, texture gradient, aerial perspective, linear perspective, motion parallax, and shadows (Lebreton, P. et al., 2014).

In a study on the process of human scene perception, researchers have demonstrated that the space-centered theory, which posits that spatial depth perception plays a dominant role in human judgments of scene attributes, holds true (Matt D. Anderson, 2022). In the book Exploring the Visual Landscape, Steffen Nijhuis et al. review past research on the objective existence of spatial depth and depth cues. They argue that the most significant depth cue is occlusion and discuss the effects of height, shadows, focal points, relative object size, atmospheric conditions, and visual illusions on depth perception, emphasizing the importance of these factors in landscape space design. Additionally, depth or distance judgments can be influenced by various factors. When the actual spacing remains constant, a smaller visual angle between two objects and the observation point results in a lower distance estimation (Levin, Charles & Haber, Ralph, 1993). Besides aiding in distance and direction judgments, depth perception is also related to judgments of object size (Inna Tsirlin, 2016; Jiehui Qian, 2016).

Some studies have pointed out that the continuity and integrity of vertical street interfaces are crucial for the clarity of street space morphology cognition (Wowo Ding, 2011), but the relationship between street wall continuity and depth perception remains unclear. Additionally, some research has used three-dimensional point cloud models to measure landscape spaces and has proposed concepts such as hierarchical permeability and spatial overall depth for spatial depth evaluation (Zhang Xiaohan.et al., 2022; Mei Liu & Steffen Nijhuis, 2020).

However, in the aforementioned research on street space perception, the "depth perception" information in visual perception has not been sufficiently emphasized. This paper aims to develop a method for evaluating street space depth perception and to analyze the mechanisms by which specific street space morphological elements or combinations of elements affect street space depth perception.

METHOD

Construction of the "Street 3D Model-Visual Scene"

Previous studies have used street view photos with too many morphological elements, making it difficult to analyze the relationship between morphological elements and visual perception individually. Therefore, this study mainly investigates the impact of the geometric characteristics of street space on depth perception. The study first constructed a baseline street space model. Using street view photos of Nanjing's wider roads with fewer obstructions(Figure 1) as an example, we consider the distance for recognizing the contours of buildings on both sides of the street to be approximately 840 meters, and we use this length as the basic length for the 3D model. Additionally, taking into account relevant provisions in Chinese urban planning and architectural design codes, we selected a street model with a width of 24 meters and building interface heights of 24 meters on both sides as the baseline model. The building interfaces consist of units with a width of 24 meters and a floor height of 4 meters, simulating the perspective changes brought by texture gradients in real scenarios (Figure 2). Since distant objects can significantly disrupt local depth perception, the model does not include blocks simulating tall buildings in the distance (Tribhawan Kumar, Donald A. Glaser, 1991).



Figure 1.A sample street view of Yanshan Road, Nanjing .Start point(a).end point(b).map corresponding(c). Photo credit: Baidu Map, bing map

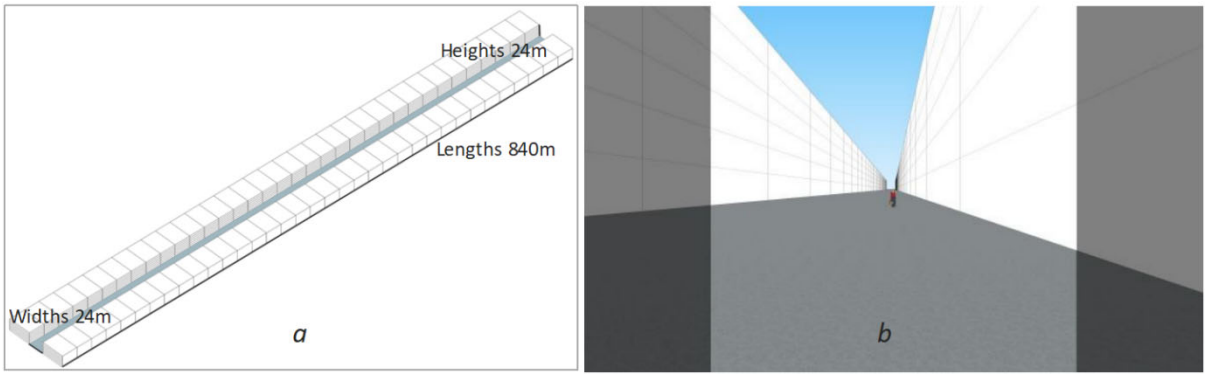

Figure 2.Baseline Street Model .axonometric view (a) ,Human view (b). Photo credit: Author's own drawing

Building on this, the study constructed three groups of street models with different geometric variables. The first group of models consists of streets with continuous vertical interfaces of varying heights and widths (Figure 3). These models are used to analyze the impact of street width, the height

of vertical interfaces on both sides, and the height-to-width ratio on depth perception. The street width and the height of the buildings on both sides were set to four different values: 12m, 24m, 36m, and 48m, resulting in 16 combinations, which form 11 different height-to-width ratio combinations.

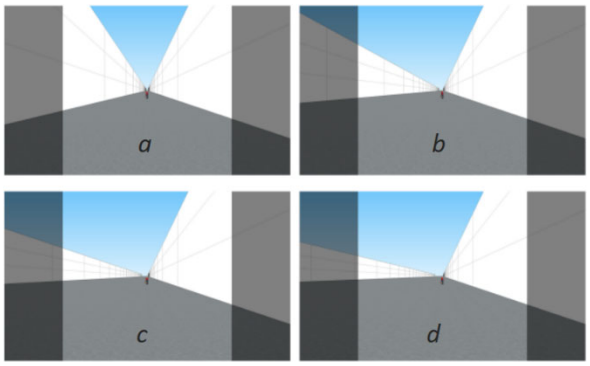

Figure 3 .Models with different widths(a.12m, b.24m, c.36m, d.48m). Photo credit: Author's own drawing

The second group of models studied the presence of openings in the vertical interfaces (Figure 4). In everyday life, streets often do not have continuous vertical interfaces on both sides; instead, there are many intersections and other openings. To simulate the impact of street openings on the perception of street depth, several models with different types of street openings were set up:A single opening with four different widths: 48m, 96m, 192m, and 384m； Two openings, with each opening having three different widths: 48m, 96m, and 192m； Four and eight openings, each with a width of 48m.

These models total nine different scenarios. The starting point of the openings in these scenarios is set at 120m from the street breakpoint, and the openings are distributed as uniformly as possible. Additionally, to explore the potential impact of the opening position, three scenarios were set with an opening width of 384m and the starting points at 120m, 240m, and 384m from the street breakpoint, respectively.

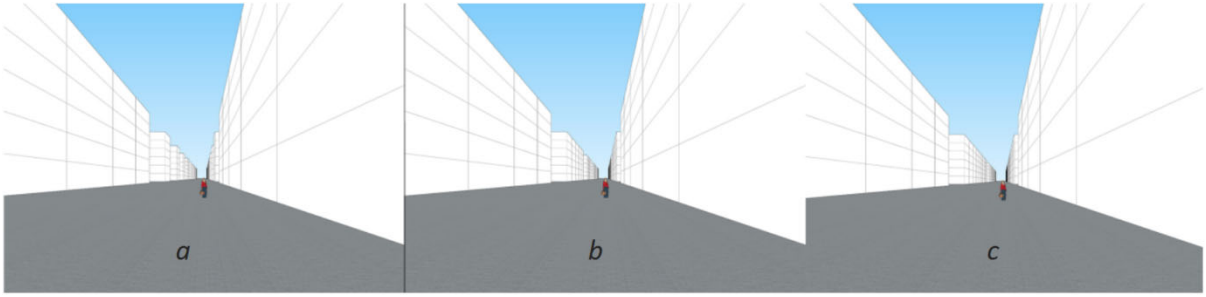

Figure 4. Models with different breakpoints(a.8breakpoints, b.4breakpoints, c.2breakpoints,). Photo credit: Author's own drawing

The third group of models was set up with buildings on both sides of the street having approximately the same average height. These models were arranged in two configurations: one with buildings arranged from low to high and the other from high to low. This setup was designed to explore the relationship between the form of the skyline profile and street depth perception (Figure 5).

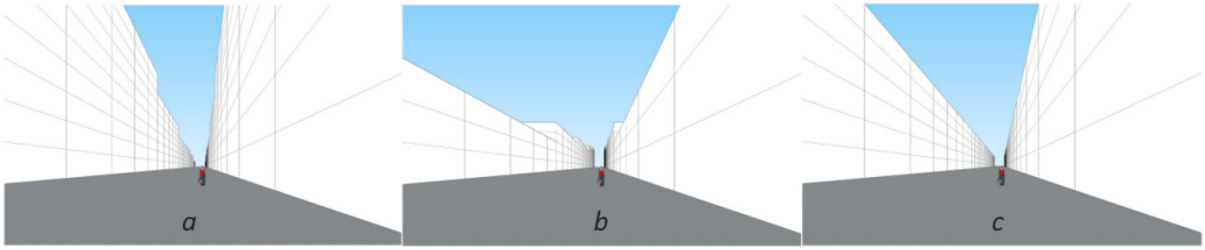

Figure5 .Models with different skyline profile(a.from high to low, b. from low to high , c.Baseline Street Model). Photo credit: Author's own drawing

Based on the street 3D geometric feature models, 30 street view images of the 3D street models were generated for perceptual evaluation. The simulated camera field of view was 60 degrees, with a downward view range of approximately 10-30 degrees when looking forward (Higuchi, 1988). Although the horizontal visual perception range of a person walking or jogging is 124 degrees (Panero & Zelnik, 1979), the clear and main focus range is about 60 degrees, and images simulated with a 124-degree field of view do not match the characteristics of human vision. Objects outside the 60-degree horizontal range but within 124 degrees are perceivable but not sensitive, so they are omitted from discussion.

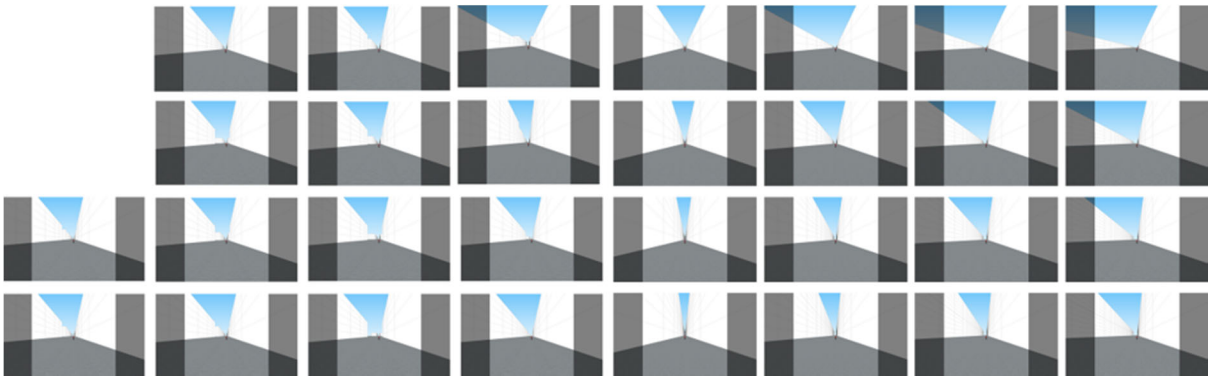

Figure6 . All 30 model pictures. Photo credit: Author's own drawing

Since changes in observation angles can affect depth perception (Charles A. Levin & R. Haber, 1993), the camera observation position also needs to be controlled. To simulate the perspective of a pedestrian, a uniform observation point was chosen at a distance of 5 meters from the right side of the building.

"Visual Scene-Perception Evaluation" Study

In the subjective evaluation of street space, researchers commonly use methods such as the Likert scale and Semantic Differential (SD) method to assess people's subjective impressions of street spaces (Xu Leiqing, 2006). In a study on cyclists' safety perceptions, the research team conducted an online survey where participants were provided with several images and asked to rate them (Rul von Stülpnagel, Nora Binnig, 2022).

In this study, an online questionnaire was used to have respondents rate their perceptions of the depth and spatial intensity of 30 street view images on a scale of 1 to 10. To eliminate the effects of comparison, the street view images in each respondent's questionnaire were randomly arranged.

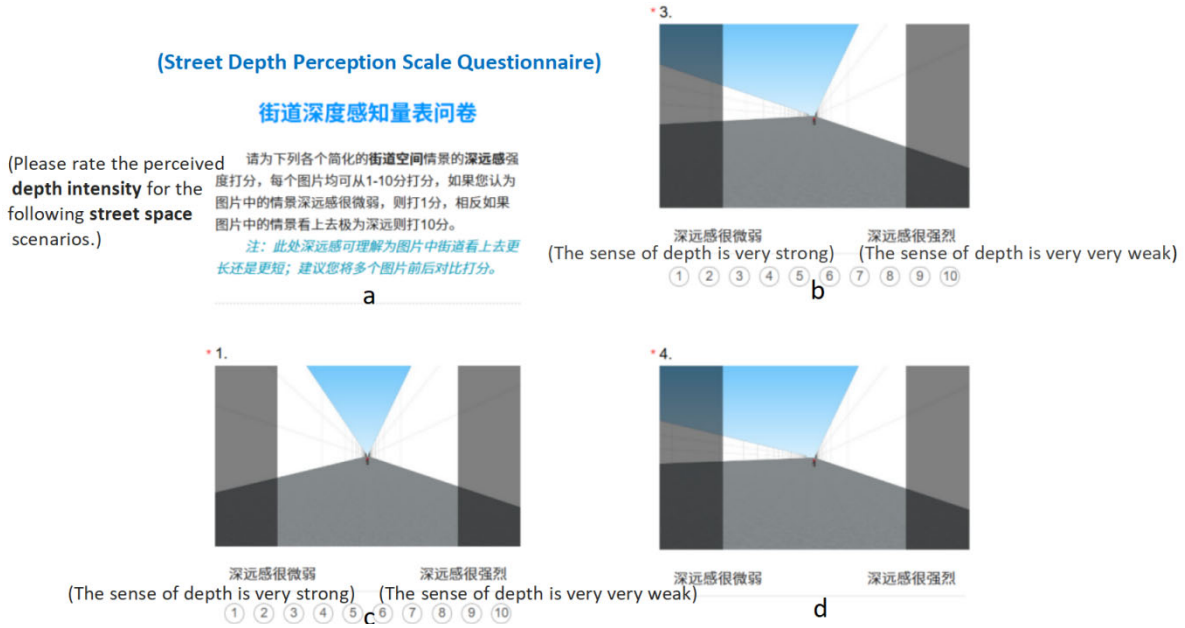

Figure7 .Screenshots of the questionnaire (partial).introduction(a).questions(b,c,d). Photo credit: Author's own drawing

The questionnaire results were analyzed using SPSS. First, the reliability and validity of the overall data were evaluated using Cronbach's alpha coefficient, KMO value, and significance tests. Then, the scale data from the questionnaire were reorganized and classified according to the street width, height, height-to-width ratio, opening types, and skyline profiles corresponding to each image. This included average scores for each scenario and individual data for each questionnaire.

The depth perception scale scores were used as the dependent variable, while street width, height, height-to-width ratio, opening types, and skyline profiles were treated as independent variables. Linear regression analysis was performed using SPSS to determine the significance of the regression relationships by observing the R-squared values and conducting F-tests, resulting in the corresponding regression equations.

Pilot Study and Hypotheses

Before conducting the main experiment, a pilot study was carried out to assess the feasibility of the experiment. Specifically, seven scenario images with different height-to-width ratios, street widths, and building interface heights were selected for a small-scale survey. A total of 15 questionnaires were collected, all of which were valid. Linear regression analysis was performed on the data, revealing that a model could be constructed with height-to-width ratio, height, and width as independent variables and scores as the dependent variable, with the formula:Score=2.554+0.346x+0.008m+0.003n,where x represents the height-to-width ratio, m represents the height, and n represents the width. The R-squared value of the model was 0.966, indicating that height-to-width ratio, height, and width can explain 96.6% of the variance in the scores. The model passed the F-test ($F = 28.225$, $p = 0.011 < 0.05$), which means that at least one of these variables (height-to-width ratio, height, or width) significantly affects the scores. Although the limited number of scenarios prevents us from identifying the specific variables influencing street depth perception, the pilot study has confirmed the feasibility of the experiment.

Based on the pilot study and existing theoretical research, several hypotheses can be proposed. For instance, given the same opening type, streets with a larger height-to-width ratio are expected to induce stronger depth perception. When the basic scale of the street is the same, more openings result in a richer texture gradient and more complex occlusion relationships, leading to stronger depth perception. In cases where the basic scale and opening width are the same, a closer starting position of the opening to the observation point will result in greater disruption of the building interfaces on both sides, leading to weaker depth perception.

RESULTS AND DISCUSSIONS

Basic Data and Analysis Methods

A total of 71 questionnaires were distributed in the formal experiment, with 67 returned. After excluding 2 invalid questionnaires, 65 valid questionnaires were obtained.

SPSS was used for data analysis. The overall Cronbach's alpha coefficient for the data was 0.941, indicating good reliability. The KMO value was 0.794, with a significance level of <0.001, indicating good validity.

Height, Width, and Height-to-Width Ratio

General Analysis:

Height:No significant correlation was found between height and scores, whether analyzing the average scores or all items. The significance level in the ANOVA analysis was 0.065, which is greater than 0.05.

Width:For all items, a linear regression analysis between width and scores resulted in the equation:$y = 8.746 - 0.071x$,where y represents the score and x represents the street width (in meters). The adjusted R-squared value was 0.214, and the model passed the F-test ($F = 298.2$, $p < 0.05$) (Figure 8).

Height-to-Width Ratio:A regression analysis between the height-to-width ratio and scores resulted in the equation:$y = 5.598 + 0.78x$,where y represents the score and x represents the height-to-width ratio. The adjusted R-squared value was 0.139, and the model passed the F-test ($F = 168.3$, $p < 0.05$) (Figure 9).

Combined Analysis of Height, Width, and Height-to-Width Ratio:When height, width, and height-to-width ratio were used as independent variables, the regression equation was:$y = 8.086 + 0.263x - 0.058z$,where y represents the score, x represents the height-to-width ratio, and z represents the width. The adjusted R-squared value was 0.218, and the model passed the F-test ($F = 97.5$, $p < 0.05$). However, the significance value for height was >0.05 in the t-tests, so the coefficient for height was excluded from the equation.

It is worth noting that despite the adjusted R-squared value being slightly above 0.2, this should be considered in the context of a large sample size and the absence of standard reference items in the questionnaire to avoid leading responses. For individual item analysis, the adjusted R-squared value for width was 0.930.

Regression Analysis of Average Scores:For average scores, linear regression analysis yielded:

Width: The equation was:$y = 8.746 - 0.071x$,where y represents the score and x represents the width. The model passed the F-test ($p < 0.001$) with an adjusted R-squared value of 0.930.

Height-to-Width Ratio: The equation was:$y = 5.598 + 0.780x$,where y represents the score and x represents the height-to-width ratio. The model passed the F-test ($p < 0.001$) with an adjusted R-squared value of 0.581.

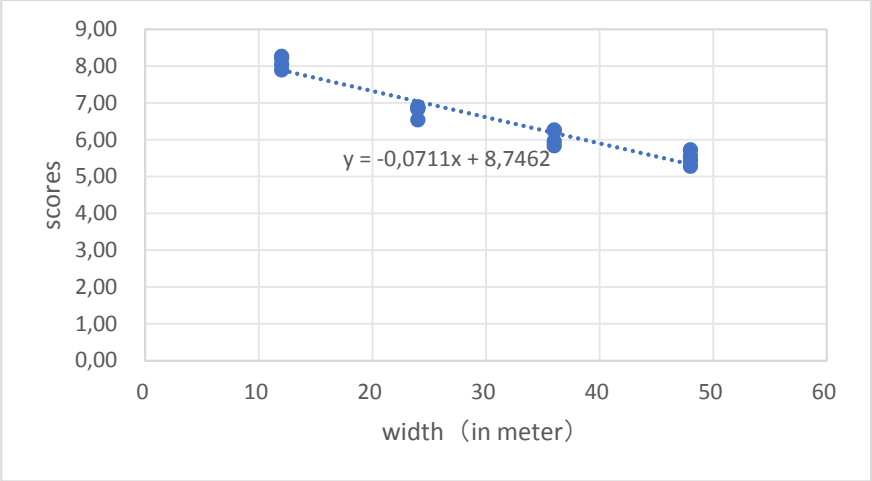

Figure 8: Regression Equation and Data for Width, where y represents the score and x represents the width.Photo credit: Author's own drawing

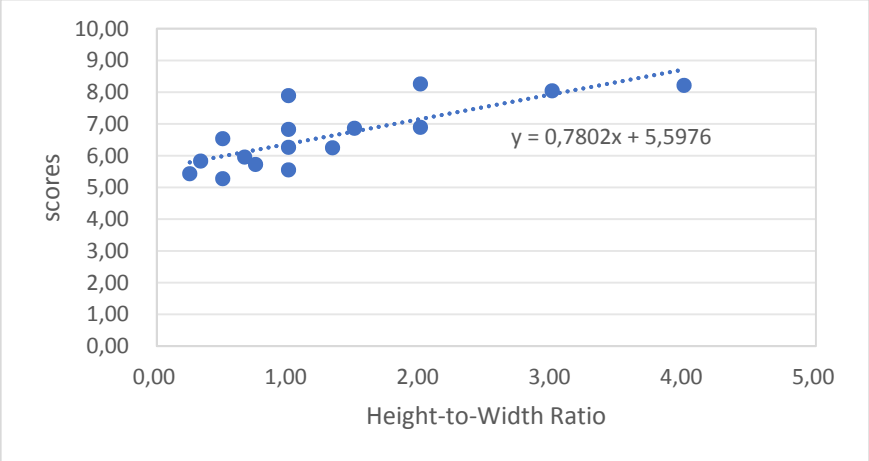

Figure 9: Regression Equation and Data for Height-to-Width Ratio, where y represents the score and x represents the Height-to-Width Ratio. Photo credit: Author's own drawing

Group Analysis:

In the experiment, the heights of the buildings on both sides were set at four different levels: 12m, 24m, 36m, and 48m. The data were grouped based on these different building heights.

It was found that in all four groups, there was a significant linear regression relationship between width and scores. The coefficients for width in the regression equations were -0.067, -0.082, -0.063, and -0.072, respectively, with no apparent pattern of change.

Additionally, in all four groups, there was a significant linear regression relationship between the height-to-width ratio and scores. The coefficients for the height-to-width ratio in the regression equations were 3.194, 1.877, 0.973, and 0.825, respectively. It was observed that as the building height increased, the influence coefficient of the height-to-width ratio decreased（Figure10）.

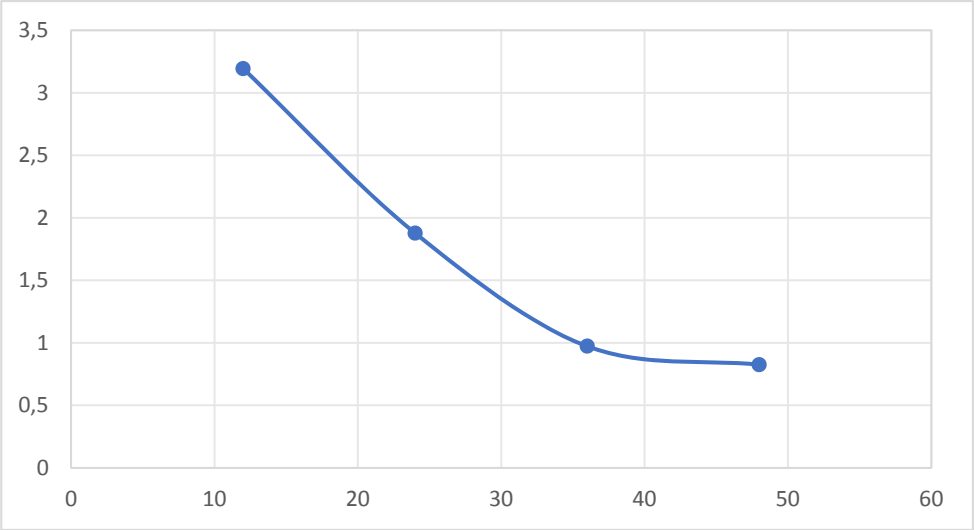

Figure 10：Regression Coefficients of Height-to-Width Ratio at Different Heights（The x-axis represents height, and the y-axis represents the regression coefficients of the height-to-width ratio.）. Photo credit: Author's own drawing

In the experiment, the street widths were set at four different levels: 12m, 24m, 36m, and 48m. The data were grouped based on these different street widths. It was found that in all four groups, height was not significantly correlated with scores. Similarly, controlling for width, height-to-width ratio, and height would be redundant, so the analysis was omitted.

There were 11 different height-to-width ratio situations in the experiment, but only the ratios of 0.5, 1, and 2 had more than one corresponding height (width). Grouping the data based on these height-to-width ratios revealed that in all three groups, there was a significant correlation between width and scores. The coefficients for width (height) in the regression equations for width (height) and scores were -0.105, -0.063, and -0.057, respectively.

The depth perception scores of streets are significantly negatively correlated with street width. This phenomenon can be explained by the fact that when the street width is larger, the visual angle between the start of one side of the building façade and the end of the street becomes smaller, resulting in an underestimation of the distance between these two points, which weakens the intensity of depth perception.

Among the variables, street width has the greatest impact on depth perception, followed by the height-to-width ratio. Although the impact of height is less pronounced, the data suggests that width and height-to-width ratio should not be considered synonymous variables.

In subsequent group experiments, the impact of width did not show regular changes across different height scenarios. This is likely because, with building height unchanged, width as a simple and clear

factor remains easy to perceive across various height scenarios, resulting in no significant variation in its impact on depth perception.

The coefficient for the height-to-width ratio decreases as height increases, suggesting that as the height of buildings on either side of the street grows, the perception of depth becomes less dependent on the height-to-width ratio and more on straightforward width judgment. This change is particularly noticeable when street height is less than 36 meters; beyond this height, the coefficient for the height-to-width ratio shows a clear marginal effect（Figure11）.

A possible explanation is that, influenced by factors such as the visual angle, as street height reaches a certain level, sensitivity to changes in height diminishes. Consequently, the cognitive factor of the height-to-width ratio, which integrates height and width, is disrupted, thereby reducing its impact.

In different height-to-width ratio scenarios, the influence of height (width) diminishes progressively. This may be because a strong canyon-like perception overshadows the single-factor perception of height or width, leading to a reduced impact coefficient. Moreover, in all height-to-width ratio scenarios, the impact of height (width) is negative, meaning that increasing the absolute scale of the street reduces depth perception. This can be interpreted as an excessively large absolute scale causing the street to appear more like a flat plaza rather than a long, narrow street extending in one direction. Fundamentally, this phenomenon might also be related to changes in the sense of volume (SOV), but this has not been confirmed with relevant experiments and data.

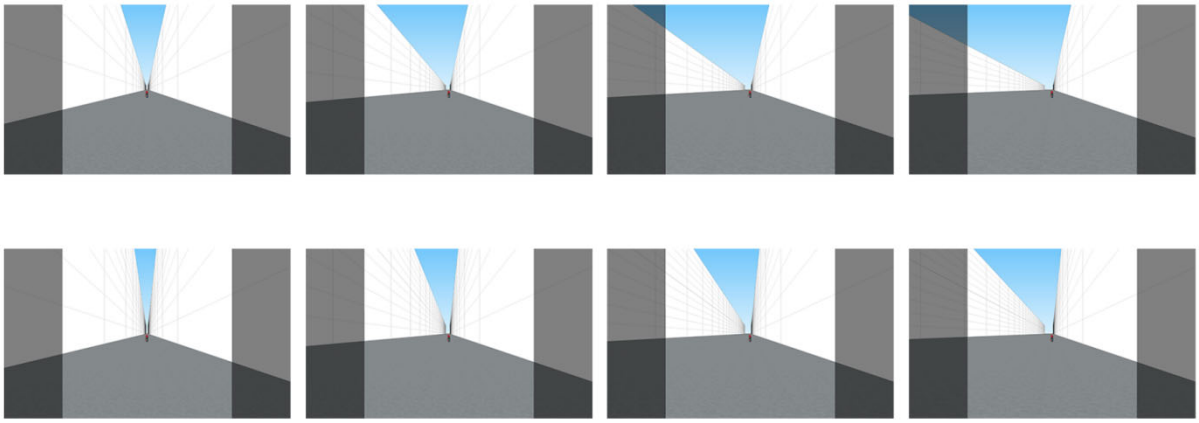

Figure 11 : Above: Streets of varying widths at 24m height.Below: Streets of varying widths at 48m height, Photo credit: Author's own drawing

Opening Types

The average scores for each scenario were analyzed. Using the number of openings as the independent variable and the scores as the dependent variable, a linear regression analysis was conducted. The resulting regression equation is:$y = 4.943 + 0.200x$, where y represents the scores and x represents the number of openings. The R-squared value of the model is 0.428. The F-test for the model showed that the model passed the F-test ($F = 6.987$, $P = 0.033 < 0.05$) (Figure12).

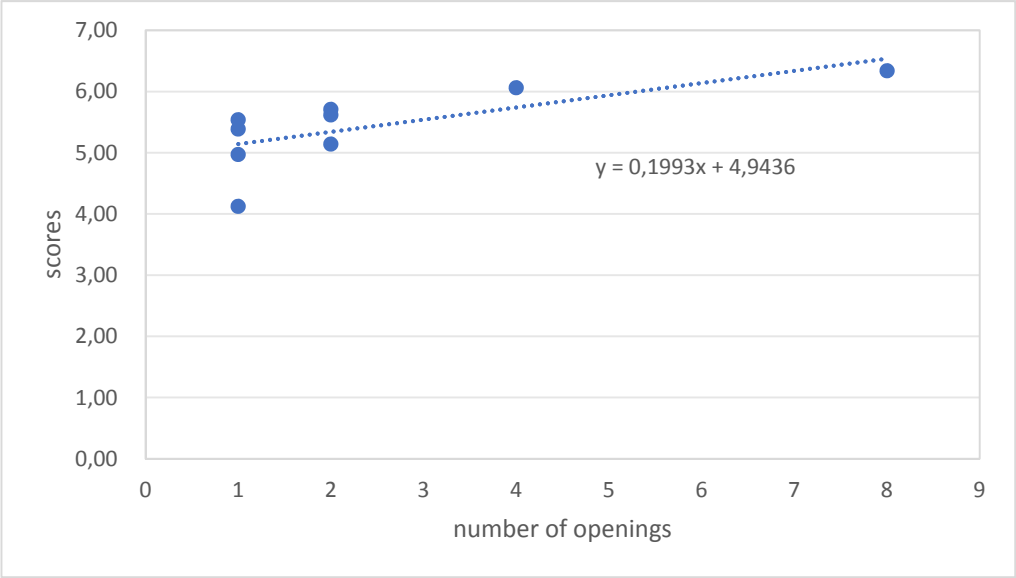

Figure12 ：Regression Equation Graph for Scores and Number of Openings， Photo credit: Author's own drawing

Using the width of a single opening as the independent variable and the scores as the dependent variable, a linear regression analysis was conducted. The resulting regression equation is:y = 6.110 - 0.005x， where y represents the scores and x represents the width of the opening. The adjusted R-squared value of the model is 0.826. The model passed the F-test (F = 39.055, p = 0.000 < 0.05).

When using the number of openings and the width of a single opening as independent variables and the scores as the dependent variable, the regression equation is:y = 5.717 + 0.112x - 0.004z， where y represents the scores, x represents the number of openings, and z represents the width of a single opening. The adjusted R-squared value of the model is 0.971. The model passed the F-test (F = 135.638, p = 0.000 < 0.05).

For scenarios with a total opening width of 384（figure 13）, the analysis was conducted using the number of openings as the independent variable and the scores as the dependent variable. The resulting equation is:y = 4.189 + 0.276x， where x represents the number of openings. The model passed the F-test (F = 25.352, p < 0.001), and the adjusted R-squared value is 0.112.

In the three scenarios where the starting points of openings were 120m, 240m, and 384m from the endpoint, the average depth perception scores were 4.12, 5.38, and 4.91, respectively.

The data indicates that the more openings there are, the higher the depth perception scores, even when the total width of the openings remains constant. This is consistent with expectations. However, contrary to expectations, even in scenarios with the most openings, the scores are still lower than those in scenarios without any openings.

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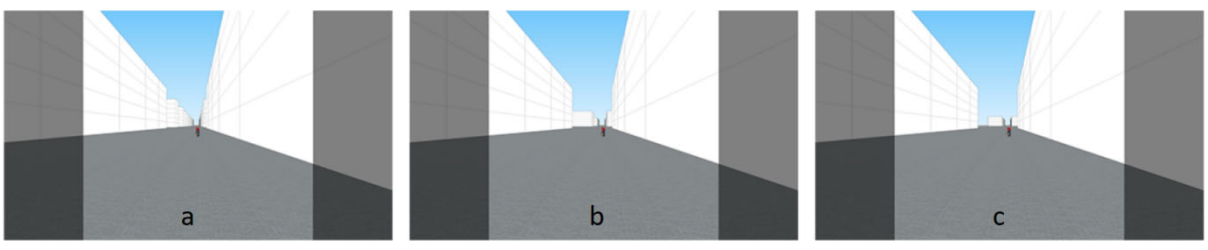

Figure13 ：Three cases with the same total opening width but different numbers of openings 8(a), 2(b), and 1(c). Photo credit: Author's own drawing

Skyline Profiles

The average depth perception scores for the scenarios with gradually lowering and gradually rising skyline profiles are 7.15 and 6.08, respectively. The average depth perception score for the initial model (with a flat skyline profile) is 6.32.

The expectation regarding the distance of openings from the observation point was that when the width of the openings is the same, the further the opening is from the observation point, the stronger the depth perception. However, experimental results show that the depth perception is strongest when the opening is located in the middle of the field of view. This could be because when the opening is too close or too far, it fails to form a clear sense of layering. When the opening is centered, it does not disrupt the gestalt perception of the street interface and adds some level of layering to the street space, resulting in the strongest depth perception, although still less than that of a complete street without openings.

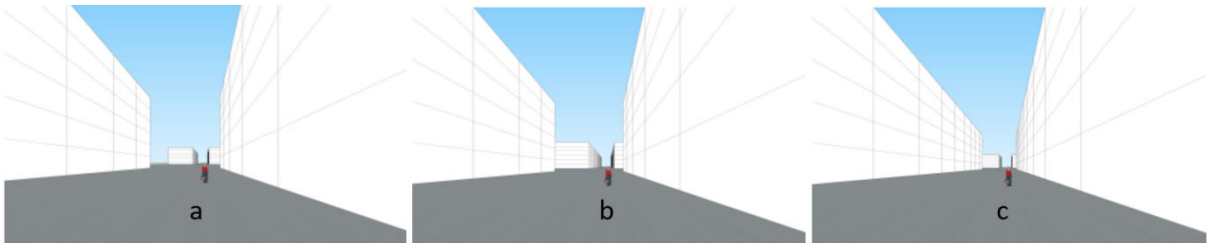

Figure14 ：Street view images corresponding to aperture distances of 120m(a), 240m(b), and 360m(c) from the observation point， Photo credit: Author's own drawing

Scenarios where the buildings on both sides gradually increase in height have lower scores, indicating that a gradually rising skyline weakens the depth perception of the street, and vice versa. It is reasonable to believe that this is caused by a perspective illusion. A gradually rising skyline makes the perspective lines flatter, and perspective lines are very important in monocular cues. The upward slant of perspective lines makes distance judgments tend to be underestimated, thereby weakening the depth perception.

Some Prospects

In the preliminary analysis, it was observed that the impact of street width-to-height ratio on depth perception changes systematically with different street widths. It was roughly estimated that this effect diminishes linearly with increasing width and appears to stabilize around a width of 36 meters. Future studies could explore this pattern in more detail by conducting experiments with a wider range of street widths and width-to-height ratios to identify more precise variation curves.

In the experimental phase related to street profile shapes, only three simple scenarios were tested: lowering, raising, and flat profiles. However, there are many other scenarios with different standard deviations in building heights and varying proportions of building protrusions into the street view that were not explored. The experiment also did not investigate how different opening types might interact with various width-to-height ratio scenarios.

Additionally, due to technological limitations, the study did not examine the effects of binocular cues such as binocular disparity and convergence on depth perception. Utilizing VR technology could potentially allow for the exploration of depth perception patterns under binocular conditions.

CONCLUSIONS

Height, Width, and Height-to-Width Ratio

Wider streets are perceived to be shorter, leading to weaker depth perception. A smaller height-to-width ratio also results in reduced depth perception. In subsequent grouped experiments, the coefficient of the height-to-width ratio decreases as the height increases. This suggests that as the height of buildings on both sides of the street increases, the dependence of depth perception on the height-to-width ratio gradually decreases, leading to a greater reliance on the simple judgment of width.Furthermore, an increase in the absolute scale of the street results in a decrease in depth perception.

We can utilize the changing patterns of height, width, and height-to-width ratio's impact on depth perception. For example, increasing the height-to-width ratio and reducing the street width can enhance the perceived depth of the streetscape, making the street appear longer. When the height of buildings on both sides of the street is below 36 meters, altering the building heights effectively changes people's perception of spatial depth. However, when the building heights exceed 36 meters, priority should be given to changing the street width rather than the height.

Form of Openings

The perception of layering affects the perception of depth. The stronger the layering, the stronger the depth perception, but it will never be higher than a street without openings.

The wider the individual opening, the lower the depth perception score. In design work, when creating large commercial streets with a wide width, simply changing the height of the buildings on both sides to alter the height-to-width ratio has a very limited effect on depth perception. The priority should be to change the number of openings and the width of the openings.

Distance of Openings and Skyline Form

A gradually rising skyline weakens the street's depth perception, while a descending skyline strengthens it.

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Application of analytical methodologies of urban morphology: characterization and aspects of Dona Veridiana Street in São Paulo at the scales of the street and the neighbourhood

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ABSTRACT

The city of São Paulo, today the most populous in Latin America, has at its roots an urban formation common to other Latin countries: its origins as a colonial city and its development through contemporary exchange between urban analysis methods from southern Europe. Within it, streets play a fundamental role in the urban debate as a public space that structures private space. In this article, Dona Veridiana Street will be used as a case study, a way approximately 500 meters long that belongs to two different districts in São Paulo: Consolação and Santa Cecília. Its way classification is indicated as collector, connecting important streets in Vila Buarque, Higienópolis and Santa Cecília neighbourhoods. Furthermore, it has mixed land use characteristics since, in its extension, it concentrates residential buildings, shops, services and unique institutional buildings such as the Santa Casa de Misericórdia hospital, in addition to connecting Mackenzie University to Largo de Santa Cecília (where the Santa Cecília Parish and the Santa Cecília subway station are located). Considering the diversity of its occupation and the presence of the aforementioned equipment and housing, it is possible to extract – from public georeferenced databases – quantitative and qualitative data that describe not only its characterization, but also evidence of its current morphology that has historical traces that justify their formation. This article seeks, based on georeferenced bases and the characterization of the way, to point out methodologies for analysing urban form and occupation through four main axes: analysis of public and private space; walkability and mobility; typology and characterization of buildings; and urban indexes applied to the territory. At the end of the article, urban propositions that can be carried out through the application of the methodologies presented are presented, as well as notes for future researches.

Keywords: São Paulo, Dona Veridiana Street, methodology, georeferenced data, urban characterization

INTRODUCTION

Dona Veridiana Street is a public street approximately 500 meters in length, located in the center of São Paulo. It has an elongated rectilinear profile that partly demarcates the boundaries of three neighborhoods: Vila Buarque, Higienópolis, and Santa Cecília. Considering the official compartmentalization of the city, which divides it into districts, the street is again divided between two districts as can be observed in figure 1: Consolação (from the intersection with Maria Antônia

Street and Higienópolis Avenue to the crossing with Jaguaribe Street) and Santa Cecília (from Jaguaribe Street to Frederico Abranches Street). The origin of these neighborhoods dates back to the late 19th century, when the Higienópolis region was composed of estates that, after being sold, underwent subdivision processes driven by the urbanization of São Paulo, which began to intensify (Instituto Itaú Cultural, 1996). It is also worth noting that a mansion built on a large plot between Higienópolis and Angélica Avenues played a fundamental role in the neighborhood's expansion: Chácara Vila Maria, which later became Clube São Paulo and is currently named Iate Clube de Santos. This mansion was built as a residence for Veridiana Valéria da Silva Prado, an heir to the São Paulo elite who had recently returned from Europe near the end of the 19th century and who today gives her name to Dona Veridiana Street, the subject of this study. At the time, the mansion became a meeting place for intellectuals of the São Paulo elite who were enthusiasts of the city's urban renewal (Instituto Itaú Cultural, ibid.).

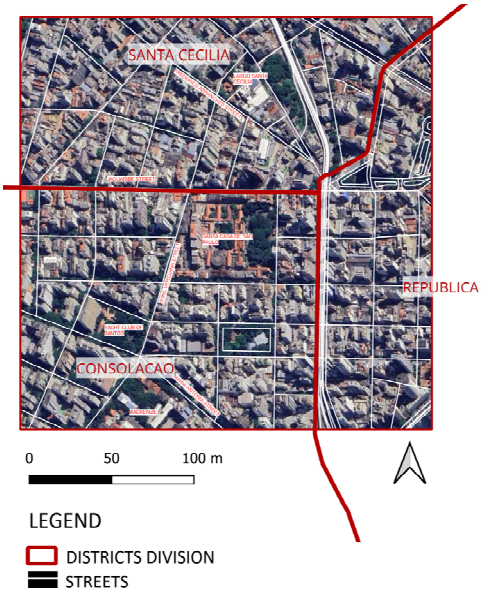


Figure 1: Location. Source: Prepared by the authors based on data from Geosampa, 2024.

This historical account for understanding the formation of streets, neighborhoods, and districts is, according to Moudon (1997), a principle for any study in the field of urban morphology. The theoretical foundations of urban morphological study are as follows: the three fundamental elements are buildings, streets, and public spaces; the scales of understanding are building/plot, street/block, city, and region; and urban form can only be understood through the comprehension of historical elements (Moudon, ibid.). Thus, it is understood that the study of urban morphology focused on an element such as Dona Veridiana Street, an important structuring axis at the neighborhood scale, offers opportunities to approach various aspects, such as the identification of a formative pattern of neighborhoods based on the study of their subdivisions; the occupation pattern of districts in comparison to the overall urbanization process of the city; the formation of plots from mansions and the subsequent verticalization process; and, finally, the identification of urban dynamics in the interaction between public and private spaces in the constitution of neighborhoods.

Buildings, plots, and blocks as elements constituting urban form analysis find synergy through the road system that connects all points. Road axes are vital for the formation of cities and regions as they enable internal and external movement, connecting cities and states and allowing the flow of people

and goods. However, as Magnani (1993) explains, the term "street" refers to a living concept since it can be understood in the simple sense as a public space for flow and transition, but it can also be understood in the complex anthropological sense, which describes it as a place and a medium for sociability among people. Thus, streets are important points in defining the territorial identities of places, and precisely because they are public spaces for multiple and common uses, they can evoke diverse perceptions among individuals, conferring complex singularities when trying to establish a unified logical notion for local description and understanding (Derrosso and Cury, 2019).

The theoretical approach to understanding the term "street" and its intrinsic relationship with daily life is developed through the referenced bibliography, reflecting the applicable concepts in the territory. Moreover, the methodology used in this article involves the use of geoprocessing as a source for data treatment and analysis, drawing on public databases. By downloading the data and processing it through specific geoprocessing software, the data becomes information (Silva, 2009). The information obtained helps contribute to a better understanding of the scales of analysis and the characterization of the elements that constitute urban space, making geoprocessing a key tool for urban morphology studies at any scale.

This article aims to present the application of analytical methods to understand the urban form of a location, using a public road as the central axis. To this end, the study begins with a contextualization of the role of urban morphology as a theoretical discipline and, through its principles and technical foundations, identifies the processes of formation of the neighborhoods and districts of São Paulo related to the street under study. After a brief survey of theoretical references on the municipal urban constitution, the study seeks to contextualize the current form of the street and its importance as a structuring axis for the public space along its length, as well as its importance as a structuring axis for the neighborhoods. These technical foundations support the georeferenced analysis, made possible by the availability of public open-source data provided by the City Hall. By combining the theoretical framework with the applied methodology, the goal is to draw conclusions and insights into what Dona Veridiana Street is and how its urban processes unfold in daily life, pointing to the possibilities of analysis from a study of urban form.

THEORETICAL FRAMEWORK

Currently one of the largest metropolises in the world, the city of São Paulo has undergone recent urbanization. Founded in 1554 by Portuguese Jesuit priests during the Portuguese colonization of Brazilian soil, São Paulo remained for three centuries as a small village with rural characteristics (Rolnik, 2009). At the end of the 19th century, the prolific coffee production established in the municipality attracted immigrants to work in the fields, laying the foundation for the initial processes of forming the city we know today. In the 1870s, the Baron of Mauá, together with the Imperial Government, began studies for the construction of a railway that would connect coffee production in the municipality of Jundiaí to the Port of Santos on the coast of São Paulo, crossing through São Paulo. The ambitious project faced the obstacle of overcoming the natural barrier imposed by the Serra do Mar mountain range, which represents a drop of approximately 800 meters between São Paulo and the coast. Given the difficulties and lack of technology in the country, foreign expertise was sought to carry out the project and build the railway, eventually contracting British engineers along with various

other immigrants to complete the construction. Thus, the São Paulo Railway Company was established, and by enabling movement through the territory, it fostered the formation of several settlement nuclei in the municipalities where there were railway stations (Mazzoco and Santos, 2005). These settlements slowly began to develop into cities, and, together with the arrival of immigrants to meet the increasingly pressing labor needs in Brazil, São Paulo experienced a demographic boom, especially from the mid-1920s onward (Santos, 1996).

The railway cuts through São Paulo longitudinally, starting in the northern region, where today the neighborhood of Perus is located, reaching the central region at the Barra Funda, Brás, and Luz stations, and continuing towards the ABC Paulista region until reaching the top of the mountain range and finally arriving in the city of Santos on the southern coast of São Paulo (Mazzoco and Santos, ibid.). This route through the city's center spurred the development of the region, which had until then been occupied by large mansions and the cultivation of various crops. Still within the central region, a settlement nucleus near the Pacaembu area began to develop in what we now recognize as the Higienópolis neighborhood. Towards the end of the 19th century, educational institutions such as the American School (now Mackenzie Presbyterian University) and Colégio Sion were established, along with imposing mansions built within the subdivision of estates that structured the neighborhood (Instituto Itaú Cultural, ibid.). The first urban estate built in the city was Vila Maria, the residence of Veridiana da Silva Prado, who had recently returned to the city after a period in Europe. These educational institutions, combined with the construction of estates and occupation by the financial elite importing concepts of European urban life, spurred intellectual activity in the region, signaling the area's growth and development as it transitioned from a fully rural to an urban morphology (Macedo, 2012).

This expansionist process quickly transformed the local urban form through the subdivision of large estates, as well as the consolidation of structuring elements of the territory such as the road network and the installation of public spaces, parks, and gardens. The central region of São Paulo covered by this study began precisely with the subdivision of these large estates, and, being a process influenced by the local elite, it underwent a renewal inspired by the architecture and urbanism of European cities (Macedo, ibid.). From a construction standpoint, a homogenization of the typological pattern of buildings constructed during this period is evident, and from an urban perspective, urban guidelines were applied, such as extensive afforestation, the opening of streets and wide sidewalks, and the installation of urban services like public lighting (Toledo, 2004). This local urban form is still partially preserved, as some of the remaining mansions have been converted into cultural and event spaces, while other institutions remain in the same locations, such as Sion, Mackenzie, and Vila Penteado, which has been converted into a school and is now home to the postgraduate architecture and urbanism courses at the University of São Paulo. Many other mansions and initial buildings in the neighborhood later gave way to various buildings as the city began to undergo verticalization (Reis Filho, 2014), while other occasional structures remain standing despite the force of urban transformation, though they do not currently have the same level of conservation as the mansions converted for non-residential use. Understanding the typological patterns of local buildings over various historical periods helps to comprehend the formative processes of neighborhoods and the motivations behind their local characterization (Moudon, ibid.).

Morphological analysis, therefore, involves understanding locations within a complex context, where it is important to analyze their historical influences tied to their current aspects (Costa and Gimmler

Netto, 2015). Considering this premise, focusing on Dona Veridiana Street as the object of study enables two distinct but congruent contexts: situating it as a structuring axis for neighborhood-scale development and its surroundings, and situating it as a structuring axis for the activities currently carried out there, considering the predominantly mixed land use along its length. From one end to the other, the studied street connects Mackenzie University with Largo Santa Cecília, where Santa Cecília Church and the Santa Cecília metro station are located. In addition to the metro nearby, the street is also part of bus routes, as well as experiencing heavy traffic from private vehicles, motorcycles, and taxis. Its importance in terms of mobility is empirically justified by the mixed predominance of occupancy by residences, commerce, services, and institutional activities, bringing together in one street the constitutive elements of the neighborhood's complete landscape.

The understanding of the historical formative elements of the region is based especially on the referenced literature, as well as historical data and photographs relevant to the period between the late 20th century and the early decades of the 21st century. The current analysis, however, benefits from the abundance of available resources, data, and information. One way to analyze the urban and morphological context through precise and unified methodologies is the use of geoprocessing resources, which, through territorial information analysis, generate guidelines, plans, and intervention projects in public spaces (Aguilar, Flain, and Coelho, 2018). This data processing, generating information, allows for a wide range of tabulations and comparisons on the urban scale in a comprehensible and graphically suitable format for territorial analysis, thus making it possible to recognize the urban form of a place in an analytical and exploratory manner, which is absolutely essential for a correct approach to the characterization of contemporary urban space.

METHOD

The theme of this article is based on the application of urban morphology analysis methods on a public road, following the methodology addressed by Borges (2020). However, before starting the digital analyses to obtain cartographies, a theoretical reference base was established, encompassing concepts that clarified the scope of work within the field of urban morphology and that indicated the aspects of analysis capable of relating the concepts of “street” obtained with the precepts of urban form studies. Based on the consolidation of the ideas to be developed, axes were established to define the scope of this article. The chosen structuring axes were three: street, block, and neighborhood. Within each axis, specific studies were proposed to establish a comprehensive morphological view of the chosen region. The survey of possible studies generated 19 potential cartographies to be developed, based on analyses of public and private relationships, walkability and mobility, building characterization, and urban indices, from which the following themes were selected to be produced according to the respective urban scales:

1. Street scale: land use, building height; and building typology;
2. Block scale: block length, average plot utilization coefficient; and average plot occupation rate;
3. Neighborhood scale: analysis of public and private space occupation, analysis of block and road system occupation; and average block area.

The criterion for choosing the street to be studied was based on two interdependent factors: it had to be a street within the city of São Paulo and close to Mackenzie University, which would allow researchers to conduct field visits. Thus, the options were limited to a radius around the university, with the neighborhoods of Higienópolis, Santa Cecília, and Consolação as possibilities. Finally, to select the specific street to be studied, the criterion was based on the diversity of identified uses, allowing morphological analysis of various aspects. This led to the selection of Dona Veridiana Street, considering its proximity to the university and its importance within the neighborhood for concentrating diverse activities and serving as a key mobility axis within and beyond the neighborhoods it passes through. The initial premise of choosing a street within the city of São Paulo was determined by the availability of data from Geosampa, a digital portal maintained by the São Paulo City Hall, which aggregates data and information on a wide range of aspects. These data are available in various formats depending on the topic addressed, with the main format for this research being shapefiles, which allow data processing in specific geoprocessing platforms.

On the Geosampa platform, all data relevant to the topics chosen for analysis in this article were selected and downloaded in the Sirgas2000 version. The main downloaded data included the official base of the municipality's administrative boundaries; the delimitation of districts, blocks, and lots; the shape of buildings; and the axis of streets and roads. All selected data were downloaded in shapefile format and processed in QGis, a free and open-source software used for manipulating georeferenced data. In shapefile format, the data contain what is called an "attribute table" embedded within, in which a series of additional information and parameters are stored. This information was filtered and graphically processed to generate specific thematic maps according to the thematic boundaries mentioned above.

After processing and systematizing all the data and information, the map generation tool within the QGis software was used, allowing for export in both vector and image formats. Once exported, the maps were analyzed in light of the theoretical framework discussed throughout this article, providing an overall view of the street's morphological characterization.

RESULTS AND DISCUSSIONS

Provide For the development of the maps mentioned, the method used was the analysis of a 1 km² buffer zone around the study object, in this case, Dona Veridiana Street. Within this boundary, which corresponds to a pedestrian walkability area, it was possible to observe data related to the street and its reverberations in the region, thus supporting the study of the street's characteristics as an element that reveals urban growth within the city. The four major themes selected for mapping (the relationship between public and private space; walkability and mobility; building characterization; and urban indices) often involve overlapping analyses, as spaces simultaneously create multiple relationships with the urban environment. In the area studied, some particularities should be highlighted: the first is that one of the blocks is entirely occupied by two hospital complexes, one public (Santa Casa de São Paulo) and one private (Hospital Santa Isabel). Another noteworthy particularity at the urban scale is the Yacht Club of Santos, which occupies a large plot with few buildings. A third point of attention is that the street has an elevation difference of approximately 24 meters over a length of 550 meters, beginning and ending at intersections with other important and high-traffic streets in the neighborhood, specifically Higienópolis Avenue and Frederico Abranches Street.

Thus, the first analysis conducted was the relationship between public and private space, which in this study was contrasted using block information (private use) and street information (public use). In the case of Dona Veridiana Street and the neighborhoods it comprises, it is visually evident from Figure 2 how much private use occupies the 1 km² area, with private space predominating over public space, as confirmed by data showing that approximately 30.5% of the area is occupied by the road system. It is worth noting that the block that holds the public hospital was considered private space, as it shares space with the private hospital and has restricted access. Within the studied perimeter, it was found that, apart from the road system, there is only one block occupied by a square, in addition to green areas and the metro station as public spaces:

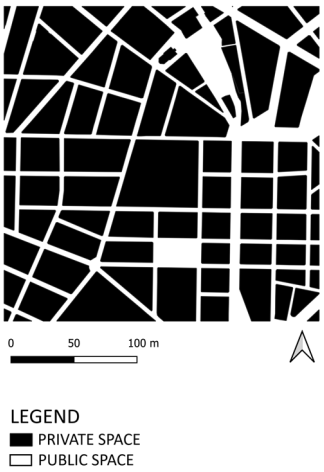


Figure 2: Horizontal permeability and the relationship between public and private space. Source: Prepared by the authors based on data from Geosampa, 2024.

To analyze the mobility characteristics, three maps were produced: the first two (Figures 3 and 4) provide a better analysis at the neighborhood scale, while the last one (Figure 5) focuses on the street scale. As can be observed in Figure 3, the map highlights the previously mentioned elements of the block and the street, but now it also considers the sidewalk, highlighted in red, as well as public-use blocks. It was possible to analyze that there is no public permeability through the blocks, and that the sidewalks do not occupy a significant portion of the urban fabric (only about 13.8% of the demarcated area), except when they gain space due to subdivisions not always aligned with the lot's planning:

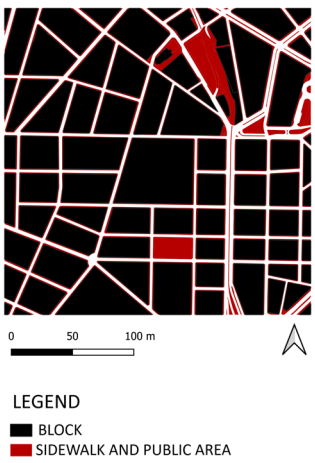


Figure 3: Walkability and mobility. Source: Created by the authors based on data from Geosampa, 2024.

The map shown in Figure 4 clarifies, through gradation, the size of the blocks, with darker tones indicating larger blocks and lighter tones indicating smaller ones. In this sense, it is possible to analyze the diversity of sizes, with a subtle predominance of blocks between 10,000 and 20,000 m²:

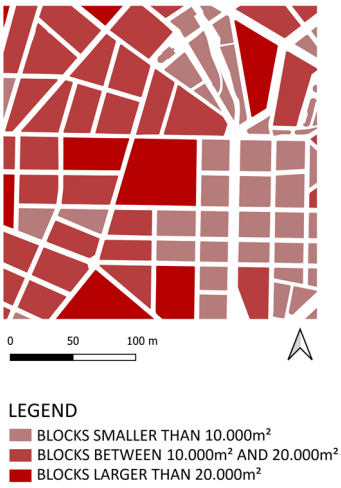


Figure 4: Walkability and mobility. Source: Created by the authors based on data from Geosampa, 2024.

Finally, the map indicated in Figure 5 shows the length of the blocks, a measurement that fosters a closer relationship with the scale of the street. It also reveals the predominance of blocks longer than 250 meters, highlighting how far pedestrians must travel during daily commutes, primarily due to the lack of permeability and enjoyment within the blocks:

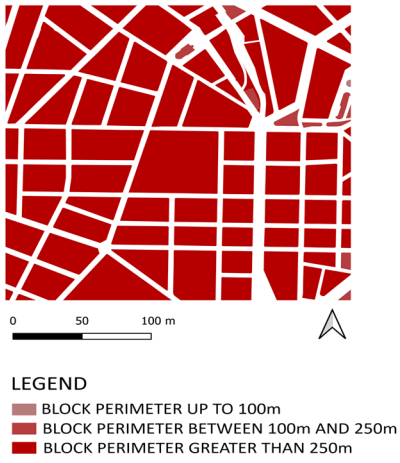


Figure 5: Walkability and mobility. Source: Created by the authors based on data from Geosampa, 2024.

Covering another scale of analysis, resources were gathered to understand the relationship between buildings and the street. The first of these is the block usage map (Figure 6). Created from data from 2021 available on Geosampa, the map shows a predominance of medium-standard vertical residential use, followed by high-standard vertical residential use. Although the map indicates only one block with a predominance of commercial and service establishments, it is noticeable when walking along the street that many residential buildings have commercial spaces on the ground floor. This contributes to a diverse urban dynamic where bars, markets, and convenience stores cater to users of the surrounding facilities:

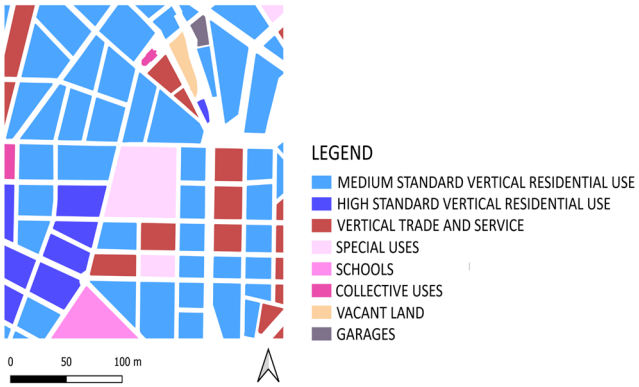


Figure 6: Predominant Use of Blocks. Source: Prepared by the authors based on data from Geosampa, 2024.

Corroborating this data is the building height map (figure 7). It is possible to first notice the diversity of building heights present in the studied area and, subsequently, that the blocks within the Consolação district (mainly those located in the lower left part of the map) are composed of tall buildings with little spacing between them. Meanwhile, in the upper left part of the map, the blocks belonging to the Santa Cecília district feature shorter buildings, with varied heights and closer proximity. Also within the street scale analysis, the aerial photo (figure 8) again confirms the profile of tall buildings:

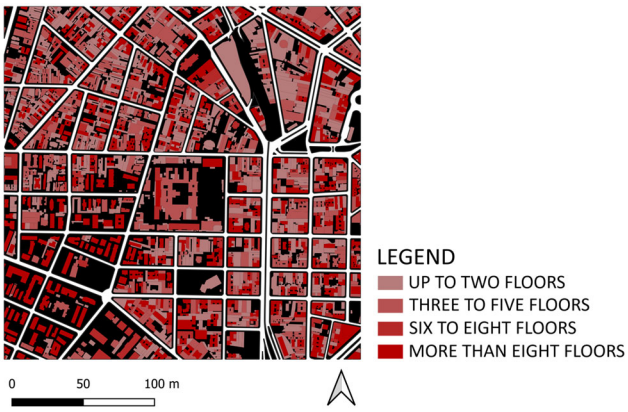


Figure 7: Building Height. Source: Prepared by the authors based on data from Geosampa, 2024.



Figure 8: Aerial Image of the Buildings on the Street. Source: Prepared by the authors based on Google Maps, 2024.

The urban indices involved in this analysis include the lot occupancy rate, the utilization coefficient (that is, how much of what can actually be built has been used), and the natural soil permeability. These values serve as construction parameters determined by the municipal sphere to guide the city's growth. The central area of the city, despite being a consolidated zone, is predominantly classified as an urban transformation zone according to urban legislation, meaning it encourages the promotion of high-density constructions that contribute to the enhancement of the landscape and public spaces.

Through Figure 9, it is possible to identify that the buildings within the study perimeter have a high lot occupancy rate, with a coefficient of buildings over blocks of approximately 0.76; however, this does not necessarily meet the total construction potential of the area, which requires a minimum building size of half the lot area and a maximum size of four times the lot area. This last analysis aligns with Figure 7, as the variety in the heights of the buildings occupying nearly the entire lot area indicates that not all construction potential has been utilized:

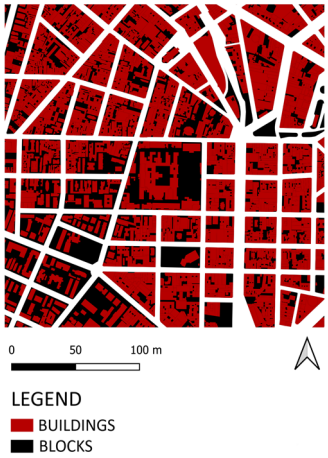
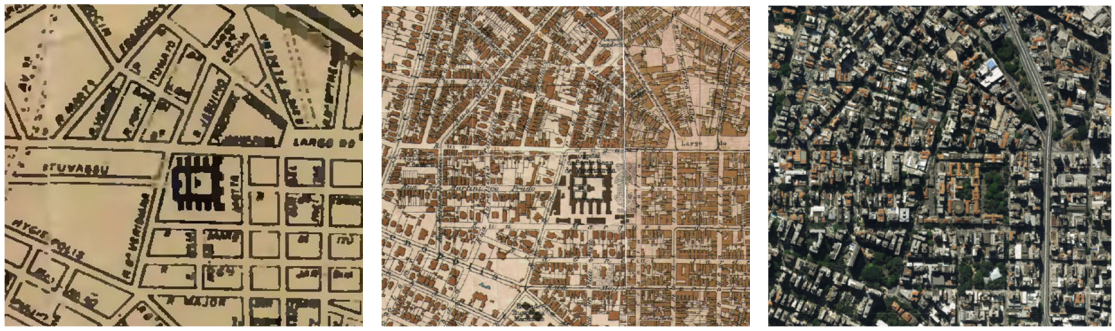


Figure 9: Buildings in the blocks. Source: Prepared by the authors based on data from Geosampa, 2024.

Finally, considering that urban form can only be understood through historical resources, the maps presented below (Figures 10, 11, and 12) allow for an understanding that the subdivision of the street is old and has been maintained since 1890. However, it is noticeable that over the years, the lots, especially in the area of the Consolação district (the lower part of the map), have undergone transformations, as have their buildings when compared to the situation in 1930 with the present day:



Figures 10, 11, and 12: Study area in the years 1897, 1930, and 2020. Source: Geosampa.

The study of the elaborated maps is based on a method that can be replicated when access to mapping tools and public city data is available. It is essential not only to read the georeferenced graphic bases but also to know how to extract specific information from them and transform it into usable data. It

is important to highlight that without the databases provided by Geosampa, the analysis of urban form would be significantly limited, primarily due to the absence of replicable parameters.

CONCLUSIONS

The result of accelerated urbanization due to coffee capital investments in the late 19th century, the city of São Paulo was organized in various ways within a constantly expanding territory, considering the occupation of its edges continually renewed by the city's growth. The analysis of this process from the perspective of urban form begins with an understanding of the occupation that is still evident today and can be recognized through the organization of blocks, streets, and lots. Rua Dona Veridiana was initially occupied by coffee barons and has undergone changes over the years; however, it retains its original structure in historical buildings. Thus, it can be understood as a synthesis of the city's processes, where growth and history coexist with tensions.

In this way, the method used to investigate urban characteristics to understand the formation processes of neighborhoods and districts was made possible by establishing criteria that encompass both current and historical data and materials. Therefore, it was relevant to analyze the public and private areas around the street to verify the regularity of the blocks, the size of the streets, the presence of parks and urban facilities, and thus confirm characteristics of urbanization with planning. The mobility maps related to the public and private area maps confirm this characteristic, as there is space for sidewalks and most blocks do not exceed an area of 20,000 m², demonstrating compliance with pedestrian scale and still providing space for urban infrastructure.

Thus, it is understood that the method used in this article could be replicated for other streets with different characteristics within the city of São Paulo, establishing comparative standards that enable the understanding of the city's transformations, recognizing that there may have been planning in urban characteristics that appear to have occurred by chance. Understanding the historical context and the current characterization is, therefore, a fundamental component from the perspective of urban morphology and allows for comprehension of the territory, a natural and indispensable tool for proposing any interventions in a complex environment such as the city of São Paulo.

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Designing morphologically appropriate urban layouts

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ABSTRACT

How to design morphologically appropriate urban layouts and refrain from the usual laissez-faire process noticed in recent urban expansions? New urban areas in Brazilian cities have shown poor sense of place and little adherence to the site conditions. This paper tackles this problem and discusses the process of designing urban layouts along with the coherence between context and urban forms. Based on the idea of 'rendimento' (yield), a concept adapted from the Italian school of type-morphology, and on specific literature review, a set of parameters for the assessment and design of urban layouts was prepared and applied to certain pre-existing anthropic conditions. The resulting layouts depict directives that are discussed. The outcome leads to the conclusion that is possible to design morphologically appropriate, economically viable, and environmentally sustainable urban layouts.

Keywords: rendimento, Caniggia, new towns, urban design, sustainability

INTRODUCTION [Heading 1]

This paper presents the initial findings of an ongoing research into designing morphologically appropriate urban layouts (Costa and Rego, 2019; Costa, 2020; Costa and Rego, 2021; Alves et al., 2023). We will explore the concept of 'rendimento' (yield) from the Italian school of type-morphology, its interpretations, and propose a new application for urban design. The study includes a case analysis of a well-regarded town layout to derive parameters for evaluating 'rendimento.' These parameters are then applied to design new urban layouts, testing their practical use and feasibility. To validate the application of 'rendimento' at the urban scale, we first establish its theoretical foundation and then apply it to Maringá, Paraná, Brazil. This city was selected for its original high-quality layout and its contrasting expansion with a more serial design, providing a basis for comparing different layouts within the same territory. This comparison allowed us to extract the qualities of the original design, relate them to 'rendimento,' and test new layouts to assess their effectiveness. Partial results from the theoretical paper in Portuguese (Costa and Rego, 2019) were applied by Gomes (2024), who used the concept of 'rendimento' to evaluate energy consumption by different types of transportation across various urban layouts. This approach is integrated into the results and discussion of new urban layouts in our research and will influence future stages.

How, what, why, and then?

How to design morphologically appropriate urban layouts and refrain from the usual laissez-faire process noticed in recent urban expansions? In a great number of cities, urban expansion is made with abstract urban layouts, contrasting with context and providing “discontinuous territories” and “contradictory landscapes” (Strappa, 2018: 11). They prioritize financial returns, leading to designs based on minimal effort and cost. These layouts often follow a common practice driven by arbitrariness, rather than context-specific criteria. As a result, many designs are two-dimensional and overlook natural and anthropic contexts, resulting in artificial and serial patterns rather than organic, contextually appropriate shapes.

The Italian school of type-morphology emphasizes the coherence of buildings, towns, and territories with their context, and offers potential solutions to the aforementioned problem. Central to this framework is the concept of ‘rendimento’ (or ‘yield’), initially developed by Gianfranco Caniggia. While this concept has been applied to buildings and territories (Caniggia, 1963; Caniggia and Maffei, 2008; Carlotti, 1995, 2012), it has not yet been adapted to the urban scale, nor does it offer explicit evaluation parameters or guidelines. However, we observed that certain cities with layouts more aligned to their context embody the principles of ‘rendimento.’

Thus, our hypothesis is that it is possible to use the concept of ‘rendimento’ as a guiding principle for the design of new urban areas. This can be done through guidelines and parameters extracted from layouts of new cities that are coherent with the context. In this way, we demonstrate that the ‘rendimento’ is applicable at the urban scale and provide an alternative to the laissez-faire process of design noticed in several urban expansions. Our main objective, then, is to provide a set of directives and strategies for the design of new urban areas based on the concept of ‘rendimento’. This objective aims to refine the process of design urban layouts, driving it away from a laissez-faire way of doing by presenting alternatives rather than proposing a completely new way of design.

METHOD

Our research is conducted as Design Science Research (DSR), aiming to refine the existing process of designing urban layouts (Peffers et al., 2008). This approach parallels the method proposed by McGlynn et al. (2024), where a ‘funnel’ model is used incorporating topography, land structure, legislation, and feasibility. At this stage, our focus is on the relationship between urban layout and topography, using the concept of ‘rendimento’ as a foundational basis.

The first part of this research involves an exploratory literature review based on works by Gianfranco Caniggia and Gian Luiggi Maffei (2008), and Paolo Carlotti (1995). We aim to investigate the application of the concept of ‘rendimento’ across different scales and explore its potential for the urban scale, including any existing evaluation parameters (Costa and Rego, 2019). In the second part, we analyse Maringá’s original urban layout using morphological analysis and literature review. We aim to understand its design in relation to topography and environmental factors, drawing on Raymond Unwin's (1909) manual and works by Caniggia and Maffei (2008), and Carlotti (1995). This helps us identify design variables in Maringá and explore their connection to the Italian concept of ‘rendimento,’ developing evaluation parameters. Finally, in the third part, we systematize the parameters developed from associating Maringá’s original layout with the concept of ‘rendimento’. These parameters are then applied to analyse Maringá's urban expansion and to design two hypothetical layouts. The first layout (Costa, 2020; Costa and Rego, 2021) uses ‘rendimento’

parameters to design a sample from a larger territory, considering only topography and comparing it with the current layout. The second layout (Alves et al., 2023) applies the 'rendimento' parameters incorporating pre-existing elements such as surrounding neighbourhoods, highways, and transmission lines.

RESULTS AND DISCUSSIONS

The term 'rendimento' first appeared in 'Lettura di una Città: Como' (Caniggia, 1963), linking it to concepts of organism and structure. It was further developed in 'Lettura dell'edilizia di base' (Caniggia and Maffei, 2008) and 'Per lo studio del processo di trasformazione del territorio romano' (Carlotti, 1995), generally referring to the efficiency of adaptation between the built environment and its context. Although the term has been associated with building and territory scales (Cataldi, 2015; Carlotti, 2012; De Martin, 2009; Rebecchini, 2008; Dalla Negra, 2015), it has not been explicitly linked to the urban scale and has been applied mainly to historical contexts in Italy. The term derives from the Italian verb 'rendere,' and its Latin root 'reddo,' meaning "to bring from one state to another" (Faria, 1962: 848-849). In type-morphology, it signifies transformation and coherence between the built artifact and its context, an idea introduced by Caniggia in 1963 and further clarified in 1979 by Caniggia and Maffei (2008).

Variants of the 'rendimento'

We can distinguish two understandings of 'rendimento'. First, the 'built rendimento' (Caniggia and Maffei, 2008; De Martin, 2009; Rebecchini, 2008; Cataldi, 2003), implicating the relation between a single building and the built environment in which it is inserted, i. e., the context. And second, the 'territorial rendimento' (Carlotti, 1995), which is associated with the idea of harnessing the territory and natural structures of an area according to their aptitudes and possibilities for human use.

In the context of building, 'rendimento' is "the dialectic between an anthropic action and an environmental reaction, constituted by the lesser or greater effort with which the environment will tend to reabsorb the result of that action" (Caniggia and Maffei, 2008: 52). Thus, 'anthropic action' can be related to 'intervention,' and 'anthropic environment' to 'context.' A higher 'rendimento' signifies that the intervention requires less effort from the environment to be absorbed and integrated, thus making it more "coherent with its context" (Rebecchini, 2008: 107). When building a house (intervention), it must fit seamlessly into its context, the urban block. Greater 'rendimento' is achieved when the new building aligns with the existing architectural 'style' without mere imitation, following the prevalent 'type' of the area (Caniggia and Maffei, 2008: 53; Strappa, 1995: 24). This means adapting to the common characteristics of the environment. 'Built rendimento' reflects the interdependence between new and existing structures. Thus, we can summarize 'rendimento', in general, as the "degree of coherence with the context" (Maffei, 2003: 82).

At the territorial scale, 'rendimento' refers to how suitable an area is for human activities like movement, agriculture, and housing (Carlotti, 1995: 19). It involves 'natural structure' and 'anthropic structure'. These two structures form the 'territory', i. e., the set of anthropic structures–pathways, productive areas, buildings, and urban centres–developed on the geomorphology of a natural area, such as ridges, valley floors, etc., which is bounded by relatively impassable natural limits (Caniggia, 1963: 12-13; Caniggia and Maffei, 2008: 209-216; Strappa, 2012, 1995). Therefore, 'territorial rendimento' refers to the utilization and adaptation of natural structures in the development of

anthropic structures within a territory. The higher the suitability of the terrain's geomorphology for these uses–in terms of slope and altitude, and its 'hierarchy' in geographic position–the greater its 'rendimento' (Carlotti, 1995: 17-18). For example, mountainous areas with steep slopes have lower 'rendimento' compared to gentler terrains like plateaus. While this concept is similar to McHarg's (1971) 'suitability,' Carlotti's idea is more aligned with Caniggia's view of anthropized territories. Thus, 'territorial rendimento' evaluates how well a territory's geomorphology and human structures interact, emphasizing the need to consider natural forms in territorial scale analysis or planning.

Urban rendimento

Cities are composed of pathways, open spaces, and buildings within specific territories that have their own natural hierarchy. Regarding from the conceptions of 'rendimento', we can state that human intervention, especially in urban design and planning, must ensure that the built environment (a comprehensive action) harmonizes with the natural context (the environment which receives it). 'Urban rendimento' recognizes this coherent relationship between the morphological elements of urban form and the characteristics of the site, particularly the relief. Thus, 'urban rendimento' can be defined as the "intrinsic coherence between the layout of the urban form and the natural context" (Costa and Rego, 2019: 7; Costa, 2020: 52). This 'intrinsic coherence' is the alignment of the urban layout with the site's natural relief and hierarchy. And it is achieved through 'organicity', with disparate parts that are well-integrated to perform a common function (Mora, 1962: 341; Strappa, 1995: 24). This can be seen by the aggregation of "elements defined by unique positions and forms," forming a cohesive whole (Caniggia and Maffei, 2008: 77). Therefore, a city demonstrates organicity when its elements—pathways, plots, buildings, and open spaces—are interdependent. This is more evident in spontaneous or informal urban fabrics (Caniggia and Maffei, 2008; Carlotti, 1995, 2012). Organic layouts are shaped by the relief and intersections of pathways, evident in ancient cities with spontaneous formation. The meeting of ridge lines, the confluence of valley floors, and the extension of interfluves structure and define these urban forms (Guerreiro, 2001). The greater the alignment of the urban layout with the site's natural relief and hierarchy, the higher its 'rendimento'.

A new planned town: the case of Maringá

With the concept of *rendimento* theoretically applied to the city scale, we then move on to the case study of Maringá, aiming to relate the requirements of *rendimento* to the qualities of the city's layout and, thereby, develop parameters for 'urban *rendimento*.' The original layout for the city of Maringá was designed between 1945 and 1947 by engineer Jorge de Macedo Vieira, who had previously worked with Barry Parker, a former partner of Raymond Unwin. It is possible to observe how this urban layout exhibits intrinsic coherence both in general and in detail, deriving from the natural morphology of the site (Figure 1).

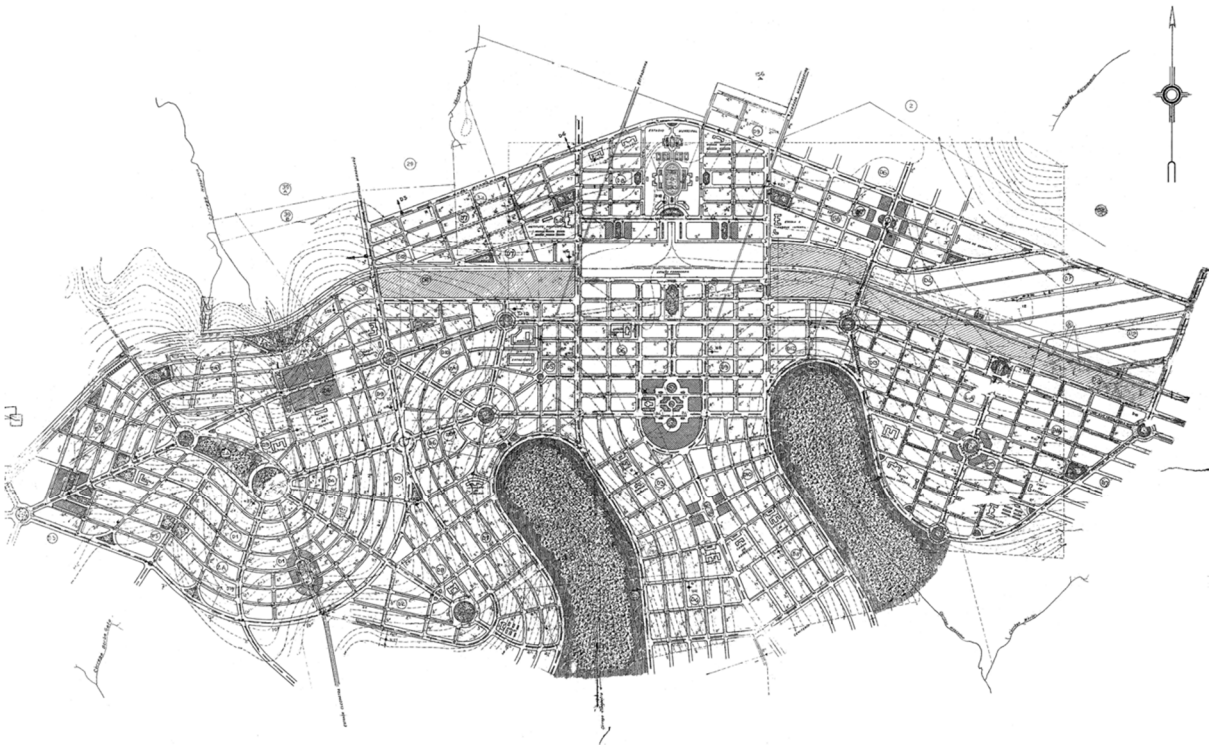

Figure 1. The original layout of Maringá, designed by Jorge de Macedo Vieira. Maringá, photo credit: Museu da Bacia do Paraná (edited by the authors).

Maringá's development began along a ridge that divides two basins to the north and south, creating a territorial crest. Secondary ridges structured the landscape, with small roads and narrow rural plots stretching from the rivers to the waterways (Beloto, 2015: 36; Meneguetti, 2007: 72; Waibel, 1949; Kohlhepp, 2015). A railway branch linked northern Paraná to São Paulo (Rego, 2009), and a train stop was established as part of a regional plan for cities spaced 15 km apart (Rego, 2001). The city was designed with a main civic centre connected to the railway, with secondary centres located on ridges or drainage lines to serve local communities. Neighbourhood layouts followed the terrain, with streets blending straight and curved lines for practicality and aesthetic appeal (Bonfato, 2008, 2003). A hierarchical layout emerged, with main avenues connected by roundabouts framing neighbourhoods and streets, preventing indiscriminate connections between them. Natural features like valley floors were integrated into the infrastructure, and deliberate street mismatches controlled traffic and defined zones. Collectively, these routes and articulations contributed to the city's organic character, reflecting the topography. Interfluves, plains, and valleys were highlighted in Vieira's design, demonstrating a design logic that integrates natural morphology with the layout of local streets in each neighbourhood.

Parameters and tests for rendimento

From the morphological analysis of the Maringá layout, five parameters for evaluating urban *rendimento* can be identified. First, **'coherence'**—the alignment of the urban layout and its elements with the site's relief and natural hierarchy. Second, **'organicity'**—the interdependence between elements of the urban layout. Third, **'hierarchization'**—the arrangement of urban elements and the subordination of some elements to others. Fourth, **'limitation'**—using urban elements to highlight

and integrate natural boundaries into the urban layout. Finally, **'continuity of routes'**—which clarifies the differentiation between neighbourhoods and their hierarchy through connected routes.

'Coherence' involves ensuring routes follow contour lines and avoid unnecessary earthworks. It also examines whether main routes align with ridgelines and whether centres and open spaces are located at key intersections of the relief, on relatively flat or gently sloping terrain, and well-connected to the broader area to support future growth. 'Organicity' refers that urban elements—routes, nodes, and poles—must work together and correspond to the site's pre-existing characteristics, ensuring coherence and mutual support within the layout. Important routes cannot lead nowhere, squares must not be placed randomly, and large facilities must consider their connection to the urban network. Using 'hierarchization' as a result of the coherence and organicity of the layout, we can examine how a central neighbourhood should have predominance over smaller ones. Similarly, routes, nodes, and poles such as avenues, squares, and centres should be emphasized based on their placement in the city, their interconnections, and the location of facilities like churches, theatres, galleries, markets, malls, and other publicly accessible spaces. 'Limitation' involves respecting natural site boundaries, such as steep valley slopes, and using urban elements like streets, avenues, or green spaces to highlight these boundaries. It distinguishes neighbourhoods without isolating them, as these boundaries can later serve as connections between areas or guide future expansions. The urban layout should have clear limits but avoid creating isolation. 'Continuity of routes' helps us understand how routes connect or separate neighbourhoods, showing how limitations and hierarchization are implemented. Interrupted streets meeting avenues prevent flow between neighbourhoods, maintaining separation and defining land use through morphology, not just regulations.

Vieira's layout exhibited both coherence and organicity. The hierarchization of the centres gave uniqueness to the neighbourhoods, while delimiting routes provided individuality and distinction to each one. Moreover, the continuity of the structuring and delimiting routes, as articulated in the Maringá's design, along with the fluidity of passage and the overall cohesion of the layout, reinforced the hierarchization and differentiation of the neighbourhoods. Thus, it is possible to say that the urban *rendimento* can be associated to a new planned town, such as Maringá.

By the other side, the current expansion layout features a complex network of streets and subdivisions that neglects the site's topography, creating steep slopes and lacking cohesive urban design. Potential centres and squares are reduced to planters, failing to occupy the most relevant topographic points. It lacks secondary centres that foster social gathering and connection with the main centre, offering only roundabouts for traffic flow—often at steep intersections where traffic lights would be more effective. Valley bottoms, once prominent in Vieira's design, are now largely occupied by blocks and lots, overshadowing their role as natural boundaries, distorting an orthogonal grid. As a result, this urban expansion exhibits minimal organic coherence and fails to align with the site's topography or the principles of original layout. The area is marked by offset streets, an absence of secondary centres, and poorly defined access points, resulting in a hierarchy focused solely on traffic rather than urban unity. Consequently, the expansion feels like a different city altogether, lacking the efficiency and character of the original layout. To assess the applicability of *rendimento* in evaluating and designing new urban layouts, two proposals for new urban areas are developed as extensions of the original Maringá design following the aforementioned parameters (Figure 2), as alternatives for the actual layout of the urban expansion. Both proposals are connected to avenues that were originally rural paths, more or less aligned with secondary ridges, but designed in a serial manner.



Figure 2. The original layout of Maringá (0), and the city's expansion with areas for the alternative layouts at south (1) and north (2). Maringá, photo credit: Prefeitura do Município de Maringá (edited by the authors).

Test 1

The layout for this area is designed to evaluate the applicability of urban *rendimento* parameters (Costa, 2020). It incorporates three key components: nodes, ridges, and valley bottoms. Routes, centres, and blocks were mapped across the area, and detailed block designs were developed in successive versions from a *tabula rasa* (Figure 3) from natural structure. In this design, the secondary ridge from Vieira's layout is repurposed as a structuring route for the new area, connecting to a primary secondary centre, which functions like a main centre for the interfluve.

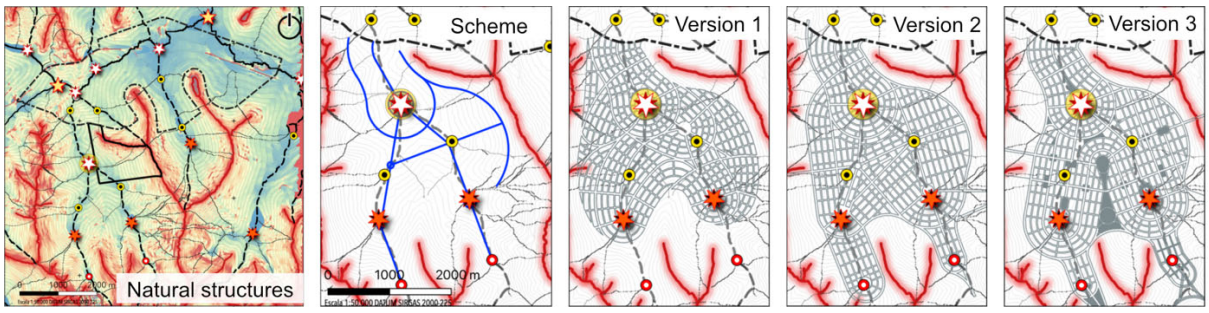

Figure 3. Different stages of design conception: from natural structure (left) to successive versions based on a main backbone of anthropic structures coherent with the site. Maringá, photo credit: Costa, 2020: 88-97.

Two avenues extend toward additional secondary centres, with all nodes interconnected by structuring routes along ridges and other avenues that link centres to the interfluve's outskirts. Streets were aligned with contour lines, keeping slopes under 8% and better stormwater management. By avoiding riverbeds and respecting valley bottom slopes, riparian forests are preserved (Figure 4).



Figure 4. The final version of first alternative layout. Maringá, photo credit: Costa, 2020: 101.

The resulting landscape resembles a terracing surrounded by green wedges, while maintaining the practicality of all neighbourhood streets connected to an inseparable network of avenues. Respect for the terrain and slope also causes the blocks to vary in size depending on their proximity to a centre, another promontory, or a boundary. Thus, the layout of this new urban area appears expandable and well-integrated with the surrounding territory.

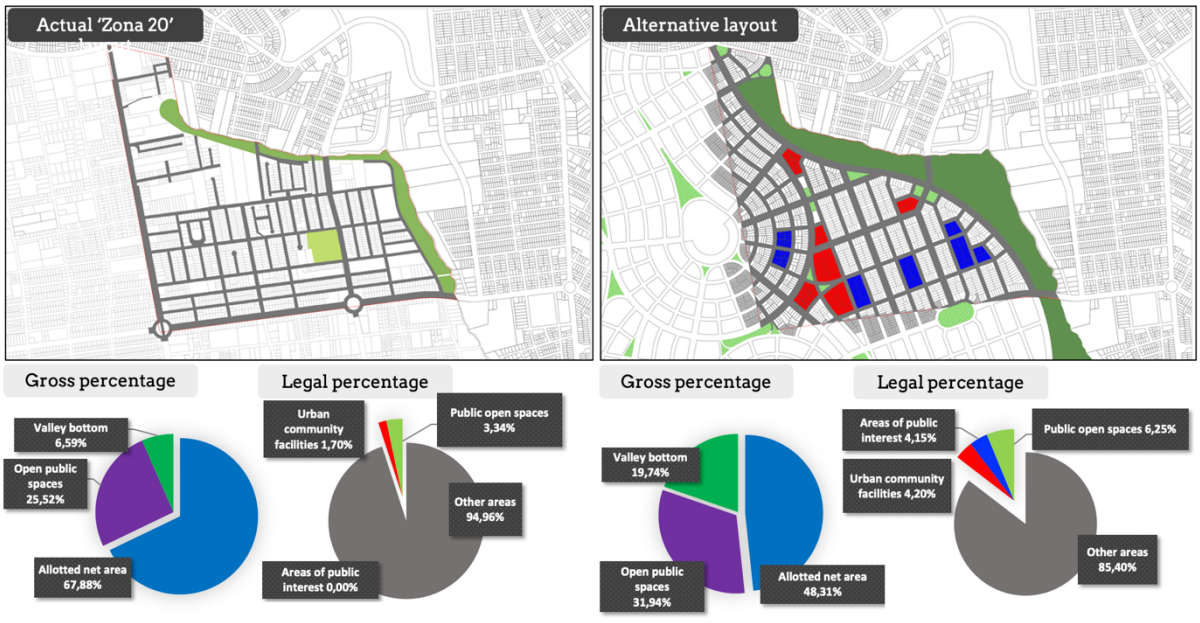

Figure 5. Comparison between layouts and percentages. Maringá, photo credit: Costa, 2020: 111.

Thanks to the forms and arrangement of the layout, the urban quality in the hypothetical design is significantly higher than in the current area. Moreover, these areas do not suffer from isolation due to steep slopes or the distance from open spaces. On the contrary, the configuration of layout elements, based on the parameters of urban *rendimento*, brings these areas closer to meeting legal requirements for higher urban quality (Figure 5).

Test 2

Instead of considering only natural structure, this layout incorporates existing elements such as surrounding neighbourhoods, highways, and transmission lines (Alves *et al.*, 2023). Therefore, pre-existences which defined urban form are considered in this challenge. Nodes, ridges, and valley bottoms were taken into account, and routes, centres, and blocks were mapped across the area with a focus on a walkability to ensure pedestrian accessibility, and sustainability (Figure 6).



Figure 6. Studies of the evolution of layout. Maringá, photo credit: Alves et al., 2023; the authors.

Since the area is surrounded by other neighbourhoods, special attention was given to connections to promote fluidity between different parts of the city. A highway passing through the north bounded the layout, and a green area was created to isolate it from noise and pollution (Figure 7).



Figure 7. Studies of the evolution of layout. Maringá, photo credit: Alves et al., 2023; the authors.

Because of the transmission lines, two of the main avenues go straight into the layout and were taken into consideration. After accounting for anthropic pre-existences, which defined the current area, the natural structure was considered for designing the layout. First, the ridge of interfluve was marked with the nodes of derivation to secondary ridges. Since the designed area lacked a natural node, an intermediary node was established between the two nodes at north and south of the site, creating a central point. Walkability radii of 800m and 400m were established from the pre-existing intersections of avenues, and their convergence near the central point formed the main centre of the area, located along the pre-existing avenue on the main ridge. The overall layout was designed as a web, radiating from the centre and the avenues branching from it, featuring smooth slopes and open spaces within the layout. Additionally, the new design includes slightly more plots than the current situation.

A verdict

The evaluation of these two hypothetical layouts, designed based on the 'urban *rendimento'* concept, suggests that this approach can be effectively adopted in the design of new urban areas. Moreover, urban layouts designed with the '*rendimento'* concept foster better interaction with nature, enhancing the interchange between urban forms and surrounding environment. The application of *rendimento* parameters indicates the potential for better stormwater management within river basins, improved socio-environmental and economic sustainability, and landscape enhancement, as the design aligns with natural site features, resulting in an organic layout. Legal aspects and feasibility are also considered in the design process, including the impact of previous land parceling, and these aspects must now be tested. Additionally, *rendimento* parameters can be applied by professionals and students, leading to accountable and reliable outcomes. In this way, we can design morphologically appropriate urban layouts, moving away from the *laissez-faire* approach often observed in recent urban expansions.

CONCLUSIONS

Presented with the real and hypothetical fabrics of a certain urban area, this work asserts that it is possible to evaluate the rendimento of an urban layout through parameters such as coherence, organicity, hierarchization, limitation, and continuity of urban layout elements. These parameters can serve to assess new urban areas, both as benchmarks for urban design and for evaluating existing areas. As qualitative parameters, all of them are interdependent. Moreover, by using these parameters in the design of new urban layouts, one can structure a series of steps for evaluation, particularly for designing with appropriate urban rendimento.

First, it is necessary to (I) analyse the pre-existing structures, namely, natural structures, anthropogenic structures, and, in addition, the morphological-cultural characteristics of the territory. Next, one can proceed to (II) plan the new urban areas to be developed on that site. This involves defining routes, nodes, and structuring, delimiting, and local elements; selecting possible connecting routes within this network; defining the potential urban nodes of neighbourhoods and local nodes, which will be responsible for the uniqueness of the city's sub-organisms. Finally, one can (III) design the streets, squares, and key buildings.

By using the characteristics of the terrain and the principle of organicity as a starting point in the design, it is possible to reduce costs, mitigate environmental damage, and address socio-economic issues. Furthermore, incorporating rendimento parameters into the design can ensure higher urban

quality, fostering a stronger identification of residents with the city and the territory to which they belong, due to the individuality created by the correspondence between layout and terrain. This creates new possibilities for establishing a more productive relationship between humans and the existing material reality.

Acknowledgements

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Effects of studentification in urban form of a university city: The case of Viçosa (Minas Gerais, Brazil)

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ABSTRACT

As urban morphology delves into the form and structure of cities, our study investigates the phenomenon of studentification as a pivotal aspect of Viçosa's (Minas Gerais, Brazil) evolving urban landscape. Over three decades, the city has experienced notable changes, with our focus centred on the central area, where the presence of students significantly impacts urban dynamics. Employing a multidisciplinary approach, we scrutinize shifts in land use patterns, categorize activities, and analyse historical as well as contemporary photographs of streets. Studentification, a concept encompassing the transformation of neighbourhoods due to a surge in student population, manifests prominently in Viçosa. This phenomenon is not only driven by the influx of students but also by the influence of the real estate market and construction industry in producing new apartment buildings catering to this demographic. We observe modifications in building configurations, notably an increase in vertical and mixed-use structures, largely driven by the demand for student accommodation. Moreover, there is a discernible transformation in commercial establishments, marked by the proliferation of restaurants, cafés, bars, bakeries, and real estate agencies catering to the student population; also, the reshape of some street designs can be identified as structural modifications. In Viçosa, studentification is concentrated around the main entrance of the Federal University of Viçosa, characterized by intense commercial and nightlife scenes, alongside a surge in apartment complexes and growth in building heights. Ultimately, our research underscores the profound influence of student presence on urban morphology, shaped not only by demographic shifts but also by market forces driving the construction of student-oriented housing. This dynamic interaction between students, the real estate market, and the construction industry significantly impacts the city's form and function, shaping its form and future trajectory.

Keywords: urban morphology, studentification, university city

INTRODUCTION

By examining the form and structure of cities, urban morphology provides a comprehensive overview of the processes that shape the urban fabric. In this context, the phenomenon of studentification has emerged as a significant and relevant issue, with notable impacts on the urban landscape of numerous cities across the globe. This study aims to analyse the process of studentification in Viçosa (MG), a university city located in the state of Minas Gerais, in the south-eastern region of Brazil (Figure 1), with a particular focus on the impacts of this process on changes in urban form.

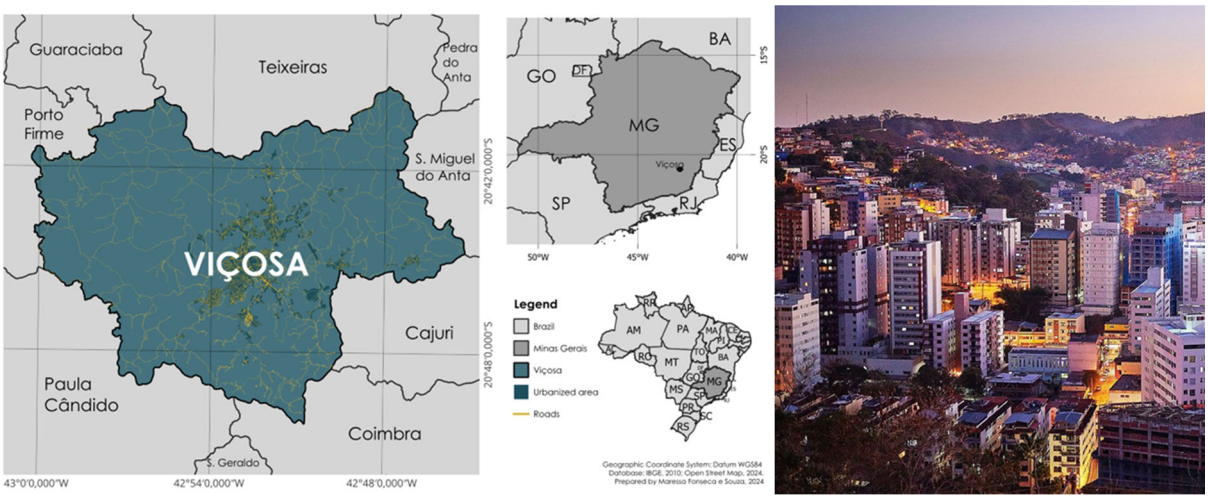

Figure 1. Viçosa'a location in Brazil. Data source: Authors and G1 News Portal, 2024.

Universities significantly impact their host towns in various ways, and morphologically, their extensive landholdings reshape the urban landscape (Larkham, 2000). Previous literature has demonstrated that university campuses and their functional and physical connections to urban environments yield a range of after-effects (Mohammed et al., 2021). Research trends have predominantly concentrated on the social or economic dimensions of this issue. However, the factors influencing the physical relationship between campuses and cities have been only moderately addressed in prior studies. We also located studies congruent to our area and theme of interest, but the literature focuses on historical, economic and political aspects of Viçosa's development, yet lacks spatial analyses.

The research is significant in that the process of studentification, as an urban transformation, has become a topic of increasing academic interest, particularly in countries of the Global North. As Chatterton (2010) notes, neoliberal educational policies, characterised by the outsourcing of activities and the reduction of student benefits, such as on-campus housing, have prompted a search for accommodation in the private sector, intensifying the process of studentification in various cities. The academic literature on studentification in Brazil remains limited, as does the research on this phenomenon in Latin American cities. Nakazawa (2017) highlights the necessity to expand the scope of studies on studentification, encompassing the examination of less investigated contexts, such as university cities in the Global South.

This study aims to address this gap in the literature by investigating the process of studentification in Viçosa (MG) and its impact on the city's urban form. The research focuses on the central area of Viçosa, where the presence of students has a significant influence on urban dynamics. The proximity to the campus of the Federal University of Viçosa (UFV) drives the demand for housing and services, creating a distinctive urban space shaped by the needs and habits of the academic community.

Hence, this study aims to investigate the impact of the evolving phenomenon of studentification in Viçosa (MG) and to contribute to the physical characterization of the phenomenon in city's urban morphology and urban dynamics. In particular, it seeks to elucidate how the demand for housing and specific services associated with the student population has influenced changes in building patterns and configurations of public spaces in the city. The research is based on an analysis of historical and

contemporary data, including maps, aerial photographs, real estate records and field observations, with the objective of providing a comprehensive overview of the urban transformations resulting from studentification.

This article is structured as follows: initially, a review of the literature on studentification is presented, contextualising the topic and highlighting its relevance to the study of urban form. It then describes the methodology used and the research results. Finally, the main findings of the research, their implications for urban planning in Viçosa and the prospects for future research are discussed.

Studentification and urban dynamics

Studentification has often been analysed as a form of gentrification (Smith, 2002), an urban phenomenon that describes the socio-cultural, economic and physical changes resulting from the influx of students into certain neighbourhoods. The link lies in the fact that the concentration of students in certain areas can trigger a process of urban transformation that resembles the patterns observed in gentrification processes. One of the main points of convergence between studentification and gentrification is the impact on the housing market. Increased student demand for housing, particularly rental housing, can drive up property values and rents, affecting the affordability of housing for the resident population and potentially leading to the displacement of former residents. This process is like that observed in cases of gentrification, where the arrival of new residents with greater purchasing power puts pressure on the property market, increasing housing costs and displacing traditional residents.

Sociocultural change is also a point of intersection between studentification and gentrification. The arrival of students in a neighbourhood can change the social and cultural dynamics, introducing new consumption habits, lifestyles and behaviours. This change can lead to conflicts between new and old residents, as well as tensions over the identity and character of the neighbourhood. Changing the socio-cultural profile of the neighbourhood is a central element of gentrification processes, with the arrival of new social groups imposing their values and customs, changing the local culture and potentially marginalising the old residents (Hubbard, 2009).

However, it is important to stress that the relationship between studentification and gentrification is neither clear nor linear. Gentrification can have positive aspects, such as the revitalisation of urban areas and the creation of new leisure and entertainment spaces that contribute to the economic and social dynamism of the neighbourhood (He, 2015; Kinton, Smith, Harrison and Culora, 2018; Prada, 2019). Moreover, the intensity and impact of studentification varies according to the local context, the public policies implemented and the specific characteristics of the student population and traditional residents.

In conclusion, studentification can be understood as a complex process, similar in some respects to gentrification, but with its own specificities. Analysing the case of Viçosa shows how the concentration of students in an urban area can affect the real estate market, socio-cultural dynamics and urban morphology, creating both challenges and opportunities for the city. Understanding the nuances of studentification is fundamental to formulating public policies that promote sustainable and inclusive urban development, reconciling the interests of the different social groups that inhabit the urban space.

METHOD

This study aims to comprehensively analyse the urban characteristics of the studentification phenomenon in Viçosa (MG). As Yin (2013) defines the case study method as an approach to a phenomenon in its reality, we employed exploratory research with a multidisciplinary method that integrated both quantitative and qualitative methods.

In order to evaluate the impact of studentification in Viçosa (MG), this study employed a methodological approach that integrated the examination of historical and contemporary data with field observations, aiming to construct a comprehensive understanding of the influence of this phenomenon on urban form. The data was gathered through bibliographic and documentary research, which included the collection of historical photographic records, satellite images, real estate records and the city's urban planning legislation.

A series of field visits were conducted with the objective of recording the physical characteristics of the urban environment, including the typology of buildings, land use patterns, and the presence of public spaces. Photographic records, including those of a sequential nature of the streets, were employed for the purpose of documenting the urban landscape and the various land uses. The data was then subjected to analysis through the systematic organisation of historical events, resulting in the creation of a timeline delineating the principal occurrences that have shaped the urban development of the study area in Viçosa, with particular emphasis on the expansion of UFV and the alterations to its student assistance policy. The urban area was mapped using a series of thematic maps which illustrate the evolution of the urban form over time. The maps include a variety of information, including details on the road network, the location and footprint of buildings, the height of buildings, the type and extent of land use, the presence of commercial establishments, and the availability of nightlife. The principal diagrams produced during the research are presented in Table 1, together with details of the sources and types of data employed in their construction.

Table 1. Summary of the diagrams drawn up for the research and their data sources

Diagrams	Data type	Data source
Figure-form	Street network over time (natural landscape, 1971, 2002 and 2023)	Google Earth imagery and Historical photography
Constructions	Buildings over time (1971, 2002, 2011 and 2023)	Google Earth imagery and Historical photography
Footprint map	Building footprint shapes over time (2002, 2011 and 2023)	Google maps imagery
Building height	Building height by number of floors	Google street view imagery; sequential street photography
Land use	Land use by type (empty lot, institutional, residential, commercial, mixed use or open space)	Sequential street photography
Commercial use	Types of commercial use at street level	Sequential street photography
Nightlife	Commercial use with night hours (open at 8:30pm-9pm)	Night street photography

The software employed for the processing and analysis of the data was Google Earth, which was used to obtain satellite images, historical maps and information on the road network, location of buildings

and land uses. Google Street View was also utilised to obtain panoramic images of the streets and to analyse the urban landscape and the different land uses. AutoCAD was employed for the drawing of the maps. The data was then organised into spreadsheets and databases.

Study area

Our study area is located within the adjacent block nearest to the main entrance to the Federal University of Viçosa (UFV) campus. The area is described as a center within the city as it ties the city's downtown commercial area to the campus (Figure 2).

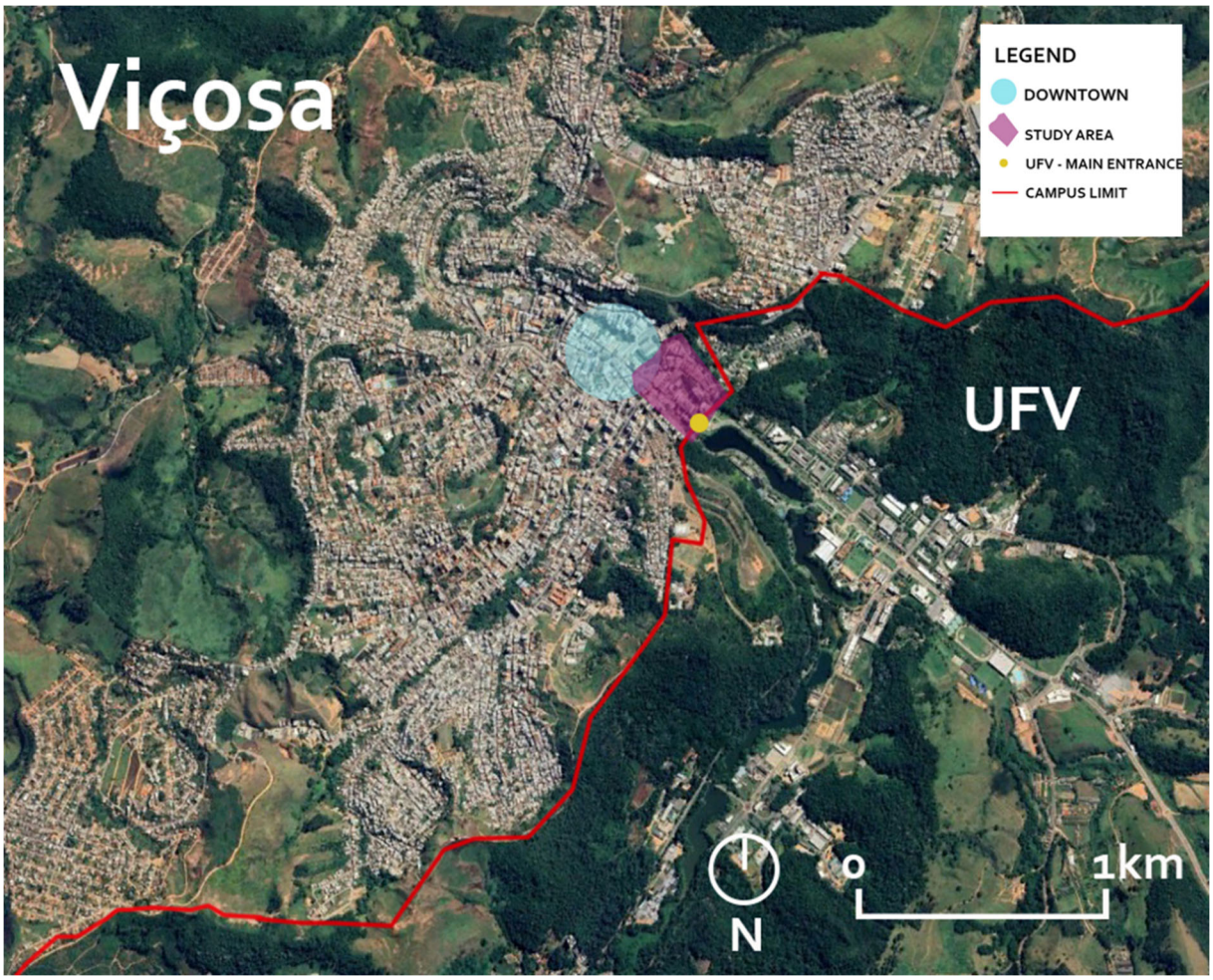

Figure 2. Data source: Google Earth with marks and highlights by authors.

RESULTS AND DISCUSSIONS

The analysis of the data collected revealed a series of significant transformations in the urban form of the study area over the last few decades. These transformations illustrate the influence of the influx of students on the city's dynamics. These changes are particularly evident in the morphology of buildings, land use, and the commercial dynamics of the area.

University campuses are associated with physical and functional alterations in their surrounding environments (Mohammed et al., 2022). As streets play an integral role in defining the overall character and functionality of urban environments (Dover et al., 2014), we have depicted the streets and paths of Viçosa over time (Figure 3).



Figure 3. Roadways and Blocks Over Time (natural environment, 1971, 2002 and 2023), credit: Authors, 2024

The maps illustrate the presence of the São Bartolomeu River, which serves as a significant morphological factor. This is not merely because rivers are a vital source of sustenance and growth; rather, it is also because Viçosa is characterised by a topography comprising numerous hills and steep inclines. Consequently, the river represents a relatively flat zone within the city. As the maps are examined in sequence, it becomes evident that the urban fabric becomes increasingly complex over time. In 1971, the presence of the railway, the Estrada de Ferro Leopoldina, is highlighted. This railway arrived in Viçosa in 1914 (CARVALHO, 2014) and was the first catalyst for the city's urbanization. In 2002, numerous new streets were constructed, with particular attention paid to the BR-120 roadway, which was opened in 1973 and connects Viçosa to major points across the country (COELHO, 2020). The old train tracks were covered, transforming Estudantes Street into a consolidated roadway. The railway was controversially paved in 2010. Finally, we present the current street configuration of Viçosa, which includes the opening of a new L-shaped street providing access to the river valley. This street has experienced significant urbanization since its opening in the 2020s.

By superimposing these maps, it is possible to trace the expansion of the city's roadways, emphasizing the significant alterations in infrastructure and spatial organization that have accompanied the growth of the student population. In addition to illustrating the construction of new roadways, the maps also document the subdivision of blocks, which exhibits irregular characteristics regarding both street length and street width. From this analysis, it can be concluded that Viçosa has developed new streets in the area, resulting in a high level of complexity and accessibility to all parcels of land.

To gain insight into the process of constructing buildings over time, we employed a visual sequencing method in addition to manually tracing building footprints. This allowed us to once again visualize the progression of the spatial occupation (Figure 4). The sequencing revealed a notable increase in the number of buildings, particularly in areas proximate to the university, reflecting an escalating demand for student housing. By means of a systematic tracking of these transformations, the maps provide a comprehensive view of how urban space has adapted in response to demographic pressures and market forces driven by the expanding student population. This offers valuable insights into the city's urban dynamics over time.

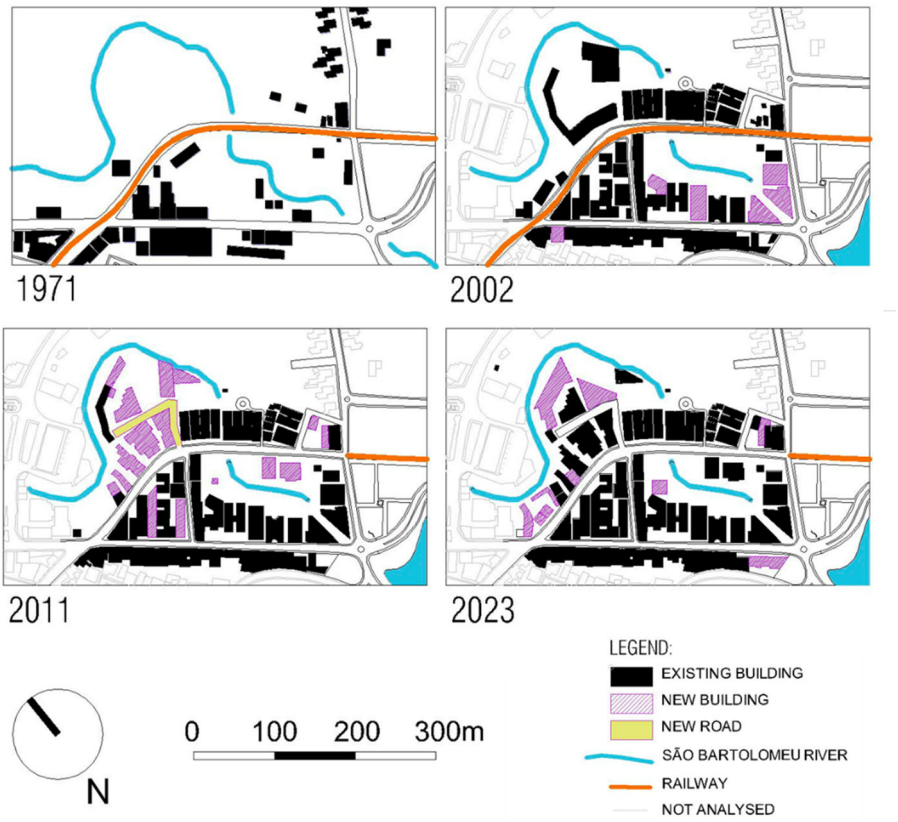

Figure 4. Building construction over time (2002, 2011, and 2023), credit: Authors, 2024

The federalization of UFV occurred in 1969, and in the subsequent years, the institution witnessed a notable expansion in the number of courses offered. By 1974, the institution had expanded its academic offerings to encompass 19 undergraduate and graduate programs. In 1975, the number of programs increased to 39 (MELO, 2021). Concurrently, in 1974, the university modified its student housing policy, effectively halting the construction of new student dormitories. Figure 4 thus lends further support to the notion that a housing shortage was already evident by the late 1970s and subsequently resurfaced in the late 2000s. This is evidenced by the fact that in 2008, with the introduction of the Program to Support Restructuring and Expansion Plans of Federal Universities (REUNI), UFV once again expanded its undergraduate and graduate course offerings significantly.

An analysis of the evolution of the built environment revealed notable changes in the form of the buildings' footprints (Figure 5). Pereira (2010) posits that architectural form is not merely a physical entity; it is also a signifier that conveys meaning. As an instrument of architectural translation, this sign serves to combine a concept with the image that represents and shapes it. An analysis of the architectural forms of new buildings revealed a clear tendency to adapt to the subdivision of land, occupying the available space to its fullest extent. Such edifices are frequently situated on residual plots of land whose shapes are irregular. This results in an architectural style that is shaped by the limitations and irregularities of the land. This may be a significant characteristic of the studentification phenomenon, as builders are so invested in a specific location that they are willing to compromise plan designs to fit their real estate in unconventional spaces.

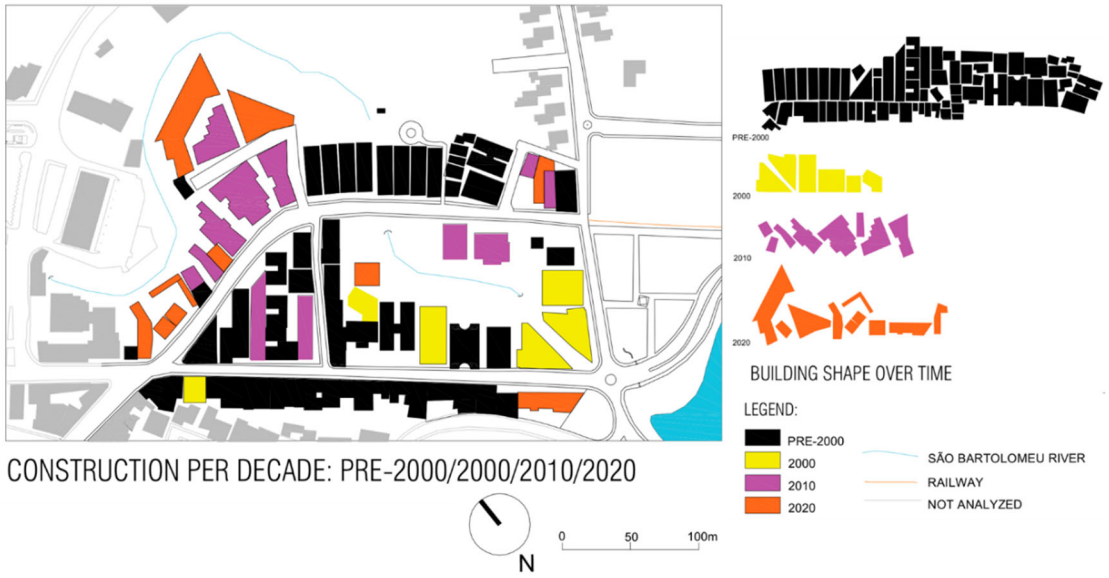

Figure 5. Building footprint over time (2002, 2011, and 2023), credit: Authors, 2024

The analysis of the building footprint reveals a notable intensification of plot occupation, with the construction of buildings of varying shapes and sizes, designed with the objective of optimizing spatial utilization. In response to the growing demand for student housing, real estate developers are modifying their projects to accommodate the available space, resulting in a diverse range of building shapes and sizes. Moreover, the height of the buildings has increased significantly, particularly since 2002, with the construction of buildings exceeding 10 storeys in height. This exploitation of the building potential of the plots is in accordance with the current urban policy. This verticalization of the area is indicative of the high demand for housing in proximity to the university campus and the pursuit of enhanced profitability by real estate investors.



Figure 6. Building heights, credit: Authors, 2024

Figure 5 thus offers a more profound comprehension of the ways in which the pressures of studentification and market demands have not only led to an increase in the number of buildings but also to significant alterations in their physical form. By mapping these changes, we can identify patterns in the way urban space has been optimized for student accommodation, resulting in more compact, higher-density developments.

The analysis of land use revealed a preponderance of mixed-use and commercial edifices in the study area, particularly following 2002 (Figure 7). This shift in land use reflects the growing demand from the student population for services and commercial establishments that offer convenience and proximity to the university campus. The concentration of real estate agents in the area also serves to illustrate the significance of location in the search for real estate, particularly in catering to the transient student population. Moreover, the research revealed a paucity of green spaces within the study area, with the exception of the UFV campus. The lack of recreational spaces and opportunities for public interaction may have a deleterious effect on the quality of life of the local population, particularly the student residents.

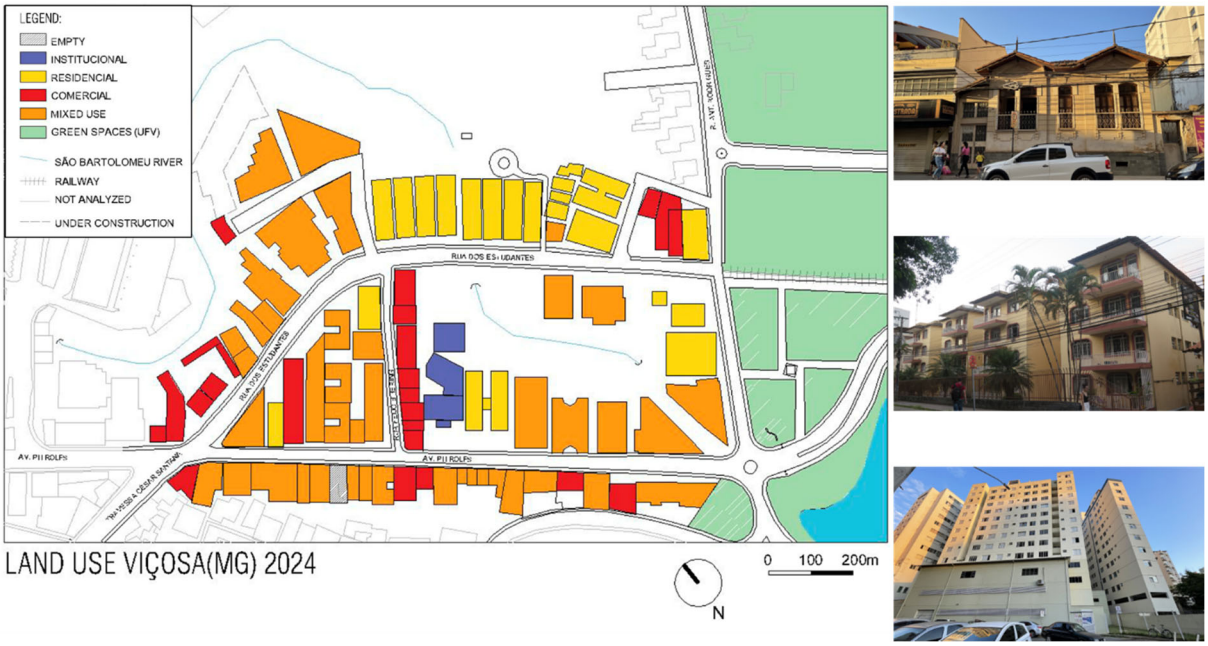

Figure 7. Land use patterns by type (empty plots, residential, commercial, mixed-use, and recreational green areas), credit: Authors, 2024

A comprehensive analysis of the commercial activities within the area revealed a diverse range of services catering to the student population, including restaurants, snack bars, and bars. The presence of gyms and nighttime services, such as markets and laundrettes, also illustrates the adaptation of local commerce to the needs of the academic community. The area's nightlife is notably vibrant, with numerous commercial establishments remaining open until late at night, catering to the student population's demand for leisure and entertainment (see Figures 8 and 9).

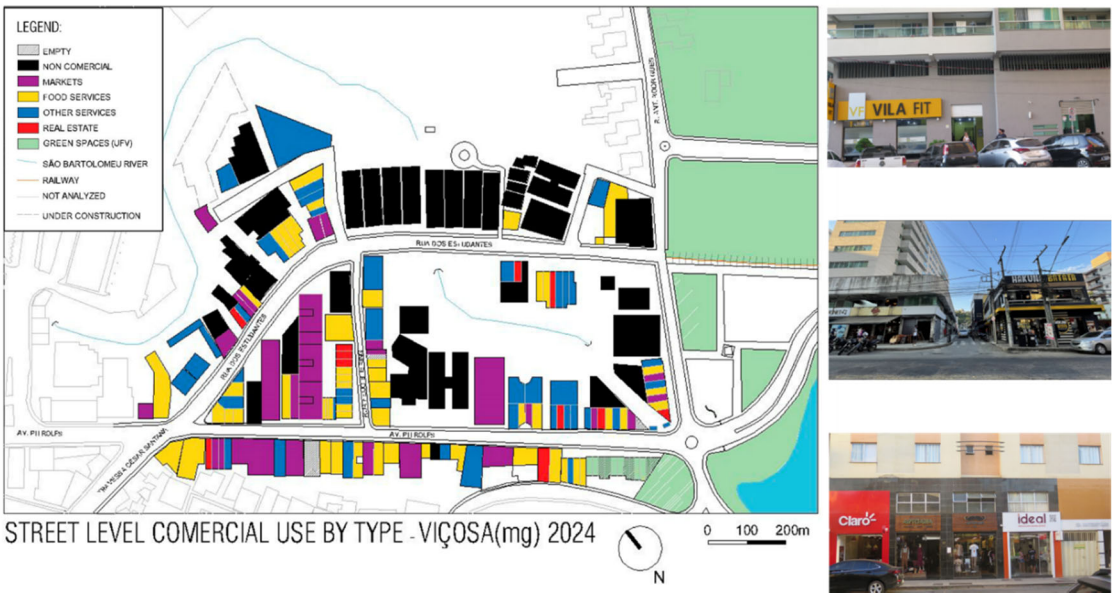

Figure 8. Commercial use by type (food services, general services, real estate agencies, and markets), credit: Authors, 2024

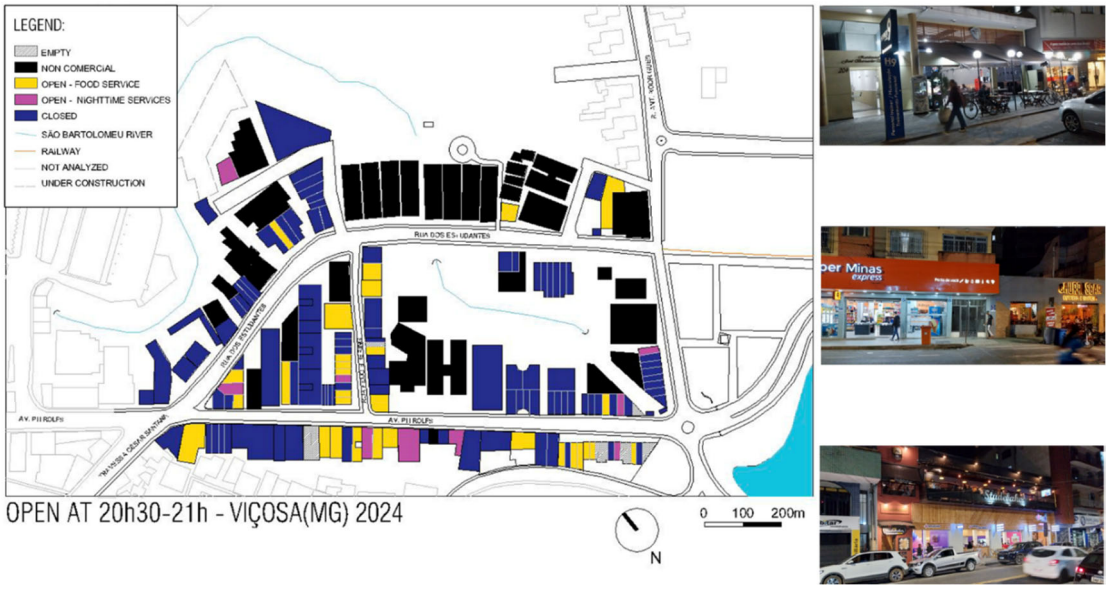

Figure 9. Nightlife - Commercial use by type, credit: Authors, 2024

The findings of this research are in alignment with those of previous studies on the impact of studentification on the urban form of university cities. As demonstrated by the research of authors such as Hubbard (2009) and Sage (2013), the intensification of the real estate market and shifts in socio-cultural dynamics are defining characteristics of studentification. The research demonstrated that Viçosa's central area has undergone a significant transformation, becoming predominantly commercial and mixed-use, characterized by high building density and verticalization. This has been driven by the necessity to satisfy the requirements of the student population.

It is essential to recognize the constraints of the research methodology. It is important to note that the study area was limited to a single block in close proximity to the UFV campus. This may not fully represent the totality of the dynamics of studentification in Viçosa. Moreover, the research was based on secondary data and field observations, which may have constrained the extent of the analysis. The

absence of information regarding the specific GIS software utilized and the unavailability of the computer code employed in the research also impedes the replicability of the study.

CONCLUSIONS

This study examined the impact of studentification on the urban form of Viçosa (MG), with a particular focus on a block situated near the UFV campus. The results demonstrate that the establishment of the university and the subsequent increase in the student population have precipitated substantial alterations in the area, including the intensification of the real estate market, the verticalization of buildings, the predominance of commercial and mixed-use developments, and the absence of green spaces. These findings align with those of previous studies on the effects of studentification in university towns, including the intensification of land occupation and changes in socio-cultural dynamics.

The research underscores the necessity for urban planning that is attuned to the ramifications of studentification, particularly with respect to the allocation of green spaces and public leisure areas, which were identified as inadequate in the study area. The incorporation of green areas into new developments and the implementation of land use policies that guarantee the provision of quality public spaces are essential measures to mitigate the negative impacts of studentification on the local population's quality of life.

It is important to note that the research is not without limitations. These include the delimitation of the study area to a single block and the reliance on secondary data and field observations. Further research could extend the geographical scope of the study to encompass other areas of the city affected by studentification. Additionally, the incorporation of qualitative methods, such as interviews with residents, students and local business owners, would facilitate a more nuanced understanding of the social and economic impacts of this phenomenon. An investigation into urban planning strategies and public policies that foster more balanced and inclusive urban development in university towns would also be a valuable avenue for future research.

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Mapping urban change using generative diagram

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ABSTRACT

Looking at critics of the Italian typological approach on urban morphology, we can identify new realities within which the concept of type develops and changes over time. In parametric architecture, the idea of type is replaced by the more dynamic concept of genotype, in which information is interconnected, linking functions, forms, and data. The generative approach in design, which views the genotype as the primary constituent, does not envisage a single outcome but a multiplicity of solutions to counteract the global environmental changes linked to the city environment. This implies that even the approach to morphological analysis with typological declination must be developed in the new design direction. Diagrams, as a tool to comprehend the city, do not explain the urban environment as a simple object but as an object understood through complexity, as Morin states. While in the past, it was sufficient to analyse a few factors in urban analysis, the city's shape is now enriched with a data substrate that can be expressed through generative design tools. In this sense, this contribution delves into a deep understanding of the representation tool, transforming the significant approach of the Italian morphological school (analysing the work of Saverio Muratori, Gianfranco Caniggia and Augusto Cavallari-Murat) into a more diagrammatical one, beneficial for the computational design approach. In conclusion, interpreting the city as a logical system through the diagram has led to the development of a new approach to the analysis of the city, which can be valuable for a generative design approach and for addressing the changes in the urban environment.

Keywords: tool, Italian studies, diagram, generative design, reading contemporary urban change

CHANGING THEORETICAL ATTITUDE

The concept of type has historically played a central role in architectural theory, particularly in the Italian context, where the cultural debate on the historical city centre brought to the development of an Italian typological approach to urban morphology. This widely discussed approach emphasizes the concept of type as a classificatory system for urban forms based on recognizable, enduring characteristics, called permanences. However, other characteristics of this typological approach are helpful in the design of the city landscape. The building type in this context interests us more for the ideas that can be extracted from it through which it is possible to decode the mechanics and formation process of its specific characters, the expression of a specific cultural area and natural environment, rather than for the classification of its physical characters (Chiappi & Villa, 1982). The social reality

defining the spatio-temporal context of urban form affects its study and the language used to describe it. Current literature underestimates this aspect, favouring the historical foundation of the object of investigation instead (Marzot, 2021). However, evolving realities in urban design and architecture are shifting this perspective, leading to a better understanding of changing dynamics in the built environment and, so, progress in visualizing the city. In this sense, highlighting the crisis contemporary cities are undergoing leads to reevaluating the concept of the type as manner of reinterpretation of urban dynamicity.

Previously, the architectural type was the conceptual output of a relatively small number of indications, almost exclusively formal, referring to distribution rules and predefined codes. However, today, the concept of genotype, a more complex set of genetic information, has appeared. Together with the "parameters" linking the function, form, and other information that we commonly call data, this concept drives design using a parametric approach. The genotype stands for an adaptable framework that organizes information by linking functions, forms, and data in response to complex urban needs (Ventura, 2015). This shift from a traditional to a more adaptable and data-driven approach is a significant development in contemporary design. As environmental challenges increasingly affect urban spaces, the genotype appears as a versatile concept, capable of producing multiple solutions. Unlike the traditional approach that views the city as a fixed entity system, the genotype's adaptability encourages a rethinking of morphological analysis within a contemporary design context. This shift towards a generative approach in design, using the genotype concept, offers a reassuring potential to adapt to contemporary technology and address urban challenges.

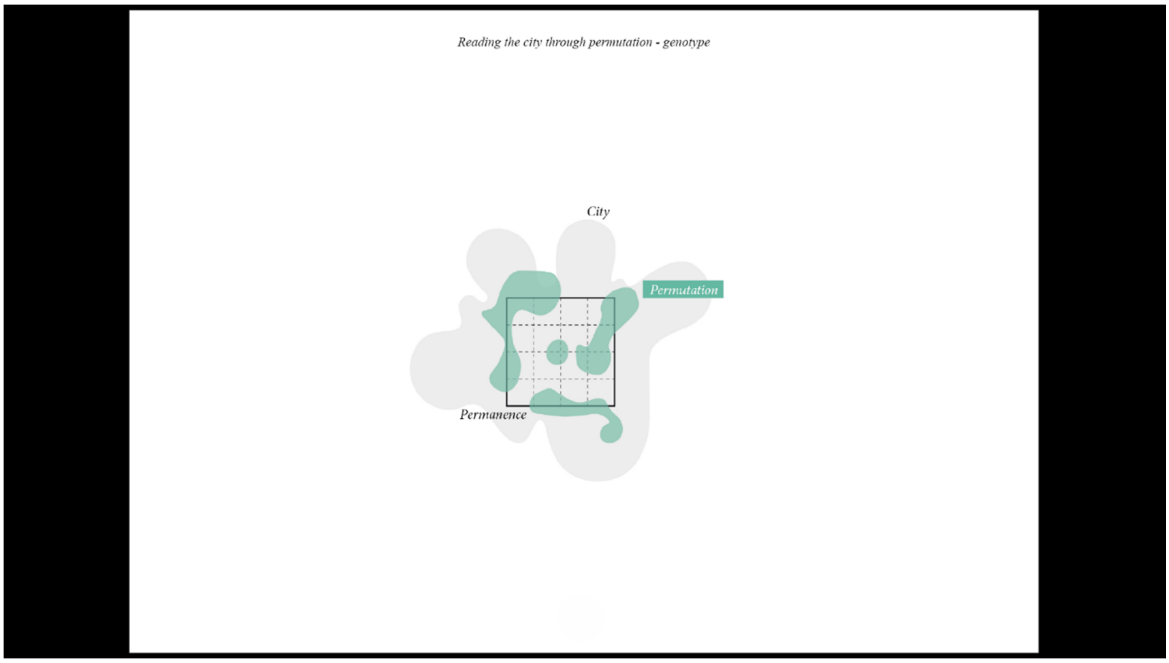

Figure 1. Changing the attitude towards space. From a city made of permanence to a city made of permutation. Photo credit: Author 2024.

This study revisits the Italian morphological approach, with a particular focus on the contributions of Saverio Muratori, Gianfranco Caniggia, and Augusto Cavallari-Murat. The aim is to reframe their typological approach through a diagrammatic lens that supports computational design methodologies. By doing so, the contribution aims to show how experiments with visual techniques

respond to the need to reconnect the issue of design with a changing theoretical attitude towards space. It can show a change in how the space is conceptualized and constructed.

FROM TYPE TO GENOTYPE

Currently, the city's science is intent on discovering how processes of different natures generate form and function by defining it as a non-linear system of actions and reactions (Marshall, 2009; Alexander, 1973). Architectural form and urban form are not only the result of a creative process but can contribute to setting up, fixing or transforming cultural foundations and social environments, producing spaces, times and vehicles of transmission (Kiss & Kretz, 2021). A theory of the city that does not consider dynamics can do little more than provide a descriptive explanation of how various economic and social forces can resolve themselves in sufficient time. Morphological analysis, which is one of the most important approaches in the study of the city, highlights how no amorphous zones exist, or where they do exist, they are found at moments in the process of transformation (Rossi, 1966).

Historically, the typological approach was grounded in key theoretical contributions that shaped different schools of thought. Argan (1956) conceptualised and marked the attention on the analogy between objects in terms of formal and functional criteria. Aldo Rossi (1966) viewed the essence of architecture as a union of tectonic, function, and stylistic elements. These contributions led to understanding type as a useful classificatory tool governed by distinct and precise rules to analyse the urban form. For Saverio Muratori (1959), the concept of type shifts from a recognition of similarity helpful for the classification to the definition of type as "a priori synthesis" lies in the architect's mind, and it is there before the object. Using the type as "a priori synthesis" means considering the type as an operative matter for design. Type serves as a structural form beyond its classificatory function, integrating spatial organisation with the more general concepts of shape (Martí Arís, 1993). Recognising types within the urban fabric led to recognising their permanence and urban structural role. However, contemporary cultural, environmental, and technological shifts redefine the architectural concept of type. Hillier (1986), in his work on space syntax, introduces the societal relevance of social value into the discourse. Saverio Muratori and Gianfranco Caniggia already mentioned the concept, but Hillier, with his approach, adds a critical informative dimension, emphasising the function of the type as both analytical and generative. Hillier, Hanson, and Graham (1986) introduced genotype as an informative entity clearly distinct from the physical building itself, while Bafna (2012), starting from their consideration, further defined genotype as a set of fundamental and culturally influenced instructions.

The genotype approach fosters new insights into urban transformation and design adaptability by conceptualising the city as a dynamic system. Through this lens, urban morphology is no longer just a matter of typological analysis, as we know from history. Now, it can embrace contemporaneity's complexities, providing a framework for generative design approaches that address contemporary cultural, environmental, and technological shifts.

In this view, the genotype emphasises the dynamic nature of urban environments, shifting the analytical and design focus from permanence to permutation. Parametric design, rooted in the computational formulation of instructions and operations, aligns well with genotype. Architects define parameters, such as dimensions, materials, and environmental factors, as input for software

programs, which then influence the overall form and structure of the building. The distinctive feature of changing a parameter and checking the results in a circular iteration allows for greater flexibility and adaptability, allowing architects to respond directly to specific site conditions and user needs and check at once the results of their reasoning.

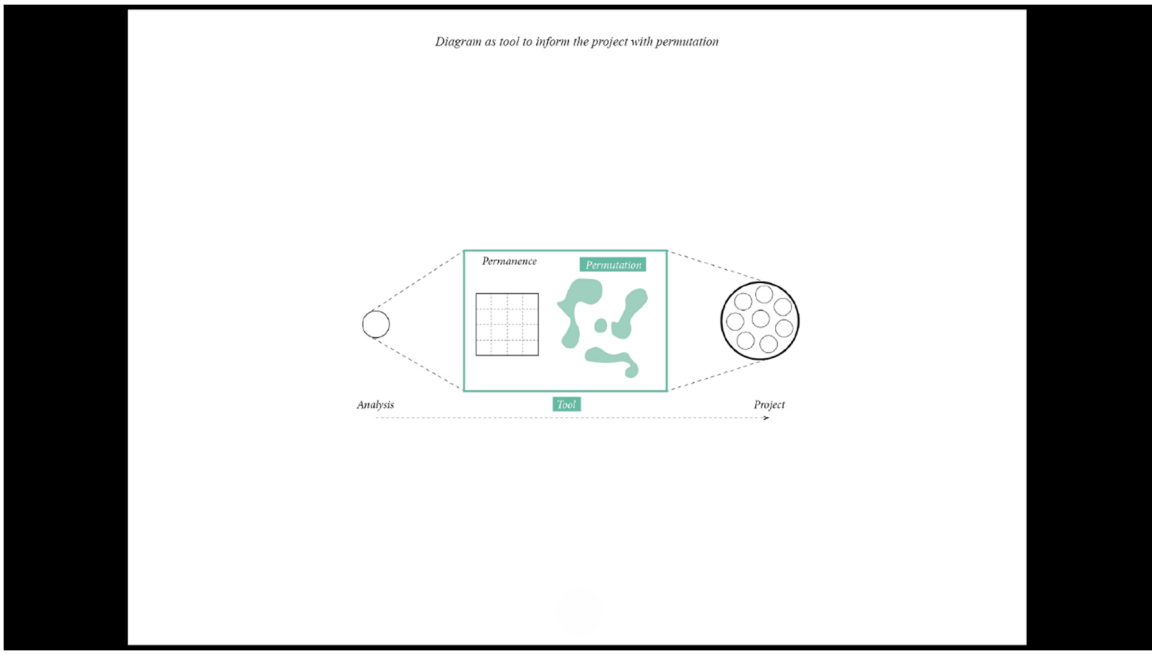

Figure 2. Diagram as a tool to inform the project with permutation. Photo credit: Author 2024.

To understand and guide the parametric approach based on genotype, it is helpful to think about diagrams as essential representations for thinking, problem-solving, and communication in design disciplines, particularly those related to creating physical forms (Do & Gross, 2001). The ability to develop multiple scenarios leads again to consider the diagram as generative, representing and analysing existing realities and envisioning realities that do not yet exist on paper or in time. It becomes a carrier for non-specific visions on the project. This assumption signifies a change in thinking, moving from the map as a guide towards an already specific project (Palma, 2001) to the map, or the diagram, as a speculator of various project possibilities. This consideration arises from using the diagram to generate new realities. The purpose is to escape the taxonomic nature of urban analysis and seek refuge in a universe of project possibilities where typology and topology engage in dialogue.

DIAGRAMMING PERMUTATION AS A WAY OF REINTERPRETING TYPE

In the Italian morphological approach, it is possible to see how Saverio Muratori and Gianfranco Caniggia informed the city evolution of Venezia and Como through an overlapping of maps of different constitutional period. Only Augusto Cavallari-Murat, a scholar from Turin, added the overlapping of the layers of the graph, similar to Hillier, to show how each part of the city centre of Turin was related one to the others. Adding the relation between different elements of the city helped to frame a new method in which the maps were not enough to hold all the information about the transformation. But now, as the city changed, it is possible to start from the method used in the past to reconstruct a process that is not just able to show what is visible in the classical representation but also what has not since now. To go further with this experiment, it is important to understand permutation in the urban environment.

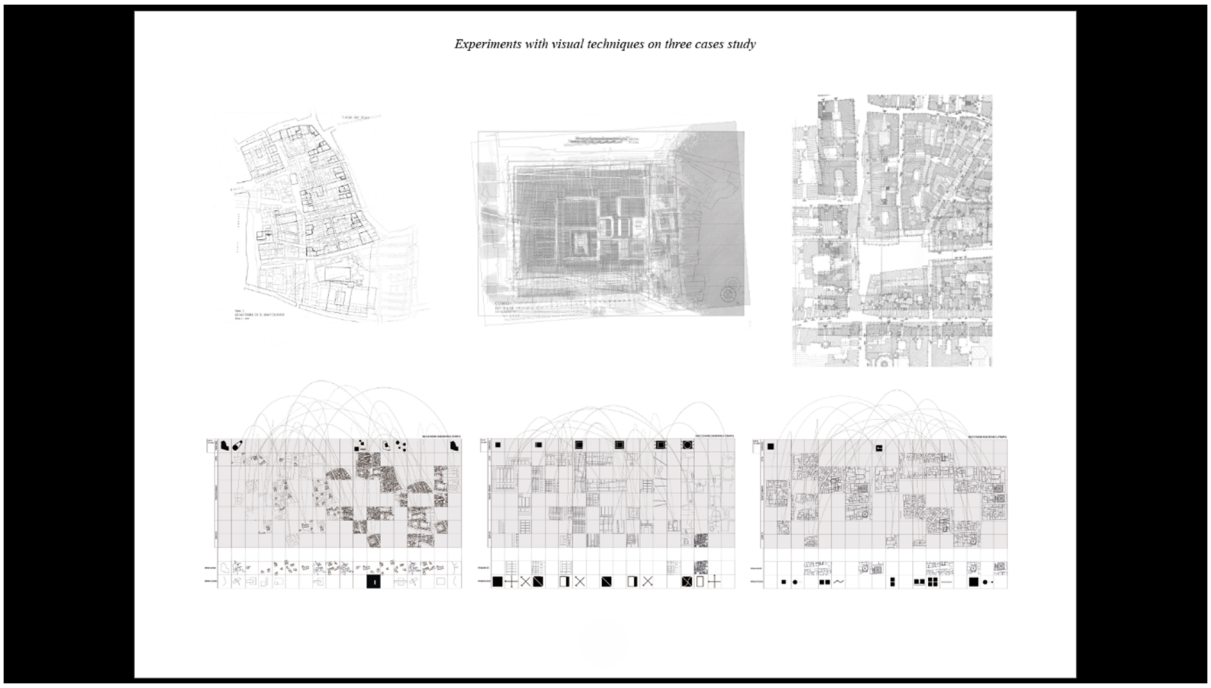

Figure 3. Diagrammatic matrix of the three cases study. From left: overlapped maps of San Bartolomeo in Venice by Saverio Muratori and subsequent matrix translation; overlapped maps of Como by Gianfranco Caniggia and subsequent matrix translation; overlapped maps of Piazza Palazzo di città in Torino by Augusto Cavallari-Murat and subsequent matrix translation. Photo credit: Author 2024.

Understanding the connection between the emerging concept of genotype and the city's dynamicity requires a unique method. This approach not only reads the fixed elements in the urban pattern, as morphological maps do, but also interprets the permutations and their rules into morphological parameters.

The method used to inform the design through permutation starts from the assumption that each map used to represent the city can be read and understood as a diagram of a system of thought. The term "figures of thought" used by Gansterer in its publication finds correspondence with Astrit Schmidt-Burkhart in connection with a paper on "figures of order" of 2004 and serves as a basis for the investigation and analysis of scientific texts in visual culture, graphemics and diagrammatic. The term comes across as setting up various concepts, models, and processes to highlight the role of diagrams as tools of thought that can stimulate a collateral point of view on the environment analysed. Figures of thought can be placed on various levels of abstraction, and the process of abstraction can be repeated several times. One does not start with mathematically abstract operations or operations that can be followed purely verbally. Still, formulations are included in the diagram that can be grasped through drawing to describe the procedure or process. In the case of the contemporary city, the process of city transition. The use or application of these figures of thought thus leads to forms that can be grasped through drawing (Gansterer, 2011). The permutations in the city are made explicit through the reconstruction of these processes, which remain hidden within classical reading methods.

Reading the urban form with a diagram is only enough if the diagram is made to focus on permutation. All the traditional morphological analysis information can be combined and abstracted with a matrix containing both permanence and permutation of the urban environment. The matrix is considered a generative diagram that uses the assemblage theory to build a specific tool that supplies the need for

a dynamic city. Some elements need to be considered in this process of configuration of a new method, starting with some basic instructions and procedures used by the Italian morphological approach that was developed in the sixties. From this, each city needs to be studied by comparing different times (diachronic and synchronic) and different scales (from macro to micro scale), understanding not just a specific object but how this object is integrated into the urban system.

Considering a part of the city in which a transformation or regeneration process is taking place, which is therefore in an unstable state of transition, it is possible to visualise, through the matrix, the changes that have occurred or are emerging. The matrix used is made by a system of frames that helps to read the city at a different scale in different scales. To give an order, it is possible, in this instance, to consider the territorial scale as the first element analysed. Through this first reading, it is possible to recognise and visualise the macro-transformations of the case under analysis within the urban fabric. These are essential moments for reading and understanding the process of change in the urban form. Abstracted and represented with a symbolic language, the territorial scale tiles are inserted into the matrix. Going deeper in scale, it is necessary to quantify and map the micro-phases of the transformation and the subcategories of the macro-transformations found on a territorial scale (meso-transformation). The coring of the part of the city analysed aims, on the one hand, to find the affinity of the transformation with the different scales of analysis, and on the other to further divide the time of the transformation. With this step, the number of frames between one scale and the next can increase by extending the number of frames on the grid.

Each meso-area of transformation inscribed within a square is positioned in the matrix grid, as is done with each micro-area. The identification of these phases not only occurs a priori during the mapping of the individual parts of the city but is constructed simultaneously with the extension of the matrix.

During the study of every single part of the city that makes up the transforming aggregate, the dependency relationships between one micro-transformation and another are found. The relationships shown between the various parts at the same scale or between the same parts at different scales are then schematised. Direct and indirect relationships between parts of the city are defined and connected by lines to make them clear. As a result of the construction of the matrix and in the identification of the logic used for the transition study, two horizontal lines appear that summarise the permanences and the permutations, or the result of the matrix. The matrix not only photographs a state of the art but contributes to starting, through the completion of the line of results, reasoning of a design type.

The permanence and permutation concepts are linked by comparing them to each other in line. The unique capability of the tool is that it gives different information at the same time and displays, in the same matrix, multiple points of view on the city.

Through the matrix, considerations arise about methods for representing the city and its transition. The permutations identified in the maps find space to be normalised and used in a propulsive way for the project. For the investigation, it is not important to observe the specific permutations of individual contingencies but to identify a method that allows for their identification through the decomposition into rules and permutation variables. The specific contingency becomes a pretext for a method analysis. The objective is to identify the invariants and permutations not as straightforward to individual case studies but as a process for determining the general rule to be traced within the

diagram. The final contribution of invariants and permutations emphasises the dynamic contribution of the matrix and the diagram.

The results of the representations aim to underline the variety of analysis possibilities of the transition, defining the logical framework of the method. The diagram highlights the importance of diagrammatic logic, which becomes a tool for revealing hidden urban dynamics. This leads to the conclusion that the goal of the diagram is not merely the representation of a specific scenario. Still, it highlights its character of multiplicity in providing ever-different scenarios informing the design. The matrix is the diagrammatic object that composes the representation, but its diagrammatic logic is exportable and adaptable to new and different images. Beyond the meaning of the image, the purpose of visualisation becomes having a critical point of view, opening new perspectives on possible representations of the transitioning city.

For this reason, the diagrammatic reconstruction of the map is just one of the possible interpretations that, through the decomposition and exploitation of hypothesis relationships, aims to provide a new point of view on the city. As understood in this way, the diagram does not correspond to a single image but to a logical system. From this method, the starting point for the design is not the static part of the city but the one that is changed. The changes bring to light the propulsive feature of the urban environment.

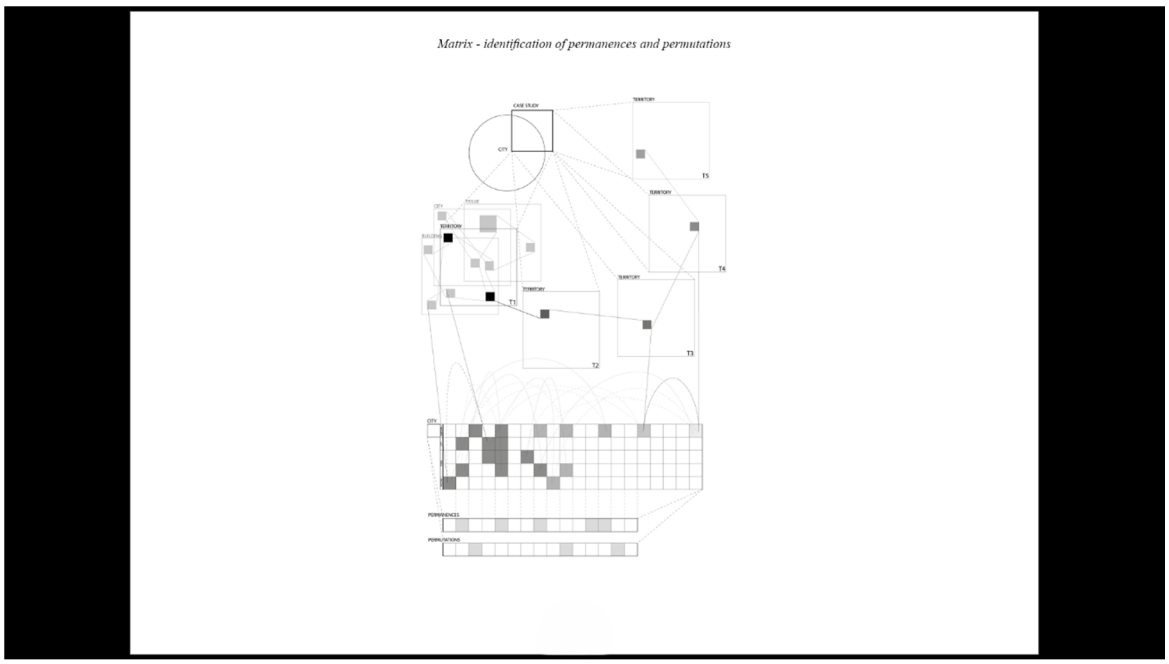

Figure 4. From a real urban change scenario to a matrix of transformation able to read permances and permutation. Photo credit: Author 2024.

PERMUTATION AS A WAY OF REINTERPRETING TYPE

As a result of the matrix, permutations are represented through symbols. This is because it is important to understand that each type of transformation is defined by a set of repeated variables rules. Symbol representation already allows a first schematisation and abstraction of this characteristic. The permutation system read through the matrix can then be subjected to a subsequent simplification by transforming the symbol into a system of codified rules. As we have seen

above, the parametric approach benefits from this type of abstraction. The methods can thus be intertwined and used simultaneously to understand and design urban transformations.

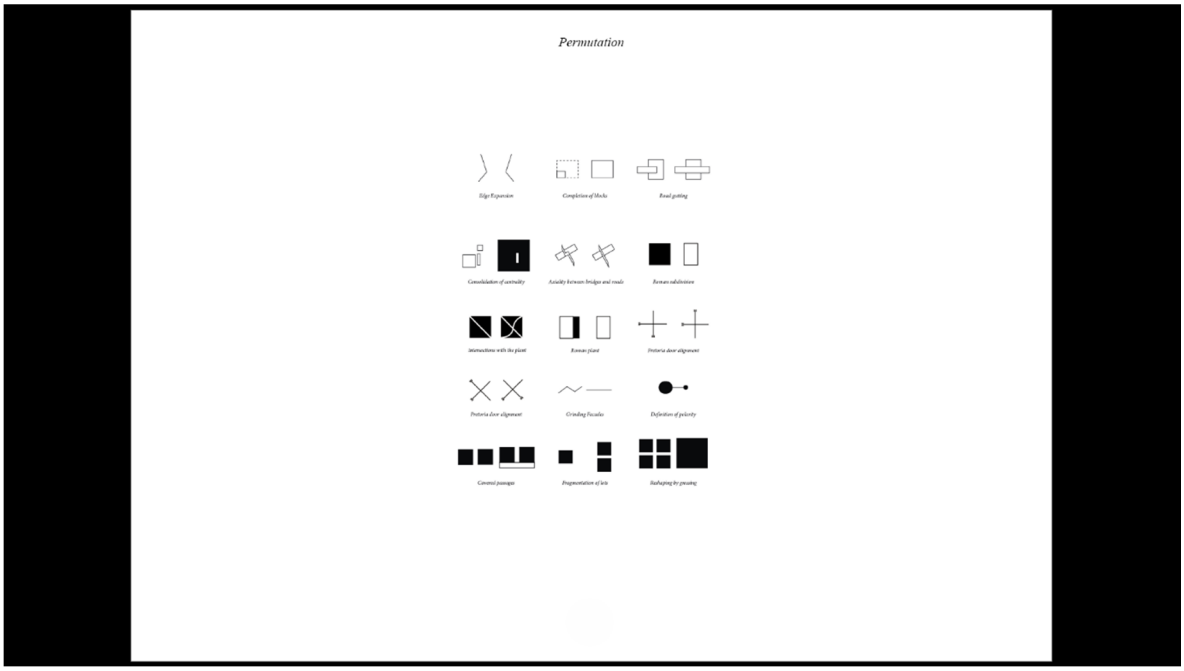

Figure 5. Permutation schematizations. Example taken from the analysis of the three cases study of Venice, Como and Torino. Photo credit: Author 2024.

One of the more popular ways of expressing design synthesis is parametric modelling, which precedes the history of rationalist architecture and computational modelling. A parametric model can be defined as an explicit representation of the design logic that maps the parameters in input to have a specific output (Davis, 2013). The literature uses many terms, such as generative system, generative model, and generative design. The term model refers to the representation of a system, an organisation of various parts to understand a specific phenomenon. Particularly in the preliminary stages of design, interaction with the partial representations is important for acquiring knowledge, creating a frame of reference, and reformulating the problem and solution in parallel (Cross, 2006). In this process, the designer constructs the design world within which the dimensions of the problem space to find solutions can be built (Schön, 1992). Subsequently, in the formulation stage, the designer develops the representations for the input, the output, and the algorithm to be encoded in the generator. It is here the codification of permutation can be inserted. This algorithm specifies the synthesis of the output design alternatives conditioned on the input information (Veloso, 2021).

In a more conventional ideation process, designers imagine worlds by interacting with drawing media; generative models induce the space of possible designs (design space) and how the designer can navigate between solutions. In the execution stage, designers interact with the generator by changing the input information and seeing design alternatives as feedback in the model's output. They can exploit a subspace of solutions satisfying specific goals or explore unexpected alternatives more easily than in the traditional method. Potentially, this stage can lead to a reformulation of the model that can be changed continuously. Generative models are constructs situated between design and computational logic. Various sources, such as human cognition, expert knowledge, social organisms, natural processes, and dynamics, can inspire their agency. They are a powerful and compelling alternative for a design that helps both from the rigour of scientific modelling and the open-

mindedness of the design artefacts (Veloso, 2021). The computational model can also frame itself, and the matrix can reshape itself and change needs in a more analogical way.

Translating the permutation into rules introduces a crucial variable to the model, moving away from the rigidity of permanence and the traditional typological approach. This process is essential in understanding and navigating the shift from the notion of type to the more complex concept of genotype. It is not just about the shape of the architectural element but about all the relations and characteristics defined within the matrix, which are of utmost importance.

AN ITERATIVE PROCESS BETWEEN DESIGN AND ANALYSIS

The diagram is a map that can be the starting point of computational design thinking and activates the development of multiple projects in the city from a specific configuration of the urban environment without excluding the architect from the design process in favour of a software-based approach based on a sorting process. Conversely, the information on permutation extracted from the diagram became the driving force for a new project. The architect is a "researcher-designer," defined by Lak and Aghmolaei, who designs and evaluates the project according to evidence (2020). Evidence that, in this case, is not based on quantitative analysis, number or index but is based on the logical construction of the analysis.

Indeed, there are contrasting interpretations of the term "diagram" in current discourse. On the one hand, some perceive diagrams primarily as tools for systematisation and problem-solving. They view diagrams as aids facilitating numerous perceptual inferences, making them highly accessible to human understanding. This perspective emphasises the role of diagrams in organising information and simplifying complex concepts.

On the other hand, an opposing viewpoint sees diagrams as catalysts for unfolding processes or as maps of movement. According to this perspective, diagrams go beyond static representations and capture dynamic and evolving phenomena. They are seen as instruments that provoke the exploration of various possibilities and reveal hidden relationships or patterns. Rather than providing fixed solutions, these diagrams encourage the generation of new ideas and the discovery of novel perspectives. (Gansterer, 2011).

The results of reading the city as a permutation through diagrams as maps of movement lead to the definition of a new paradigm in the urban environment. It opens a methodological discourse beyond the relation between causes and effects. Linking the genotype, the diagram, and the vision of the urban environment through permutation leads to a question about integrating the diagram in a more computational approach, as flexible media can be reshaped again and again, filling the gap between a more static analysis and a more technological and dynamic way of conceiving the project.

The experiment conducted in this research, conceived in a more institutional framework of a PhD dissertation, stresses the computational part to prompt a reflection on how we look at the city and the methods we use to analyse and design it. The aim is to promote a design that puts the process of reiteration between design and analysis back at the centre by making it explicit and comprehensible so that we can intervene at any time with changes and new requirements.

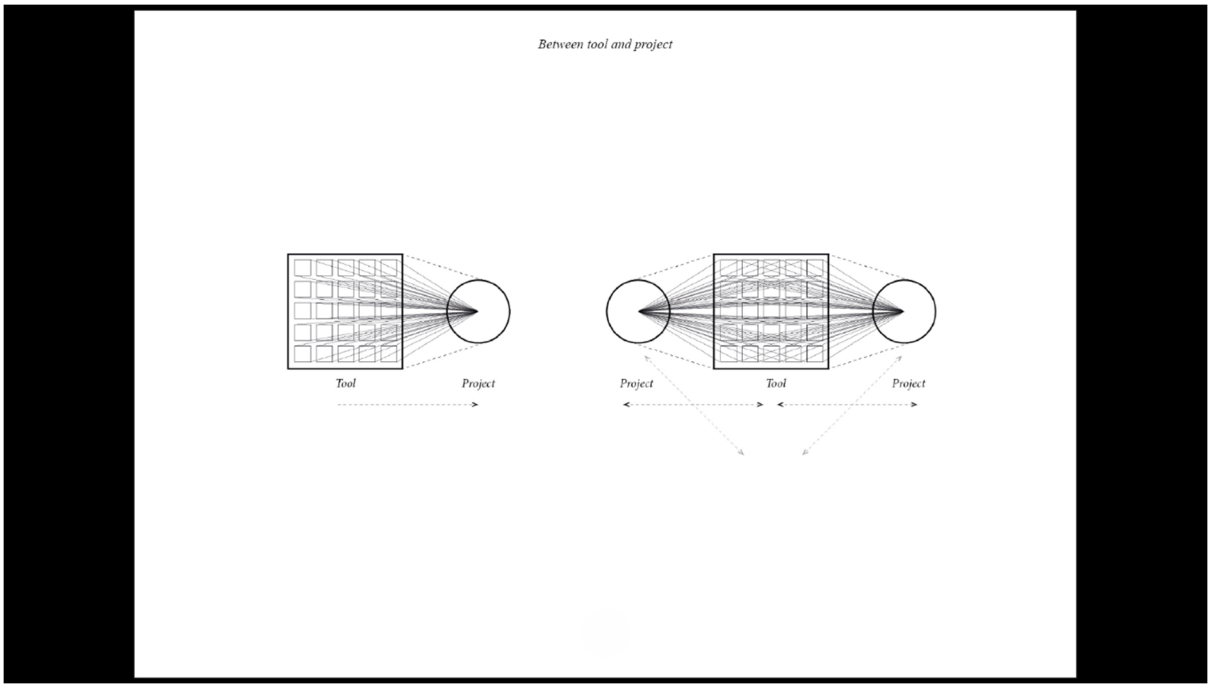

Figure 6. Tool between analysis and design. Photo credit: Author 2024.

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Regional morphological design. Transitional pedagogies for new urban questions and scales

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ABSTRACT

New pedagogical paradigms, combining research with education has over the last 10 years gained significant ground in the field of urban morphology (Oliveira and Liu; 2022). As extensions to the various analytical approaches, set in place by the historic schools of thought, new perspectives that tailor qualitative and quantitative data sets with design research have begun to emerge. Moreover, with the increasing awareness of regional and territorial questions (natural systems, bio-physical systems, and transitional habitational processes) coupled with increasing agglomeration of urban landscapes into new regional scales, there appears to be less dependency on established discourses as architecture, geography and town planning, and a greater need to strategize the development of regions and territories through new morphological lenses.

This paper explores the innovative application of urban morphology in tailoring 'regional morphological design' as a novel educational medium. The paper argues that urban morphology can be tailored to the regional design scale, creating urban territories that both reflect and enhance the unique characteristics of their spatial, geographical, cultural, and social contexts. The paper will present case studies and empirical data through studio work spanning 5 years in support of the regional morphology design arguments, contributing to the growing body of research on the applications of urban morphology.

The paper concludes with recommendations for integrating urban morphology into regional design practices and educational curricula, outlining the key questions and steps required for a regional morphological pedagogy, and its valance to conventional scales, urban elements, and analysis.

Keywords: Regional Morphological Design, Morphological Pedagogies, Transitional Design, Design-research

INTRODUCTION

Historical Context of Urban Morphology

The field of urban morphology has historically concentrated on examining the physical attributes and arrangement of urban areas (Moudon, 1997; Levy, 1999; Conzen, 2004).

Each of the three main morphological schools and their pedagogical streams (British, French, Italian) have had a significant impact on the analysis and conceptual development of new spatial concepts. As streams of thought, these schools have influenced the positioning of analytical takes as well as the delineation of spatial methods in relation to spatial patterns and their connections to typologies, developmental patterns, or societal relevance.

As well known, the British school, associated with M.R.G. Conzen, emphasizes the analysis of town plans, building forms, and land use patterns, through historical spatial patterns. This systematic approach focuses on the physical structure of urban areas. In education, it promotes a rigorous analytical framework, teaching students to dissect urban areas into constituent parts. The 'Conzenian' curriculum includes fieldwork, mapping exercises, and GIS technology to analyze urban patterns. The goal is to equip students with skills to critically assess urban environments and contribute to urban planning and design (Conzen, 1960). This school is known for its scientific methodology and detailed urban landscape studies.

The Italian school focuses on typology and architectural elements of urban forms, emphasizing building types and their evolutionary processes (Oliveira & Liu, 2022). Scholars like Saverio Muratori and Gianfranco Caniggia have been influential, bulding on the work of Muratori. This approach involves examining architectural styles and socio-cultural factors in urban development. While conventional methods have yielded useful knowledge about urban design, the Muratorian scope is generally limited to smaller dimensions, such as individual buildings or communities. In education, the Italian school encourages an architectural perspective, teaching students to analyze typological and morphological characteristics. The curriculum includes architectural history, design theory, and urban analysis, fostering appreciation for aesthetic and functional urban aspects. Students learn the interplay between architecture and urbanism, preparing for roles in urban design and heritage conservation (Muratori, 1960; Caniggia & Maffei, 1979).

The French school delineates the historical and geographical evolution of urban forms, focusing on how past events shape current urban layouts. This approach involves detailed cartographic analysis and historical documentation. Key figures like Pierre Merlin and Françoise Choay have contributed to this field. In education, the French school promotes a multidisciplinary approach, integrating history, geography, and urban planning. Students analyze historical maps and documents to understand urban development layers. The educational focus is on understanding historical contexts and their impact on modern urban forms, fostering a comprehensive view of urban evolution (Merlin & Choay, 2000).

While these schools were prominent during their respective eras, the validity of their approaches and their relevance to the current developmental challenges are still being questioned in two distinct lines of enquiry; (a) applicability to new urbanization trends and (b) teaching methodologies. As Oliveira and Liu (op.cit) highlights, the last decade has shown a notable increase in the use of innovative

teaching methods that integrate research and education in the study of urban morphology. For example, the influence of quantitative methodologies in the development of the discourse, proving fertile ground for the germination of computational and data-heavy methodologies such as Space Syntax and later variations of geospatial approaches.

From an educational standpoint, the new scalar structure and developmental challenges require new educational tools that are linked to the study of urban form as a scientific discipline. Considering Oliveira's (2018) summary on morphological education, we problematise morphology and pedagogy through four lenses. First, the dependency on Western and Eurocentric precedents lacks a wider perspective on global streams and developmental trends. Second, and especially for our purposes here, traditional scale orders lock down with the introduction of new scale variations that influence morphological concepts. And thirdly, the potential impact of morphological pedagogies linked to the continued historical reflection of urban form misses potentials for transforming morphological inquiry from an analytic to a projective discourse. And finally, how to harness pedagogies to effectively teach the interconnection between these three aforementioned outliers to sustain the future of the discourse?

In the wider spectrum, new educational paradigms are emergent. Some streams are making efforts to integrate both qualitative and quantitative data, allowing for a more comprehensive comparison of both spatial qualities and the factors that influence their change. Here we think of questions concerning climate, heritage development, and super-tall, super-vertical living. These paradigms enhance conventional analytical methods by integrating qualitative and quantitative datasets with design studies and design analysis. This combination facilitates a more thorough comprehension of urban structure and its consequences for present-day urban challenges. Qualitative data, such as interviews and field observations, can offer valuable insights into the social and cultural aspects of urban spaces. On the other hand, quantitative data, such as surveys and empirical measurements, can provide objective measurements of the physical characteristics of urban areas. The use of data and computational approaches, such as Big Urban data (Boeing, 2021), Smart City data (Marcus, 2017), and Agent Based Modelling, presents challenges to pedagogies in terms of approach, tools, and the integration of such.

Furthermore, the emergence of concepts like as urban compaction (Endemann, 2024) and regionalisation (Yang, et al, 2022) is placing significant demands on the development of other more morphological pedagogies (Trisciuoglio, 2024), due to the new and emergent qualities of the built landscape.

This paper addresses the challenges presented by the outline of giga and biophysical systems and the specifics of a pedagogical in the domain of urban morphology. The paper first discusses the challenges posed by the biophysical and scale complexities of giga areas as a morphological concern. Utilising the results of a master's level morphological studio, this study presents the combined results of a regional morphological approach that took place over a period of 4 years. The study provides ideas for incorporating urban morphology into regional design processes and educational curricula. It outlines the essential issues and actions needed for a regional morphological pedagogy, and highlights its relevance to conventional scales, urban features, and analysis.

Regional and territorial questions within pedagodgy

"Form no longer exclusively follows function, but now has its own capacity, its own power, its own value. Within certain limits, urban architectural form and urban space open up new possibilities for use and thus make various new programs scenarios possible" (Rosenmann, 2002: 44).

The increasing awareness of regional and territorial questions has led to a shift in focus from established discourses in architecture, geography, and town planning (Rosenmann, 2002; Meijer, 2004). Transitional habitational processes (Heckmann, 2022), such as globalisation processes influencing urbanization (Hu, 2015), United Nation's Sustainable Goals and other 'wicked urban questions' (Göransdotter, 2021), significantly impacts questions related to urban development and therefore, urban form. Conversely, natural systems, climate and topography such as rivers and forests, play a crucial role in shaping new urban strategies associated with bio-physical systems (Galaz) and their formal expression.

Rosenmann (op cit) argues that as urban areas continue to grow, merge or expand into larger regions, is an increasing need to plan the development of these regions using innovative spatial concepts. This approach aims to highlight regional morphological characteristics beyond just functional performance. Rosenmann's statement proposes directing the study of morphology towards new enquiries about scale, including regional clusters and geopolitical alignment to gradually integrate metropolitan areas, sections, and surrounding regions into a unified metropolis.

From our perspective, 'regional morphological design' (RMD) is a developing discipline that customises urban morphology to the scale of regional design and scales of planning. This method seeks to establish urban areas that accurately represent and improve upon the distinctive attributes of their spatial, geographical, cultural, social surroundings and equally the experiential qualities of regions. An instance of a RMD approach would take into account the natural and bio-physical systems of a specific area, together with its cultural and social settings, in order to create urban spaces that are both functional productive, even if they remain visually incoherent .

The urban agglomeration of the Greater Bay Area, China (GBA), includes 11 cities: Guangzhou, Forshan, Zongshan Bao'an, Dongguan, Zhuhai, Shenzhen, Hong Kong, Macau, Jiangmen, and Huizhou. These cities have a combined official urban population of more than 86 million (ref). The Greater Bay Area (GBA) comprises two Special Administrative Regions (S.A.R.) - Hong Kong and Macau, which are known for being global financial and casino centres respectively. It also includes two Special Economic Zones (S.E.Z.) - Shenzhen and Zhuhai, with Shenzhen being one of the largest migrant cities. Additionally, the GBA has three significant logistics centres, three international airports, and several ex-urban or former village areas such as Longgang, Shunde, and Nansha. The region exhibits a large diversity of spatial conditions and varying levels of uneven spatial development, all within an area of 56,000km2.

The integration of this global-scale megalopolis or mega-region agglomeration presents geographical and structural complexities. For example, the combination of infrastructure, logistics, and replication at a geographical level, such as the duplication of cargo handling facilities, or rivalry between cities in the Greater Bay Area (GBA), or the competitiveness for logistical preference.

The mega-region agglomeration phenomena present a knowledge gap. First, the extension of the morphological lens from a regional scale to the sub-national scale in morphological research has had limited examination with minimal data to challenge the morphological provenance at the sub-national level (cf. de Jong & Rosenmann, 2002: 37). Second, critical for our purpose here, from an educational standpoint, the limited capacities in address the new scalar structure and developmental challenges beyond the isolated regional view requires other educational tools specific to the study of urban form as a scientific discipline. It remains essential to requestion the absence of scalar thinking and the possible influence this has on morphological teaching methods. This includes further development of spatial attributes and the conceptualisation of future urban areas as expressions of scale. With all educational concerns and scales covered through the educational lens, the lack of other scales and strategies indicates a potential for scale development through both the units of morphological expression as well as its approach to developing new mega scale propositions.

RMD METHOD

The Regional Morphological Design (RMD) approach utilises the theoretical and conceptual frameworks to understand the megaregional situation and its manifestation in the GBA. We use the technique of speculative gameboarding as a pedagogical and scaling tool. Since 2018, this technique underwent testing in 12 studios, leading to the completion of over 60 group projects, including the involvement of more than 300 students.

Gameboarding is the foundational process for creating scenarios and is used as a tool in spatial planning and design research. In addition, gameboarding is based on the concept of scenario testing and proposition formulation in the area of spatial planning, specifically on a large-scale region known as the GBA (Bruyns, et al.). This is achieved by using gameboard concepts and procedures. The work presented challenges the use of strategic planning as a speculative tool to implement formal strategies at regional and territorial levels, including environmental systems and their large-scale regions, while also being grounded in the study of form and structure.

Speculative gameboarding is used in RMD design studios in a distinctive manner, which is influenced by three fundamental variables.

At first, the students only used tangible elements like as paper, cardboard, pins, stickers, and threats to depict their spatial plans on a physical gameboard, which consisted of a printed map of the GBA. The use of text and descriptive labelling is minimised, with digital technologies such as CAD and GIS only serving as spatial validators in the final stages of the strategic process.

Second, students are allocated morphological themes that focus on distinct geometric shapes, such as points, lines, rings, or crosses, as spatial components. The interpretation of these may be either as an urbanisation process or as a actual built object, and as choice is left to the discretion of each group. Additional abstract geometric notions, in what we define as morphological qualities as edge city, strip city, or radial city, have also been explored. In harnessing a single morphological theme, students are urged to convey their regional plans in unconventional ways and to cultivate morphological propositions in a more innovative manner.

Third, students are urged to construct their gameboard scenario’s in rapid succession. The purpose is not to meticulously create accurate strategic spatial representations of the megaregion, but to swiftly

develop spatial ideas through experimental steps on the gameboard. Students are restricted to a maximum of two days per development cycle, depending on the studio size and group compositions. Other studio's lasting one to two weeks, inspire students to create a new gameboard in only a few hours. The creation of "game conditions" facilitates the direction of the morphological concept, establishing leading tools for experimenting with various spatial situations.

Finally, students have the option to construct gameboards by assuming the roles of various stakeholders. This may cover the position of residents, farmers, historians, developers, ecologists, or infrastructure experts to help further determine aspects as land use, residential qualities, ecological and agricultural emphasis or, how to integrate infrastructure with historical areas or which land uses would be preferred by the residents of a certain location. This includes the definition of priority hierarchies, earmarking which functions would urban planners give the most priority to, or what types of density would be most preferable for real estate developer.

The objective of regional morphological design is to capture and convey the spatial attributes of the region through an 8 layer variable:

1. Building typologies: differentiation between different densities, heights, mix of functions, and street patterns.
2. Land-Use (built-up areas): functions typically related to areas, such as residential, industrial, commercial values.
3. Land-Use (non-built-up areas): functions found in areas with pervious surface, such as agriculture, forest, and other natural features.
4. Water: different features and hierarchies of the water itself as well as water related infrastructure; e.g. fresh and saltwater.
5. Transport/ Mobility: anything related to human movement; roads, rails and other functional units.
6. Administration: hierarchy of administrative boundaries and special zones; province, city, district, and villages.
7. Existing Plans: collection of administered plans to be implemented in the future; master plans, development plans, expansion plans; to be collected on different scales, not only for a city.
8. People: features that describe characteristics of residents, workers, visitors, etc. of a specific area; demographics, ethnicity, income, migration.

RMD's morphological evolution also considers several spatial features linked to emerging urbanisation principles. These themes have a significant impact on the present process of urbanisation, contributing to the development of increased variety within a group's physical layout or structure. For instance, these values encompass:

1. Commoning: A land-use paradigm that emphasizes the shared use of resources, making them public, sharing economy.

2. Self-Sufficiency: striving for a state in which a territory has the capacity to be largely independent from external production, electrical power, or food production.

3. Compaction: A development model that focuses on the intensification of built environments, multi-functionality, and transit-oriented development.

4. Shrinkage: The unconventional idea to reverse current development trends and focus on the parts of a territory that may be suitable to shrinking.

5. Informality: strengthening of systems that emerge beyond regulated administrative processes and planned spatial development, urban infill and urban villages.

6. Circularity: spatial patterns that encourage circular flows of resources, initiated by shared knowledge on innovative socio-economic practices.

During the process of developing spatial propositioning, ambiguous spatial values are transformed into specific morphological interventions. This transformation is guided by fundamental concerns that revolve around the processes of concentration, clustering, densification, and intensification at a morphological level, by questioning: Can the existing method of urbanisation in the GBA, which is mostly focused on constructing super dense and super tall buildings, adequately address the diverse range of demands that are shaped by societal values?

The last stage of the RMD involves integrating the strategies, taking into account their individual strengths and weaknesses across scales and forms of expression. In order to accelerate the process of spatially resolving these issues, the groups analyse the morphological characteristics of specific nodes. Each node is enlarged and further developed through the 1:200,000 scale of the GBA map. Nodal testing and integration facilitate the advancement of game boarding development by examining the proposition's connections to values and stakeholders' perspectives. This procedure is iterated at the 1:50,000 and 1:200 scales in order to elucidate the structural attributes and dimensions of the GBA, with a specific emphasis on unique conditions, as well as the integration at both higher and lower scales within the GBA.



Figure 1: Regional Morphological Design in a studio setting. Photo credit: authors, 2024.

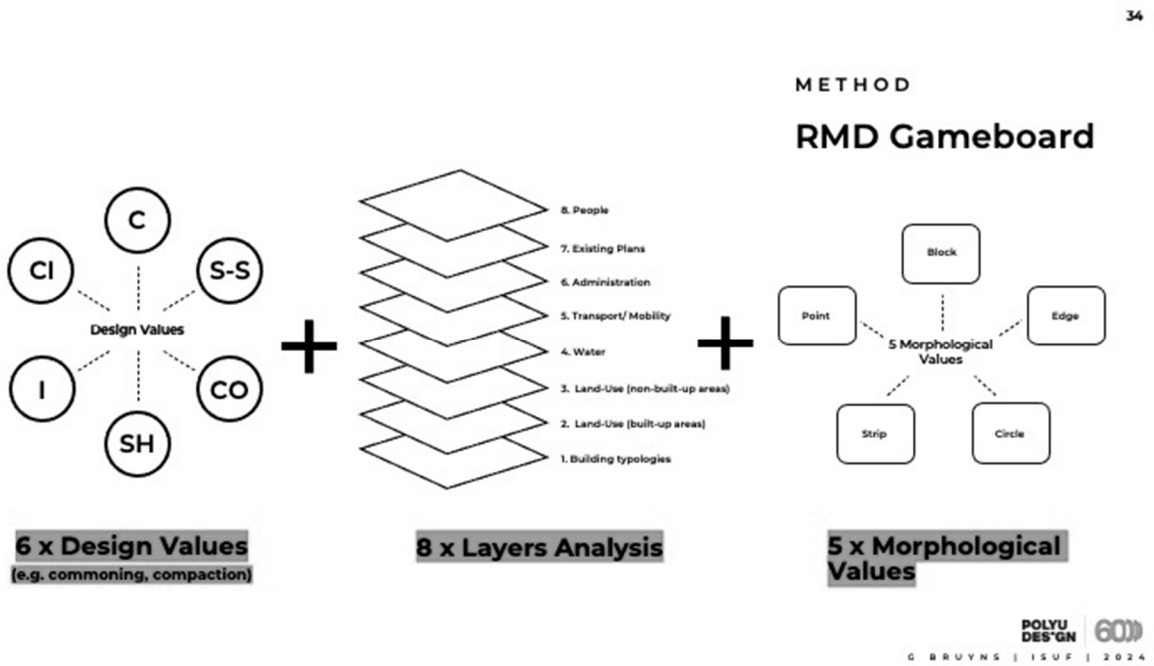

Figure 2: Regional Morphological Design's diagrammatic structure, expressed as Spatial Values, Urban Layers and Morphological Values. Photo credit: authors, 2024.

RMD RESULTS AND DISCUSSIONS

The results obtained from the RMD research and its more than 60 scenarios have important consequences for the area of urban morphology, both in terms of the development of its discourse and its chosen educational methodologies.

1. The RMD serves as a foundation for discussing the wider consequences of the morphological findings obtained from the extensive testing of the speculative gameboarding technique, including both successful and unsuccessful implementations.

2. The success may be attributed to the variety of new morphological frameworks, as shown by the more than 60 proposal and its detailed resolution, which has produced a varied and comprehensive body of work on urban form that was previously deemed impossible.

3. The RMD as a body of design-research, indicates that conventional analytical methods must be modified to tackle current urban concerns, especially those pertaining to regional and territorial issues, beyond simple functional arrangement, typological composition, or social density. The inclusion of spatial considerations in morphological thinking has the potential to provide fresh perspectives on the development of both a field of study and the pedagogical approaches used in regional questions, and even possibly, links to other domains of study, as for example, environmental ecology.

4. In addition, customising urban morphology to the distinctive attributes of each region amplifies regional uniqueness, which was previously deemed unattainable owing to the large scale of governing systems in these locations. Normative scale limits associated with the block, plot, building, neighbourhood or region have in the RMD pedagogy, become inclusive of the sub-national and regional scales as part and parcel of morphological inquiry, supporting new scales for formal and configurative enquiry (cf. Bruyns, et al, ISUF, 2024)

5. Correlations between strategic aspirations and spatial patterns are crucial for understanding how urban morphology develops, serving as both an analytical framework and a teaching tool. The RMD results indicate that combining qualitative and quantitative data sets with design research may provide another layer in the comprehensive knowledge of urban form, and in our view attributed to the inclusion of the regional or sub-national levels of developing urban morphology. level. This approach also helps identify the issues that formal spatial characteristics would encounter due to emerging urbanisation patterns, spatial and environmental characteristics, or the significance and impact of resilience of cities as a formal reaction in the built reality.

6. Another advantage for the RMD technique is its emphasis, equally to the complexity of local conditions and their impact on regional systems and identities, on the relevance of various spatial configurations, typologies, and patterns in planning. The local scale in the RMD is nevertheless as crucial for perceived misunderstanding in which sub-national and regional scales replace local distinctiveness in favour of just regional concepts and methods. The RMD technique provides an advantage by emphasising the importance of various spatial arrangements, typologies, and patterns in planning, while also, in parallel, considering the particular local circumstances and their impact on regional systems and identities.

7. The RMD technique provides an advantage by emphasising the importance of various spatial arrangements, typologies, and patterns in planning, while also, in parallel, considering the particular local circumstances and their impact on regional systems and identities. The local scale in the RMD method is therefore crucial, in contradiction to what one would expect of regional scale strategies. The value of the local in the RMD strategic thinking scheme clarifies

scalar misinterpretation, taking into account the specificities of the local context, rather than prioritising regional ideas and methods at the expense of local distinctiveness. Local scale in the RMD curriculum is therefore a key resolver of embedding morphological specifics to contextual questions.

8. The limitations of the RMD method emphasise that the inclusion of urban morphology as part and parcel of design curriculum may need modifying several traditional features of educational delivery and the use of morphological/spatial data. From what we have observed, the willingness of students to include new data or adapt to new ways of strategic experimentation encourages further explorations.

9. Finally, the challenges presented by the RMD approach is only valid with the continuous renewal of design iterations, on an annual basis. The importance of maintaining the explorations of regional form becomes static and one dimensional if no comparison to other options, variations, or iterations are possible.

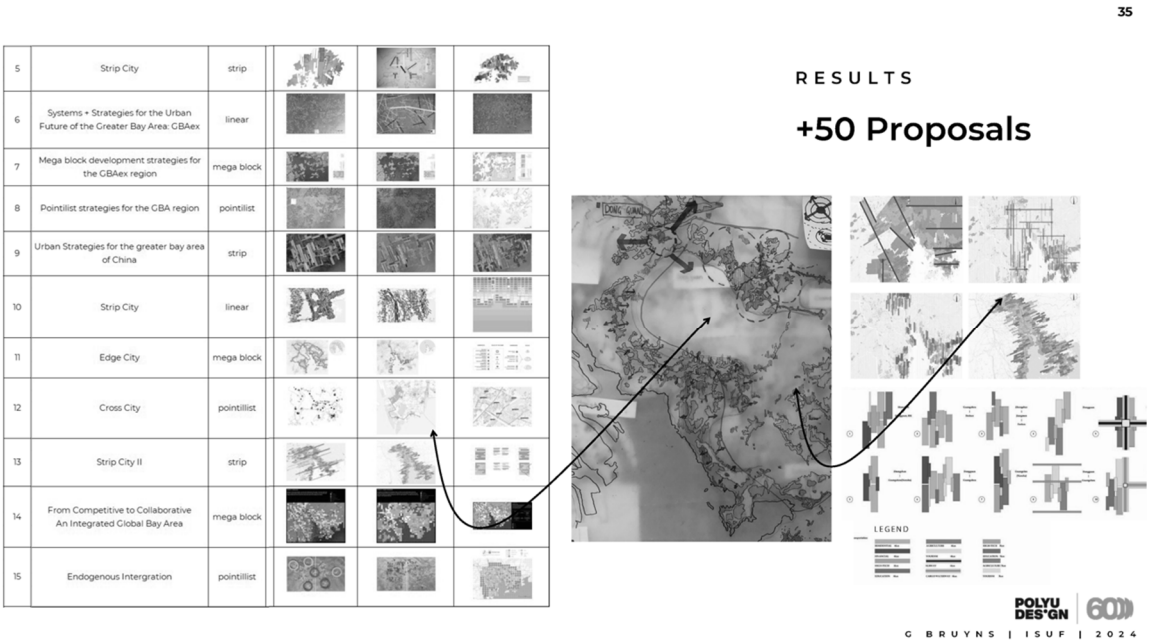

Figure 3: Regional Morphological Design translations processes. Individual proposal are iterated and developed in scalar levels for further contextual testing. Photo credit: Students - The School of Design, POLYU, and students – Faculty of Architecture, TU Delft, 2024.

CONCLUSIONS

This research explores 'regional morphological design' as an innovative instructional tool in urban morphology. By adapting urban morphology to the regional design scale, urban areas can enhance and reflect the unique spatial, geographical, cultural, and social characteristics of their surroundings. This paper contributes to the growing body of research on urban morphology by presenting findings from five years of RMD studio work. As educators, we stress that speculative gameboarding should

not be directly applied to actual planning processes. Current urban development methods often overlook their negative impacts on environmental sustainability and social justice.

To effectively respond to the ongoing transformation of urban environments in the GBA and globally, it is essential for students, practitioners, and academics to adopt techniques that match the scale of megadevelopments. A key finding is that this approach to game development, particularly in morphology, relies more on strategic thinking than solely on data or additional factors. Design elements are integrated indirectly, highlighting valance with other fields of spatial inquiry such as engineering and data metrics. While beneficial to an extent, this approach has limitations when considering the future of urban landscapes on a larger scale, for example, the iterative guidance required and the consistent cross comparison between iterative steps. Still, despite such challenges, the integration of RMD into morphological sciences can offer significant advantages by envisioning new variations in the spatial qualities and characteristics of diverse places, as those outlined by the GBA territory.

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Streets of Goiânia: a cartography of (its) experiential heterotopias

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ABSTRACT

Based on the premise that public spaces can, under certain circumstances, take on the form of heterotopias, as approached by Michel Foucault (2013), this article proposes an analysis of the modes of appropriation of a common place, a street in downtown Goiania. The starting point is the question: How do street appropriations, in their various socio-spatial everyday configurations, evidence, reflect, and influence the emergence of experiential heterotopias? The attentive observation of a Parisian location, conducted by Georges Perec (2016), inspired our (sequential) participant observation of “Goianiense” public spaces. The text explains how everyday situations could articulate experiences and ambiences on the streets of downtown Goiania, through a cartography of heterotopias in the square of Rua Oito, in front of Octo Marques Gallery, located in the Parthenon Building, downtown Goiania. As part of a more complex research, that aims to understand patterns of sociability that could have an effect in the production of urban commons in public spaces of Goiania, we present analyses and reflections on the ambiences that emerge in this location, stemming from the experiences and routines of the local residents, along with a study on the person-environment relationship in the alley that is part of the morphology of this location. Describing public spaces from the perspective of heterotopic spatial configurations, we advocate for urbanity-as-becoming. These analyses contribute to urban studies by providing a theoretical foundation for the concept of "experiential heterotopia," a term referring to a space appropriated by tactical uses (monitored).

The following guidelines provide instructions to format your full paper, specifically on the way how text should be formatted, table and figures captioned, and references cited. The conference proceedings will be published in an electronic format. The paper should be submitted in a Word document (.doc or .docx) and shall be written in accordance with instructions of Urban Morphology Paper Submission Guidelines.

Keywords: experiential heterotopia, experience, street identity, urban intensity

INTRODUCTION: PLACE, NAME, AND TRANSFORMATION

Based on the premise that public spaces can, under certain circumstances, take the form of what Foucault (1967) suggested as heterotopias, this article aims to analyse the ways in which people appropriate a singular place in the centre of Goiania. We will observe, thoroughly, repetitive and banal events in Felicíssimo do Espírito Santo Square, popularly known as Gari’s Square, questioning the role

of street life, in their most diverse everyday socio-spatial configurations, and searching for experiential heterotopias. The question could be as follows: How do people (which we could call pedestrians, citizens, humans, and bodies that matter) can articulate modes of existence open to the otherness in the streets to resist the process of (de)memorization of public spaces promoted by public policies?

Gari's Square is located in the alley between the fourth and seventh street, in the Goiania Downtown, as we can see in the first drawings by Attilio Corrêa Lima, who designed various configurations of alleys for the city. It can therefore be deduced that its form is linked to the construction of Goiânia, in 1933. The official place name is in honour of the Brazilian military officer and politician Felicíssimo do Espírito Santo Cardoso (1835-1905). For many years the place remained abandoned and lacked urban design improvements. Some sources inform that before the Parthenon Building was built, a public market was in the same block (1940-1970). After that, it was moved to the third street, seven blocks away. Since the changes, the remaining plot is used for minor service activities. Its 'oblivion' is understandable. Despite this, many people use the place as a daily route, and the presence of the Otto Marques gallery may also have contributed to the place receiving more attention from society. As there was a requalification of the public space, a general refurbishment was carried out, with new accessible pavements, street lighting, benches, rubbish bins and flowerbeds.

Gari's Square is one of the smallest public places in a city that was planned to be monumental, with wide streets and many open spaces. It articulates very heterogeneous uses and functions but remains invisible to most of the Goiania population. Its official name is "Felicissimo do Espirito Santo", but it's best known as Gari's Square in homage to the trash collector who's author of the sculpture in that place. Some urban objects stand out in the landscape of the Gari's Square, a small piece of urban land (a rectangle measuring approximately (20x30)m), which allow us to identify the relationships that define the ethical/aesthetic regimes of experiential heterotopias: the Octo Marques Gallery; the (huge) (exaggerated) Parthenon Building; the abandoned grocery store; the streets surrounding the boundaries of the square; the snack bar; the second-hand clothing store; the shop selling plants, miscellaneous items, and household goods; the parking lot; the small office building; the clothing store; and the beauty products store. The photos show all these objects/buildings, their respective constituent elements, and the unusual relationship among them, as well. One of the highlights of the new square is the work of art 'The Samaritan', a sculpture created by Onildes Alves dos Santos, a garbage collector, in celebration of the city's 86th anniversary. As well as the sculpture, the square also received a water fountain surrounding the sculpture to emphasise the art even more. Today, the place is mainly maintained by volunteers of the surrounding shops, since the fountain no longer works. Something that stands out is the care taken by the neighbourhood regarding the square's vegetation, which has a strong presence in the landscape.

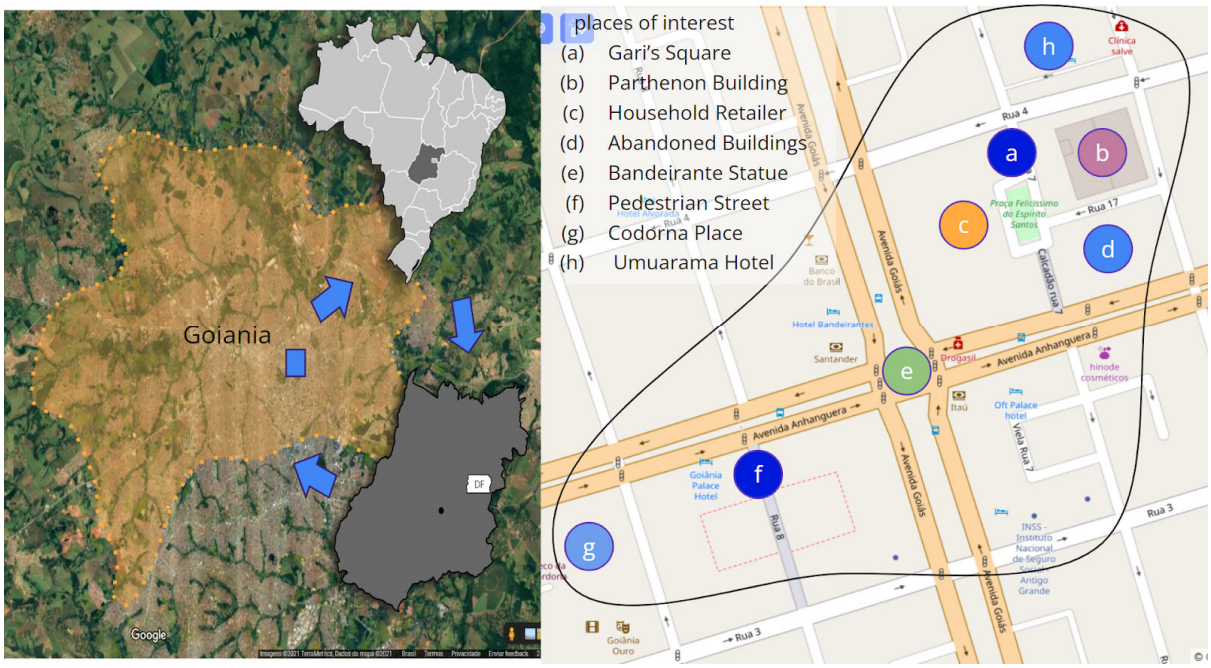


Figure 1. Figure 1: Location of Gari's Square, in Goiania Downtown, image credit: authors, 2024.

Contemporaries perspectives of heterotopia

"Of Other Spaces" (Des espaces autres), also commonly known as "Heterotopia", was initially a lecture carried by Michel Foucault to a group of architects in 1967. Emplacement means, according to Foucault, that relations between locations in space are the constitutive principle of space perception. We will therefore describe the streets as: a) deviant trajectories (deviation, crisis, instability: alleys are places of deviation / alleys located crises / alleys make transient cuts in space-time); b) mnemonic labyrinths (dysfunctional / hyper-functional / dysfunctional: alleys are organized according to sovereign agency / alleys induce power relations that result in confusing uses and functions); c) resonant rhizomes (juxtaposition / superimposition: on the (geographical) borders of alleys there is the juxtaposition of various microcosms (social, cultural, ethnic, political) / only relational topologies could describe the juxtaposition of these microcosms); d) rhythmic fragments (anachronistic situations: alleys allow the occupation of space in divergent temporalities / alleys induce incompatible rhythms of appropriation of everyday life); e) liminal places (disjunctive practices of exception: the existence of alleys presupposes a system of (implicit or explicit) border control); and finally, f) invented landscapes (synecdoche (or the part for the whole) (from the singular to the universal): through insurgent (surrealist) practices alleys associate utopias and dystopias that present themselves as generic landscapes or displaced landscapes). These analyses contribute to urban studies by offering a theoretical basis for the concept of 'experiential heterotopia', a term that refers to a space that is appropriated by tactical uses of (guarded) places.

From Foucault (2013), we learn that heterotopies are more than places or physical elements allocated in the real world. As an urban condition with "dissociative identity disorder", heterotopies are places where events play a crucial role in the complex web of everyday life interactions and situations, reenacting multiple aspects of cities' common spaces. Moreover, we can understand its six spheres of socio-spatial coherence as ways of relating to those heterotopies in the sensible forms of the city.

Thus, we adapted it to describe Felicíssimo do Espírito Santo Square or Gari's Place, located in Goiania Downtown. Following Foucault (2013), we tried an approach that pushed his ephemeral spatial turn beyond abstractions. Through the concepts of deviance, memory, resonance, rhythm, threshold, and illusion, we could, even tentatively, describe "place" as an (assemblage) of contradictory, heteroclite, and mostly disconnected, urban conditions. The relational spaces that emerge from this (material and immaterial) assemblage could be seen as interlaced dispositions (or social dispositives) as follows: a) deviant trajectories; b) mnemonic labyrinths; c) resonant rhizomes; d) rhythmic fragments; e) liminal places; and finally, f) invented landscapes.

A bibliographical review of Michel Foucault's concept of heterotopia can include a variety of authors who have commented on, expanded or criticized his ideas. Such authors include the works of Agamben (2010), Bachelard (2008), Edward Soja (1989), Kevin Hetherington (1997), Peter Johnson (2006, 2013), Michel de Certeau (1998), Henri Lefebvre (1991), Martins (2003), and Marc Augé (2009). Soja is an urban geographer known for his work in human geography and urban planning. He has deepened Foucault's concept of heterotopia in his own work, especially in his idea of 'Third Space'. Hetherington is a sociologist who has written extensively on spaces of identity and difference, including a critical analysis of the concept of heterotopia. Johnson is a geographer who has explored the concept of heterotopia in relation to geographical and cultural spaces, contributing to the theoretical and applied understanding of the term. An Italian philosopher known for his work on the state of exception, Agamben also discusses the concept of heterotopias, often in relation to his own concept of 'spaces of exception'. Although Certeau did not comment directly on Foucault's heterotopia, his work in 'The Invention of Everyday Life' offers perspectives that complement and contrast with Foucault's ideas, particularly in relation to the use and appropriation of urban spaces. Known for his work on the phenomenology of space, Bachelard offers a perspective that can be useful for understanding the concept of heterotopia, especially in his work 'The Poetics of Space'. His ideas on the production of space and everyday life in cities offer a critical basis for exploring and contrasting with Foucault's notions of heterotopia. Known for his concept of 'non-places', Augé offers a vision that can be seen in dialogue with Foucault's heterotopias, especially in relation to modern spaces of anonymity and transience.

An intriguing case for another account of heterotopia, less influential (and controversial) than the Foucauldian one, is made by Lefebvre (1991). It's important to be informed that the concept of heterotopia developed by Foucault (2013) differs radically from that of Lefebvre (1991): it delineates, potentially, liminal social spaces where some "differential condition" is not only possible, but fundamental for the definition of "revolutionary trajectories" (Santos Junior, 2014; Butler, 2012; and Purcell, 2002). In The Urban Revolution he outlines, dialectically, the recent history of urbanization and sustained his first critique of urban society, in which urban space is not defined in terms of industrial rationality, but as a dialectical process of contrasts, oppositions, juxtapositions, and tensions: a growing 'differential reality', with a potential for unstable transformation. Lefebvre (1991) searches for a paradoxical space, in which actual and virtual (presence and absence), characteristics of urban spaces, should be dialectically juxtaposed. He identifies and analyses three possibilities for this spatial approach: a) identical spaces – isotopies (spaces that can be compared, quantified, mapped, spaces of order, rational, contained spaces; b) non-places, or utopias, theoretically defined as spaces of consciousness, imagined spaces, ephemeral places of joy and contemplation; and c) other places, understood as heterotopies, spaces of difference, ambiguous, both excluded and interwoven,

as the (liminal) landscapes of the margins of nascent cities. It is the last that has transcendent possibilities, a virtuality already present that will absorb and overcome the other two topoi.

More recently, Alatalo et al. (2024), Zhu (2024), Sacco et al. (2019), and Stavrides (2007), offers new insights into the meaning of heterotopia as a lens through which the unstable conditions of urban environments could be understood.

Identity and intensity as dispositions for urbanity

Extensive and intensive spaces, actual and virtual spaces. DeLanda (2005) asserts that we experience artificial and natural environments, in the most varied situations and material conditions, according to two phenomenological paradigms, one of which is mediated by extensive attributes (zones of extension), while the other, less known, articulates intensive attributes (zones of intensity). The reflection on the distinction between these two paradigms remains at the level of philosophical abstraction, despite its relevance in the constitution of subjectivities. What is extensive differs from what is intensive as attributes related to quantities (additive and divisible) differ from those related to magnitudes (non-additive and indivisible). The knowledge of the dimensions of a given environment (perimeter, area, volume) is distinct from the average temperature in various zones of this environment. If the environment presents an isothermal tendency, dividing its area in half would not alter this tendency, preserving the same thermal magnitude as the previous, larger environment. For Deleuze (1994), in order to produce changes in intensive attributes, there must be a “difference” in the intensity gradient of matter, which is not produced by the mere addition of more of the same material (repetition), but rather a critical change in environmental conditions.

DeLanda (2005), in presenting a philosophical formula according to which differences of intensity are productive because they virtually result in bundles (sets) of unstable multiplicities, does not ignore the role of extensive differences in the (continuous) actualisation of the becoming of spatial structures. The distinction between the diversity of a world given to perception and that which is at the origin of this perceptual phenomenon by means of the concept of difference is a key element in Deleuze's (1994) ‘realist’ ontology and implies a certain essentialism in order to understand the production of ‘extensities’ (extensions) by intensities, of what is extensive by what is intense, of phenomenological attributes by the attributes of the world itself (nuomena, nuomenon). In other words, in certain conditions of instability, material or immaterial, of the constitutive elements (constituents) of (anthropized) environments, differences in the zones of critical intensity can lead to the emergence of extensities, extensive environmental conditions, whose spatial matrices follow criteria, or parameters, defined by non-metric qualities (projective, differential, topological), gradations, nuances, rhythms, intensities, among other magnitudes (of immanence). The differential spaces resulting from the interweaving of intensive and extensive parameters show flows rather than fixed flows, force fields that articulate (Brownian) movements measured in a non-metric way, resulting in a form of multiplicity, intrinsically defined, without being subject to external geographical references. If the sensible world consists of topological spaces that generate (construct) biological, physical, chemical and social processes, inhabited by extensive spaces, there is the possibility of mediations through restrictions of immanence.

METHOD: PEREC, FOUCAULT AND DELANDA

The paper adapts three methods for discovering smallness in public spaces. Firstly, we translated the way of seeing the street of Georges Perec (2016), a French writer who tried to understand the reality of smallness in the streets of Paris, to our context in Goiania. In his book, he describes the transit of people, animals, objects and interactions that take place during the period of his observation, in order to generate a reflection on the emergence and formation of the ambience of the place. The observations made by him in Saint-Sulpice Place in Paris, allows for an in-depth and contextualised analysis of the dynamics of sociability in public space, which was adapted to the Brazilian context. Therefore, in the many visits we carried out at the 'Gari's Square', we observed different everyday life situations. The operation was quite simple. The researcher chooses a spot and stays for around 15 minutes, carefully observing what happens, which singular event could develop in that timelapse. A list of interactions among humans, no-humans and objects, should be recorded in a fieldwork notebook. Everything you think is relevant, anything that catches your eye: people passing by, working, talking or interacting in any way, animals, the weather, cars, presence, absence, among other situations.

Secondly, we conducted visual analysis of 18 photos, chosen out of hundreds, decodifying the relationship among many elements of urban space. Doing this, we reconnect the variables to get meaningful insights about patterns of spatial conflicts. Thus, based on the six dimensions defined from the interpretation of Foucault's (2013) theory on heterotopia, we developed some propositions that could act as operational tools for identifying everything that was "out of frame" in the places we choose to observe: 1) Deviance (deviant trajectories) states that every culture has its own ethic codes, every society has its own rules and constraints, its own traditions, where behaviour that doesn't fit into these pre-established terms is considered deviant from the established norm. Thus, the concept of heterotopia varies depending on the society to which it refers, and its definition is not universal. 2) Memory (mnemonic labyrinths) is related to the function given to a certain element, object or place in society. Over time, 'a society can make a heterotopia that exists and that has not ceased to exist function in a very different way' (Foucault, 2013, p.117). Therefore, heterotopias can acquire different meanings and functions in themselves without ceasing to be present. 3) The third principle - resonant rhizomes - consists of the power of the heterotopia to 'juxtapose several spaces in a single real place' (Foucault, 1967, p.118). Once again, the culture of the place can influence the juxtaposition of internal microcosms that are often not perceived by those who are not part of that particular group or social circle. Photography is a device that can illustrate this principle, since the same place can take on different configurations, resulting in an invisible juxtaposition, which at a given moment no longer exists, but can be captured and witnessed by photography. 4) In the fourth principle - rhythmic fragments - heterotopias are associated with what Foucault (2013) calls 'cut-outs of time' (p.118), where there is a kind of rupture of traditional time. This 'heterochrony' can be defined both by the accumulation of elements, culminating in what would be a 'place of all times, which is itself outside of time' (p.119), as is the case with museums and libraries, which are configured as a place of accumulation and constitute heterotopias; but also by the ephemerality of everyday events, such as fairs, parties and concerts, which remain in a given place for a short period of time, giving a whole new meaning to what previously existed there. 5) The fifth principle - liminal places - is governed by a system of opening and closing where, at the same time as heterotopias are isolated, they also become penetrable. According to Foucault (2013) 'everyone can enter these heterotopic allocations, but, in truth, this is only an illusion: one believes one is entering and is, by the very fact of entering, excluded'

(p.119). Some places operate under certain social, cultural, political and economic circumstances, which exclude those who don't share them, a kind of intangible frontier that is only seen by those who 'experience' it from the inside, from a subjective perspective. 6) The sixth and final principle - invented landscapes - is related to the function or role it represents, 'the role of heterotopias is to create another space, another real space, as perfect, as meticulous, as well arranged as ours is disorganised, badly laid out and messy' (Foucault, 2013, p.120). This heterotopia of compensation arises when people want to project an image of comfort made up of the total opposite of what is undesirable. This is what shopping centres are like, unreal, invented places designed to function as objects of desire through shop windows and what cannot be achieved in real life. In general, this heterotopic principles functions as a kind of externalised desire, which can take different forms, not just that of the shopping centre, but which is based on a created and illusory space.

RESULTS AND DISCUSSIONS

In our description of public spaces from the perspective of heterotopic spatial configurations we defend urbanity-as-becoming. Even on the micro-scale of an urban block, there is the possibility of demonstrating that restricted public spaces can be constituted as "urban environments" that articulate forms of experiential heterotopias. These analyses contribute to urban studies by offering a theoretical basis for the concept of "experiential heterotopia", a view of relational space that is appropriated by tactical uses of (un)controlled places. During our observations, we spotted a curious detail: a white kombi that is always parked in the same spot in the square, in front of the Otto Marques Gallery. Apparently, no one owns the vehicle, and it seems to have been there for a long time. A quick search of the newspaper "O Popular" revealed that the Kombi has already attracted the attention of many people. In fact, it is abandoned, and its original owner has never been identified, which has transformed it into a kind of art gallery, hosting works by various graffiti artists in the centre of Goiania and becoming an interactive element in that neighbourhood.

Some urban objects of different scales stand out in the landscape of Gari's Square - a rectangle measuring approximately (20x30)m - which can inform the relationships that define the ethical/aesthetic regimes of experiential heterotopias: the Octo Marques Gallery; the Parthenon Building; the abandoned grocery store; the roads that surround the square; the boundaries of the square (); the snack kiosk; the used clothing store; the plant, variety and household utensil store; the parking lot; the (small) office building; the clothing store; the beauty products store. The photos show all these objects/buildings and their respective constituent elements. Even at the micro-scale of an urban block, we demonstrate that restricted public spaces can constitute "urban ambiences" that articulate forms of experiential heterotopias. We describe the streets as: a) deviant trajectories; b) mnemonic labyrinths; c) resonant rhizomes; d) rhythmic fragments; e) liminal places; and finally, f) invented landscapes. These analyses contribute to urban studies by providing a theoretical foundation for the concept of "experiential heterotopia," a term referring to a space appropriated by tactical uses (monitored).

Deviance. Deviant trajectories keywords: woman, green trunk, bunch of objects, parking lot, octo marques gallery, unexpected use of the street, and face mask. A woman walks in the street carrying a green trunk (cleaning container) with a bunch of objects. In the background is the entrance to the "Octo Marques" Gallery fence for protection and the concrete wall of the Parthenon Building parking lot. There is a black car parked and an empty bag next to the curb. The situation of deviation emerges

from the unexpected use of the street, as it is in the wrong direction literally, figuratively, and symbolically. The use of the face mask on her face implies another situation of deviation: the Covid-19 pandemic.

Memory. Mnemonic labyrinths keywords: Kombi, brutalist facade, loose leaf, cardboard box, abandoned, trash, utility vehicle, mnemonic mazes, and uselessness. This van, a Kombi, parked on the street for months, interacts with the "Octo Marques" Gallery and the brutalist facade of the Parthenon Building. On the sidewalk floor, a loose leaf and a cardboard box unbalance the monochromatic concrete tone of the pavement. The vehicle seems to be abandoned, with various objects piled up inside it, like trash. Its primordial function as a utility vehicle metamorphoses and reconnects us to mnemonic mazes where we could get ourselves seeing, feeling, and thinking in the surreal atmosphere of its emptiness and uselessness.

Resonance. Resonant rhizomes keywords: the deco building, beam of light, shadow, void, invisible buildings, fracture, woman, bench, and car. A view of the square from the parking lot entrance, located on the opposite corner of the "Neco Building". The standout visual element is a beam of light that occupies the centre of the image, resulting from the shadow and the void between two "invisible" buildings that pair with the other two in the right and left portions of the picture. There is a visual fracture in the landscape, through a rupture in space-time that crosses the square diagonally. Amid regions kept in shadow, a woman remains sitting on a bench in the square, next to a white car.

Rhythm. Rhythmic fragments keywords: incoherent elements, ghost, boots, clothesline, reading, cross-legged, paper, statue of a black woman, and gaze. Three apparently incoherent elements balance each other in a very peculiar situation. A "ghost" person, who's only legs and boots can be seen, washes green rugs hanging on an improvised clothesline in the street. Sitting cross-legged on a wooden bench, a man could be reading something (magazine? book? newspaper?), holding a rolled-up paper in his left hand (which means an anachronistic situation in the era of digital technologies). Finally, the statue of a black woman with wavy hair observes something over the square with its freezing gaze.

Threshold. Liminal places keywords: temporary garbage deposit, disposable packaging, bags, common trash, curb, trees, hazed landscape, and situation. The place is used as a temporary garbage deposit, as an assemblage of non-regulated, informal liminalities. Contingent use. Useless use. The disposable, the ephemeral. Disposable packaging and garbage bags accumulate next to a container with "common trash" written on it. The curb still exists under so many boxes, defining a strange threshold between the square and the street. The trees overlap the vertical elements of the Parthenon Building and, together with some parked cars, create a hazed landscape. Uncollected trash in the square becomes an occasional, transitory, and incoherent situation.

Illusion. Invented landscapes keywords: sculpture, black concrete, monument, female figures, amphoras, unreal, office building, joy, and "gods with us". The sculpture, made of black concrete, it's a kind of local monument in the square. Located in its central part, over a white base, it represents two female figures holding jugs (amphoras) pouring water on the ground. The monument has no real connection with local culture. It seems an (unreal) meaning of joy. In the background, the office building with arched windows dominates the urban landscape. The shops on the ground floor are

closed, and, in the left corner of the image, the private parking lot wall displays the message “God With Us”.



Deviance. Deviant trajectories. [woman, green trunk, bunch of objects, parking lot, octo marques gallery, unexpected use of the street, face mask]



Memory. Mnemonic labyrinths. [Kombi, brutalist facade, loose leaf, cardboard box, abandoned, trash, utility vehicle, mnemonic mazes, uselessness]



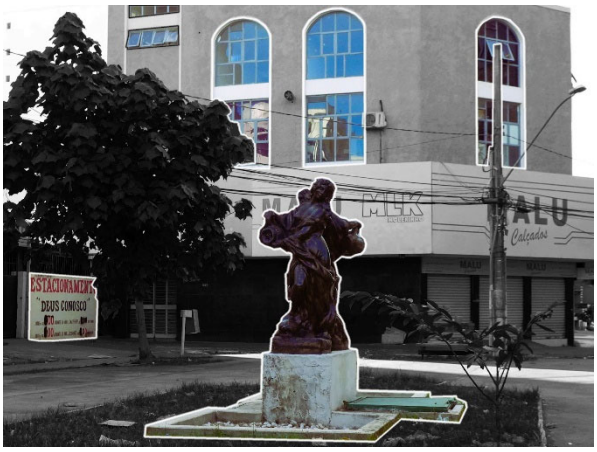
Resonance. Resonant rhizomes. [the deco building, beam of light, shadow, void, invisible buildings, fracture, woman, bench, car]



Rhythm. Rhythmic fragments. [incoherent elements, ghost, boots, clothesline, reading, cross-legged, paper, statue of a black woman, gaze]



Threshold. Liminal places. [temporary garbage deposit, disposable packaging, bags, common trash, curb, trees, hazed landscape, situation]



Illusion. Invented landscapes. [sculpture, black concrete, monument, female figures, amphoras, unreal, office building, joy, gods with us]

Thinking Liminal Spaces in Goiania Downtown

The existing literature on heterotopias usually reflects how “other spaces” can influence the dialectic of relational space in neoliberal urbanism, while articulating the political action in contested territories. The creation and arrangement of elements in the relational space is not a passive process, as it is directly related to economic forces and agents, being the object of power relations. Most of these elements can be strategically linked to institutions and their architectural forms, acting as landmarks in space and in the urban popular imagination.

The configuration of situations in the relational space is not a passive process, as it is directly related to economic actors and agency, being the object of asymmetrical power relations. These analyses intend to contribute to urban morphology research by providing a theoretical and empirical approach for the concept of "experiential heterotopia", which could help to understand how a space is appropriated and used as resistance territory. In our description of public spaces from the perspective of heterotopic spatial configurations we defend urbanity-as-becoming. Even on the micro-scale of an urban block, there is the possibility of demonstrating that restricted public spaces can be constituted as “urban environments” that articulate forms of experiential heterotopias. These analyses contribute to urban studies by offering a theoretical basis for the concept of “experiential heterotopia”, a view of relational space that is appropriated by tactical uses of (un)controlled places.

The synthetic framework we developed here describes the photos using two levels of meaning, one compositional, relating the elements to each other, and the other, analytical, explaining the ways and modulations of these relationships with heterotopias. Thus, we should only "cut out" the analytical level. We should cut out two or three elements related to the principles of heterotopia, according to Foucault.

The act of producing diagrams in the photographs, in order to emphasize heterotopias, follows the propositions listed by Deleuze (2007), consisting, firstly, of differentiating the colour black and white - it's good, but I need to emphasize more the elements that are going to be coloured - and I thought

about creating a white border around it, it could be a thicker border, it would interfere with the image, I want it to interfere with the image, we could even think about using colours for these borders afterwards, I didn't want to blur the image because that would impair the reading, because as you know, the whole image will show an environment that could be a heterotopia effect, we're only going to highlight some elements, but the whole environment is an effect, we're going to imagine the square as one kind of heterotopia.

CONCLUSIONS

We present analyses and reflections on the ambiences that emerge in this place, which are the result of the experiences and routines of the people of the region, as well as a study of how the relationship between person and environment works in the alley that forms part of the morphology of this place. In our description of public spaces from the perspective of heterotopic spatial configurations, we defend urbanity-as-devour. Although on the micro-scale of an urban block, there is the possibility of demonstrating that restricted public spaces can be constituted as ‘urban ambiences’ that articulate forms of experiential heterotopias. We present an analytical framework that reflects on the ambiences that emerge in Gari’s Square, which are the result of the experiences and routines of people in the region, in addition to a study on how the relationship between person and environment works in the alley that is part of the morphology of this place. In our description of public spaces from the perspective of heterotopic spatial configurations we defend urbanity-as-becoming. Even on the micro-scale of an urban block, there is the possibility of demonstrating that restricted public spaces can be constituted as “urban environments” that articulate forms of experiential heterotopias. We described the urban environment of a small place as: 1) deviant trajectories; 2) mnemonic labyrinths; 3) resonant rhizomes; 4) rhythmic fragments; 5) liminal places; and, finally, 6) invented landscapes. These analyses contribute to urban studies by offering a theoretical basis for the concept of “experiential heterotopia”, a term that refers to a space that is appropriated by tactical uses of (un)controlled places. The article complements existing literature on heterotopias and ambiences, questioning how "other spaces" can influence the dialectics of relational space in capitalism (neoliberal urbanism) while reflecting on contested territories.

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The morphology of transformations in the form and landscape of the Metropolitan Region of Rio de Janeiro: analytical processes on urban fabrics and open spaces

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ABSTRACT

The research developed by the authors' research group focuses on the morphological analysis criteria applied to the Metropolitan Region of Rio de Janeiro, using geoprocessing techniques. We identify the morphological aspects in the transformation processes and their impacts resulting from: urban legislation codes and development plans; public infrastructure investments; socio-spatial inequalities; environmental conflicts; contradictions between current legislation, municipal macro zoning and urban occupation patterns. This article presents the classification of urban and rural fabrics and of public and private open spaces, especially in the metropolitan Eastern and Northern parts, seeking to understand how the configuration of these spatial systems takes place. We propose to describe degrees of urbanization, pointing out conflicts regarding the use and expansion of land occupation in these territories, and, in the process, we highlight the importance of water bodies as part of the planning and management of cities and regions. To this end, we survey the following aspects: the population evolution increases or decrease; the physical, territorial and environmental components; the context of the metropolitan economical basis; and the methodological strategies, as related to mapping activity. The preliminary results indicate the role of open spaces in their relationship with the resulting landscape, as well as the consequences of municipal urban regulations (master plans, management plans, macro zoning) and the current degree of urban fabrics' consolidation. In our analysis, we consider the indicative trends in morphological transformation, whether by the addition of new urbanized areas, the replacement of building types, or the increase of the built mass within the fabric. In accordance with our objectives, we conclude that our efforts to understand the various transformation processes, that affect landscapes, urban configurations and socio-spatial form, allow us to upgrade our theoretical and empirical debates as well as provide subsidies for the decision-making process in urban and regional planning.

Keywords: morphology, transformation, landscape, metropolis, Rio de Janeiro

INTRODUCTION

This paper presents the objectives, methodology, and preliminary results of research concerning the mapping of urban fabrics and open spaces in the Metropolitan Region of Rio de Janeiro (RMRJ),

developed by the SEL-RJ Group (PROARQ/FAU-UFRJ). By comparing municipal legal regulations and the current level of consolidation of urban fabrics, revealed by the mappings, we intend to analyze the socio-spatial processes and forms in the Eastern and Northern portions of the RMRJ.

The main objective is to apply territorial analysis criteria, using geoprocessing techniques, seeking to identify the processes of landscape transformation and impacts arising from urban legislation and urban development plans, public investments, socio-spatial conflicts and inequalities, environmental conflicts, contradictions between current legislation, municipal macro-zoning, and urban occupation patterns (Pereira et al., 2022).

To understand the impact of the set of transformations in the regional and urban space, we considered: data on income distribution; the significant presence of environmental components; the construction of new highways; and the installation of large urban projects (Oliveira et al., 2012).

In this sense, this paper presents the preliminary results and analyses of the mapping of open spaces in their relationship with the resulting landscape, the analyses of municipal legal regulations, and the current level of consolidation of urban fabrics, seeking to understand how the configuration and appropriation of these spaces work.

Study Area

The research takes as study area the Eastern and Northern portions of the RMRJ – areas in green and red, as shown in Figure 1 – consisting of a total of 16 municipalities.

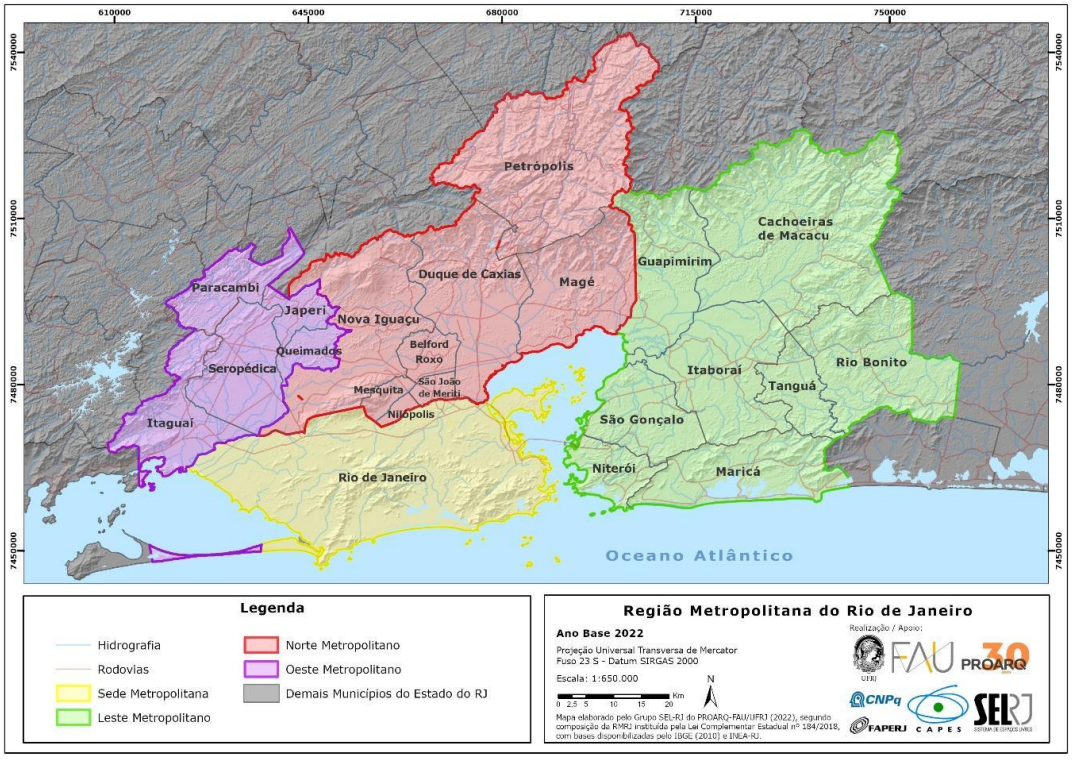

Figure 1. Map of the RMRJ and internal regionalization. Source: Prepared by the SEL-RJ Research Group, 2023.

According to the Brazilian Institute of Geography and Statistics (IBGE-2022), the total population of the two portions is 5.137,754 inhabitants, representing 42.7% of the RMRJ population, distributed over approximately 543 hectares, representing 72.1% of the entire territorial extension of the RMRJ.

Table 1 below shows the overview of population evolution in the municipalities studied in recent decades compared to the State Capital, the State of Rio de Janeiro, and the RMRJ.

Table 1. *Population and Territorial Area - Eastern and Northern Metropolitan Area. Source: IBGE (adapted by the authors).*

MUNICIPAL ITY	YEAR			POPULATION GROWTH		TERRITORIAL AREA (KM²)
	2000	2010	2022	2000-2010	2010-2022	
Belford Roxo	434.474	469.332	483.087	8,0%	2,9%	78,985
Duque de Caxias	775.456	855.048	808.152	10,3%	-5,5%	467,319
Magé	205.830	227.322	228.127	10,4%	0,4%	390,775
Mesquita	166.080	168.376	167.128	1,4%	-0,7%	41,169
Nilópolis	153.712	157.425	146.774	2,4%	-6,8%	19,393
Nova Iguaçu	754.519	796.257	785.882	5,5%	-1,3%	520,581
Petrópolis	286.537	295.917	278.881	3,3%	-5,8%	791,144
São João de Meriti	449.476	458.673	440.962	2%	-3,9%	35,216
Northern Metropolitan	**3.226.084**	**3.428.350**	**3.338.993**	**6,3%**	**-2,6%**	**2.344,582**
Cachoeiras de Macacu	48.543	54.273	56.943	11,8%	4,9%	954,749
Guapimirim	37.952	51.483	51.696	35,7%	0,4%	358,443
Itaboraí	187.479	218.008	224.267	16,3%	2,9%	429,961
Maricá	76.737	127.461	197.277	66,1%	54,8%	361,572
Niterói	459.451	487.562	481.749	6,1%	-1,2%	133,757
Rio Bonito	49.691	55.551	56.276	11,8%	1,3%	459,458
São Gonçalo	891.119	999.728	896.744	12,2%	-10,3%	248,160
Tanguá	26.057	30.732	31.086	17,9%	1,2%	143,007
Eastern Metropolitan	**1.777.029**	**2.024.798**	**1.798.761**	**13,9%**	**-11,2%**	**3.089,107**
Rio de Janeiro (Capital)	5.857.904	6.320.446	6.211.423	7,9%	-1,7%	1.200,329
Rio de Janeiro (State)	14.391.282	15.989.929	16.054.524	11,1%	0,4%	43.750,425
RMRJ (22 municipalities)	**11.254.026**	**12.241.449**	**12.022.110**	**8,8%**	**-1,8%**	**7.530,938**

It is possible to observe that in the period 2000-2010, all municipalities had a population increase, with the Eastern Metropolitan area growing above the RMRJ average (8.8%). Between 2010 and 2022, there was a population decrease in almost all municipalities in the Northern Metropolitan area, except for Magé (0.4%) and Belford Roxo (2.9%), and the Eastern Metropolitan area with Niterói and São Gonçalo showing population loss. It is worth noting the growth of Guapimirim and Maricá in the period 2000-2010, with 35.7% and 66.1% respectively, which may have been motivated in part by the installation of the Rio de Janeiro Petrochemical Complex (COMPERJ). Maricá again had a population increase of 54.8% in the period 2010-2022.

Income Pattern

The analyses of the RMRJ population profile were complemented with income data (Figure 2). Although the IBGE base year is 2010[71], it is possible to observe that the highest average incomes are concentrated in the municipalities of Rio de Janeiro and Niterói – in sectors of the cities where

71 It is important to note that the IBGE database was affected by the non-occurrence of the Demographic Census in 2020 due to the Covid-19 pandemic. Although the survey was conducted in 2022, many of the data are still awaiting release

residential neighborhoods with higher real estate value are located. The concentration of jobs, income, services, and infrastructure in the metropolitan core is confirmed when we observe that 45.5% of the metropolitan GDP[72] of R$ 740.7 billion is concentrated in the city of Rio de Janeiro (IBGE, 2022).

This socioeconomic imbalance among RMRJ municipalities is further attested by the predominance of incomes from 0 to 3 minimum wages in almost all municipalities in the Eastern and Northern Metropolitan areas, except for Niterói, and some areas of income above 3 minimum wages in the municipalities of Petrópolis and Cachoeiras de Macacu.

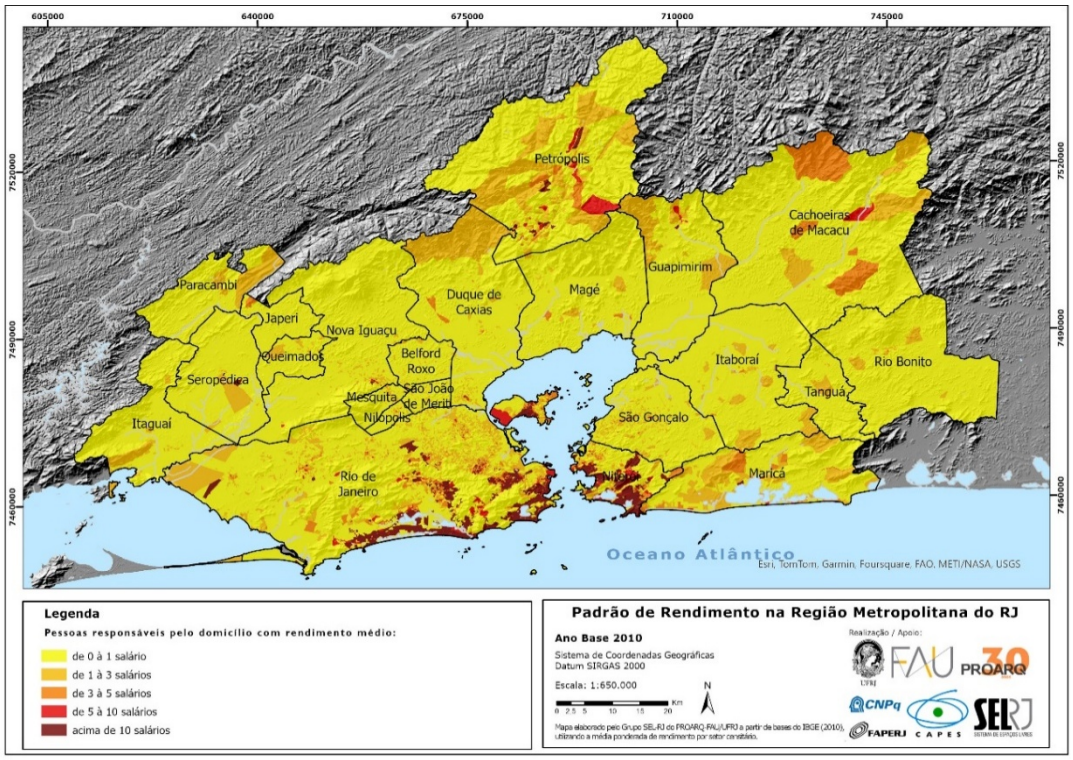

Figure 2. Income pattern in the RMRJ. Source: IBGE, 2010 (adapted by the authors, using the weighted average income by census sector).

Environmental Conservation Units in the RMRJ

The RMRJ territory has a strong environmental component, attested by the presence of restingas, sand ridges, dunes, forested slopes, springs, lagoons, lakes, beaches, marshes, and mangroves. In this sense, federal and state Environmental Conservation Units (UCs) were mapped to observe the existing degrees of fragility and preservation, as well as their relationship with the built environment (Figure 3).

The RMRJ has approximately 36% of its territory occupied by protected areas. In the Metropolitan North, a large part of the Integral Protection and Sustainable Use UCs are located, in occupied surface

72 GDP - Gross Domestic Product: it is the sum of all final goods and services produced in a region during a given period, reflecting the economic performance of that area

area. According to PEDUI[73] (2018), Atlantic Forest wooded areas correspond to 36% of the metropolitan territory, and the hydrography, whether freshwater or maritime, signals the need for attention to environmental components in any planning or development project for this territory. The research surveys found that, with rare exceptions, these areas were ratified by municipal spheres of environmental protection as areas of local relevance protection, organized into categories of Macrozones, Zones, and Areas of Special Environmental Interest, complementing the protection framework of the three spheres of power.

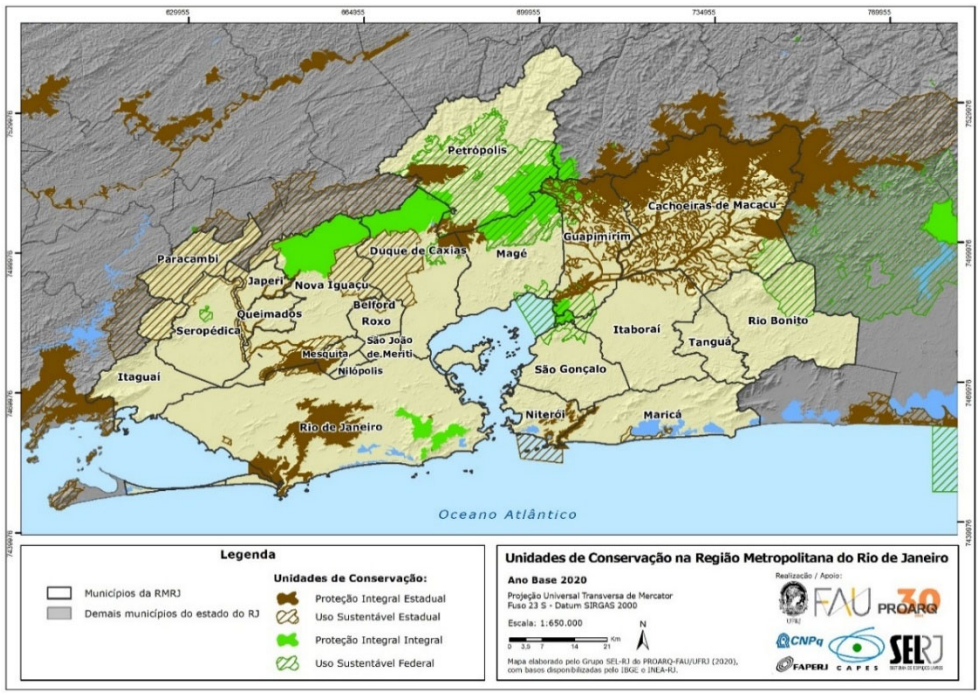

Figure 3. Map of Conservation Units in the RMRJ. Source: Prepared by the SEL-RJ Research Group, 2022.

The economic restructuring project of the RMRJ

From 2006, the RMRJ underwent an economic restructuring based on the oil matrix, with investments of R$ 180 billion between 2011 and 2013. The project included enterprises such as the Petrochemical Complex-COMPERJ, the Duque de Caxias Refinery-REDUC, expansion of the Port of Itaguaí, Metropolitan Road Arc, and the Jaconé Terminal (Figure 4). These actions drove intense demographic movement, supported by federal policies such as PAC[74] and Minha Casa, Minha Vida[75], directly impacting the municipalities in COMPERJ's area of influence. This megaproject motivated the restructuring of the RMRJ as a planned spatial unit and the creation of a metropolitan plan, focusing on economic development, regional integration, and job creation. However, the socio-spatial impacts exceeded its limits, causing the proliferation of environmental liabilities, abandonment of vast land extensions, intense real estate speculation, and growth of slums, among other aspects observed in the territorial organization of the metropolitan space (Binsztok, 2018; Bienenstein et al., 2018).

73 Strategic Plan for Integrated Urban Development of the Metropolitan Region of Rio de Janeiro

[74] Growth Acceleration Program (PAC) was a federal government plan, launched in 2007, aimed at encouraging economic growth through investments in infrastructure, sanitation, housing, and energy

[75] A Brazilian government initiative, created in 2009, to facilitate access to housing for low-income families, offering subsidies and facilitated financing for home ownership

Despite this, the project led to the reinstitution of the RMRJ and the creation of a governmental apparatus for its management.



Figure 4. RMRJ Spatial Structure Map. Source: prepared by the SEL-RJ Research Group, 2022.

In addition to these projects, several other local investments were also generated aimed at the economic sector, the preparation of a favourable environment for COMPERJ's operation, and the expansion of mobility within the metropolitan territory.

Finally, it is worth emphasizing the decline of the project, which was strongly reduced and removed from the priority agenda following the political changes that occurred in the 2018 elections, with the governmental bodies and instruments created to manage it being dismantled, leaving serious consequences for the municipalities directly involved.

THEORETICAL FOUNDATION AND METHOD

The mappings of urban fabrics and public and private open spaces in the RMRJ result from the adaptation of thematic cartography in a GIS[76] environment, built over the years by the national research network QUAPÁ-SEL, correlating open space systems (SEL) and urban forms in Brazilian cities through systematic and comparative landscape analysis (Macedo et al., 2007).

The mapping and characterization of open spaces in the RMRJ involved refining the classification proposal for categories applied to the mapping of public and private open spaces, in a preceding stage, in the municipality of Rio de Janeiro (Tângari, 2021).

Preliminary Surveys

[76] *"Geographic Information Systems are information systems specially built to store, analyze, and manipulate geographic data, that is, data representing objects and phenomena where geographic location is an inherent and indispensable characteristic for handling them." (CÂMARA et al., 1996).*

The first step was to understand the role of urban legislation in the production of urban space, starting from the understanding of urban complexity and morphological structure in relation to the conflicts and contradictions that permeate the appropriation and management of open spaces.

Data Modeling

Concurrently with the collection and analysis of municipal legislation, vector cartographic surveys were carried out at different scales, from various sources: Conservation Units, Permanent Protection Areas, hydrography, lagoons and mangroves (INEA-RJ); municipal, district, state, neighborhood and census sector boundaries (IBGE); delimitation of urban blocks[77] (Metropolitan Chamber), etc. The systematization of these surveys has been used in a complementary way to the mappings of urban fabrics and open spaces, contributing to critical analyses of the areas under study, undergoing constant updating.

Mapping and Classification

Urban Fabrics

The mapping of urban fabrics covers the entire municipal surface, including urban and rural territories, through nine classes and four subclasses, as shown in Table 2 and Figure 5. The adaptation of the methodology developed for mapping the municipality of Rio de Janeiro had as its main innovation the introduction of the subclasses Agrosilvopastoral Domain (use and agricultural aptitude of lands for a certain type of production, in forest covers or forage); Parceled and Occupied Urban Fabric; Parceled and Unoccupied Urban Fabric; and Unparceled and Unoccupied Urban Fabric (in areas of unconsolidated urban fabric[78]).

Table 2. *Classification of Urban Fabrics. Source: SEL-RJ Group/PROARQ/FAU-UFRJ.*

CLASSES	SUBCLASSES	DESCRIPTION
Forest Cover	-	Continuous patches with predominance of dense forest vegetation
	Agrosilvopastoral Domain	
Forage	-	Continuous patches with predominance of shrub vegetation, grasses or herbaceous plants
	Agrosilvopastoral Domain	
Rocky Outcrop	-	Exposure of rocks or rocky walls
Dunes and Beaches	-	Sand strips and sand ridges
Mangroves	-	Transition strips between terrestrial and marine environments
Water Bodies	-	Visible water surface (perennial or not)
Consolidated Urban Fabric	-	The reference is the urban block (or corresponding polygon) with more than 50% of its surface occupied
Unconsolidated Urban Fabric	Parceled and occupied U.F.	The reference is the urban block (or corresponding polygon) equal to or less than 50% of its surface occupied
	Parceled and unoccupied U.F.	
	Unparceled and unoccupied U.F.	
	Agrosilvopastoral Domain	
Domain Use Space	-	Union properties, Marine Lands, University campuses, airports, ports, etc.

[77] The urban block base for the RMRJ municipalities was obtained through a technical cooperation agreement with the Metropolitan Chamber of Rio de Janeiro, derived from an aerophotogrammetric survey at a scale of 1:2,000 of the RMRJ, within the scope of contract 001/2015, contracted by the Rio de Janeiro government SEGOV and UGP Metropolitana LOAN 8327-BR (2016)

[78] The research relied on visual interpretation of satellite images to identify recent changes in urban occupation patterns, as access to officially approved land subdivisions at the municipal level was not available.

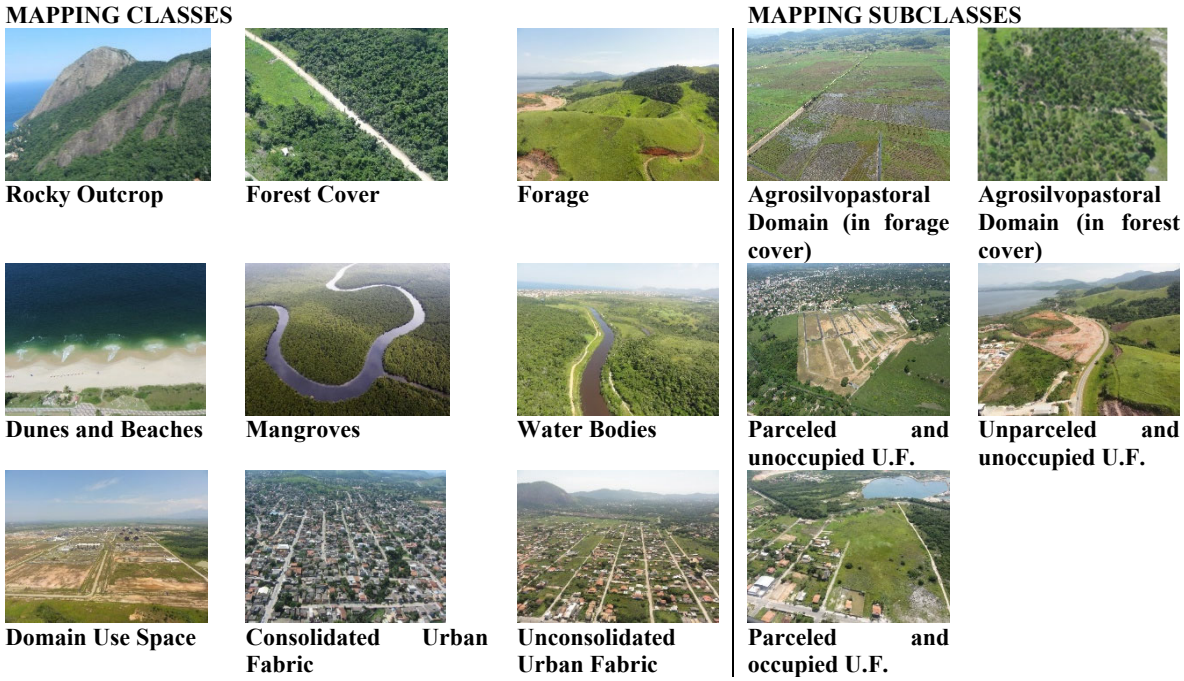

Figure 5. Aerial photographs exemplifying the mapping classes and subclasses. Source: SEL-RJ Group Archive, 2019 and O Globo, 2011.

Open Space System

The classification used is divided into six major classes and twenty subclasses (Table 3). The spatialization of this classification can be apprehended through the images included in Figure 6. Urban legislation and property situation were the aspects that helped us propose this subdivision (Tângari, 2018).

Table 3. Classification of Open Spaces. Source: SEL-RJ Group/PROARQ/FAU-UFRJ

PRIVATE OPEN SPACE			
CLASSES	**OPEN SPACES (%)**	**SUBCLASSES**	**DESCRIPTION**
PRIVATE	Up to 30%	Higher density	Block with up to 30% Open Spaces
	30 - 50%	Medium density	Blocks with open spaces between 30 and 50% of the area
	Above 50%	Lower density	Block with 50% or more Open Spaces
PUBLIC OPEN SPACE			
CLASSES	**DEFINITION**	**SUBCLASSES**	**DESCRIPTION**
ENVIRONMENTAL	Open space of environmental character, where leisure and recreation activities can also occur.	Conservation unit	Corresponds to areas covered by Integral Protection Conservation Units (Municipal, State, and Federal).
		Beach	"§ 3. Beach is understood as the area periodically covered and uncovered by water, plus the subsequent strip of detrital material, such as sand, gravel, pebbles, and stones, up to the limit where natural vegetation begins, or, in its absence, where another ecosystem begins" (Law No. 7,661/1988)
		Water bodies	Visible water surface, perennial or not, supported by INEA-RJ databases.
CIRCULATION	Open space of urban or rural character, related to the	Road median	Central or lateral road median or residual road adjustment located on or along public roads - with or without vegetation.

	circulation of vehicles or pedestrians, where activities of recreation, commerce, sports, culture, education, political actions, and festivities may also occur.	Parking lot	Public vehicle parking area - pocket or similar - that does not refer to parking spaces on streets.
		Pedestrian overpass	Elevated pathway for preferential pedestrian circulation and prohibited to motorized vehicles.
		Roundabout	Island, usually circular in shape, surrounded by roads for returns and intersections, with or without vegetation.
		Street, avenue, and sidewalk	Roads intended for the circulation of vehicles, draft animals, and pedestrians. Generally includes: streets, avenues, highways, roads, lateral sidewalks, passages, stairways, public easements, and related.
		Bus Terminal	Set of bus bays located outside the street's traffic lane for stops with shelters for pedestrian protection.
PERMANENCE	Open space of urban or rural character, related to recreation, sports, culture, education, political actions, and festivities.	Soccer Field	Isolated informal open space where people play ball. Does not include soccer fields in squares and parks.
		Parks	Public open space specifically decreed as a park. Visually defined, vegetated or not, with dimensions larger than an urban block, cross-referenced with the city hall's land use map.
		Square	Area determined in subdivision project as public open space for recreational activities.
INFRASTRUCTURE	Spaces of urban or rural character, related to administrative infrastructure of transportation, energy distribution, sanitation, etc.	Up to 30% open spaces	Dominial assets, i.e., public property, granted for special uses - railways, ports, airports, university campuses, cemeteries, gas pipelines, electricity transmission, etc.
		Between 30%-50% open spaces	
		above 50% open spaces	
UNIDENTIFIED OPEN SPACE			
CLASSES	**DEFINITION**	**SUBCLASSES**	**DESCRIPTION**
NOT IDENTIFIED	Public or private open spaces, of urban or rural character, with unidentified function, which may or may not be subject to occupation.	Vegetated area	Area with predominance of vegetation cover (low-lying or arboreal) that may or may not be subject to occupation, with unidentified subdivision and property, not belonging to Conservation Units or Parks.
		Not defined	Everything that is not covered in the other categories

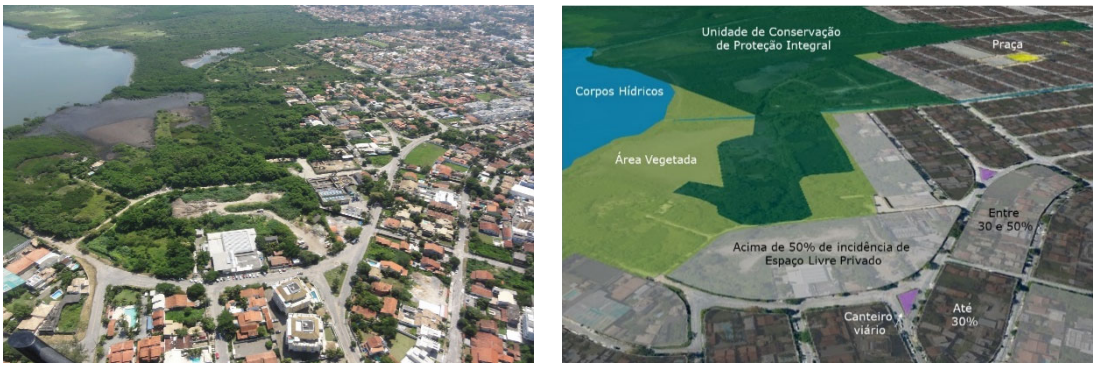

Figure 6. Comparison between aerial photo of Niterói and subclasses of open space mapping. Source: SEL-RJ Group Archive, 2019.

RESULTS AND DISCUSSIONS

In this section, we will present the results related to the mapping, classification, and quantification of urban fabrics and open spaces in the Eastern and Northern Metropolitan areas. From the preliminary reading of the territory of the sixteen municipalities, it was possible to extract and quantify the data, presented below.

Mapping of Urban Fabrics

From the mapping of Urban Fabrics in the Eastern and Northern Metropolitan areas (Figure 7), except for the municipality of Petrópolis, which is still in progress, it was possible to extract data for preliminary analyses.

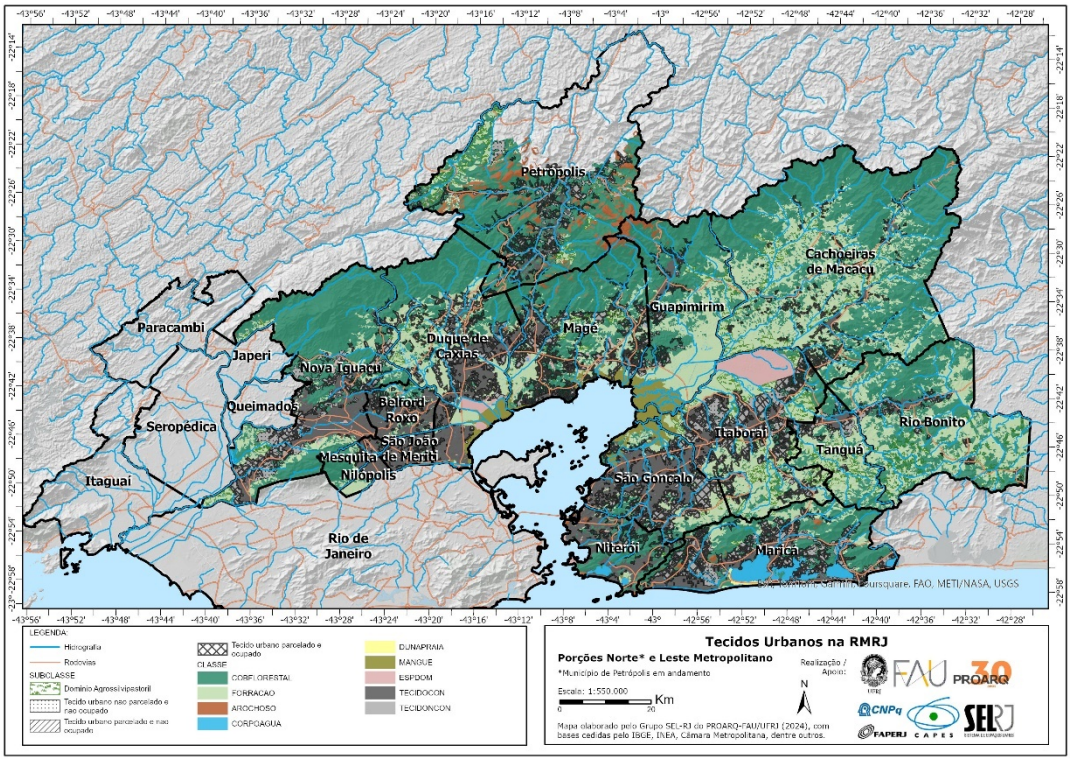

Figure 7. Urban Fabrics Map in the RMRJ. Source: prepared by the SEL-RJ Research Group

Data obtained in the study area (Figures 8 and 9) highlight the predominance of Forest Cover (41.5%) and Forage (27.5%) areas, due to the significant presence of Full Protection and Sustainable Use Conservation Units and the predominantly rural characteristics of some municipalities. The analysis also points to heterogeneity among municipalities. While the municipalities of Belford Roxo, Niterói, São Gonçalo, and São João de Meriti have more than half of their territory occupied by urban fabrics (consolidated and unconsolidated), the municipalities of Cachoeiras de Macacu, Guapimirim, Rio Bonito, and Tanguá have more than 70% of their territorial occupation composed of Forest Cover and Forage.

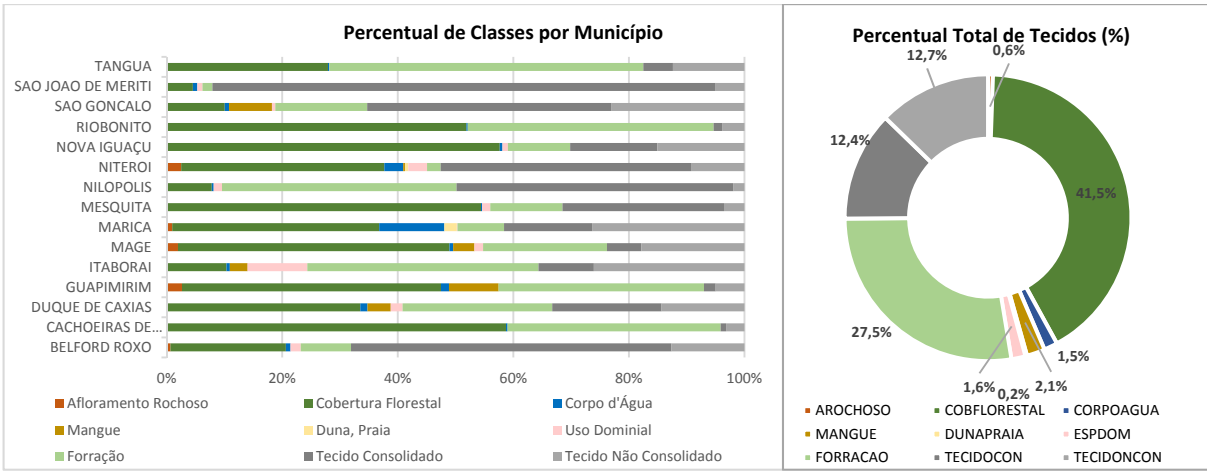

Figure 8. Graphs highlighting the percentages of urban fabric classes in the Eastern and Northern Metropolitan areas. Source: prepared by the authors.

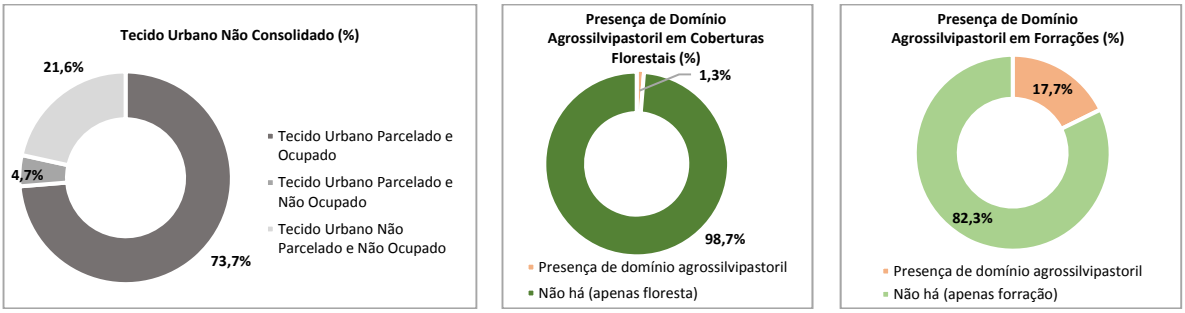

Figure 9. Compilation of quantitative results of urban fabric subclasses in the Eastern and Northern Metropolitan areas. Source: prepared by the authors.

In Figure 9, we have the quantitative results of urban fabric subclasses. It is possible to observe the predominance of parceled and occupied urban fabric in 73.7% of the unconsolidated urban fabric areas, indicating a strong process of urban fabric consolidation after the implementation of the megaproject. It is noted that there is no significant presence of agrosilvopastoral activity in Vegetation Covers; in contrast, they represent 82.3% of the total forage area, which still confirms the predominance of rural characteristics in some municipalities.

Mapping of the Open Space System

The mapping of public and private open spaces in the Eastern and Northern Metropolitan areas, except for Petrópolis and Duque de Caxias, which are still in progress, allowed for the extraction and quantification of preliminary data (Figures 10 and 11).

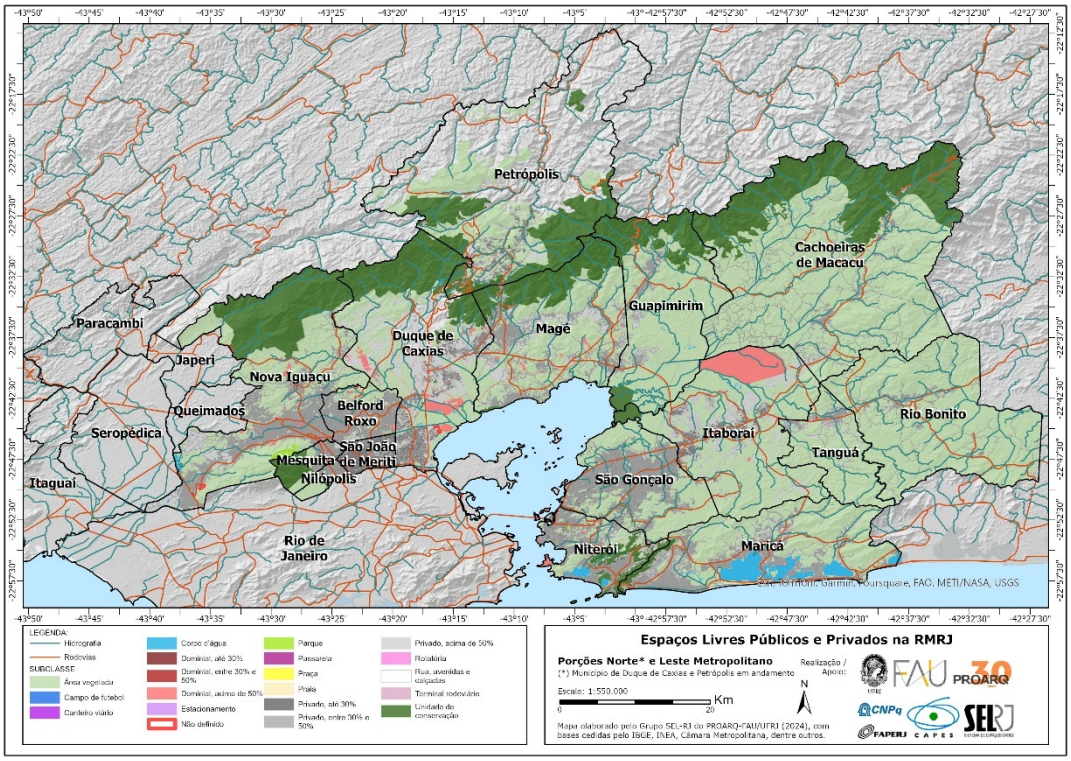

Figure 10. Open Spaces Map in the Northern and Eastern Metropolitan areas. Source: prepared by the authors.

In the graphs of Figure 11, it is possible to observe the massive predominance of public open spaces over private ones in the study area. However, the interpretation of percentages requires caution, considering the unequal distribution and accessibility of these spaces, as well as variations in urban occupation and the presence of rural and environmental areas.

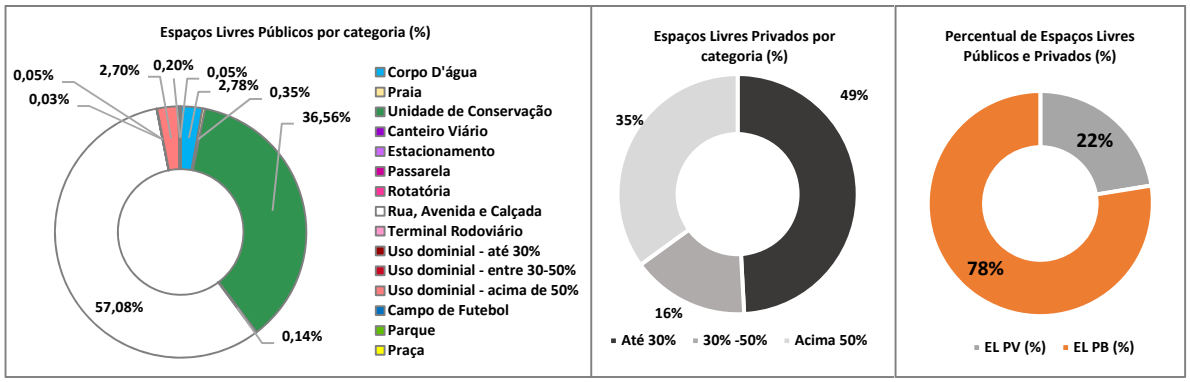

Figure 11. Synthesis of quantitative results of public and private open spaces mapping in the Eastern and Northern Metropolitan areas. Source: prepared by the authors.

Still, on these graphs, it is worth highlighting: the weight of Full Protection Conservation Units (36.56%), a relevant portion of conservation and environmental protection areas, which should be observed by local and regional land use planning; and the category Street, Avenue and Sidewalk (57.8%). Much more than just their capacity for vehicular and pedestrian flow, circulation spaces, as a rule, are the places of greatest expression of daily life, stage and product of urban cultural expression (Macedo et al., 2018).

In Figure 12, we have the percentage of total open spaces. The predominance of vegetated areas (62%) is related to the abundance of spaces with vegetation cover (low or arboreal) that may or may not be occupied, not belonging to Conservation Units. These areas may also be related to the extent of agrosilvopastoral activities, which was not always possible to detect through visual interpretation of satellite images, requiring further investigation, either through dialogue with local governments or field visits. In any case, the relative weight of vegetated areas should be analyzed on a case-by-case basis and related to the pattern of land use and occupation, and to the understanding of the historical evolution of urban development in each municipality.

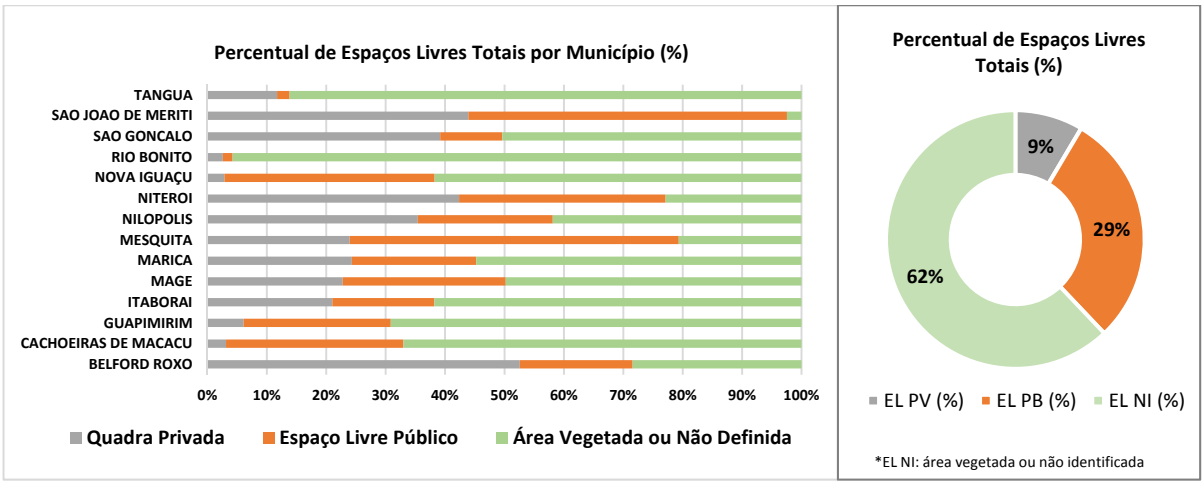

Figure 12. Graphs highlighting the percentages of total open spaces in the Eastern and Northern Metropolitan areas.

São João de Meriti, with more than 90% of its territory urbanized, has 97.3% of its public open spaces in the category Street, Avenue and Sidewalk, evidencing the need for a careful analysis of the data. In private open spaces, blocks with up to 30% of open spaces predominate, signaling the consolidation of urbanization in most municipalities and the chaining of spatial restructuring, with the introduction of large projects of regional impact, especially regarding impacts on municipalities in the immediate surroundings of COMPERJ. Like the municipality of São Gonçalo, with 71% of its blocks in this category. Niterói stands out in the category between 30% and 50% (27%), while Cachoeiras de Macacu leads in the category above 50% (84%), reflecting its recent urbanization process driven by the introduction of large projects of regional impact.

CONCLUSIONS

According to the objectives described in the Introduction of this article, we conclude that our efforts to understand the complex and multiple processes that affect the transformation of the landscape, and socio-spatial forms have allowed us to advance in reflecting on the theoretical and methodological debates of the SEL-RJ Research Group and to advance, refine and revise the methodologies adopted.

In general, we can affirm that in the research on the RMRJ, initiated in 2019, we observed disparities, contradictions, and sociodemographic, economic, and political-administrative imbalances, expressed directly in the landscape and indirectly in surveys of external sources as well as in the mappings carried out systematically for the fabrics, open spaces, and centralities existing in the municipal territories.

When we chose to initiate the research by analyzing legal and normative frameworks, this heterogeneity regarding future projections of urban and rural territory occupation signaled to us the importance of research that can inform public policies.

However, we more objectively hope that the information generated, processed, and analyzed, as presented in this article, can primarily foster dialogues between administrative instances, but above all, between public authorities, private agents, and the population. Thus, the processed information is made publicly available through workshops, colloquiums, meetings, and publications, to foster the desired dialogues and responsive actions with civil society, which can use them as a tool for social participation.

Acknowledgements

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Urban morphology, transit-oriented development (TOD), and planning: a case study from Aotearoa New Zealand

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ABSTRACT

Geographical urban morphology provides a systematic framework for urban form research. In particular, it has been applied in planning, architecture, and urban design, towards seeking economically efficient, environmentally sustainable, and socially inclusive future built environments. Despite growing interest in transforming the intellectual ideas of urban morphology into operational tools, practical bases are yet to be fully achieved. In connection with an investigation in Auckland, New Zealand, where transit-oriented development (TOD) has been promoted as a planning response to excessive automobile travel and associated urban problems, this paper reports the use of urban morphology to reveal the development process of Auckland's railway station catchment areas. Clarifying the developmental or evolutionary process provides a foundation for future development to build upon, enhancing place identity and meeting future needs. Alongside global morphological and TOD studies, this research contributes to innovative sustainable development in New Zealand and enhances the practicality of morphological methods.

Keywords: urban morphology, sustainable urban form, transit-oriented development, New Zealand

INTRODUCTION

First established in central Europe in the late 19th century, geographical urban morphology (M. R. G. Conzen, 1960; Gauthiez, 2004; Whitehand, 1981) was later consolidated as an approach for studying urban form in research conducted by M.R.G. Conzen. Beginning in the 1950s, Conzen used town-plan analysis to clarify the geographical arrangement and distinctiveness of towns by systematically examining their constituent elements and tracing their evolution over time (Kropf, 2009). The framework not only enables a critical analysis of buildings and urban fabrics but also informs and shapes the design process (Strappa, 2023). Not surprisingly, it has since been applied in planning, architecture and urban design (Whitehand, 1981).

Despite the increasing interest in transforming the intellectual ideas of geographical urban morphology into operational tools (Gu et al., 2019; Whitehand, 2009), its full potential is yet to be realised. In particular, traditional morphological data collection and analysis require greater clarity. There is a need to improve urban morphology to enable reproducibility and methodological

compatibility across disciplines (Zhang et al., 2023) and establish a dependable methodology for measuring and classifying urban forms (Dibble et al., 2019), thus widening its applicability.

The morphological approach strives to disclose the 'genesis' or 'engendering process' of landscape forms as a developmental or evolutionary process. Alexander (2004) claims that in order for people to create a sustainable world and maintain its uniqueness, they need to recognise that the living environment transforms in a holistic and sequential unfolding process, inheriting and strengthening the good qualities of systems and rectifying the flaws. This 'structure-preserving (and enhancing) transformation' maintains and improves a place's existing structure or essence, the streets, squares, or urban neighbourhoods, even as they evolve and develop (Alexander, 2002). This morphological process uncovers what will emerge and is always informed by the form at the moment just before (Tan et al., 2024). City planning thus seldom begins with a blank canvas and the existing land uses play a crucial role in shaping future development (Atkinson-Palombo & Kuby, 2011).

It is argued that the challenges facing urban morphology are frequently related to ignorance of the dynamics of spatial-temporal processes. Seeking to address this gap, this paper explores the challenges facing urban morphology through the exploration of transit-oriented development (TOD). TOD offers a promising approach to achieving carbon neutrality, which remains an important priority for both local and central government. However, practical strategies and methods for TOD implementation are underdeveloped in New Zealand. Based on the 50% benchmark for usage of sustainable transport (Hale, 2014), many of the railway station catchment areas in Auckland show low usage of sustainable modes of transport (public transport, walking and cycling). According to the analysis of data from the 2018 New Zealand Census, 28 out of the 39 railway station catchment areas below 30% of travel by sustainable modes (Li, 2024). This underutilisation of rail transport is an obvious problem, and there has been no investigation of the causes from a morphological perspective. Geographical urban morphology provides a systematic approach to reveal the complex process of TOD development and redevelopment. Specifically, morphological approach is used in this study to analyse the relationship between the urban development process and the current underutilisation of railway stations in Auckland and provide suggestions for future TOD development.

Morphological periods, fixation lines and plan units are Conzenian terminologies (Larkham Peter J. & Jones, 1991). Urban developments can be conceptualised as a series of morphological periods that leave distinct residues in the urban landscape (M. R. G. Conzen, 1960). Each morphological period represents a portion of history that has distinctive forms based on socio-economic conditions. These forms leave varying degrees of residue depending on the requirements of the societies that follow (M. R. G. Conzen, 1988). The idea of fixation lines has been applied in various planning and design research. For example, the city walls of Pingyao are a fixation line that can be traced from historical maps as well as on the ground now, reflecting the influence of historical structure on built form (M. Conzen et al., 2012). While city walls and mountain ranges have been explored as fixation lines, there has been no research into railways as fixation lines in TOD. The railway line has a significant influence on urban form and urban development, dividing the land into parts and forming a frame or barrier for development. The ever-changing relationship between the railway and urban form is therefore worth investigating to ensure new development can be continuous and respond to problems left historically by prior development. The plan unit which is defined as an area having similar development qualities can be recognised from a town plan that is different from its surroundings – in terms of its combination

of streets, plots and buildings in the developmental process (M. R. G. Conzen, 1960). It takes various sizes, ranging from a single plot to a large portion of a town (Gu, 2014).

This paper therefore addresses the following questions: in what way and to what extent can morphological concepts support explanations of the development process of railway station catchment areas? Given the available qualitative and quantitative data for historical development, how can urban morphology be applied to help reveal the changing morphological process of TOD? Answers to these questions are provided by means of a critical examination of urban development and other changes in the area around the Panmure railway station in Auckland. The case study area has a rich history and has been deeply influenced by Auckland's complex transportation evolution and urban development. This paper reports an in-depth study of the 15-minute walkable catchment area around Panmure railway station. The transition to mobility in urban environments can start with these railway station catchment areas which are still in operation and have more potential for TOD than other areas of the city.

The paper is organised into two parts. First, the morphological periods of the study area are described in connection with the concept of fixations lines. The complex layering of the spatial-temporal landscape forms the basis for urban landscape assessment using historical maps and documents. The second part reports the morphological units based on data collected for each morphological period. The resulting plan units will support the continuity of future development.

METHOD

The methods used to explore the evolving relationship between the Panmure railway station and its surrounding area mainly derive from town-plan analysis, notably reconstruction of the urban development process through analyses of historical series of ground plans and documentary records. The systematic survey conducted for this study used multiple sources including historical maps, property data, Auckland Council Geomap, and field surveys to explore patterns of development (Gu, 2014). Plans and maps of Panmure are widely available, beginning with cadastral maps from 1860 (Auckland Libraries Heritage Collections, 1860a, 1860b). These historical maps play a crucial role in reconstructing the development history of the urban landscape (Gu, 2014). Property Guru offers a comprehensive collection of New Zealand property-related information. This dataset includes details such as the names of occupants and owners and the ages of most buildings. A plot-by-plot field survey allows land uses to be identified.

The use of geospatial technology, particularly an integrated GIS system, is increasingly important for analysing and synthesising morphological data. It enables multi-source data to be assembled into a single database for analysis. More importantly, it can spatially relate data from different sources and produce new or missing variables in separate datasets. In this research, the plans and maps of the study area were georeferenced in GIS (Tümtürk et al., 2024), and the ground plan information then digitised in ArcGIS Pro.

Panmure and its morphological periods

With 170 years of European history, Auckland is the largest urban area in New Zealand (Gu, 2010). The evolution of society since early colonial days has affected the building types and ground plan,

influencing the development and transformation of building forms, which often leave marks on the ground. About 18 per cent of Auckland's total urban land area lies within the 15-minute walkable zones around its 39 railway stations. The railway station area in Panmure provides an ideal case study, with its historical development and current form representative of many urban railway station areas. The study area was delineated as the surface included within a 15-minute walkable distance of the railway station.

Located in East Auckland, the Panmure station is close to the Auckland CBD and Manukau central business districts. The suburb of Panmure lies between Mount Wellington and Panmure Basin, offering a mountain view and water connections to the Hauraki Gulf and Waitematā Harbour. Throughout the years, key changes in planning, infrastructure, and policies have greatly shaped the development of Panmure and its adjacent urban areas (Beharrell, 2024).

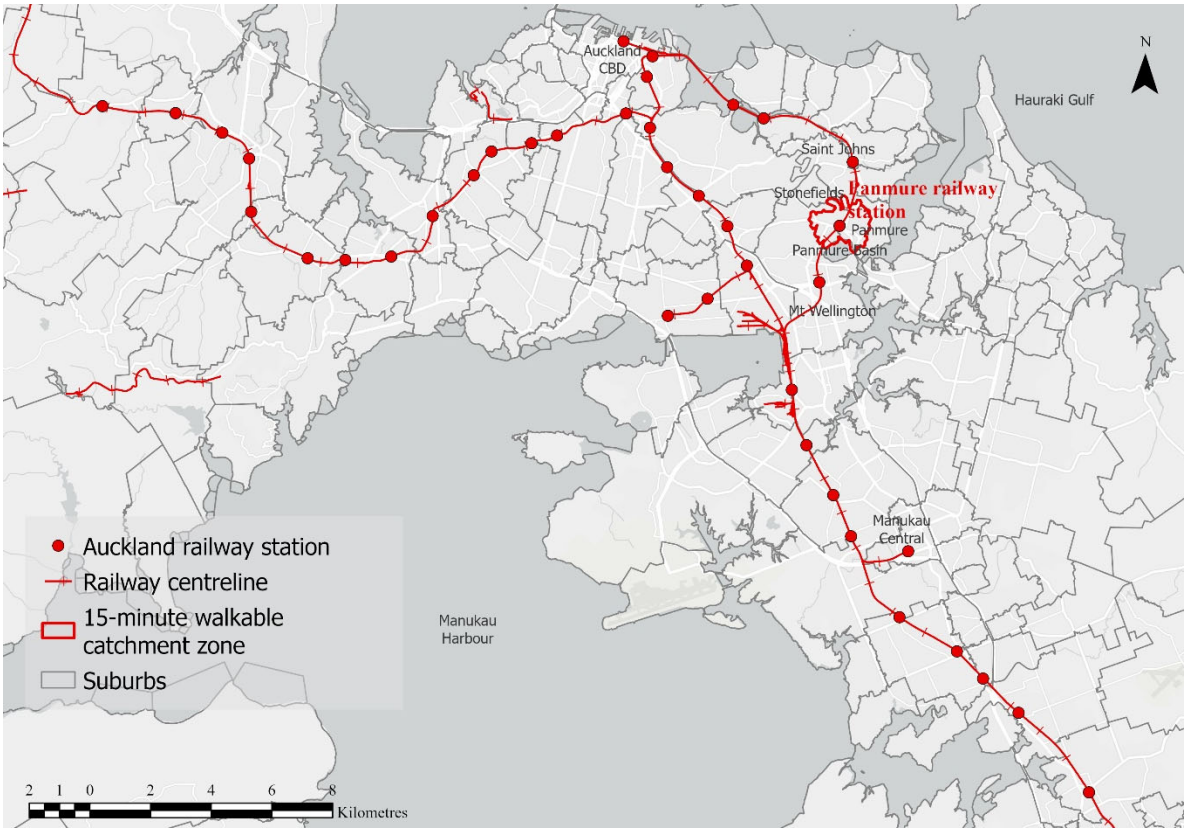


Figure 1. Railway stations in Auckland and Panmure railway station 15min walkable zone

Based on a review of the historical records of Panmure, its development can be categorised into four morphological periods of growth and change: pre-urban development (1840s–1880s), railway colonisation and expansion (1890s–1930s), segregation and fragmentation (1940s–1990s), urban redevelopment and revitalisation (2000s–now).

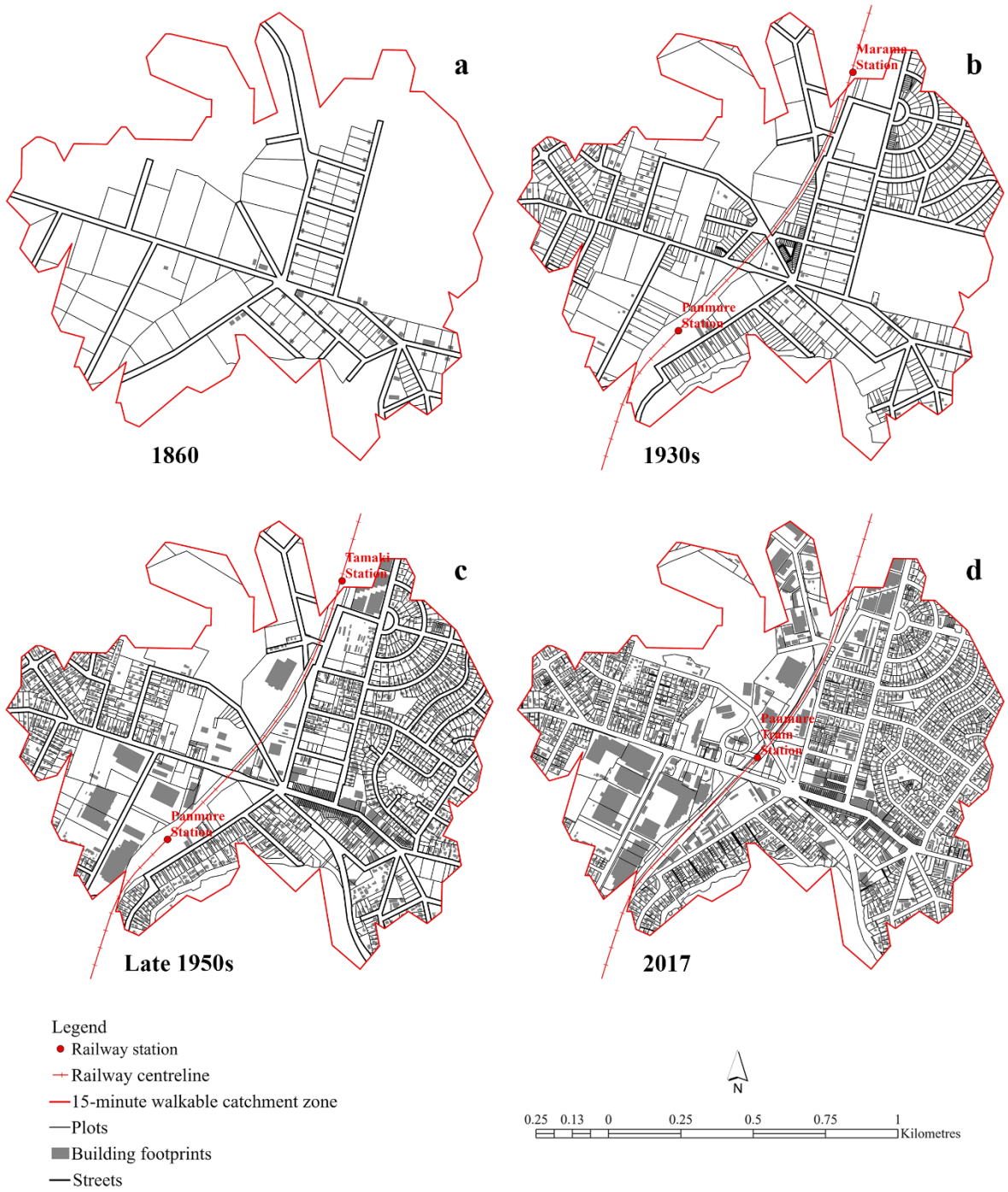


Figure 2. Streets, plots and buildings in the 15min walkable catchment area of Panmure in (a) 1860, (b) 1931–1940, (c) late 1950s and (d) 2017 (based on Auckland Council, 1958, 1959, 2024; Auckland Libraries Heritage Collections, 1860b; Auckland Libraries Heritage Collections Map 71, 1931)

Pre-urban development (1840s–1880s)

Panmure started as a defence post in the 1840s, when it was established as one of Auckland's fencible settlements (Hoffman, 2019) on divided farmlands. Situated along feared potential Maori invasion routes to Auckland after the outbreak of hostilities between Maori and the Crown in the north, Howick, Panmure, Otahuhu and Onehunga were the locations chosen to provide places for 2,500 Fencibles and their family members (almost double the population of Auckland at that time), who

travelled from the UK to New Zealand between 1847 and 1952 (Howick Historical Village, n.d.). The word Fencible comes from ‘defencible’, meaning ‘capable of defence’. The Fencibles had served as soldiers in the wars of Britain in the 1830s and 1840s. To emigrate to New Zealand under the Fencible scheme, retired soldiers were required to be under 48 years of age and of ‘good character and industrious habits’ (Howick Historical Village, n.d.). These retired soldiers were enlisted to serve for seven years in exchange for a cottage and one acre of land (Howick Historical Village, n.d.).

Panmure became a busy place in the mid 19th century, partly because of its location near the narrowest part of the isthmus, on the route between Auckland and the largest fencible settlement of Howick. People and goods were transported across the water by ferry at the narrow point below Mokoia Pa (Auckland Transport, 2018).



Figure 3. Fencible cottage and Panmure ferry in the 1860s (Auckland Libraries Heritage Collections 1031-P619-06, 589-0426)

Railway colonisation and expansion (1890s–1940s)

Railway construction in Auckland dates back to 1863 with the railway system starting to take definite shape in the 1870s (Davidson, 1931). Upon the arrival of railway to Auckland to carry not only goods but also passengers (Lowe, 1973), Panmure became a busy transport hub (NZ Herald, 2010). Steamers from Auckland stopped there on their way to the goldfields in the Coromandel and Firth of Thames. New developments and plans for land around the railway line also started during this period. The original Panmure Station opened on 16 November 1930, showing in Figure 2 (b), on a site to the south of the current station.

After World War I (1914–1918), the newly established profession of town planning and its advocates aimed to provide solutions for the challenges of postwar resettlement in both urban and rural areas, and showcase the effectiveness of town planning (Miller and Roche, 2003). Town planners in New Zealand adopted town planning concepts from Britain, and were especially influenced by the Garden Suburb model when accommodating soldier settlements (Miller and Roche, 2003).

Starting from the beginning of the 20th century, the garden suburb movement gained popularity, with the Tamaki Heights Garden Suburb designed by E. V. Blake (see Figure 4) showing marked garden suburb appeal. The subdivision shown in Figure 4 was marketed by brochures and newspaper advertisements from 1926 to 1928(Miller, 2004). However, the Garden Suburb experienced slow development and was eventually incorporated into the State Housing program, which led to changes in its layout (C. L. Miller, 2004).

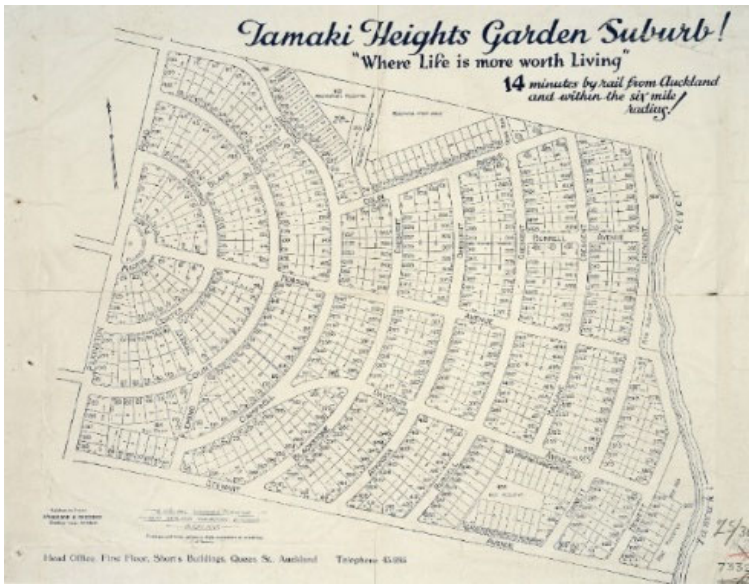


Figure 4. Panmure store and sales advertisement of Tamaki Heights Garden Suburb development allotments (Auckland Libraries Heritage Collections, 1920)

Segregation and fragmentation (1950s–1990s)

Up until the mid-20th century, Panmure remained a prosperous but predominantly pastoral area (NZ Herald, 2010). It was only after the explosive suburban development around it following World War II (1939–1945) and the construction of better bridges to Pakuranga (NZ Herald, 2010) that Panmure grew significantly and transformed into a commercial centre. During the period 1950–1955, Panmure grew from a small village with a few shops and a hotel into a busy suburban shopping hub with the development of the West Tamaki housing estate (Hoffman, 2019).



Figure 5. State houses on Pilkington Road and Main road (Queens Road) in the 1960s (Auckland Libraries Heritage Collections 895-A62539, Auckland Libraries Heritage Collections 786-A18-03)

In 1948, there was initial discussion about an eastern motorway to cater for Auckland's future growth (Cayford, 2011). In 1955 as part of a Master Transportation Plan, a South Eastern Motorway was proposed to link the central business area to eastern areas of Auckland, Mt Wellington Highway and the existing SH1 Motorway at Mt Wellington via Tamaki (Cayford, 2011). In the 1960s, the Eastern Corridor was part of the regional highway plan (1965 Report on a Comprehensive Transportation Plan for the Auckland Regional Authority), with land designated for a motorway. The intended motorway was changed to a limited access (arterial) road in 1967 (Cayford, 2011). In 1974, the eastern corridor was incorporated into the Auckland Regional Planning Scheme, with the

Auckland Regional Authority revisiting the idea of a four-lane arterial road in 1975. (Cayford, 2011). In 1993, the Auckland City Council designated the corridor route under the title Proposed Limited Access Road – Eastern Highway. Effective until 2004, the designation was then extended in August 2004 for ten years to 2014 (Cayford, 2011). The development of highways has meant the urban development of the area no longer centres on the railway. As a result, superblock types have formed with through roads for private cars and more cul-de-sacs (Figure 2 (c)).

The creation of the Auckland Regional Planning Scheme in 1988 established a framework for managing coordinated growth in the Auckland region, setting rules to manage expansion and development (Hoffman, 2019). It helped address the previous segmentation and fragmentation.

Urban redevelopment and revitalisation (2000s-now)

Since the beginning of the 2000s, there have been efforts to seek collaborative solutions for urban development and infrastructure improvements around railways. In 2004, the Hobson Bay, Purewa Creek, Glen Innes/Panmure, SH1 and Tamaki River corridors were recommended as the preferred routes between Auckland's CBD and the Tamaki River (Cayford, 2011). Local elections in October 2004 led to a reconsideration of the project by the Auckland City and Manukau City Councils and Transit New Zealand, with more emphasis on passenger transport and improving roads to carry passenger transport. Auckland City subsequently resolved there would be no highway component for the project north of Glen Innes. The Auckland-Manukau Eastern Transport Initiative (AMETI), which originated from the Eastern Highway project, is a package of transport improvements in the Glen Innes – Panmure – Pakuranga –Botany corridor. The project aims to provide a high-quality strategic transport link between Auckland City and Manukau City via their eastern suburbs. Requiring major public investment, AMETI includes land use zoning changes and an urban design approach, providing bus lanes and other bus priority measures, an improved road network, improved walking and cycling facilities, and travel demand measures (Cayford, 2011). Still ongoing, the Auckland Manukau Eastern Transport Initiative (AMETI) involves major public investment (Cayford, 2011). The area's transport infrastructure developments highlight its important role as a transport node and crucial interchange.

Panmure is also the focus of large public investment as part of the Tāmaki urban transformation led by the Tamaki Regeneration Company, a government-council joint venture. The project was set up with the aim of building 7,500 new homes and community facilities over the next 15−20 years. The area has seen a high level of local board planning, with strong political and community backing for change. Launched in 2012, the Tamaki Transformation Programme is the country's first urban regeneration programme. As described in the project plan for Panmure, many of Panmure's facilities and natural assets are underutilised due to poor local connections. The town centre needs to maximise the benefit of transport investments, including through AMETI, greenways, and improvements in walking and cycling. The area offers a wide range of local services, leisure and recreational facilities, including council amenities, that can be enhanced to support future growth (Panuku Development Auckland, 2018). Panmure's town centre is strategically located, featuring infrastructure and access to public transport. The area has the potential to meet the pressing need for sustainable and quality urban development.

The town centre regeneration plan by Panuku Development was approved by Auckland Council's Planning Committee in 2018. It seeks to strengthen links between Panmure Station and the town centre(Panuku Development Auckland, 2018). The Unlock Panmure Project includes planning for new

precincts and new projects within the precincts to create a thriving town centre, upgraded public spaces and more(Eke Panuku Development Auckland, 2023).

The Panmure railway station was relocated to its current site in 2007. Since the opening of the upgraded station in 2014, there has been significant growth in train boardings in Panmure. Based on 2018−2019 data, Panmure station has become the third busiest station, following Britomart and New Market station (L, 2019).

The morphological structure of the Panmure railway station area

Panmure in 1860 was characterised by large plots and empty land as shown in Figure 2 (a), which the railway line later cut through created a divide (Figure 2 (b)), many smaller plots resulted as large plots were subdivided. The two sides of the divide subsequently experienced different type of development, in part related to the location of the train station. The original garden suburb development is still evident on the northeast side of the study area. Seeking to reverse this trend, efforts are now being made to recover a coherent urban form through reconnecting the separate developments.

The plan units

Examination of change in the ground plan has been an important basis for the identification of six plan units in the Panmure 15-minute walkable catchment areas (Figure 6 and Table 1). The area with the longest development history is identified as the first plan unit. Subsequent development was the Garden Suburb unit. The railway station unit, suburban expansion unit and residential unit were developed in similar periods. Notably, the railway station unit is completely different from the other two residential units in terms of form and uses, the fixation line has a major influence on the result.

The fixation lines in the form of natural and artificial features, such as city walls, rivers, mountain ranges and railways, are often seen as a barrier to development (M. R. G. Conzen, 1960). It has major influences on the formation and changing direction of urban development and expansion. The spaces around fixation lines have many things in common. For example, these areas often act as corridors, and they have low density, exerting less pressure on land. A trend can be identified whereby socio-economic factors influence the lines, in this case, it is the arrival of the railway line, on one hand, the railway station site brings new development and commercial for the area, and it prospers. On the other hand, the railway track attracts freight yards, industry and housing to develop nearby (Bertolini, 1996). It is important to recognise the long influence brought by the railway line on the surrounding development forms part of the history and identity of the place.

Under certain conditions, urban development can move beyond the barrier to continue (Gu et al., 2022). In the railway line case, the divided environment has been an obstacle in station redevelopment projects, methods of going beyond the constraints include vertical crossing, or having the railway line below or above the ground (Bertolini, 1996). Even with the physical barrier removed, the characters of the developed area brought by the fixation line will still be part of the unique feature on the ground (Gu et al., 2022).

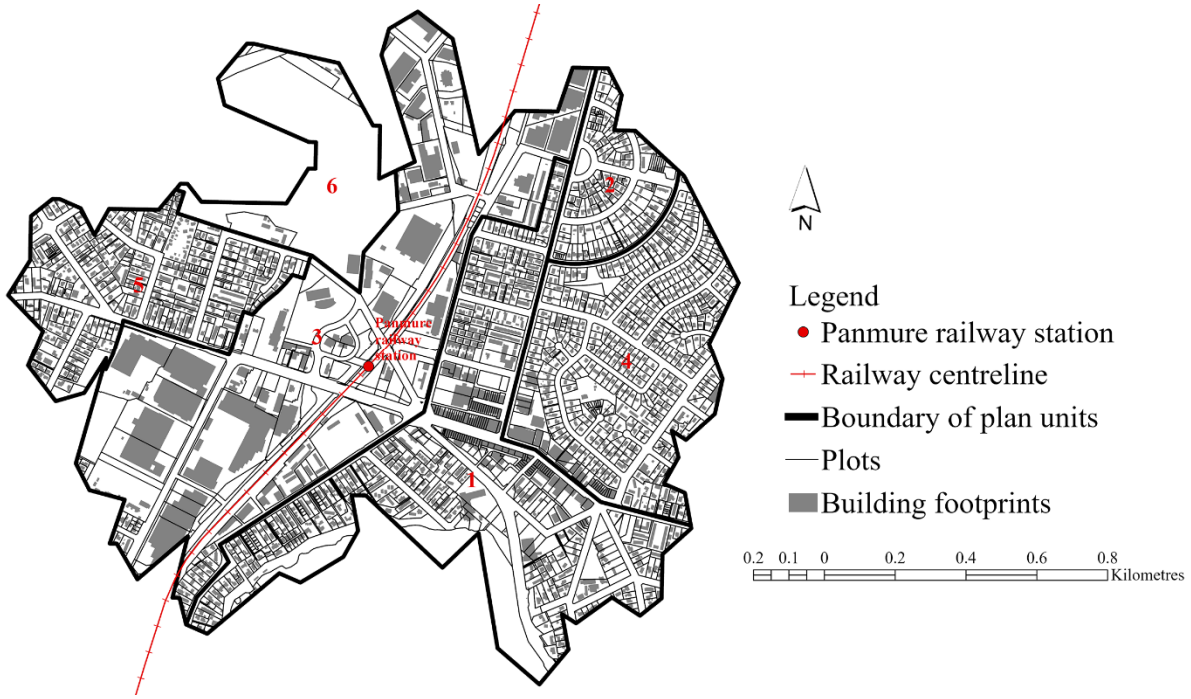
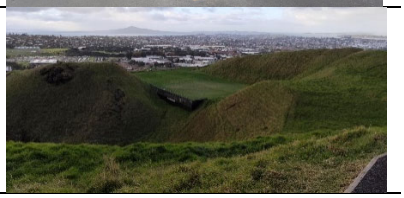


Figure 6. Plan units in the 15min walkable catchment area of Panmure. (1) Historical development, (2) Garden suburb unit, (3) Railway line unit, (4) Suburban expansion unit, (5) Western residential unit, (6) Mt Wellington Domain unit

Table 1. Plots and their metamorphosis and buildings and their block plan in the plan units (Authors own photo 2024).

Plan units	Plot	Building	Image
1.Historical development unit	Mainly small- and medium-sized plots mostly in the form of 1950s	Mixture of commercial, residential and recreational buildings	
2.Garden suburb unit	Planned layout with regular plots	Residential buildings and local commercial stores	
3.Railway line unit	Mainly large plots for industrial purposes resulting from plot subdivision and amalgamation	Industrial, public transport and commercial buildings	
4.Suburban expansion unit	Mainly small plots	Mainly residential buildings, will small portion of commercial and institutional buildings	

5.Western residential unit	Mainly small plots	Mainly residential buildings	
6.Mt Wellington Domain unit	Single large plot	Natural landscape, horticulture yard and recreational buildings	

TOD planning and design

Auckland Council's Plan Change 78 regarding intensification is underway and expected to be finalised by 2025. Prioritising rapid transit, it recognises that strategic planning and development around train station areas are urgently needed (Auckland Council, 2023). The provisions of the plan change have the potential to impact the Panmure station area, with provision for six-storey buildings within the 800-metre walking catchments of rapid transit network stations (RTNs) through rezoning residential land in RTN walking catchments to Residential – Terrace Housing and Apartment Building and rezoning all other existing urban residential land to the revised Residential – Mixed Housing Urban category, unless there are valid reasons not to (Auckland Council, 2022). The provisions of Plan Change 78 will likely increase the speed and scale of development in Panmure as the market responds to the new planning regime. As a result, residential intensification and population growth in Panmure will probably be faster and higher than projected in the Auckland Plan 2050 (Auckland Council, 2024b). The spatial distribution of future populations will change as a result.

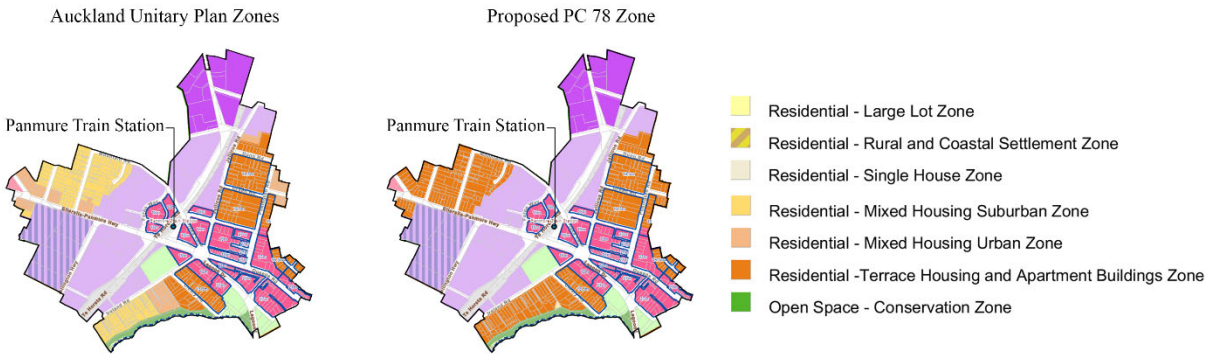


Figure 7. Auckland Unitary Plan Zones and Proposed PC 78 Zones, propose change residential-mixed housing suburban zone and residential-mixed housing urban zone to residential-terrace housing and apartment buildings zone (Auckland Council, 2022).

However, the PC 78 zones lack the consideration of the spatial-temporal processes of the areas and acknowledge little about the characteristics and their difference regarding to their development process (Gu, 2014). It will potentially lead to a fragmented landscape. To create a coherant landscape, the unit-specific (Gu, 2014) and place and form-based design is recommended. The 'pull factors'

including improved accessibility, pedestrian friendly, and close to public facilities (Gehrke et al., 2019; Zondag & Pieters, 2005) will be integrated in different units.

For the historical development unit, the town centre, the emphasis could be on the historical connection with the railway lines. Improving public space and roads, for easy access and ensuring a pedestrian-friendly environment. The Garden suburb unit had historical connection with the previous Tamaki station, work could be done to enhance the pedestrian-friendly travel from the residential area to the railway station. The western residential and suburban expansion units could focus on intensification.

The railway line unit which based on the PC78, has no change proposed. This area could be focused on having denser mixed-use development around the railway station, as there are many publicly owned land available which many of them currently used for open-air parking. Developing homes, employment, and supporting retail as well as other services immediately adjacent to, if not directly above the railway station. The roads need to be improved for easy pedestrian use and cycle and connecting to the other units in this walkable catchment area, to create a highly connected spatial layout to supplement TOD. To minimise the negative effect of rail tracks and maximise the development TOD neighbourhoods to accommodate people with various social status's desire of living in a TOD neighbourhood (Olaru et al., 2011).

CONCLUSIONS

Applying a morphological perspective to TOD study is important, as the physical form of TOD greatly influences its success. By following a morphological approach to TOD, continuity can be retained and enhanced, and local characteristics preserved, leading to a more successful development around railway stations. This paper examined the evolutionary process of Panmure railway station 15minute walkable catchment area. The distinct characteristics of each morphological period were identified by reconstructing the historical ground plan, analysing how the past influences the present, and determining the factors that future planning needs to consider by tracking the continuous transformation of form from one period to another.

Subsequently, the identification of morphological units can support future planning and design decisions, ensuring that the developmental process is incorporated into the morphological research and the planning and design guide (Gu, 2014). The resulting findings and the recommended strategies for each unit type contribute to research and planning practices aimed at recovering a sustainable urban form in the railway station catchment area.

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A study of residential block patterns conducive to public transport accessibility: taking Nanjing as an example

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ABSTRACT

Most residential areas in China are closed communities. The distance from residential units to public transportation stations increases due to the influence of neighborhood patterns. By assessing the extent to which different factors, such as community shape, area, entrances, and road networks, affect residents' public transportation usage, theoretical support can be provided for optimizing the design of residential neighborhoods. Using three residential blocks in Nanjing, China as samples, GIS was employed to calculate the shortest distance from each residential building in the neighborhood to the nearest subway station. The straight-line distance and detour index for each Origin-Destination (OD) path were calculated. On the other hand, the morphological factors of each neighborhood were analyzed, and a Pearson correlation analysis was performed to determine the relationship between the shortest distance and morphological factors. The results show a strong positive correlation between the shortest internal distance in a neighborhood and the area and perimeter of the neighborhood, and a significant negative correlation with entrance density.

Keywords: residential block, unit neighborhoods, morphological relation, public transportation route

INTRODUCTION

Residential areas serve as the starting or ending points of daily commutes for urban residents. The path length and comfort level significantly influence whether residents choose to walk. In Singapore, where walking and public transportation are well-developed, it is stipulated that 8 out of 10 households should be within a 10-minute walk to a metro or light rail station. In China, the establishment of subway stations strives to accommodate the needs of residents within a ten-minute living circle. However, Chinese residential areas, influenced by construction periods and policies, are often enclosed communities with varying shapes and sizes. Research has shown that enclosed communities have a significant impact on pedestrian paths through actual pedestrian tracking and network simulation comparisons (Sun et al., 2020). Current scholarly research indicates that, typically, grid-like street patterns are the most conducive to pedestrian traffic, while curvilinear layouts are the least (Sandalack et al., 2013; Cheng, 2017). However, the intricacies of residential block networks in

China are notable, with significant variations across different periods. This complexity arises from a multitude of factors, including the urban road network, the configuration of entrances and exits in both closed and open neighborhoods, and the internal road systems within closed neighborhoods. To date, there has been an absence of comparative studies examining the walking distances to public transit stops, the extent of detours, and other related metrics for residential neighborhood patterns that have emerged during the different periods. Therefore, analyzing the correlation between residential area form factors and the paths from building units to metro stations is crucial in distinguishing factors that promote public transportation usage.

This paper compares three residential blocks from different periods (Figure 1): Suojincun (1980s), Longjiang (1990s-2000s), and Aoti (2010s), observing the differences in path performance and detour situations to identify factors that support public transportation use.



Figure 1. Case selection: three residential blocks from different periods of time.

LITERATURE REVIEW

Neighborhood Plane Patterns in Different Era

In the 1980s, residential planning in China began to introduce comprehensive development methods, but the planning and design system was not yet mature, resulting in neighborhoods of varying sizes. The development of residential areas in China during the 1980s can be divided into two phases: 1980-1984, during the early stages of reform and opening-up, and 1985-1990, under a planned commodity economy system. During the early phase (1980-1984), most residential areas were built as welfare housing to address housing shortages. Company-built housing was the dominant form of construction, and Suojincun, the first case in this study, belongs to this category. In the later phase (1985-1990), residential areas were built during the transition from welfare housing to commercial housing. These

neighborhoods reflect the exploration and transition toward the commodification of housing (allowing real estate business operations). After 1984, various county- and city-level development companies in Nanjing were established, marking a gradual shift towards a planned commodity economy in the housing market. At that time, Nanjing adopted a "dual-track system" of both distribution and commodity housing to gradually transform the urban housing allocation system from low-rent state-owned housing to a commodity-based system (Wang, 2021).

In the 1990s, with rapid socioeconomic development, China embarked on the "Research on Urban Residential Housing for a Moderately Well-off Society." Residential layouts underwent significant changes during this period. As the commercial housing market emerged, residential construction expanded in scale, and high-rise buildings became more prevalent, resulting in more complex spatial layouts. Linear layouts remained the mainstream, but enclosed and point-type layouts began to be widely used. Residential planning also became more focused on human-centered design, incorporating more public activity spaces, optimizing traffic flow, and increasing green coverage to meet the growing residential needs (Kai, 2009).

Entering the 21st century, as cities expanded, new residential neighborhoods were developed through urban design, creating more regular block patterns. Neighborhood blocks became smaller in horizontal scale, while building heights increased. Public facilities, green spaces, and other amenities became more abundant, contributing to unique plane patterns, such as circular driveways and fire lanes.

Existing research has summarized the urban texture and contours, classifications of neighborhood road networks, patterns of street grids and block divisions, and the formation of neighborhood forms based on walled-and-gated systems. These studies highlight the impact of walled-and-gated systems on travel routes, and various indicators, such as shape index and road depth, have been used to quantify neighborhood forms. These studies support the classification of neighborhood plane patterns and the layout of public transportation stations (Zhao, 2015; Zhang, 2022; Wu, 2017; Ma, 2019; Li, 2020; Zhang et al., 2023).

Residential Road Network

Scholars at home and abroad often classify road network patterns based on shape characteristics and explore the features of different road network patterns in terms of traffic connectivity, safety, and land use vitality. McCluskey, J. (McCluskey, 1992) summarized road network patterns into four types: serial, radial, branch, and grid. Cai Jun (Cai, 2008) categorized road networks by their graphical features, including grid patterns, radial plus ring patterns, and grid plus radial patterns. Kang Wangquan (Kang et al., 2016) further classified residential road networks into grid, tree-like, closed loop, and "Poundbury" patterns. Previous studies have shown that grid-like road net-works with high connectivity (permeability) result in the highest travel efficiency, whereas curved roads lead to the opposite. However, public transportation efficiency, beyond just the road network, depends largely on land use mix and traffic structure. Various studies have analyzed the relationship between residential neighborhood pat-terns and public transportation trips, confirming that neighborhood patterns do affect public transportation use (Zhao et al., 2021; Sandalack, B. A et al., 2013; Cheng, 2017; Hajrasouliha and Yin, 2015; Peng, 2014; Wu, 2017; Zhang, 2022; Liang, 2022).

The current state of residential road networks in China generally presents the following structure: major and secondary roads divide large residential blocks or districts, while secondary and side roads divide unit neighborhoods (smaller residential areas). Roads within these neighborhoods often serve as internal roads, connecting to the city's main or secondary roads through 2-3 entrances. The structure of residential road networks thus simplifies into two levels: the road network between unit neighborhoods established by the urban road system, and the internal road network of each unit neighborhood and its connection to the external urban road network (Zhou and Qian, 2017).

METHOD

Model construction

To quantitatively study the relationship between residential neighborhood pat-terns and transportation routes, a GIS model was established based on the available data for the selected residential areas. The selected cases are urban blocks divided by major and secondary roads or natural barriers, with the land use within the plots primarily for residential purposes. The model uses urban arterial roads as its framework, including the road networks within the case study areas and their surroundings, as well as subway stations, gated community entrances, and the distribution of residen-tial building entrances.

In the simulation process of the GIS urban model, residential buildings are used as event trigger points, and subway station entrances are used as target points to find the shortest path. The choice model presents a relatively simplified representation of real-world travel decisions, operating as an idealized model. Due to the specific impact of China's gated community system, a single residential block may contain multiple unit neighborhoods. In most cases, the path choice is affected by the presence of gates (either the gate of the resident's community or those of other communities), leading to detours. Thus, an OD cost matrix is used to calculate the OD distance between each path, further calculating the detour index for each path. Through these steps, the shortest distance and detour index from each building to the nearest subway station can be obtained, allowing for the evaluation and analysis of the subway

Indicator statistics

To study the factors influencing the shortest distance from residential units to subway stations, the following table 1 lists potential influencing factors. Both online and offline research methods were used to collect relevant data for the three sample residential blocks—Suojincun, Longjiang, and Aoti—including information such as area, shape, entrances, intersections, and their correlation with public transportation use(Figure 2). For convenience, each factor is represented by simplified notation in the text.

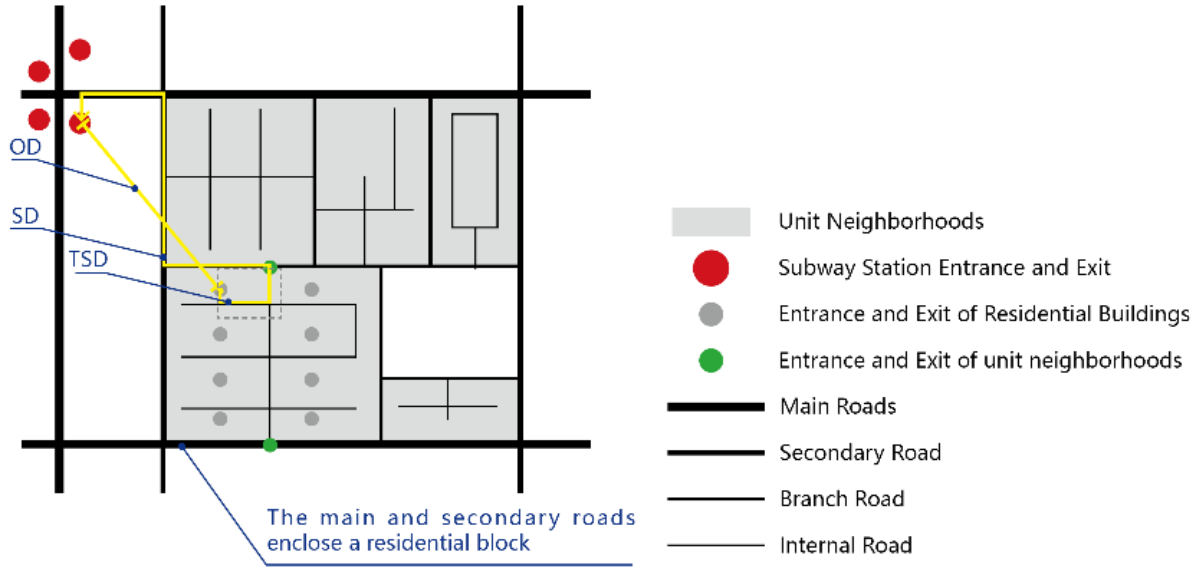

Figure 2. Possible Morphological Influences Graphic Supplement.

Table 1. Possible influences on neighborhood morphology of the shortest distance from residential buildings to subway stations.

Factor	Notation	Definition	Formulas
Shape Length	L	Shape length of unit neighborhoods	/
Shape Area	A	Shape area of unit neighborhoods	/
Shape Index	SI	the index of how much shape deviates from the circle.	$SI = \frac{L}{2\sqrt{\pi A}}$
Number of Entrances and Exits	NE	Intersections points of internal unit neighborhoods roads with public roads	/
Density of Entrances and Exits	DE	Number of entrances and exits for average area in unit neighborhoods	$DE = \frac{NE}{A}$
Total Length of Road Network	RL	Total length of roads within the unit neighborhoods	/
Road Density	RD	Length of road network for average area in unit neighborhoods	$RD = \frac{RL}{A}$
Number of Road Network Intersections	NIR	Number of intersection of two or more roads within a unit neighborhoods	/
Density of Road Network Intersections	DIR	Number of Road Network Intersections for average area in unit neighborhoods	$DIR = \frac{NIR}{A}$
Shortest Distance to Subway Station	SD	Shortest distance routes from building entrances to the nearest subway station under the influence of other unit neighborhoods gatedness	/
Shortest Distance to the Subway Station (Part of the Residential Blocks)	TSD	the part of SD inside the unit neighborhoods	/
Linear distance between Origin and destination	OD	Linear distance between Origin and destination	/
Pedestrian Route Directness	PRD	Indicates the directness of the pedestrian path	$PRD = \frac{OD}{TSD}$

Pearson correlation analysis

The Pearson correlation coefficient (r-value) ranges between -1 and 1 and is used to represent the strength and direction of a linear relationship between two variables. The closer the absolute value of the correlation coefficient |r| is to 1, the stronger the linear relationship between the two variables;

the closer it is to 0, the weaker the relationship. The significance level (P-value) is used to determine whether the correlation between two variables is significant. If the P-value is less than 0.05 (or 0.01), the correlation between the two variables is significant, meaning the null hypothesis (that the two variables are uncorrelated) can be rejected. If the P-value is greater than 0.05, the correlation between the two variables is not significant, and the null hypothesis cannot be rejected. In this paper, "" is used to indicate significant P-values: "" means the P-value is less than 0.05, and "**" means the P-value is less than 0.01.

DATA

Data sources

The data in this paper come from two main sources. The first is the GIS model data, which includes both the initial input data and the calculated data. Due to the difficulty of obtaining urban data, the basic data for the model was sourced from various places: the building and road network structures were derived from processing Baidu map files; the subway station coordinates used were obtained from Gaode maps; some gated community entrance data came from field research and CAD drawings. Using this data, the GIS model was constructed to calculate values such as SD, TSD, and PRD for the three samples. The second source is a list of correlation factors com-piled from field research and online data, as shown in Table 1.

Data processing

For data analysis, two levels of analysis were conducted: overall analysis (SD and PRD) and unit-neighborhood-level analysis (the relationship between TSD and other factors).

SD and PRD data processing

The GIS model was used to calculate the SD and PRD values for each residential building in the three samples, and the results were color-coded (Figure. 3). The gray lines represent the road network framework, and the black lines represent the key factors influencing public transportation trips: time and distance. To simplify calculations, a five-minute walking time was converted to a 400m walking distance, and a corresponding ten-minute walking time was set to 800m. In Figure 3, the unit neigh-borhoods data is layered with the building-level data. If the residential buildings within the unit neighborhoods are at the same level, the two will completely overlap; otherwise, the buildings will display different color scales on the unit neighborhoods map. This diagram shows that, depending on the unit neighborhoods 's shape, each building's SD can vary significantly.

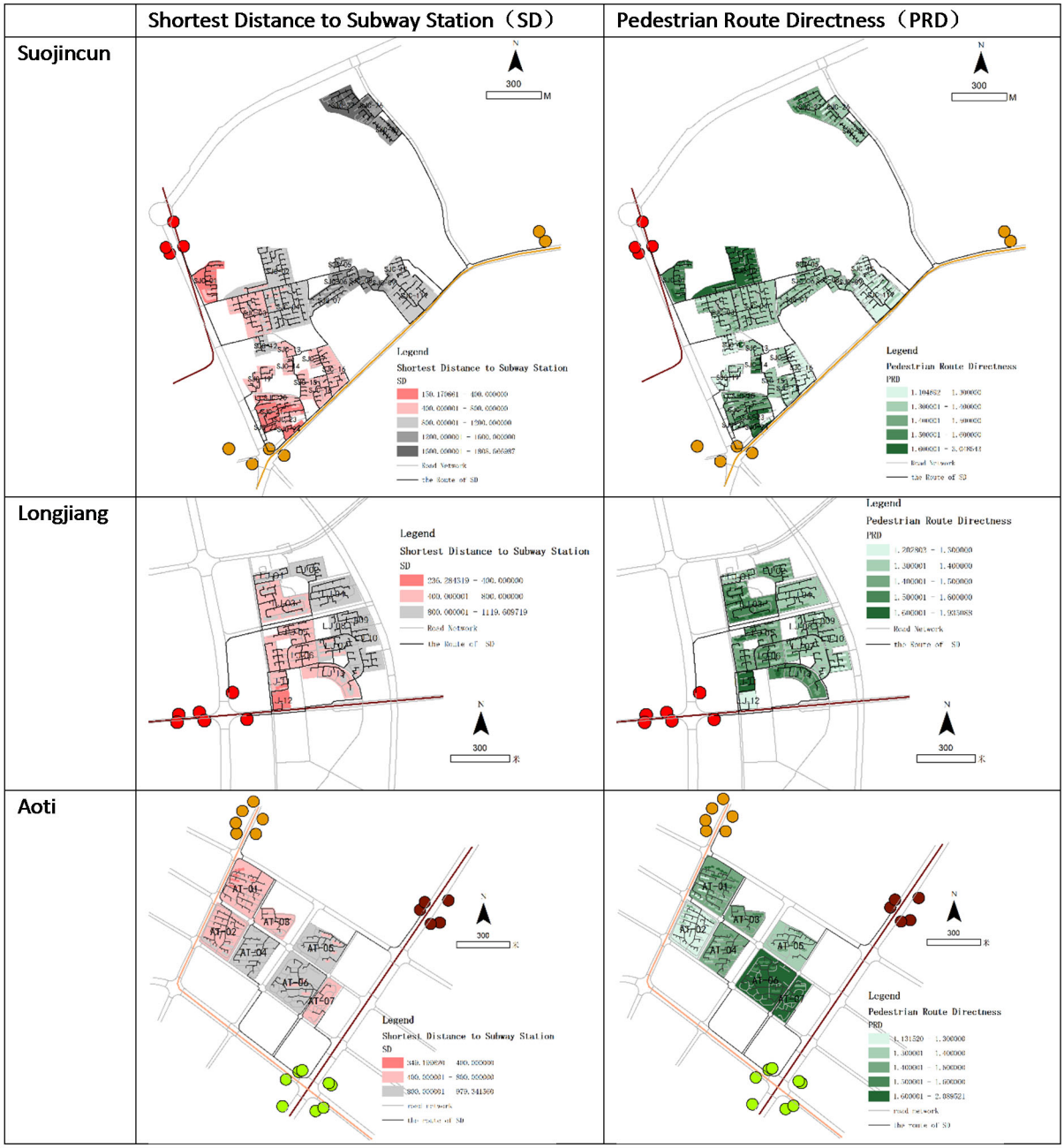

Figure 3. Visual representation of shortest distance SD and pedestrian route directness for three cases based on unit neighborhoods

To obtain more accurate data, the SD and PRD for the three samples were categorized into threshold percentages (Tables 2).

Table 2. SD and PRD statistics.

	Number of buildings	SD < 800	SD <800(%)	PRD <1.2	PRD < 1.2(%)	PRD>1.5
Suojincun	323	131	40.56%	12	3.72%	67
Longjiang	102	43	42.16%	0	0.00%	21
Aoti	106	62	58.49%	4	3.77%	24

TSD correlation data processing

At the unit-neighborhood-level, the aim was to determine the factors affecting the shortest distance (TSD) within the unit neighborhood. Therefore, from the indicators listed in Table 1, ten factors were selected for analysis: L, A, SI, NE, DE, RL, RD, NIR, DIR, and TSD. Pearson correlation analysis was conducted, and the results are shown in the heatmap (Figure. 4).

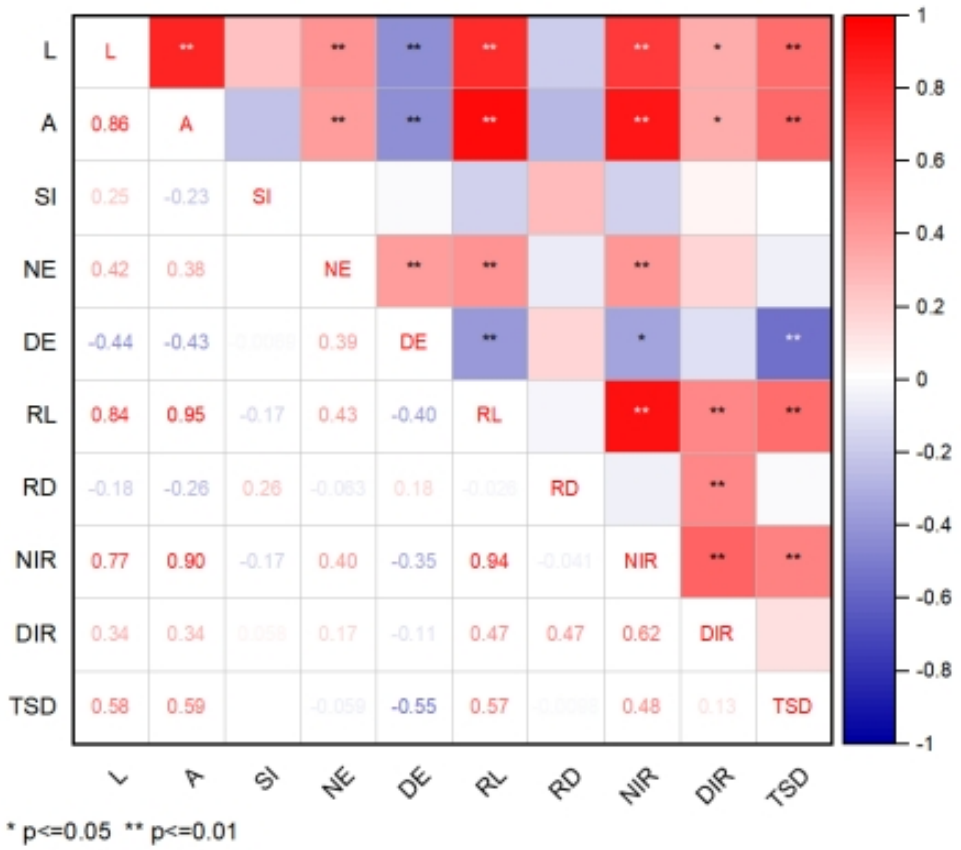

Figure 4. Graphical representation of Pearson correlation analysis

RESULTS AND DISCUSSIONS

Holistic analysis

Comparing Figure 3 and the SD and PRD values between samples, the following conclusions can be drawn: First, the relative location of unit neighborhoods to subway stations within a residential block has a significant impact on SD. This is more evident in large residential blocks. For example, in the Suojincun case, the closer a unit neighborhood is to the main roads and subway stations, the shorter its SD. Second, within the same unit neighborhood, SD between different buildings can also vary due to the road network pattern. Third, a major reason for the large SD and PRD values may be that the outer parts of residential blocks, defined by major and secondary roads, are primarily occupied by office and commercial buildings, which forces detours within the residential buildings. Fourth, it can be preliminarily concluded that the more entrances and stations there are, the more route options residents have, which can reduce SD to some extent. Additionally, the location of entrances is also important, particularly whether they are near the main roads leading to the subway stations.

From the data in Tables 2, the percentage of buildings within the sample neighborhoods that can reach the nearest subway station within ten minutes (800m) is 40.56%, 42.16%, and 58.49%, respectively. The percentage of PRD values within 1.2 (indicating a more direct walking path) is 3.72%, 0%, and 3.77%. The percentage of PRD values exceeding 1.5 (indicating significant detours) is 20.74%, 20.59%, and 22.64%. Based on these findings, the following conclusions can be drawn: First, none of the three sample neighborhoods meet the defined "ten-minute subway living circle" (800m) standard in China, nor do they meet Singapore's standard (where 8 out of 10 households can reach a subway station within ten minutes), and there is still a considerable gap from this standard. Second, disregarding the number of subway stations, the three cases show that SD tends to increase with the area size of the unit neighborhoods. In some cases, the unit neighborhoods are located inside the residential blocks, requiring significant internal travel. Third, PRD values show less overall variation but significant differences within individual unit neighborhoods.

Unit neighborhoods level analysis

Graphical explanation

From Figure 4, we can observe that the lower-left values represent the r-value, where |r| closer to 1 indicates a stronger correlation. The upper-right colors, red and blue, respectively, indicate positive and negative correlations, while "*" represents significant P-values. The figure shows that L, A, DE, RL, and NIR all have P-values smaller than 0.01, indicating significant correlations, while RD and DIR do not show significant correlations.

Conclusion verification

The figure shows that TSD has the highest r-values with neighborhood area and perimeter, at 0.59 and 0.58, respectively, and both are immutable factors. On the other hand, other factors, such as road network length (RL) and the number of intersections (NIR), may increase with area size. Therefore, L and A are identified as significant factors correlated with TSD. Due to the significant differences in area sizes among the sample unit neighborhoods, the correlations of RL, NIR, and DE with TSD need to be further verified. By sorting the sample data by area size (A) from smallest to largest and overlaying L, RL, NIR, and DE line graphs (Fig. 5), we can see that the L, RL, and NIR curves closely follow the area size curve, while DE shows a different trend as area increases. This may be due to the mutual influence of variables. The figure indicates that RL and NIR are significantly positively correlated with L and A. As unit neighborhood area increases, road network length and the number of intersections also increase, and TSD increases accordingly. The variables are interrelated, so a simple correlation between any two cannot be established. In fact, the correlation between TSD and RL/NIR is actually due to the correlation with area (A). Thus, it can be concluded that the shortest distance (TSD) within a neighborhood is significantly correlated with Shape Length (L), Shape Area (A), and Density of Entrances and Exits (DE).

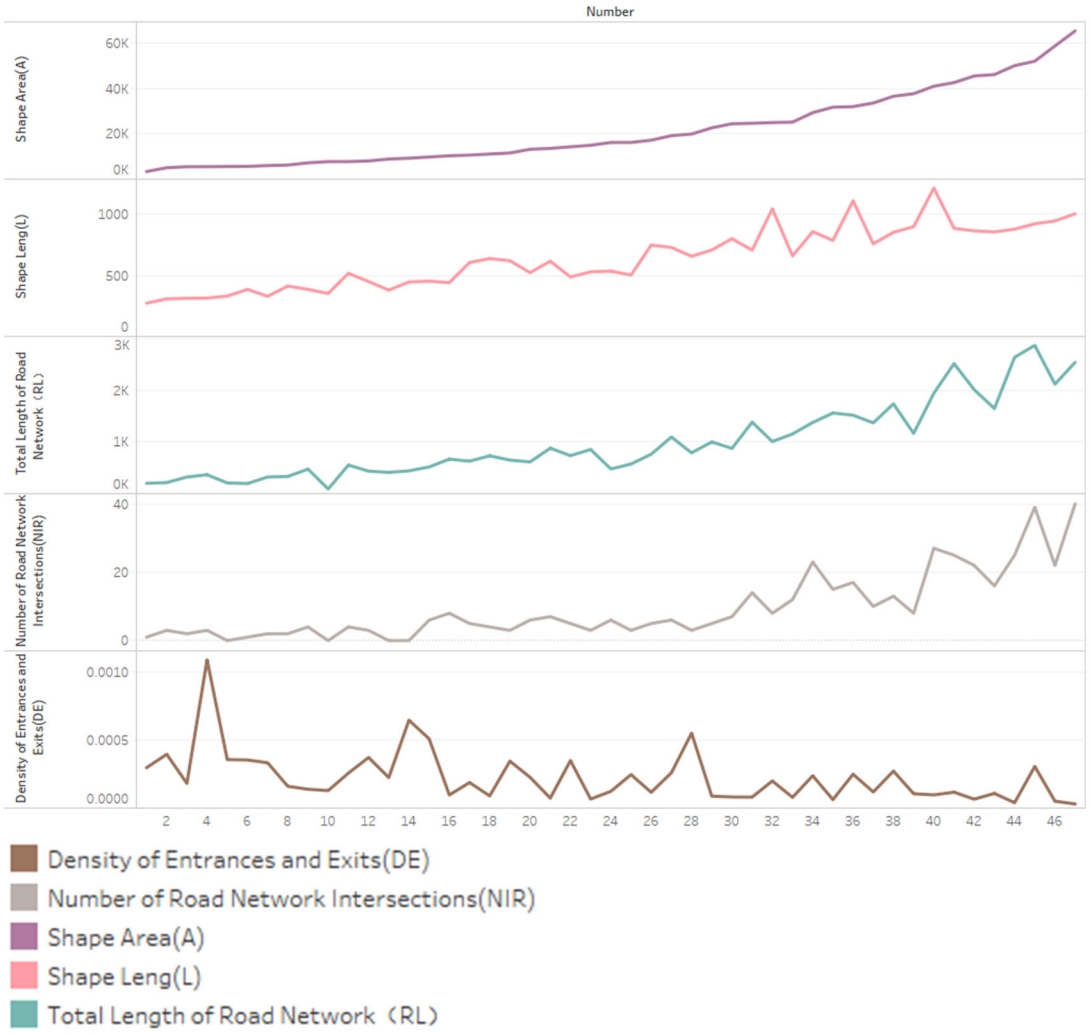

Figure 5. Distribution of L,RL, DE,NIR data in ascending order of shape areas （A）.

This study explored the relationship between subway travel paths and neighborhood morphological pattern, proving that neighborhood shape has a significant impact on residents' subway travel paths, specifically in terms of entrance density, shape, and area. this study further compares and quantifies potential influencing factors (such as entrances, shape, area, and road network density). This study found no significant correlation between the shortest path (TSD) within a unit neighborhood and road network density or intersection density. The reasons for this may be: First, statistical errors. Some non-residential buildings within the unit neighborhoods were excluded, leading to an overestimation of some areas (A), while the road network only included paths to residential buildings, possibly causing some errors. Second, certain special cases in the sample may not have been excluded, causing interference.

CONCLUSIONS

This study analyzed the relationship between residential neighborhood patterns and public transportation access, focusing on three residential blocks in Nanjing, China. By constructing a GIS model to calculate the shortest distances (SD) and detour indices (PRD) from residential buildings to subway stations, we identified key factors influencing public transportation usage in closed

communities. The findings reveal that the area and perimeter of residential neighborhoods have a significant positive correlation with the shortest distance (TSD) to subway stations. Larger neighborhoods, especially those with complex internal road networks, tend to require longer walking distances. Additionally, the density of entrances and exits (DE) has a significant negative correlation with TSD, meaning that increasing the number of entrances and exits can reduce travel distance and promote better public transportation access. However, the presence of gates in China's gated communities often forces detours, which negatively affects walking routes. The results suggest that optimizing the spatial layout of neighborhoods, particularly by increasing entrance density and improving internal road networks, can enhance residents' access to public transportation. These findings provide practical insights for urban planners and policymakers to promote public transportation usage and improve neighborhood designs for more efficient pedestrian travel.

However, the study also revealed some limitations. The GIS route choice model used in the simulation simplifies real-world pedestrian behaviors, as it does not account for factors such as comfort, infrastructure, or personal preferences. In reality, pedestrians may choose routes based on factors beyond just the shortest distance. Additionally, because the study was conducted using actual residential areas with varying characteristics, inter-neighborhood differences may have influenced the results, introducing potential errors. The mutual influence of different factors, such as area size and road network length, further complicates the analysis. To address these limitations, future research could incorporate virtual samples to control for specific variables and isolate their effects on public transportation usage. Additionally, conducting real-world surveys and comparing them with model simulations would provide a more comprehensive understanding of pedestrian behaviors and their relationship to neighborhood design. In conclusion, this study provides valuable insights for urban planners and policymakers. By optimizing the spatial design of residential neighborhoods—particularly by increasing entrance density and improving internal road networks—public transportation usage can be promoted, contributing to more sustainable and accessible urban environments.

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Cooling outdoor spaces around elderly housing

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ABSTRACT

Due to the global temperature rise and heat island effect, urban heat is expected to increasingly have consequences for both health and liveability of urban inhabitants, particularly among vulnerable groups such as elderly with less financial means. Although research has been conducted on urban heat and related human thermal stress, more research is needed for the elderly demographic group. This research investigates which design interventions are effective in decreasing outdoor heat stress around social housing for elderly in the urban context of Amsterdam, the Netherlands. The findings of this study have practical implications for decision-makers and contribute to building a methodology for recognizing and mitigating human heat stress for vulnerable groups. Three exemplary cases of buildings for elderly in heat-prone areas were selected. In a first phase, the microclimate was simulated with the use of ENVI-met for a representative hot day, followed by the PET (Physiological Equivalent Temperature) modelling in BIO-met. The analysis of resulting climatic values (air temperature, radiation, humidity, and wind) investigated their contribution to heat stress. In a second phase, mitigation measures were selected based on the probable main cause of heat stress and assessed on their efficiency through simulations. The results suggest that 1) outdoor spaces connected to social housing buildings in Amsterdam suffer extreme heat stress during heatwaves; 2) punctual interventions around buildings are insufficient in decreasing heat stress of elderly. Finally, the study discusses the need for systemic mitigation strategies and fundamental role of morphological characteristics.

Keywords: outdoor heat stress, cooling measures, urban morphology, elderly, Amsterdam

INTRODUCTION

Urban heat stress and health

Due to the global temperature rise, the increasing frequency and intensity of heat waves, and urban heat island effect, outdoor and indoor overheating are expected to have significant consequences on the physical environment and the health, liveability and well-being of the urban population (Aghamolaei and Lak, 2022; Antoniou et al., 2024; Yung et al., 2019). Elderly, defined as people with an age greater than 65 years (CBS, 2023), are among the most vulnerable to climate-related diseases.

Their vulnerability is due to their decreased metabolic rate and cognitive functions, malfunctioning of neurosensory systems and thermoregulation, delayed responses to health risks and side-effects of medication that most elderly people use (Aghamolaei and Lak, 2022). Additionally, elderly are often facing difficulties finding adequate thermal conditions in their houses and neighbourhoods. This problem is exacerbated for those living in social housing, who have limited financial resources to afford active cooling or recover from the consequences of heat damage (Gemeente Amsterdam, 2020b). Both indoor and outdoor heat stress can cause a range of health problems, including thermal exhaustion, heat stroke and headaches, as well as severe breathing problems and aggravation of cardiovascular, respiratory, and cerebrovascular diseases (de Nijs et al., 2019; Pijpers-van Esch, 2015). Climate-related diseases result in over 150,000 deaths each year worldwide and 250 deaths in the Netherlands (RIVM, 2021). At the start of 2019, Amsterdam counted 108,000 elderly, however by 2039, this number is projected to increase by 68%, bringing the elderly population to 181,000 (Gemeente Amsterdam, 2022). With temperatures rising and the population of elderly growing in proportion to the total population, heat-related deaths are likely to increase (Aghamolaei and Lak, 2022).

Amsterdam, among other cities, is already working to develop effective climate action plans and create comfortable outdoor and indoor environments, to minimize the impact of urban heat on health and well-being of vulnerable elderly (Gemeente Amsterdam, 2021; Gemeente Amsterdam, 2024). Although catalogues and toolkits (Lenzholzer, 2010; Pijpers-van Esch, 2015; Osmond and Sharifi, 2017; Klemm, 2018; Kluck et al., 2020; Snep et al., 2021; Mounayar and Florentin, 2022) have been advanced in recent years offering comprehensive lists of solutions to mitigate heat stress, insufficient guidance is offered to designers and planners for selecting and tailoring measures for specific urban contexts. Studies have demonstrated the negative impact of urban heat stress on general urban inhabitants (Antoniou et al., 2024,) and the relation between morphological characteristics and thermal comfort (Maiullari et al., 2021; Peng et al., 2022). However, few studies address socio-economic factors (Indraganti and Rao, 2010; Yung et al., 2019). More specifically, there is little research related to improving urban microclimates for social housing and elderly groups in metropolitan areas. Therefore, to address this gap, the primary objective of this study is to identify which interventions are most effective in reducing heat stress in outdoor spaces in the context of Amsterdam. The paper will focus particularly on overheating risks of spaces frequently used by elderly groups, guided by the question "Among green facades, tree shade, and fountain misting, which urban design interventions are effective in mitigating outdoor heat stress around social housing for the elderly in Amsterdam?".

First, the paper describes potential cooling measures for reducing heat stress. Second, the urban context of Amsterdam and the three selected case studies are described. Following, the methodological steps taken to conduct the research are explained. Finally, the results are presented and discussed, followed by conclusive reflections.

Reducing urban heat stress

Thermal comfort, generally defined as the subjective feeling of thermal satisfaction, is influenced by multiple climatic factors (such as air temperature, radiation, humidity, air movement) (Nasrollahi et al., 2020) and personal factors (clothing, metabolic rate and activity level) (ASHRAE, 1992). Since urban microclimate is influenced by elements of the built environment, namely the city's morphology, materialization and landscaping, interventions on morphological and material characteristics can play a major role in mitigating heat and consequent thermal discomfort (see table 1). For example,

interventions on the form of buildings and urban fabric configuration can potentially influence air temperature by increasing shaded areas and guiding air flows, while increasing green coverage and using materials with high albedo would influence reflection of short-wave radiation and humidity levels (Kluck et al., 2020; Mounayar and Florentin, 2022; Pijpers-van Esch, 2015). While sometimes it's most efficient to combine multiple interventions, the findings of Arrar et al. (2024) indicate that in some cases this practice does not significantly improve the cooling effect and is less feasible compared to single measures.

One well-established urban cooling measure is to increase the vegetation cover. For social housing, Snep et al. (2021) concludes that vegetation is an effective and feasible option to tackle heat stress in outdoor spaces. Of all types of vegetation trees are most effective on thermal comfort (Kluck et al., 2020). Tree cover has a large impact due to evapotranspiration and intercepting short- and long-wave radiation at crown level (Lenzholzer, 2010; Pijpers-van Esch, 2015). Tree shading ensures that the direct short-wave radiation reaching surfaces (pavements, walls, and roofs) and the human body is 10 times smaller (Kluck et al., 2020). According to Klemm (2018) 10% tree coverage in a street profile reduces the temperature with 1.0 K. However, a downside of trees is that the air flow reduces due to the increased roughness of the urban landscape (Osmond and Sharifi, 2017).

A second measure is the implementation of green surfaces, grass cover as well as green facades. To reach the optimal cooling potential grass areas need to remain well-irrigated and can be combined with tree cover. For green walls, the air temperature reduction is in the immediately adjacent outdoor spaces (Osmond and Sharifi, 2017). Green facades are especially interesting cooling measures in dense cities, as they can be particularly effective in narrow streets (Kluck et al., 2020).

Another way to cool through evaporation, is the implementation of water elements. Fountains are effective cooling devices for small-scale urban spaces according to Kluck et al. (2020). Optimal evaporative cooling can occur with the aid of natural wind flow. When implementing evaporative-cooling interventions, one should bear in mind that the relative humidity is recommended not to pass 50%, because this will negatively impact perceived thermal comfort (Osmond and Sharifi, 2017).

Table 1. Measures to reduce urban heat stress.

Mitigation measures	**Cooling processes**	**Maximum temperature reduction (Osmond and Sharifi, 2017)**	**Potential PET reduction (Kluck et al., 2020).**
Green facade	Evaporation: cooling of surface temperature and air temperature	Surface temperatures: 5-15°C Air temperature: 2°C	unknown
Trees and Grass cover	Shading and evaporation: cooling of surface temperature and air temperature	Surface temperatures: Grass cover: 15°C, Tree shading: 15°C Air temperature: Combination tree + grass: 1 - 2°C	Trees: 0,4 - 4,9°C Grass: 0,4 - 4,9°C
Fountain misting	Evaporation: cooling of air temperature	Air temperature: 3 - 8°C	1,0 - 5,0°C

The case of Amsterdam

As previously mentioned, Amsterdam is selected as case study in this research. The climate adaptation plan (Gemeente Amsterdam, 2021) has clearly stated the priority to create comfortable outdoor and indoor environments, minimizing the impact of urban heat on health and well-being. To achieve this goal, the municipality is exploring new guidelines, with a particular focus on vulnerable locations such as childcare and nursing homes. Some research has already been conducted to formulate specific

analyses and guidelines for heat mitigation (Kluck, Klok, et al., 2020). Other studies have provided data by aggregating historical heatwave data using maximum Physiological Equivalent Temperature (PET) values from past decades (Klimaateffectatlas, 2023). Our preliminary analysis based on this dataset (figure 1), shows that almost all areas within the municipal administration of Amsterdam exhibit high PET values exceeding 35°C, indicating strong heat stress, with the old inner-city showing higher PET values of 41°C, indicating extreme heat stress.

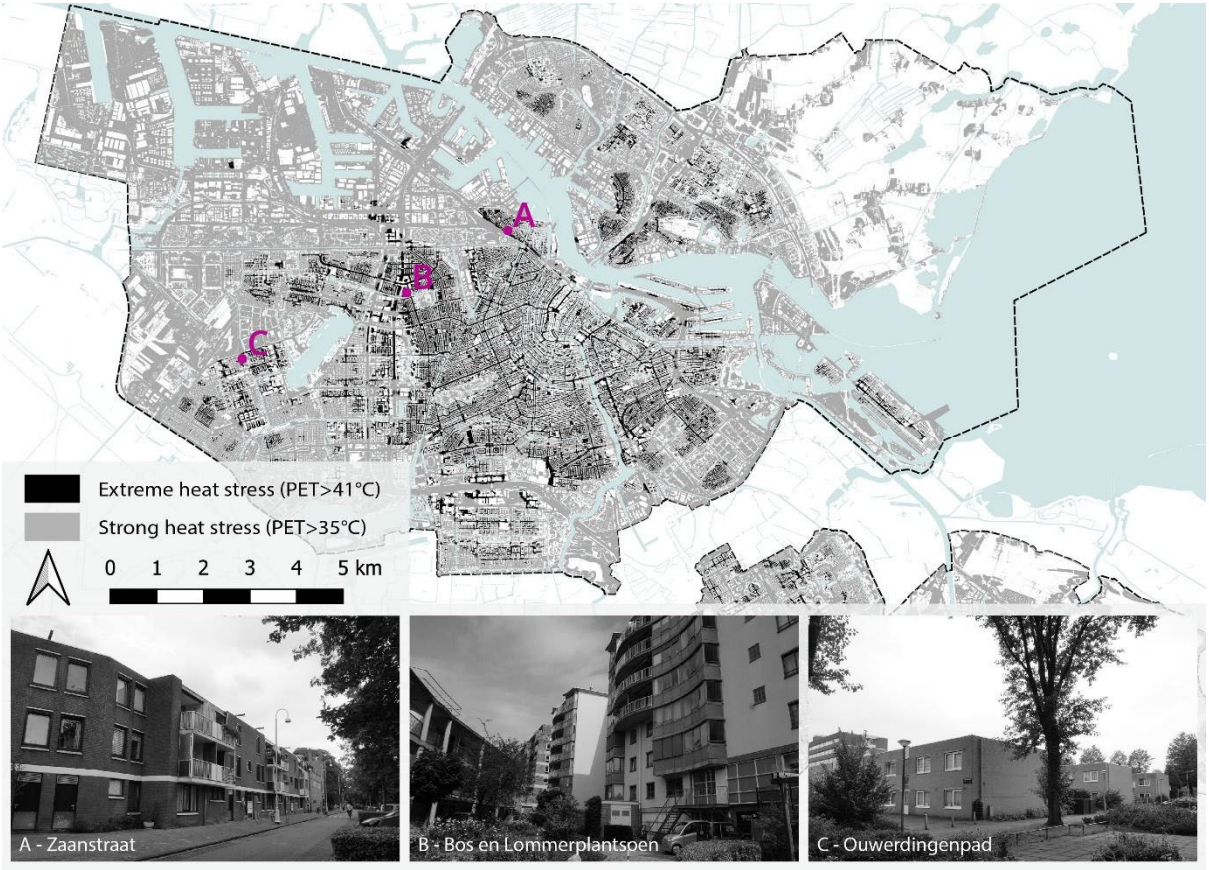

Figure 1. Strong heat stress (PET>35°C) and Extreme heat stress (PET>41°C) (based on: Klimaateffectatlas, 2023)

This city-scale heat stress analysis combined with socio-demographic data (CBS, 2021; AFWC, 2022) reveals that many elderly communities are located in heat-prone areas. For this study, the three most representative neighbourhoods with the top three highest number of elderly in social housing and percentage of the outdoor space exposed to extreme heat stress were selected.

METHOD

In order to provide insight into which urban design intervention is effective in mitigating outdoor heat stress around social housing for elderly, the research was structured in four consecutive phases (see figure 2).

First, spatial and climate data were collected for the three selected locations. On this base, input data for microclimate modelling were prepared: 1) Digital spatial model (area input files) with a 3m grid. 2) Material database including building materials, soil types and vegetation and 3) Weather data. In the second phase microclimate simulations of the status quo were carried out using ENVI-met and BIO-met. Results allowed us to analyse PET and its key climate components, such as air temperature,

radiation, humidity, and wind, to determine the main locations for heat stress interventions and climatic components to address. In the third phase, microclimate simulations were carried out for the three locations after including the selected heat stress mitigation measures (green facades, tree shading and water misting). Finally, for each location, a comparative analysis was carried out to evaluate the reduction of PET for different age groups (35-year-olds and 80-year-olds).

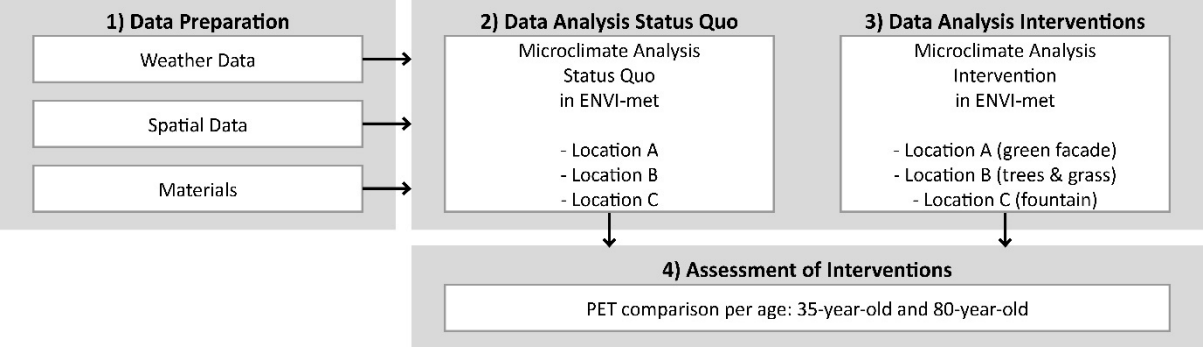

Figure 2. Methodology scheme

Data preparation for microclimate simulations

To model the microclimate in ENVI-met and subsequently, thermal comfort in BIO-met, spatial, and weather data were retrieved from national datasets. Specifically, for building the spatial model of the three locations data were retrieved for buildings, surfaces, and vegetation. For the morphological analysis on the neighbourhood scale the Local Climate Zones (LCZ) framework was employed. The buildings' geometry properties (height [m], footprint [m^2], etc.) were retrieved from the Kadaster database of the Netherlands (Kadaster, 2023). Vegetation cover, geometrical characteristics of trees (height, crown diameter) and plant types were retrieved from city datasets (Atlas Leefomgeving, 2020a; 2020b; Gemeente Amsterdam, 2020a). Existing datasets were enriched through the reporting of surface and building materials based on Google Satellite and Google Street View. For vegetation, soils and building materials the project mainly used the ENVI-met system database.

The Area Input File for ENVI-met was structured based on an equal grid size of 3m (x,y,z). In the previous GIS analysis, a 50m buffer from senior houses was created. To cover the entire buffer surface the extent of the area input file was 300m x 300m each. For the interventions simulation the same area file was used as the status quo, with only the cooling measure as alteration. At location A green facades were applied, at location B trees and grass were implemented and at location C a fountain was introduced, and the trees were replaced with smaller less dense trees.

Climate data were retrieved from the closest KNMI weather station at Schiphol Airport (KNMI, 2023). Since heat stress frequently occurs in summer, especially during heatwaves, the recent heat wave in August 2022 was selected. The warmest day of this heatwave, the 12th of August (KNMI, 2022) and the previous day were simulated by using KNMI data as climate boundary conditions with a Simple Forcing setting. Specifically, hourly values of air temperature and relative humidity were forced, while wind speed was set at the average wind speed of the day (4 m/s) with the predominant wind direction (55°).

Microclimate analysis of status quo and interventions

The air temperature, mean radiant temperature, direct short-wave radiation, humidity, wind speed and wind direction were modelled with ENVI-met and the physiological equivalent temperature (PET) for a 35-year-old male and for an 80-year-old male were modelled in BIO-met. BIO-met simulates the PET "based on the Gagge-2-node model, it relates skin and core temperature generated by the outdoor environment to the indoor air temperature resulting in the same temperatures. The calculation is based on stationary conditions (no movement through the environment)." (ENVI-met Applications Homepage, 2024). The calculation is based on a "standard human according to ISO 7730" (ENVI-met Applications Homepage, 2024). For both ages, the metabolic rate differed, while other parameters such as clothing factor remained the same. Finally, the cooling effect of the implemented measures was further analysed by using the following formulas (table 2).

Table 2. Measurements to assess cooling effect

Scale	Measurement	Formula
Block	Maximum difference PET [K]	$max_\Delta PET(i,j,H_{14:30}) = max_{ij} \mid PET_{map1}(i,j,H_{14:30}) - PET_{map2}(i,j,H_{14:30}) \mid$ Where, $PET_{map1}(i,j,H_{14:30})$ is the PET value at grid (i,j) at the hottest hour of the day $(H_{14:30})$ observed before the intervention (status quo), $PET_{map2}(i,j,H_{14:30})$ is the PET value observed after the intervention, and max_{ij} the function to identify the coordinate (i,j) that maximises the difference in PET values between two PET maps.
	Average difference PET [K]	$\Delta avg_PET(H_{14:30}) = avg_PET_{map2}(H_{14:30}) - avg_PET_{map1}(H_{14:30})$ Where, $\Delta avg_PET(H_{14:30})$ is the difference between $avg_PET_{map1}(H_{14:30})$ the average PET values of the central 75m of the status quo and $avg_PET_{map2}(H_{14:30})$ after the intervention at 14:30h.
Single human	Difference PET [K] at data point	$\Delta PET(x,y,H_{largest}) = PET_{map1}(x,y,H_{largest}) - PET_{map2}(x,y,H_{largest})$ Where, $PET_{map1}(x,y,H_{largest})$ is the PET value observed for the status quo at grid (x,y) on the PET map at $(H_{largest})$, the hour of the day where ΔPET is largest. $PET_{map2}(x,y,H_{largest})$ is the PET value at the same grid (x,y) on the PET map observed after the intervention. Grid (x,y) is the grid where the PET value was highest in the building's adjacent outdoor space, as observed before the intervention (Status Quo).
	Cooling timespan at data point [h]	$TS_{cooling}(x,y) = \{(H_{start},H_{end}) \mid \Delta PET(x,y,H) > \Delta T \; for \; all \; H \in [H_{start},H_{end}]\}$ Where, ΔT is the temperature difference threshold to be compared with ΔPET at the selected pixel (x,y); in this paper ΔT = 1 K, a perceived temperature difference, is used. H represent the time of the day. H_{start} and H_{end} are the start and end times of the cooling window, respectively.

RESULTS

The results of the heat stress modelling for three locations are here reported using PET thermal indices, accompanied by four underlying meteorological factors: air temperature, solar radiation, relative humidity, and wind speed. First, PET values in the status quo situation for a typical 35- and 80-year-old person at the hottest time of the day (14:30h) are visualised and described for the three case studies. Then, the variations in PET between status quo and intervention scenarios (for typical 80-year-old person) calculated and visualized at the same spatial scale and same time. Finally, PET values for all ages across the three points of interest (single human scale) are presented over 24 hours.

Morphological characteristics

The spatial and thermal conditions of these three areas and their outdoor spaces (Location A, B and C) are described in table 3.

Table 3. Urban Morphometrics (Atlas Leefomgeving, 2020a; Atlas Leefomgeving, 2020b; Centraal Bureau voor de Statistiek, 2021; Demuzere et al., 2019; Kadaster, 2023)

Scale	Metric	Location A (Zaanstraat)	Location B (Bos en Lommerplantsoen)	Location C (Ouwerdingenpad)
Neighbourhood scale	Local Climate Zone (LCZ) classification	LCZ-6 open low-rise LCZ-3 compact low-rise	LCZ-6 open low-rise LCZ-8 large low-rise	LCZ-6 open low-rise
Block scale	Building Heights [m] (50m buffer)	15.01 ±1.87	22.11 ±7.37	13.86 ±10.58
	Number of buildings	26	3	12
	Ground Space Index (GSI, 25m buffer)	0.18	0.25	0.26
	Floor Space Index (FSI, 50m buffer)	0.93	1.15	1.03
	Green Area [m^2] (50m buffer)	2473	3507	2938
	Tree Coverage [%]	5.81	1.44	3.85
Single building scale	Building Height [m]	10.16	9.38	5.07
	Building footprint [m^2]	977	236	575
	Building surface to volume ratio [m^2/m^3]	0.32	0.38	0.41

From a morphological and climate perspective, locations A, B, and C all fall under the same local climate zone (LCZ6 - open low-rise classification). However, Ground Space Index (GSI) and Floor Space Index (FSI) indicators reveal significant differences in building density and coverage across the three locations. These differences result in varying street aspect ratios and orientations, as well as distinct green coverages, making each location look quite different despite the same LCZ classification. Additionally, detailed morphological differences can be observed by comparing building compactness at the single-building scale.

Thermal stress levels at location A (Zaanstraat)

Status quo

The comparison (figure 3) shows that in both cases, the majority of the area is affected by extreme heat stress (PET>41°C), and a typical elderly is generally at a higher level of discomfort compared to a middle-aged person (2 to 6 K). The patterns of PET value distribution are, however, similar and highlight the high PET temperatures in the outdoor space adjacent to the building's southwest facade. The PET in the status quo situation reaches a maximum temperature of 57.78°C for 35-year-olds and 58.96°C for 80-year-olds. The average PET for 80y is 48.24°C (SD=4.53) in the area.

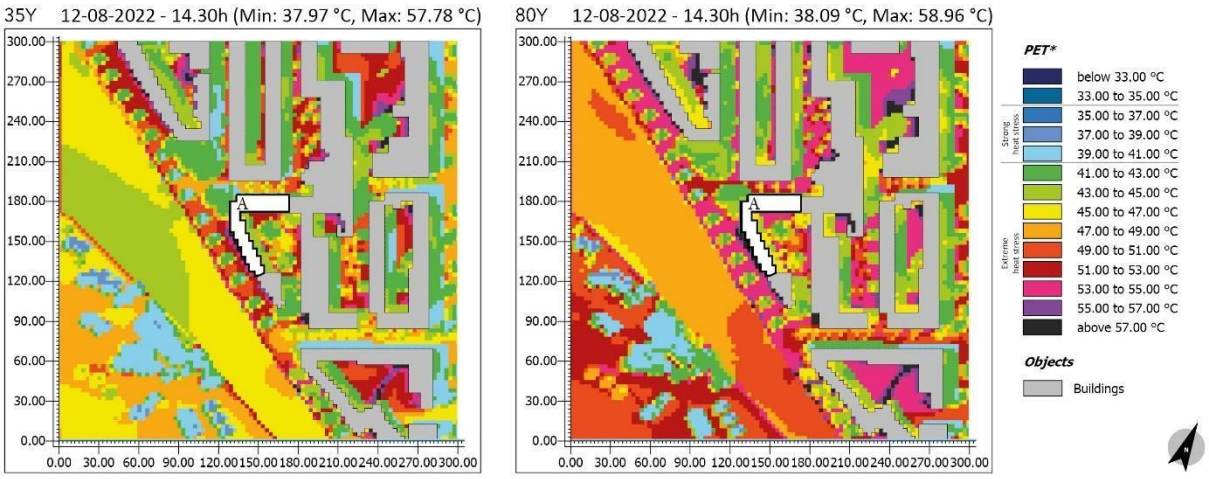

Figure 3. Status quo (35y - 80y)

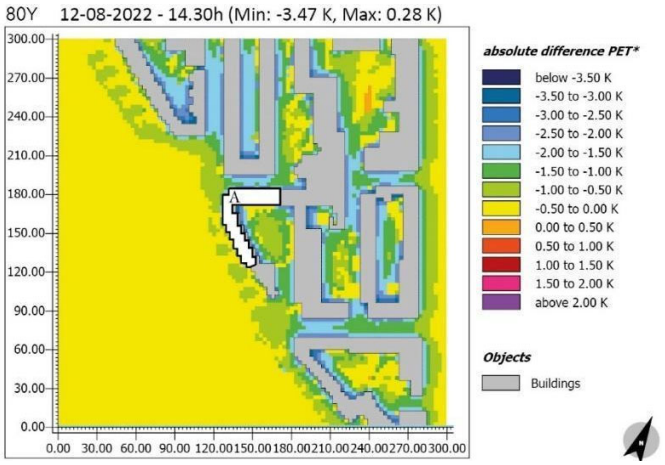

Figure 4. Implemented measures (80y)

The most influential parameters contributing to the heat stress in the outdoor space at the southwest facade are the high mean radiant temperature of max. 67.52°C and low wind speeds (max. 0.45 m/s). The mean radiant temperature is an indicator of high radiation and reflection. Based on this analysis, green facades were introduced on all existing building envelopes as mitigation measure to reduce thermal stress.

Intervention

Converting existing façades into green facades generally brings an increase in human comfort. At Location A the maximum PET reduction in the area was -4.64 K for 35-year-olds and -3.47 K for 80-year-olds. Around the social housing building PET reduction changes according to the building orientation. Compared to the status quo, in the green façade scenario PET decreased along the southwest street between -1.00 K to -0.50 K (figure 4) while on the north and east sides of the buildings decreased between -2.00 K to -1.00 K. The mean radiant temperature in the southwest street only decreased -2.50 K to -2.00 K, while at the north-east side of the buildings the mean radiant temperature decreased -3.00 K to -2.00 K. As a consequence of the intervention the relative humidity increased between 1.00% to 2.00%, however, on a hot and dry day, this is beneficial as it increases the relative humidity to a more comfortable percentage.

Thermal stress levels at location B (Bos en Lommerplantsoen)

Status quo

The comparison in figure 5 shows that for both ages, the majority of the area is affected by extreme heat stress (>41°C), with a typical elderly generally at a higher level of discomfort compared to a middle-aged person (2 to 6 K). The patterns of PET value distribution are, however, similar and highlight the highest PET temperatures in the street on the east side of the building. At location B the PET reaches a maximum of 57.78°C for 35-year-olds and 58.96°C for 80-year-olds for the status quo. The average PET for 80y is 50.11°C (SD=4.60) in the area.

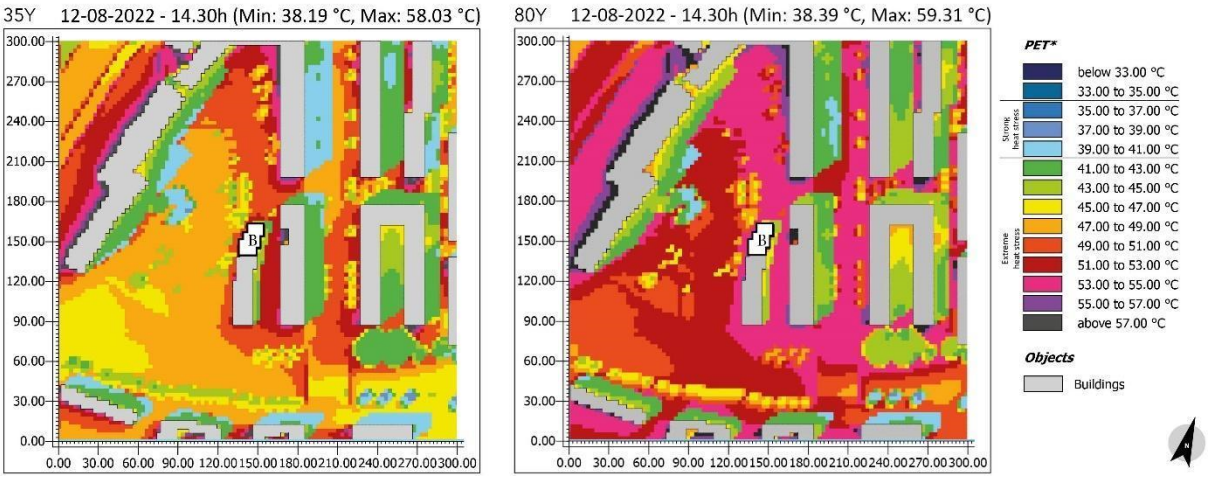

Figure 5. Status quo (35y - 80y)

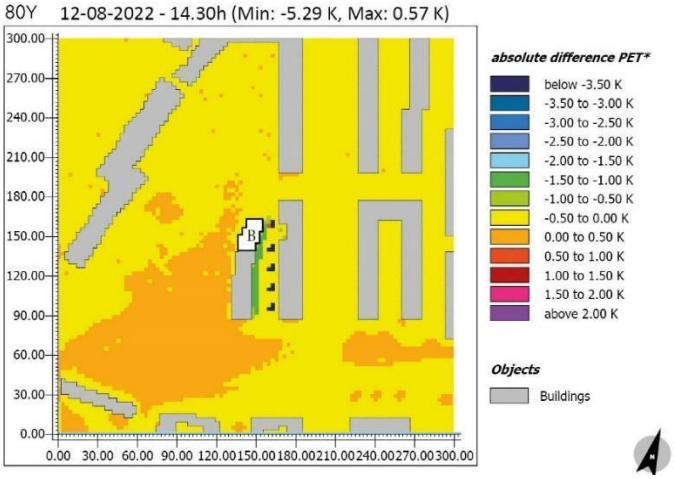

Figure 6. Implemented measures (80y)

The most influential parameters contributing to the heat stress in the east street are the wind (below 0.30 m/s), the direct short-wave radiation and the mean radiant temperature (max. 67.52°C). Because of the high radiation, assumptions were that the shading is insufficient, relating to the low building heights and low tree crown area, and the paving materials emit heat. Thus, as mitigation measure the vegetation cover, in the form of tree shading and grass cover, is increased.

Intervention

Increasing the vegetation cover generally increased the human comfort. At location B, compared to the status quo the PET reduction is between -1.00 K to -0.50 K on the grass surfaces and -5.36 K under the trees for 35-year-olds and -5.29 K for 80-year-olds, as visible in figure 6. The short-wave radiation has decreased (with -601.31 W/m^2) at the locations of the trees in the eastern street at 14:30h. The mean radiant temperature decreased by -2.00 K to -1.00 K.

Thermal stress levels at location C (Ouwerdingenpad)

Status quo

The comparison (figure 7) shows that for both age groups, the majority of the area is affected by extreme heat stress (>41°C), and elderly are generally at a higher level of discomfort (2 to 6 K). Again,

with similar patterns of PET value distribution, with the highest PET values found in the outdoor spaces on both east and west sides of the building. At location C the PET for 38-year-olds reached a maximum of 58.03°C and 59.27°C for 80-year-olds. The average PET for 80y is 49.01°C (SD=4.61) in the area.

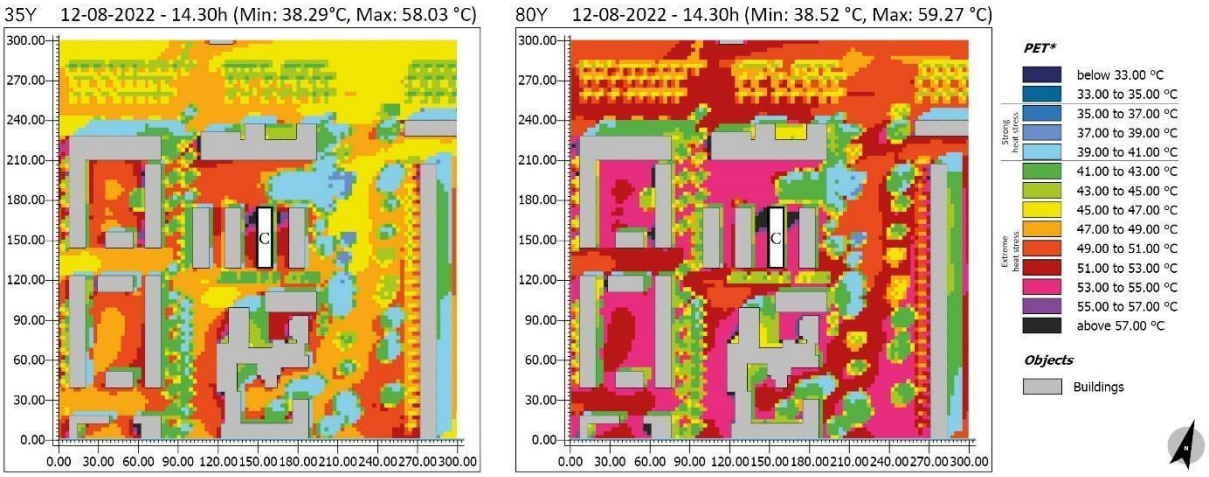

Figure 7. Status quo (35y - 80y)

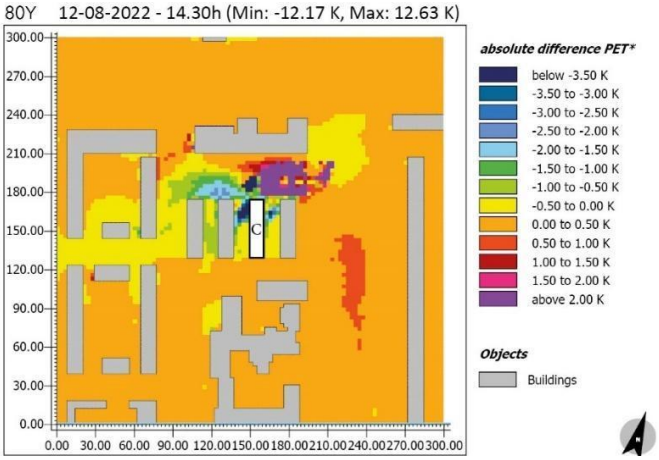

Figure 8. Implemented measures (80y)

The most influential parameters for Location C are the wind (below 0.15 m/s) and air temperatures (above 32.10°C). This could be caused by 1) streets not aligning with the wind direction, and 2) a lack of evaporative cooling from vegetation. To improve the evaporation the implemented measure of this location is a fountain implemented northeast of the building. To increase the impact of the fountain, the roughness elements are adjusted. Meaning, large dense trees are replaced by smaller trees north of the building, allowing more wind to flow through both streets.

Intervention

Implementing the water misting generally increased the human comfort. Compared to the status quo the air temperature decreased by 1.00 K and the wind speed increased to 0.55 m/s, resulting in a maximum PET reduction of -8.70 K for 35-year-olds and -12.17 K for 80-year-olds (figure 8). The wind direction is from the fountain north-east of the building, directly to the streets on either side, which spreads the effect of the fountain to the areas with high PET values. However, compared to the status quo, an increase in PET can be seen north of the building where the tree crown area was reduced.

PET per age group over 24 hours

The comparison of status quo and intervention scenarios shows that thermal stress reduction of the three cooling measures differs over 24 hours. The change in PET values of the three locations at a data point close to the building at which the PET before the cooling measure was highest was explored (figure 9).

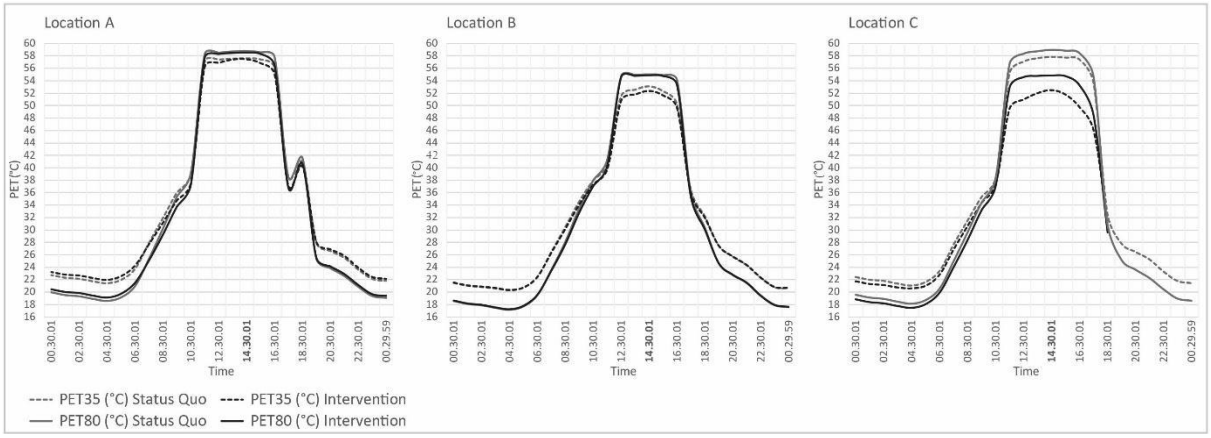

Figure 9. Data retrieved at the point of max. PET (small portion of data is missing in subfigure C, from 18:30).

It can be observed that the timespan of the cooling effect at the selected data point is different for all interventions. The differences in both efficiency and timespan of the different cooling interventions are detailed in table 4.

Table 4. Effectiveness of cooling interventions (in this paper, 14:30h is identified as the hottest time)

Scale	Measurements of cooling effect	Green facades (Location A)	Tree shading (Location B)	Water misting (Location C)
Block scale	$max_\Delta PET(i,j,H_{14:30})$	-4.64 K for 35y -3.47 K for 80y	-5.36 K for 35y -5.29 K for 80y	-8.70 K for 35y **-12.17 K for 80y**
	$\Delta avg_PET(H_{14:30})$	-0.83 K for 35y **-0,87 K for 80y**	-0.30 K for 35y -0,22 K for 80y	-0.31 K for 35y -0,04 K for 80y
Single human Scale	$\Delta PET(x,y,H_{largest})$ during daytime	10:30h -1.46 K for 35y -1.85 K for 80y	11:30h -0.80 K for 35y -1.05 K for 80y	17:30h -7.63 K for 35y **-6.30 K for 80y**
	$\Delta PET(x,y,H_{14:30})$	-0.21 K for 35y -0.27 K for 80y	-0.75 K for 35y -0.14 K for 80y	-5.28 K for 35y **-4.10 K for 80y**
	$\Delta PET(x,y,H_{largest})$ during nighttime	+0.61 K for 35y +0.63 K for 80y	+0.08 K for 35y +0.08 K for 80y	-0.45 K for 35y -0.65 K for 80y
	$TS_{cooling}(x,y)$	09:30–11:30 and 16:30–18:30 for 35y 09:30–11:30 and 16:30–18:30 for 80y	none for 35y 11:30–12:30 for 80y	11:30–18:30 for 35y 08:30–19:30 for 80y

Comparing the three measures, it appears that water misting has the largest impact on the heat stress for both age groups. Both the reduction in PET and duration of the effect are largest for this measure. The cooling effect ΔPET for 80y, is more than 1 K at during two short timespans for the green facades, while the tree cooling has one timespan, and water misting cools for the longest time. The cooling effect of the interventions is most needed at the hottest time of day (14:30). At this time of day, the intervention water misting has the highest cooling effect of the three, both in the area with Max_ΔPET of -12.17 K for 80y and at the selected data point with ΔPET -4.10 K for 80y. The cooling interventions of location A, B and C reach their maximum cooling at the selected data point at different times. The

maximum cooling effect of tree shading (location B) and water misting (Location C) are reached 3 hours from the hottest time of day, while the green facades reach their maximum cooling 4 hours before the hottest time of day. Location A and B both have an increase in heat stress during the night, while water misting keeps lower temperature at day and night.

DISCUSSIONS

To answer the research question "Among green facades, tree shade, and fountain misting, which urban design interventions are effective in mitigating outdoor heat stress around social housing for the elderly in Amsterdam?" a microclimate analysis of three vulnerable locations in Amsterdam during heat waves was conducted in this study.

The microclimate analysis of the status quo confirms that the heat stress in the building's immediate surroundings during a heat wave is extreme. For the status quo in all three areas there are no places to be found below the threshold of strong heat stress (PET=35°C) and only few places below the threshold of extreme heat stress (PET=41°C), especially for elderly (age 80 yrs). Some studies have found that BIO-met underestimates the PET values in case of high values (PET>32°C) (Yin et al., 2019, Zhang et al., 2022), therefore the actual PET values might be even more extreme. While having similar local climate zones, the three areas result in different microclimates and different thermal comfort levels. The scale of the Local Climate Zone appears to lack the capacity of reflecting and differentiating the thermal comfort of the three locations, confirming previous studies which highlighted the LCZ limitations in capturing the microclimate interactions between individual buildings and the surrounding environment (Maiullari et al., 2021). Noticeable was that at all three locations the wind speeds in the building's immediate surroundings are low (max. 0.45 m/s), which is likely one of the main contributing factors to the high PET values. This is confirmed in a review article by Nasrollahi et al. (2020) who has found that there is a direct relationship between area density and thermal comfort. Due to the limited ventilation of all three urban areas, the effect of the cooling measures might also be limited.

Comparing the different interventions, fountain misting has the highest cooling effect and longest timespan. These findings are in line with Kluck et al. (2020), a study in the same climate context. However, during the warmest time of the day (14:30h), the efficiency of all interventions is insufficient in decreasing the PET below the threshold of extreme heat stress (41°C). Noticeable was the increase in PET during nighttime for the interventions trees and green facades, this can be explained because an increased vegetation cover can cool through heat absorption during the daytime and traps the dissipated heat during the nighttime (Osmond and Sharifi, 2017). This research used single punctual mitigation interventions. The study by Arrar et al. (2024) suggested that combined mitigation measures increase the complexity and have limited cooling benefits suggested, single mitigation measures were more effective and feasible. However, the findings of this research suggest that single measures are insufficient in decreasing heat stress. Therefore, more research needs to be done to find optimal combinations of mitigation measures.

From an analytical perspective, this study suggests that digital tools can be used for mapping heat risks around neighbourhoods to inform designers and policymakers. However, the knowledge of cost effectiveness and maintenance of urban design interventions is equally important as understanding the cooling effects. Thus, both feasibility and suitability of the cooling measures should be part of a

larger assessment. Further research is needed to investigate which cooling measures might be favoured by different age groups to create more inclusive and safe thermal environments.

Limitations and further steps

The thermal comfort analysis in this research is based on ENVI-met simulations and PET calculations in BIO-met not validated through climate measurements. Many other studies have confirmed the accuracy of ENVI-met in Dutch case studies (Taleghani et al., 2015), while only a few studies exist on the accuracy of the PET calculation. However, one study confirmed that the accuracy of the PET calculations in BIO-met is sufficient with 7% (Tseliou and Tsiros, 2016). Therefore, in future studies, actual climate measurements of urban heat should be done to validate the ENVI-met result in these three locations and questionnaires should be carried out to examine if the heat can be tolerated by the elderly. Additionally, in this research individual parameters (like level of activity and clothing) are not considered despite their impact on outdoor thermal comfort.

Due to the computation costs of ENVI-met simulations a compromise was found on the model resolution (3m grid). Also, only one exceptionally hot dry day with low wind speeds could be modelled. The chosen interventions had a positive impact under these weather circumstances, but the consequences of the interventions during more humid or cold days might be different. Future studies should explore the effectiveness of mitigation interventions during days with different climatic profiles.

CONCLUSIONS

This study addresses the impact of urban heat on human thermal stress in Amsterdam. The research focuses on interventions to improve urban thermal comfort for elderly around social housing buildings. Three representative cases in heat-prone areas were selected and analysed during a representative hot day through microclimate modelling of the status quo in ENVI-met and modelling of resulting PET (physiological Equivalent Temperature) values in BIO-met. On this base three heat mitigation measures were selected and applied (green facades, tree shade, and fountain misting). A second assessment through microclimate and PET modelling allowed us to compare the level of cooling efficiency among measures and their cooling timespan.

The microclimate analysis of the status quo suggested that outdoor spaces connected to social housing buildings in Amsterdam suffered extreme heat stress during heat waves. Results show that the three vulnerable locations, despite falling in the same LCZ-6 open low-rise class, had very different morphological, microclimatic and thermal comfort characteristics bringing average PET values for 80y to 48.24°C (location A), 50.11°C (location B) and 49.01°C (location C). Additionally, the analysis of the heat stress mitigation interventions shows that punctual interventions around buildings are insufficient in decreasing heat stress for elderly at the hottest time of day. Green facades contributed to decrease the surface temperature of the facade and the air temperature near the facade, resulting in a maximum decrease in PET of -3.47 K for elderly at location A. Increasing the surface covered by trees and grass, decreased both the surface and air temperature, resulted in a maximum PET decrease of -5.29 K for elderly at location B. Fountain misting reduced air temperature, decreasing the PET by maximum -12.17 K for elderly at location C. Among the three measures fountain misting provided the

highest reduction in PET, however, none of the measures decreased the PET of the area below the threshold of 41°C PET, extreme heat stress, for elderly residents.

Finally, this study suggests a need for systemic heat mitigation strategies and for further exploring the role of urban fabric morphological characteristics to create inclusive and safe thermal environments. While the approach used in this paper has contributed to the knowledge base to guide design intervention for a cool and comfortable outdoor environment, future research should focus on the potential of combining several measures and on their suitability for elderly residents.

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Impact of The Oriental Pearl Tv Tower on the urban form of Lujiazui district in Shanghai

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ABSTRACT

In the course of China's reform and opening up, Shanghai's Lujiazui District has emerged as one of the country's most important central business districts, undergoing political, economic and cultural changes over the years. The Oriental Pearl TV Tower, a representative landmark of Shanghai, is a part of the development of this district. Although the evolution of urban form in Shanghai has been a considerable research topic, previous studies have not explicitly discussed the impact of the Oriental Pearl TV Tower on urban form. This article focuses on how the TV tower has influenced the area's urban form. It covers the process of site selection, the urban design competition, and the tower's development after completion. In terms of urban planning, the preparation and location of the TV tower were intimately linked to the development of the area. Regarding urban design, most of the proposals submitted to the Lujiazui Urban Design Competition resemble the TV Tower that has yet to be built. Architecturally, it influenced the layout and form of neighboring buildings, for example the form of Shanghai International Convention Center. The article utilizes documentary research, drawing analysis, and oral history interviews, drawing on valuable materials from the Shanghai Municipal Archives and other sources, as well as interviews with individuals who experienced the events. Furthermore, this study will also serve as a complement to a practical example of the relationship between iconic architecture and urban form.

Keywords: urban form, CBD, the Lujiazui area, the Oriental Pearl Television Tower

INTRODUCTION

During the period of reform and opening up, China's economy and trade developed rapidly, and urban construction was in full swing, marking an important period of transition for modern China. The Lujiazui area of Shanghai serves as a key example of urban development during this period, with its urban form evolving in tandem with the changes and developments witnessed in the economic system, ideology, and other aspects.

The Oriental Pearl TV Tower, erected during this period, has become a prominent landmark in Shanghai and has played a pivotal role in the development of the Lujiazui district in Pudong. From the perspective of urban space construction, the preparation of the Oriental Pearl TV Tower is inextricably linked to the urban planning of the Pudong area. Additionally, it has significantly impacted the urban

design competition and the final planning. Following the completion of the Oriental Pearl Tower, neighboring buildings were constructed rapidly, and the form of the International Convention and Exhibition Center was also significantly influenced by the Oriental Pearl Tower. The buildings situated in close proximity to the TV Tower collectively contribute to the formation of a multi-level architectural layout and a distinctive skyline for the Lujiazui area. Ultimately, tourists visiting the area will have spatial experiences at varying locations due to the differing roles these locations play in the urban space.

The Oriental Pearl TV Tower has exerted a pervasive influence on the urban landscape and architectural form throughout its lengthy history, from the period preceding its construction to the present day. Accordingly, this paper employs a diachronic perspective, utilizing literature analysis, drawing analysis, and field research to elucidate the role of the Oriental Pearl TV Tower in the urban development of the Lujiazui area during the preparation, design competition period, and the complete time period subsequent to the completion of the tower. Furthermore, it endeavors to illuminate the relationship between the landmark building and the evolution of urban form.

The Oriental Pearl TV Tower and Lujiazui Urban Design

Site Selection of the Oriental Pearl TV Tower and Lujiazui Urban Planning

The Huangpu River divides Shanghai into two parts: Pudong (east) and Puxi (west). Before China's reform and opening up, development focused mainly on Puxi, while Pudong received less attention.(Fan Weida, 2004). In the early 1980s, Lujiazui in Pudong was designated for a riverside park under city planning efforts.

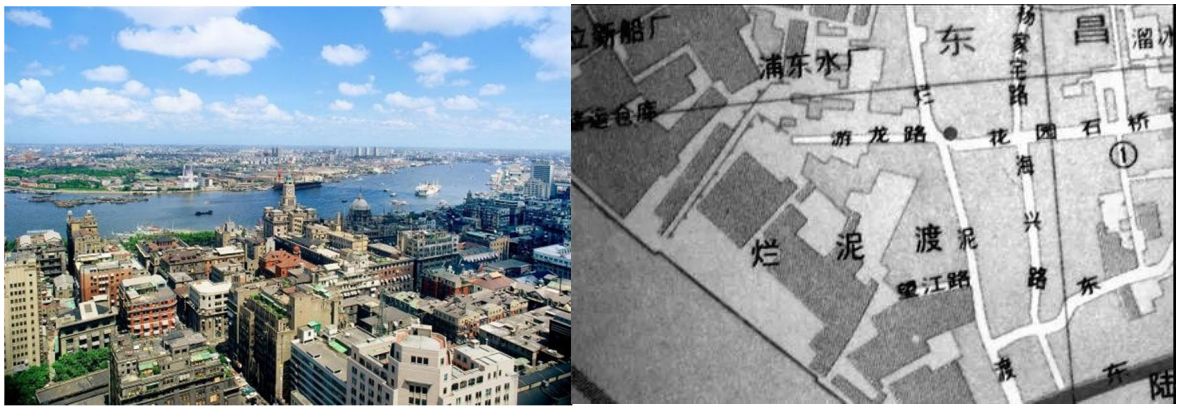

Figure 1, 2. The undeveloped Lujiazui area of Pudong

The Oriental Pearl TV Tower, a superlative telecommunications structure symbolizing China's modernization, was a pivotal element in the design. Four sites were initially considered. The locations under consideration were People's Square, situated in the heart of the city; the Nanyang Road area on West Nanjing Road; Jing'an Park; and the site of the former British Consulate, which was ultimately selected due to its superior urban development in Puxi. However, all were rejected due to issues like proximity to City Hall, existing leases, and the need for demolitions(Wu Jimin, 2014).

During the reform and opening up, the Shanghai Municipal Government identified Pudong as a key area for development. In 1984, discussions commenced, and on April 18, 1990, the Chinese government officially announced plans to accelerate the development of the Pudong New Area. The

Oriental Pearl TV Tower, as a symbolic project, marked the first significant undertaking in this development.



Figure 3. Description of Pudong Development in Liberation Daily

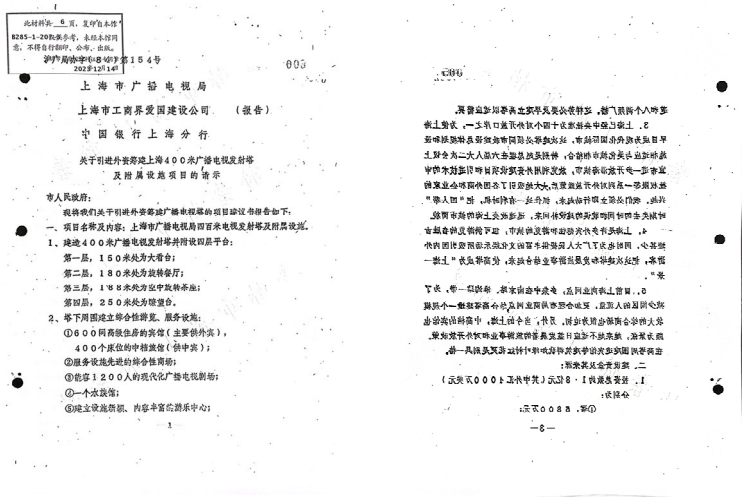

Figure 4,5. The Oriental Pearl TV Tower Request for Proposal Archives

Lujiazui’s strategic position at the confluence of the Huangpu River made it the ideal site, though initial plans were delayed by a Port Authority proposal for a shipping building. A pivotal meeting at the Shanghai Seven Heavens Hotel, led by Zhang Shaoliang, resolved this, with Ni Tianzeng agreeing to allocate the site for the TV tower and compensate the Port Authority. On August 23, 1984, the Shanghai Municipal Radio and Television Bureau submitted a report titled "Opinions on the Site Selection of the 400-meter TV Transmission Tower," outlining plans for the tower in Lujiazui. By March 1985, the "New TV Broadcasting Tower and Subsidiary Facilities" report was approved by the municipal government.

In May of that year, the Shanghai Municipal Planning Commission approved the report, finalizing Lujiazui in Pudong as the site for the TV tower. All stakeholders agreed that this prominent location should be reserved for the tower, given its symbolic importance to Shanghai.

The central government's decision to prioritize Pudong's development elevated Shanghai's national strategic role. Pudong's development was not only an economic initiative but also a key opportunity for China to showcase the success of its reform and opening up policies to the international community. The Oriental Pearl TV Tower stands as a prime example of this vision, justifying its location in Lujiazui.

The Oriental Pearl TV Tower and Lujiazui Urban Design Competition

Following the proposal for Pudong's development, urban construction in Lujiazui began. In May 1992, prominent firms including STUDIO FUKSAS, Rogers Stirk Harbour + Partners, Toyo Ito & Associates, Dominique Perrault Architecture, and the Design Group of Shanghai (composed of the Shanghai Municipal Planning and Design Institute, the East China Design Institute, and Tongji University) were invited to participate in the design competition(Yan Xubian, 2001).

A clear axis can be observed in the proposals by the Chinese consulting group, Italian firm Fuksas, and British firm Rogers. In these schemes, major roads or rivers serve as the axis. The Chinese proposal is particularly notable for its strong axial focus, aimed at creating a monumental, iconic effect. This axis takes the form of a wide boulevard leading directly to the Oriental Pearl Tower, offering unobstructed views of the tower at its terminus. Approximately one-quarter of the designated space is allocated for green areas and urban squares, reinforcing the tower's role as a major urban node. The symmetrical layout along the boulevard follows Lujiazui's arc along the river, with roads on both sides converging towards the central axis. The Oriental Pearl Tower acts as a focal point, enhancing the plan's directionality, visual emphasis, and spatial organization.

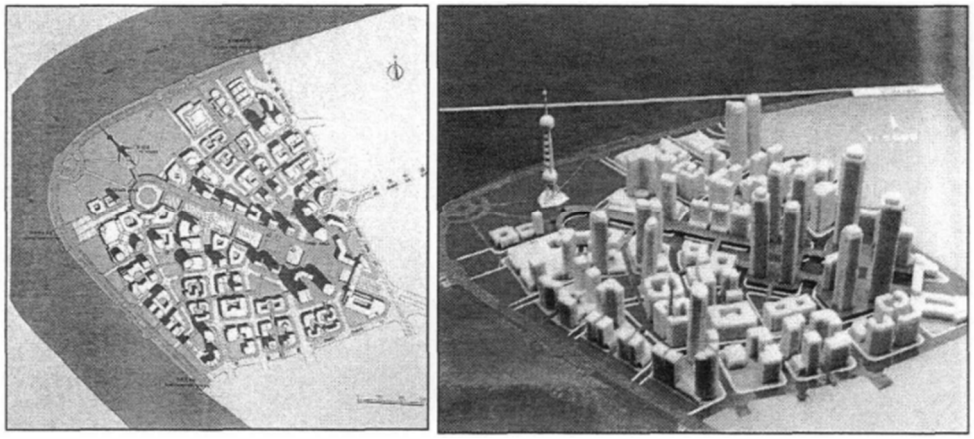

Figure 6. The proposal by the China Shanghai United Consulting Group

Both the Italian and British proposals incorporate curved lines, circular or elliptical elements, and enclosed spaces. While their axes are less pronounced, they also direct attention to the Oriental Pearl Tower. The British plan reduces the volume and number of buildings near the tower, creating an open space that frames the tower. In both schemes, the Oriental Pearl Tower serves as the terminus of the axis and the central node of the urban design.

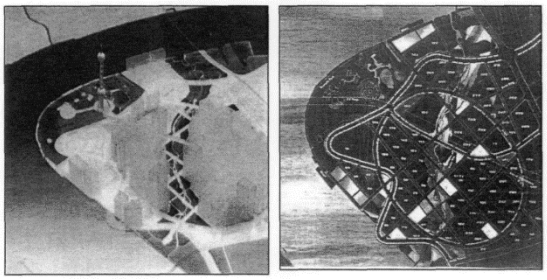

Figure 7. The Italian proposal

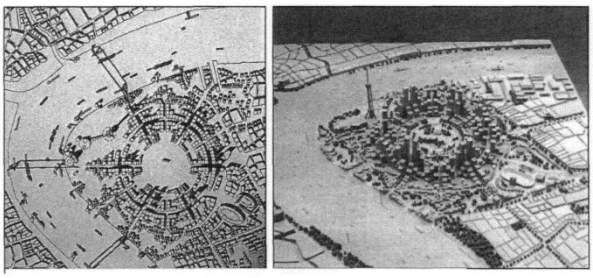

Figure 8. The British proposal

The French and Japanese proposals both adopt linear approaches. The French plan extends along the river in a right-angled configuration, forming the basis for a high-rise building layout. The Oriental Pearl TV Tower is positioned slightly off the corner at the second building location, and the plan lacks a clear axis. The Japanese proposal introduces a linear "ribbon city" concept to the south, with the Oriental Pearl Tower at the start of the first development ribbon. Neither plan emphasizes iconicity or

monumentality, so the tower does not play a central role in the design. However, due to its size, height, and location, the tower remains a prominent feature in both plans.

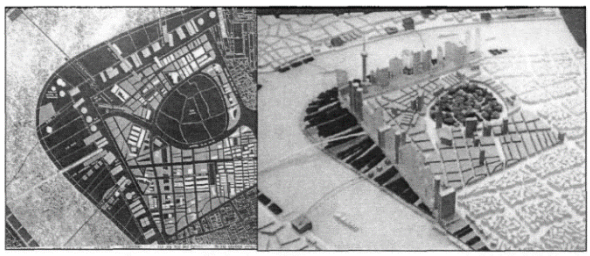

Figure 9. The French proposal

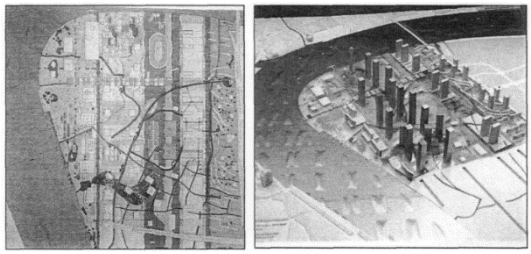

Figure 10. The Japanese proposal

After the initial phase of the competition, the Shanghai Government determined that a more comprehensive assessment was required. The Shanghai Municipal Planning Department agreed, leading to program modifications and the creation of three enhanced comparative plans, which were eventually unified. While the final plan differs from the originals in many respects, the road network, central axis, and orientation toward the Oriental Pearl TV Tower remain strikingly similar.

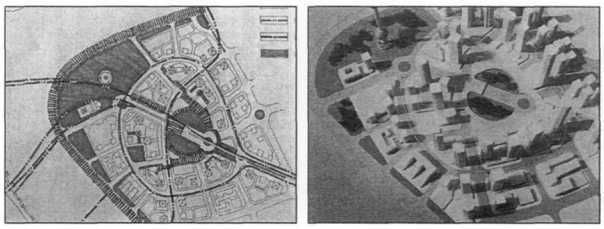

Figure 11. The deepening proposal 1

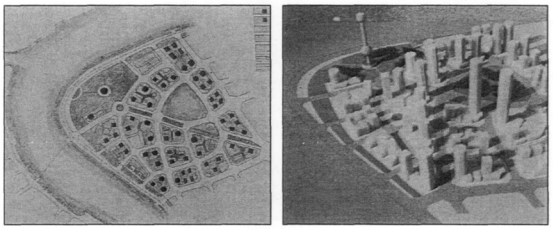

Figure 12. The deepening proposal 2



Figure 13. The final proposal

The positioning and objectives of the Lujiazui area's development were instrumental in shaping its final form. The initial goal of the Lujiazui master plan was to "face the world, face the 21st century, face modernization," aimed at presenting China's urban image to the global community during a transformative period of reform and opening up (Yang Jiying, 1998). This clear objective, rooted in political, social, and national consciousness, encompassed several intentions: creating modern architectural forms, preserving Chinese characteristics within a contemporary context, and

developing urban identity and imagery. The symmetrical layout and iconic Century Boulevard exemplify this vision. The Oriental Pearl Tower, with its distinctive design and status as an architectural icon, became the focal point of the design process and influenced the evolution of various proposals.

The Oriental Pearl TV Tower and neighbouring buildings

Planning International Convention and Exhibition Centre

The International Conference Centre, designed by the Zhejiang Provincial Architectural Design Institute and completed in 1999, received the 'Top Ten Gold Medal Buildings' award during the 'Fiftieth Anniversary of the Founding of the PRC Classical Architecture Selection.' However, the architectural community was critical, with none of the jury members voting for it. Despite this, the International Conference Centre secured ninth place in a selection made by leaders, citizens, and experts. Its form, location, and layout are closely interconnected with the Oriental Pearl TV Tower.

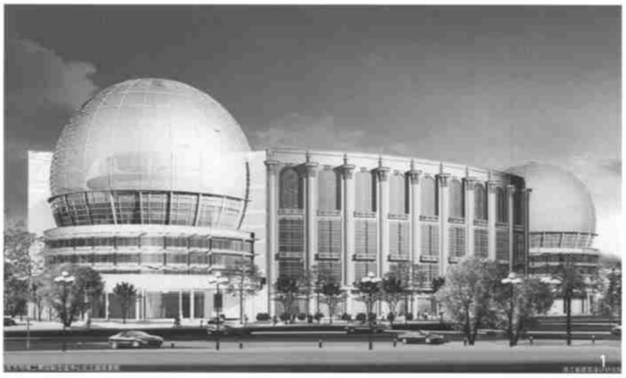

Figure 14. Programme rendering of the International Conference Centre



Figure 15.Riverside Exterior

The design of the International Conference Centre has been significantly shaped by the concept of leadership, with the Oriental Pearl TV Tower serving as a primary source of inspiration. The north and south sides of the centre are built on two- and three-storey podiums, respectively, featuring two glass-topped globes arranged in a grid pattern. The north globe has a diameter of 50 meters, while the south globe measures 38 meters, reflecting the large and small spheres of the Oriental Pearl Tower. The location and height of these spheres are deliberately linked to the tower, views from the Bund on East Nanjing Road are tangential to the tower's central sphere. This design echoes traditional Chinese concepts of the square and circle, resonating with the adage "the big pearl falls from the jade disc." The layout of the Conference Centre further reflects the tower’s influence, with the main entrance located on the east side of the podium, aligning with the south square of the Oriental Pearl Tower. Additionally, a 30,000 square meter green plaza at the main entrance serves as a key feature of the Pudong Riverside Tourism Zone(Li &Peng, 2000).

In light of the rushed circumstances and the need to satisfy leadership's intentions while advancing the project, the approach of responding to the Oriental Pearl Tower was the most feasible option available at the time. It proved to be the quickest and most effective strategy under the circumstances.

Lujiazui Architectural Layout

The Oriental Pearl TV Tower, the International Convention Centre, the Port Tower, the Customs Building and other edifices are situated in the Lujiazui area along the river. Within the central ring road, one may find the Jinmao Tower, the World Financial Centre and other structures. In the central green area, there are clusters of super-high-rise office buildings, including the China Insurance Tower and the Shanghai Securities Tower, among others. The Oriental Pearl TV Tower is notable for its distinct form and volume in comparison to the surrounding buildings. Together with the Jinmao Tower and the World Financial Centre, they represent a prominent feature of the area. The urban image of the Lujiazui area is inextricably linked to the configuration of these super-tall buildings.

The riverine space can be differentiated according to the relative distance between the location and the river. This results in the formation of three distinct levels: the riverbank, the central ring road, and the central green space. The river bank and the internal ring road constitute the first level of urban development. The buildings on this level face the opposite bank of the river, forming the primary visual aspect of the city. The Oriental Pearl TV Tower serves as a prominent symbol of the city. The second level of the Jin Mao Tower and the World Financial Centre represents the pinnacle of the urban fabric, a central point of prominence that is balanced by the surrounding context. The third level is characterised by a concentrated arrangement of buildings, with a compact distribution and narrow gaps, creating a strong sense of building groups.

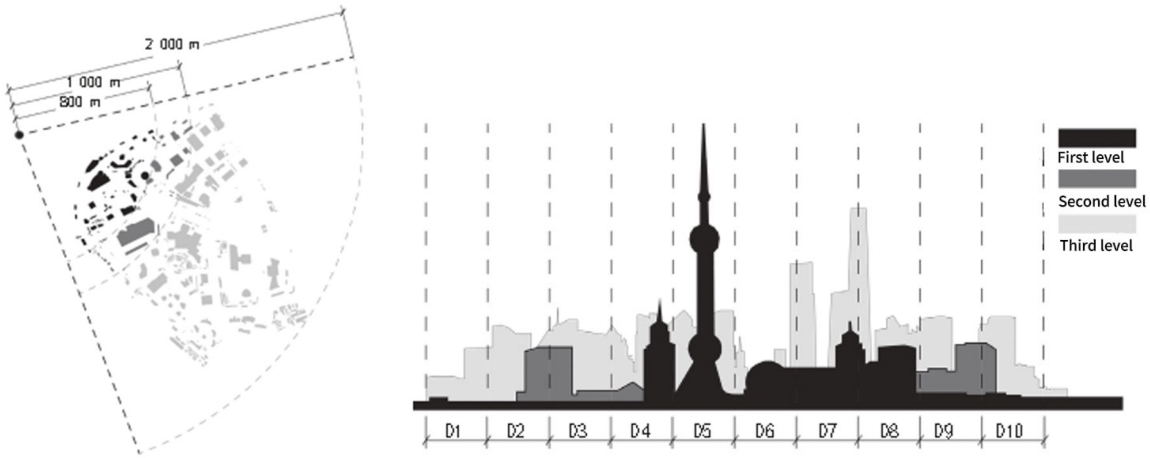

Figure 16, 17. Lujiazui Complex Levels

A skyline analysis is a method of abstracting the linear form of a group of buildings by removing the influence of the exterior surface and other details. The skyline of Lujiazui is a pervasive image in various media, serving as an emblematic representation of Shanghai. As illustrated in the accompanying figure, the image of Lujiazui is readily discernible in the photographs of the Oriental Pearl Tower and the Jinmao Tower. The Lujiazui skyline, observed from different perspectives, assumes various forms. However, it is consistently dominated by three super high-rise buildings: the Oriental Pearl Tower, the Jin Mao Tower, and the World Financial Centre. These structures serve as the high point, balancing the skyline of the entire centre.

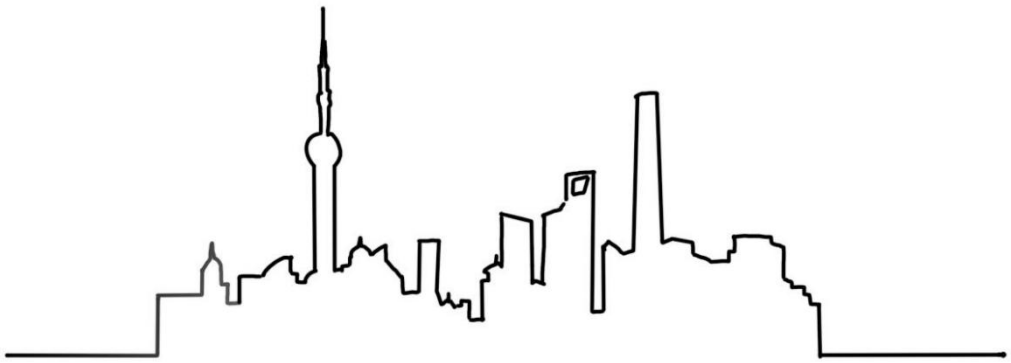

Figure 18. Lujiazui skyline

The Oriental Pearl TV Tower and the Spatial Experience of People

Road

The roads in the Lujiazui area are closely associated with urban landmarks, and Century Avenue itself is an iconic landmark in Lujiazui, representing an axis running through the entire area with an extremely strong pointing direction.

Firstly, with a length of 5.5 kilometres and a width of 100 metres, the road has an extremely wide sense of space and is planned to be an iconic landmark. The endpoints of the avenue are the Oriental Pearl TV Tower and Pudong Century Park, which point directly to the tallest landmark building in Lujiazui: the Oriental Pearl Radio and TV Tower. This serves as a visual guide, thereby reinforcing the avenue's strong directionality. Furthermore, the peripheral ring road and its connecting roads comprise a narrower road system in comparison to Century Avenue, which serves to reinforce the directionality of the road towards the end marker. From the perspective of the surrounding buildings, the majority are super-high-rise structures with a disproportionate ratio to the road. The buildings on either side have minimal impact on pedestrians, further reinforcing the sense of directionality. The observer is naturally guided by the high-rise buildings in front of them as they walk along the road, with the point of the road – the Oriental Pearl – appearing to be the destination.

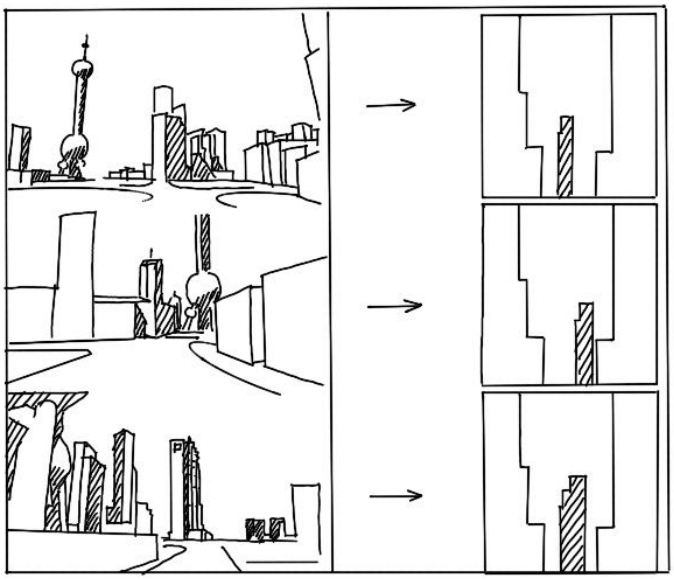

Figure 19.Visitors travelling on the main road in relation to the Pearl of the Orient

Boundary

Boundaries are linear elements within urban space, yet they are not identical to roads. Rather, they constitute interruptions and divisions between spaces. Boundaries delineate the boundaries of space and are integral to the formation of spatial perception.

The Oriental Pearl TV Tower is situated at the confluence of the Huangpu River and the Lujiazui area. The architectural image of the two sides of the river is markedly distinct. The Bund is a modern historical architectural conservation group, whereas the other side of the river, the Lujiazui area, is a modern super high-rise building group, symbolising the image of a modern city undergoing rapid development and progress. The disparate spatial systems give rise to divergent urban landscapes on either side of the border, engendering the impression of observing one another across the river. From this vantage point, observers can discern the comprehensive architectural and spatial configuration of the Lujiazui area, which offers a distinctive spatial experience that is challenging to perceive from within the area itself. The urban image on one side of the border is more often realised by looking into the area from the other side. Consequently, the location of the Oriental Pearl TV Tower at the border of the Lujiazui area serves to shape the image of the area as a whole.

The Lujiazui area CBD represents a significant departure from China's traditional approach to urban development. It is a testament to the country's embrace of foreign investment and international competition, showcasing a striking international display of political symbolism and economic development. Furthermore, it offers a conceptualisation of the city as a temporal entity, encompassing the past, the present and the future. The architectural style of this area can be described as a synthesis of nostalgic and modern elements. The Oriental Pearl TV Tower, with its traditional Chinese symbolism of 'big pearls falling from a jade disc', and the Jinmao Tower, with its dense eaves, serve to reinforce the traditional forms, whilst simultaneously demonstrating the novel aspects of modernity. The high-rise buildings of Lujiazui, situated across the river from the Bund, symbolise an imaginative vision of the future, with the past left behind. This district is defined by two distinct areas: the traditional 'old' Shanghai on the other side of the Huangpu River and the modern

districts that have developed around it. These two areas provide a clear contrast between the past and the present, and offer a vision of what the future may hold. The visual and physical distance between these two areas greatly enhances this contrast.

Nodal

From an urban perspective, a nodal space can be defined as a square, a green space, a corner, or an area (Kevin Lynch, 1960). In Western urban design, the central space of the city is frequently the square space. Monumental buildings are often situated at its centre and converge in the vertical dimension. To illustrate, the renowned clock tower of St. Mark's Square in Italy serves as a conduit between two squares, simultaneously establishing itself as the emblematic focal point of the space and influencing its significance in conjunction with its cultural attributes.

In the Lujiazui area, the node space of the Oriental Pearl TV Tower is particularly noteworthy. It comprises a green space and a ring road. The area surrounding the Oriental Pearl Tower is characterised by a high population density, reflecting its status as a popular tourist destination. In contrast, the end of the ring road on Century Avenue is characterised by a lower density of motorised vehicles and a greater diversity of human activities. The area is comprised of two distinct spaces: an open space designed for tourist use and a green space situated in front of the International Convention Centre, which serves the attendees of the conference. The open space also constitutes a set of urban images, namely the modern urban image comprising the Oriental Pearl Tower and the International Convention Centre.

METHOD

1. Literature Review

This study examines the history of the Oriental Pearl Tower using archival materials from the Shanghai Municipal Archives and construction records from the East China Architectural Design Institute. Urban planning resources are drawn from publications by Lujiazui (Group) Co., Ltd., with additional references from journal articles, theses, and news reports. These sources will be analyzed to explore the Tower's connection to urban design and spatial development in Lujiazui.

2. Blueprint and Image Analysis

Design blueprints, historical photographs, videos, and contemporary site images of the Oriental Pearl Tower will be analyzed to assess the Tower’s role in the design competition and its spatial relationship with the urban environment post-construction.

3. Field Investigation

Fieldwork was conducted at the Oriental Pearl Tower, including the exploration of its public spaces, forecourt, and surrounding buildings. This hands-on investigation aims to provide a clearer understanding of the Tower's influence on the planning and layout of the Lujiazui high-rise cluster and urban space.

RESULTS AND DISCUSSIONS

Provide a concise, clear and precise description of the results and their interpretation. You may use tables, drawings, figures, and diagrams to illustrate your findings. Make sure to dedicate enough space for discussing your results and to reflect on how they can be interpreted from previous studies' perspectives and the working hypotheses/research questions. The findings and their implications should be discussed in the broadest context possible, and the limitations of the work should be highlighted.

CONCLUSIONS

Firstly, with regard to preparation and site selection of the Oriental Pearl Tower: As one of the key architectural projects in the Pudong development, the Oriental Pearl Tower was intended from the outset to transform the cityscape and become a landmark of Shanghai. The final choice of the Lujiazui area in Pudong highlighted its important geographical location and its strategic significance in showcasing Shanghai's international image.

Secondly, in the Lujiazui Urban Design Competition, the Oriental Pearl Tower, a landmark that has yet to be constructed, exerted a considerable influence on the national programmes and the final programme. The final scheme, which has been further developed and refined, continues to place the Oriental Pearl Tower at its core as an iconic building. This is evident in the design of the roads along the main axis, the overall road system, the axial pointing, and the nodal spaces.

Thirdly, from the perspective of surrounding Architecture, the Oriental Pearl Tower, together with surrounding buildings, forms the skyline of Lujiazui and shapes the city's image. The design of the International Conference Center, constructed after the completion of the Oriental Pearl Tower, was profoundly influenced by the tower's design. Its design incorporates the imagery of "big pearl and small pearls falling on a jade plate," featuring a spherical and cylindrical shape that complements the sphere of the Oriental Pearl TV Tower.

Finally, in terms of urban space: the Oriental Pearl Tower plays a significant symbolic role in the Lujiazui urban space through three key aspects: guiding road systems, shaping regional boundaries, and forming node spaces. It serves as a crucial landmark that not only directs the layout of road networks but also helps define the edges of different urban zones. Additionally, it creates distinctive focal points within the city. By integrating these functions, the tower significantly contributes to shaping Lujiazui’s urban identity and the development of a complex, multi-layered urban space.

Acknowledgements

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Measuring urban vitality of historic districts and exploring its relationship with the visibility of historic buildings—taking the Hengshan-Fuxing Roads historic protection zone in Shanghai as an example

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ABSTRACT

This study proposes a quantitative approach to measuring the urban vitality of historic districts, an area traditionally studied qualitatively. It collects Location-Based Services (LBS) data, social media check-in data, and urban sentiment data for the researched historic district, using these as dimensions to measure urban vitality. The study then utilizes the Analytic Hierarchy Process (AHP) to assign weights to these dimensions, creating a quantifiable index for urban vitality. Using GIS, the study analyzes potential physical space factors affecting the urban vitality of historic districts. The study applies the Spearman correlation to these factors, finding that the visibility of historic buildings has the most significant impact on urban vitality. Additionally, the percentage of green views and facilities also influences urban vitality of historic districts.

Keywords: urban vitality, historic districts, Location-Based Services (LBS) data, Analytic Hierarchy Process (AHP), spearman correlation.

INTRODUCTION: QUANTITATIVE ASSESSMENT OF URBAN VITALITY IN HISTORIC DISTRICTS

Urban vitality, a fundamental indicator of place-making and urban livability, has been widely analyzed through the lens of various urban big data sources. With the rise of smart city technologies and the increasing availability of large-scale data, researchers have gained unprecedented access to metrics that capture the dynamism of urban environments. These metrics can be broadly categorized into three distinct types based on their emphasis on spatial patterns, physical environments, and subjective experiences, each offering unique insights into urban vitality.

1) Spatiotemporal Distribution of Human Activity

This approach leverages Location-Based Services (LBS) data to monitor the intensity and spatiotemporal patterns of human activity (Jin et al., 2017; Jacobs-Crisioni et al., 2014; Li et al., 2016). By tracking the real-time movement of individuals, often through mobile signaling data, researchers can infer urban vitality by mapping the density and movement patterns of the population across

different times and spaces. These patterns, in turn, provide a proxy for understanding the vibrancy of urban streets and districts, particularly in highly trafficked areas.

2) Objective Characteristics of the Urban Physical Environment

The second approach focuses on the physical attributes of the urban environment, particularly the distribution of commercial establishments, urban amenities, nighttime lighting, and other built environment features. This is primarily achieved through Points of Interest (POI) data, which capture the spatial arrangement and density of key urban functions (He et al., 2018; Q. Li et al., 2022; Yue et al., 2019; Zeng et al., 2018). By analyzing POI data, researchers can assess how the configuration of the urban landscape influences social interactions and economic activities, and thereby measure the vitality of urban spaces. This method is particularly useful for understanding how different land uses and facilities contribute to urban vibrancy.

3) Subjective Perception of Urban Activity

The third category utilizes data derived from social media platforms to capture subjective experiences and perceptions of urban environments (Long & Huang, 2019; Ye et al., 2018). User-generated content such as texts, images, and videos posted on social media provides qualitative insights into how people perceive and engage with urban spaces. These subjective data sources offer a nuanced understanding of urban vitality, reflecting the emotional and experiential dimensions that traditional spatial metrics may overlook.

While these methods have proven effective in assessing vitality in conventional urban contexts, historic districts present unique challenges that complicate their application. The urban vitality of historic districts is deeply intertwined with cultural, architectural, and temporal factors that cannot be fully captured through standard POI, LBS, or social media data alone. Historic districts often embody a complex blend of preservation and modern adaptation, where the layering of history and contemporary use creates a distinct urban fabric.

In recent years, there has been increasing recognition of the need to preserve and revitalize historic districts within the broader framework of sustainable urban development. As urban growth shifts from expansion to stock renewal, the preservation of historic areas has become a key priority in urban regeneration efforts. Despite the growing attention to historic districts, there remains a significant gap in the quantitative assessment of their urban vitality. Existing methods, which focus on either the physical or social aspects of urban spaces, often fail to account for the intricate dynamics that define the vitality of these areas.

To address this gap, it is essential to establish a more comprehensive index that integrates contemporary quantitative urban morphology with big data analytics. This approach would allow for a more nuanced and efficient assessment of the urban vitality of historic districts. By incorporating data on the visibility of historic buildings, spatial configuration, and human activity, we can create a more robust framework for measuring vitality. The index we propose not only offers a means of quantifying vitality but also provides insights into the relationship between urban vitality and the visibility of historic buildings—an often-overlooked factor in the analysis of historic districts.

REVIEW: CURRENT RESEARCH AND GAPS IN MEASURING URBAN VITALITY OF HISTORIC DISTRICTS

Urban vitality of historic districts

Urban vitality is a multifaceted concept, encompassing the dynamic interactions of people, activities, and spaces within urban environments. Historically, urban vitality has been measured through various data sources, such as Location-Based Services (LBS) and social media, which capture spatial-temporal human activity and reflect the emotions and interactions of people in urban spaces. These data provide a more nuanced understanding of how vitality manifests in urban settings. The vitality of historic districts, as a subset of general urban vitality, should similarly be understood through a multidimensional approach. However, historic districts pose unique challenges, as they represent a blend of cultural preservation and modern urban usage.

Numerous studies have examined factors influencing urban vitality in typical urban districts, often focusing on elements such as street design and land-use diversity. For instance, Xu and Kang (2014) used questionnaire-based surveys to identify how physical design elements, such as sidewalk width and interface transparency, significantly influence street vitality. Their findings emphasized the importance of pedestrian-friendly environments in fostering vitality. Long and Zhou (2016) analyzed mobile phone POI data to identify functional mixture and population density as critical factors in promoting street-level vitality. These studies illustrate that urban vitality is shaped by both spatial configuration and the variety of functions present in urban areas.

Despite these findings, there has been limited research into the specific factors affecting the vitality of historic districts. Historic districts possess distinct characteristics that set them apart from typical urban spaces, including unique architectural forms, cultural heritage significance, and often more constrained development regulations. Some scholars, such as Li et al. (2024), have argued from a qualitative perspective that elements such as the layout, density, and visibility of historic buildings are particularly important in shaping the vitality of historic districts. However, the current academic discourse lacks a standardized framework for quantitatively measuring these factors in historic contexts. Thus, further research is needed to explore these unique aspects of vitality in historic districts more deeply and to develop more refined measurement methodologies that capture both their physical and experiential dimensions.

Visibility of historic buildings

The visibility of historic buildings plays a pivotal role in defining the character and identity of historic districts. Kevin Lynch's seminal work on urban imageability underscores the importance of spatial visibility in how people perceive and navigate urban environments. In the context of historic districts, the visibility of architectural heritage reflects a core preservation principle—the "authenticity" of place (Wan & Li, 2016). Ensuring that historic buildings remain visible and accessible to the public is crucial not only for preserving their cultural value but also for maintaining the historic district's role as a living part of the urban fabric.

Despite its importance, the visibility of historic buildings has not been effectively measured in many prior studies due to limitations in analytical techniques. Traditional research on historic buildings has predominantly focused on qualitative studies examining their architectural and cultural significance.

These studies often explore aspects such as the artistic elements, structural integrity, and cultural heritage embodied by historic buildings (Meng, 2024). However, they rarely incorporate quantitative measures of visibility, which could provide more precise insights into how these buildings contribute to the overall vitality of the district.

Recent advances in urban morphology and spatial analysis have opened new possibilities for quantitatively measuring the visibility of historic buildings. While some scholars have begun to explore correlations between the visibility of historic buildings and urban vitality, the field remains largely underdeveloped. Lu et al. (2023) provided some preliminary quantitative evidence suggesting that the visibility of heritage buildings may positively influence the vitality of historic districts. However, their research lacks comprehensive qualitative analysis that fully explores the experiential aspects of visibility. The absence of integrated qualitative and quantitative approaches leaves a significant gap in understanding how visibility affects not only the perception but also the actual functioning of historic districts.

Research progress & current gaps

Although significant progress has been made in measuring urban vitality in conventional urban areas, there remain several key gaps when it comes to historic districts. Firstly, while numerous approaches exist for measuring urban vitality, including LBS data, POI analysis, and social media-derived metrics, these methods have not been synthesized into a comprehensive index specifically tailored for historic districts. Given the unique cultural, architectural, and spatial characteristics of these areas, a more holistic vitality index is needed to account for their complexity. Secondly, in addition to the commonly studied factors affecting urban vitality, such as density, functional diversity, and spatial configuration, there is a critical need to identify whether there are distinct factors that uniquely impact the vitality of historic districts. For example, elements such as the preservation of architectural heritage, the integration of modern amenities, and the relationship between old and new urban forms may play a significant role, but they remain understudied. Thirdly, there is a notable lack of research on the quantitative measurement of the visibility of historic buildings and its relationship with urban vitality. While some studies have suggested potential correlations between visibility and vitality, comprehensive analytical methods that combine both qualitative and quantitative perspectives are missing. Developing these methodologies would provide more robust tools for urban planners and conservationists to assess and enhance the vitality of historic districts, ensuring that these culturally significant areas remain vibrant and livable parts of the city.

In summary, while the study of urban vitality has advanced considerably in recent years, the unique challenges of measuring vitality in historic districts call for more tailored approaches. There is a pressing need for integrated methods that consider the visibility of historic buildings alongside other factors, allowing for a more nuanced understanding of how historic districts function and thrive within the broader urban context.

METHOD

Study area

This study examines the Hengshan-Fuxing Roads Historic Protection Zone in Shanghai, covering an area of approximately 7 km^2 (Figure 1). Known for its rich collection of historic buildings, particularly the renowned garden villas, the area is characterized by heritage-protected roads and alleys that

reflect various historical periods. As a vibrant hub for tourism and everyday life in Shanghai, the district boasts a wide variety of commercial and entertainment activities. The diversity in architectural styles and building functions, combined with the dynamic street life, makes this historic protection zone an ideal case study for exploring the relationship between urban vitality and the preservation of cultural heritage.

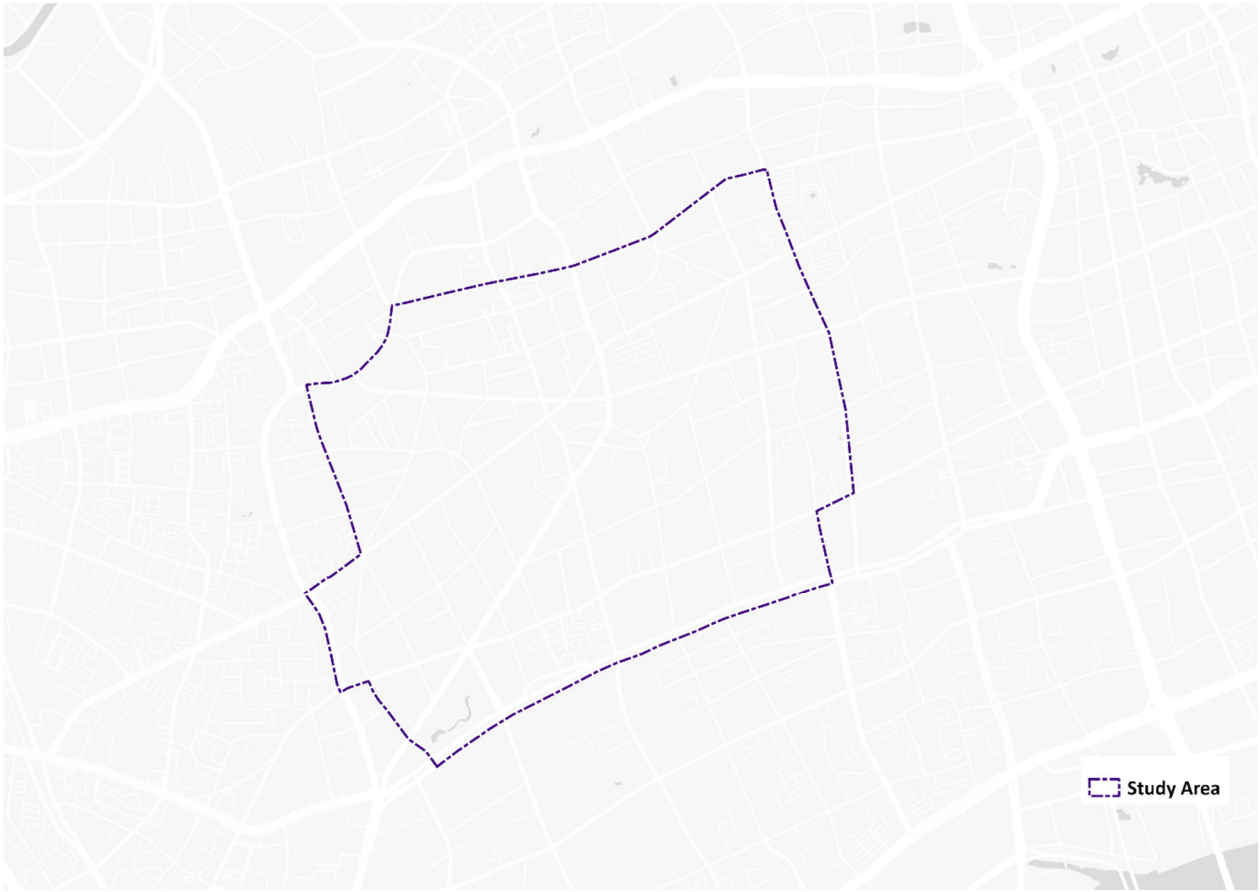

Figure 1.Study area: the Hengshan-Fuxing Roads Historic Protection Zone in Shanghai, photo credit: drawn by the author

Research framework

This study is structured into two primary components (Figure 2). The first component focuses on assessing the urban vitality of historic districts. Using the Analytic Hierarchy Process (AHP), expert evaluations are applied to data sourced from Location-Based Services (LBS), social media check-ins, and urban sentiment analysis. These evaluations are used to calculate weighted proportions, which are then integrated to derive vitality scores for each street segment.

The second component involves significance analysis. Initially, the study employs QGIS and machine learning-based street view image segmentation techniques to identify potential factors influencing vitality within historic neighbourhoods at the site. Following this, Spearman's correlation analysis is conducted to determine the most significant factors impacting urban vitality within the area.

The research is organized into four main stages: (1) data collection, (2) assessment of urban vitality in historic districts, (3) identification of factors influencing vitality in historic areas, and (4) analysis of the

significance of these factors on urban vitality in historic districts. This structure ensures a comprehensive understanding of both the vitality and the underlying factors that contribute to the vibrancy of historic areas.

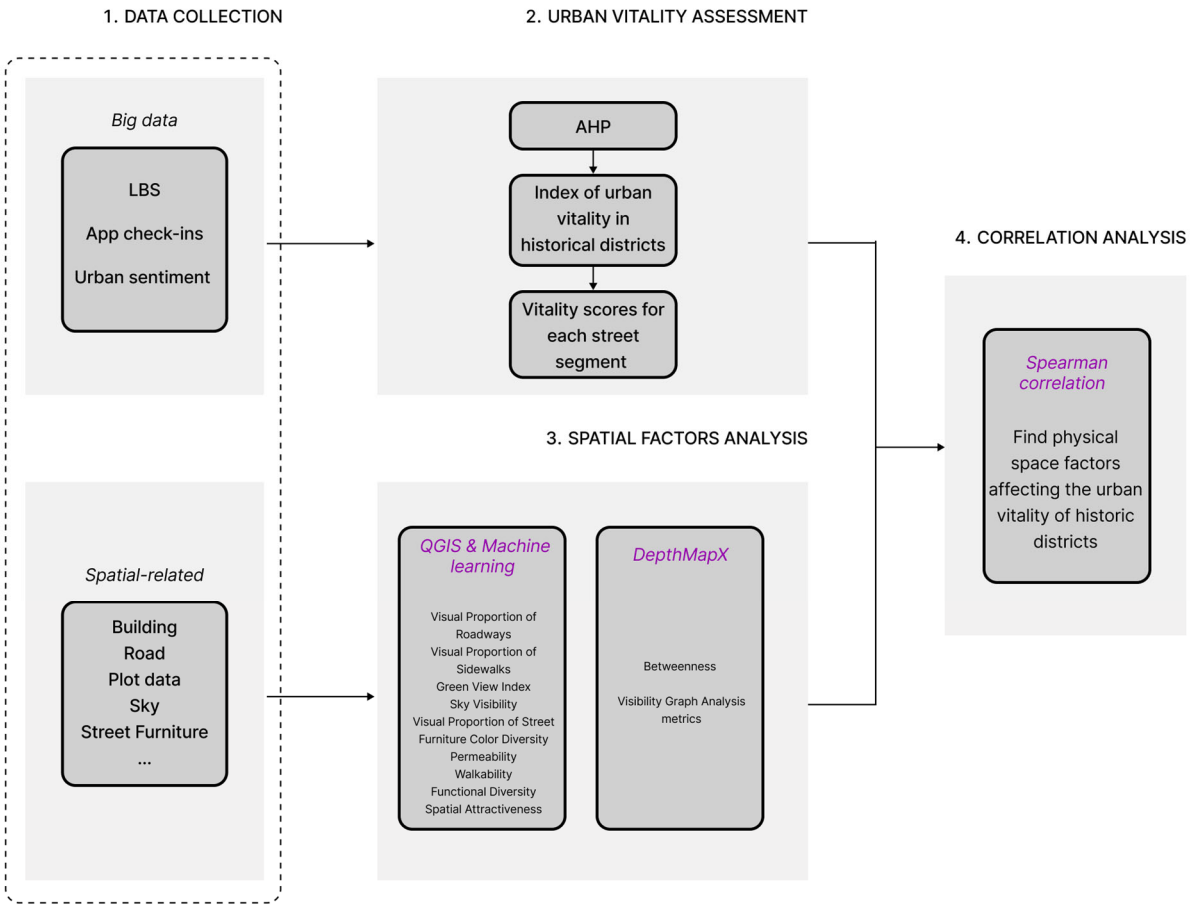

Figure 2. Research framework, photo credit: drawn by the author

Measuring urban vitality in historic districts

Collection of diverse data

Location-Based Service (LBS) data

This study utilizes anonymized geographical data from Baidu's Huiyan service, providing precise time and spatial location information based on user GPS. To represent population vitality, all LBS trajectory points at 16:00 every afternoon were aggregated for each week. Using GIS spatial connection techniques, the grid data was weighted to the roads, enabling the derivation of urban vitality values for each street segment based on LBS data. This data constitutes the first dimension of vitality measurement.

Social media app data

Data from "Xiaohongshu," China's popular social media app for check-ins and interactions, was selected. This dataset includes GPS positioning. For this study, 6452 Xiaohongshu data points with GPS positioning within the site were chosen, providing quantitative data on check-in numbers and textual data on specific notes.

An analysis was first conducted based on Xiaohongshu check-in data. Building on the previous step of road segmentation and GPS positioning, the number of check-ins on each street segment was calculated, forming the second dimension of vitality measurement.

A second analysis was conducted based on Xiaohongshu note design. Utilizing Natural Language Processing (NLP) for sentiment analysis, each note's sentiment was scored from 0 to 1 (with 0 representing more negative evaluations and 1 representing more positive evaluations). This process yielded the public sentiment on each street segment, i.e., the average sentiment values per street segment, constituting the third dimension of vitality measurement.

Index for urban vitality of historical districts

This research utilizes the Analytic Hierarchy Process (AHP) to establish the final measurement indicators for assessing the urban vitality of historical districts. AHP is a quantitative analytical method commonly applied to complex decision-making scenarios. We engaged multiple experts to evaluate and weigh three dimensions of vitality measurement for historical districts. The resultant weight distribution is as follows:

Index for Urban Vitality of Historical Districts=50%×LBS Data+30%×Xiaohongshu Check-in Data+20%×City Sentiment Analysis Data derived from Xiaohongshu Notes

Using this formula, the vitality scores for each street segment within the site are calculated, as depicted in Figure 3.

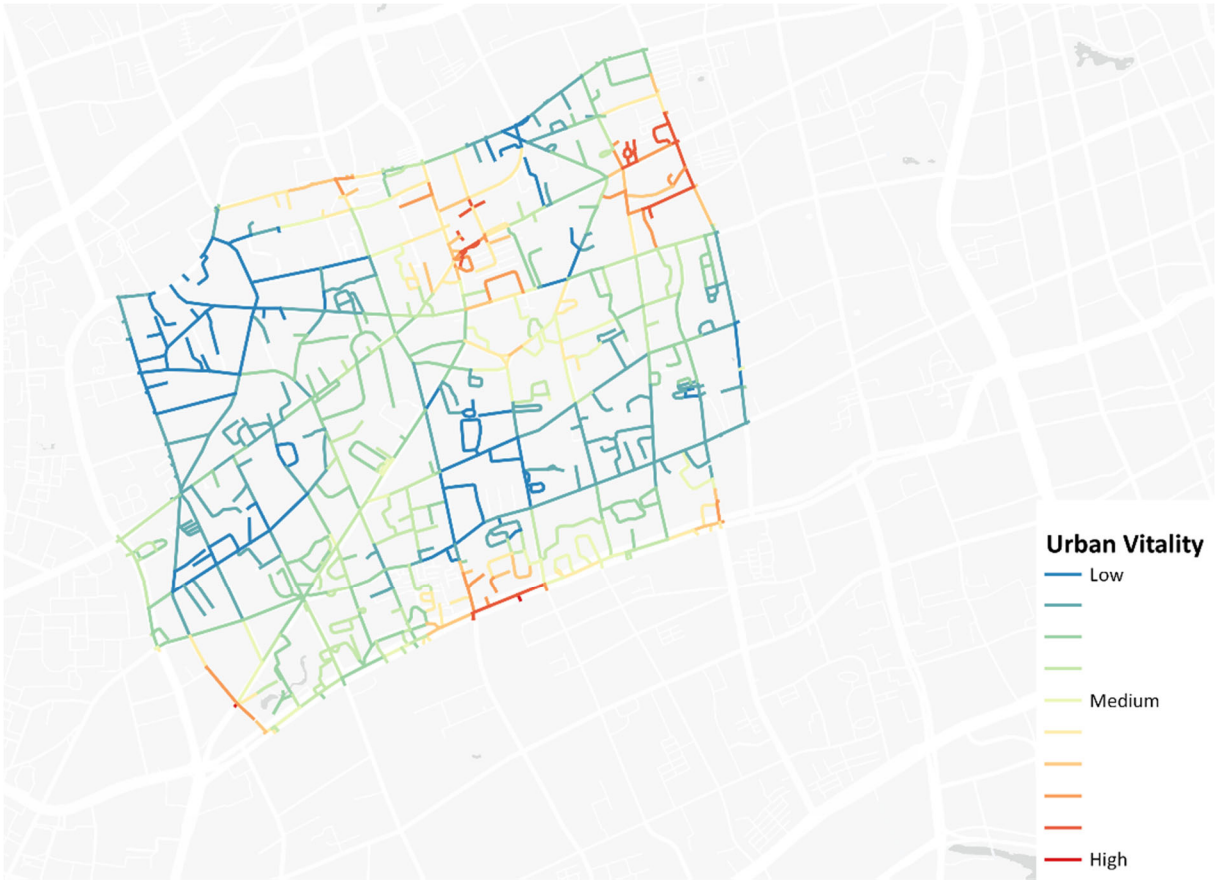

Figure 3. The vitality scores for each street segment within the site. Photo credit: drawn by the author.

Indicators Influencing the Vitality of Historic Districts

Drawing on the insights from Section 2.3 regarding factors influencing the vitality of historic districts, this study computed data for several potential influencing factors. Initially, spatial syntax-related data for each street segment, within a 1200-meter radius, was analyzed using DepthMapX to obtain street Betweenness and Visibility Graph Analysis metrics. Subsequently, Baidu Maps street view data and machine learning-based image segmentation techniques were employed to extract various visual metrics from each street view image. These metrics include Visual Proportion of Roadways, Visual Proportion of Sidewalks, Green View Index, Sky Visibility, Visual Proportion of Street Furniture, Color Diversity, Permeability, Walkability, Functional Diversity, and Spatial Attractiveness. Each image's GPS location from Baidu street views was used for visualization in QGIS, and spatial join techniques were applied to map point data onto road data, deriving specific values for each street segment.

Furthermore, to analyze the correlation between urban vitality of historical district, historical architecture, and district morphology from a quantitative morphological perspective, this study utilized QGIS to calculate the Edge Rate, Proximity Rate, Building Articulation Index, and Road Network Density for each roadway. The Edge Rate indicates the proportion of street walls or the continuity of the street interface, while the Proximity Rate measures the degree to which the street facade is close to or distant from the street boundary. The Building Articulation Index represents the variation in building height. Detailed results are presented in Table 1.

Table 1. *Indicators Influencing the Vitality of Historic Districts.*

Indicators

Space Syntax-related Indicators	Btweeness1200 (BtA1200) Visibility Graph Analysis (VGA)
Google Street View-related Indicators	Visual Proportion of Roadways (VPR) Visual Proportion of Sidewalks (VPS) Visual Proportion of Buildings （VPB） Green View Index(GVI) Sky Visibility (SV) Visual Proportion of Street Furniture (VPSF) Color Diversity (CD) Permeability Walkability Functional Diversity (FD) Spatial Attractiveness (SA)
Quantitative Urban Morphology-related Indicators	Edge Rate (ER) Road Network Density (RND) Proximity Rate (PR) Building Articulation Index (BAI)

Correlation analysis

Prior to conducting the correlation analysis, data cleaning was performed. Initially, among the original 926 street segments, 44 segments with an urban vitality score of zero (as derived in Section 3.2) were removed. Additionally, 226 segments where the Quantitative Urban Morphology-related Indicators were zero were also excluded, resulting in 654 effective street segments.

Subsequently, Spearman correlation method was employed to analyze the impact of various factors on the urban vitality of historical districts, aiming to identify the most influential factors within the site. Spearman correlation is a non-parametric statistical method used to assess whether there is a monotonic relationship between two variables. The term "non-parametric" indicates that this method does not assume any specific distribution for the data. Instead, it calculates correlations based on the ranks of the data rather than their actual values. The final analysis results are presented in the tables below.

Table 2. *The final analysis results*

Indicators	Beta	p-Value
VPR	36.64	0.145
VPS	-51.69	0.373
VPB	-45.21	0.022
GVI	-126.82	<0.01
SV	30.88	0.562
VPSF	222.02	<0.01
CD	-8.15	0.034
Permeability	88.38	0.237
RND	-6.02	0.101
Walkability	495.50	0.109
FD	-0.87	0.580
SA	0.74	0.504
BtA1200	-0.0083	0.103
VGA	110.06	<0.01
ER	-1.30	0.616
PR	-6.40	0.043

BAI	9.53	<0.01



Visibility Graph Analysis	Visual Proportion of Street Furniture	Building Articulation Index

Figure 4. *Indicator with the positive correlation.*



Green View Index	Visual Proportion of Buildings

Figure 5. Indicator with the negative correlation.

According to the analysis, the Visual Proportion of Buildings (VPB) has a significant negative impact on the Urban Vitality Index, with a coefficient of -45.21 and a p-value of 0.022, indicating that areas with dense building concentrations tend to have lower street vitality values. Similarly, the Green View Index (GVI) also exhibits a significant negative effect (coefficient of -126.82, p-value < 0.001), suggesting that higher vegetation coverage may be associated with lower street vitality. Conversely, the Visual Proportion of Street Furniture (VPSF) and Visibility Graph Analysis (VGA) demonstrate strong positive impacts (VPSF coefficient of 222.02, p-value = 0.001; VGA coefficient of 110.06, p-value < 0.001), indicating that the openness and quantity of street furniture are likely crucial factors in enhancing street vitality. Additionally, the Building Articulation Index (BAI) shows a positive influence (coefficient of 9.53, p-value = 0.001), further emphasizing the positive correlation between the variability in building heights and street vitality.

Although variables such as road proportion and sidewalks did not show statistical significance in this model, the significant results obtained provide important insights into potential factors influencing street vitality.

DISCUSSION & CONCLUSIONS

New insights

The findings from this study on the Hengshan-Fuxing Roads Historic Protection Zone provide several new insights into urban vitality dynamics. The significant negative impact of the Visual Proportion of Buildings (VPB) on the Urban Vitality Index highlights the challenges posed by high-density urban environments. It suggests that excessive building density might stifle the vibrancy and perceived accessibility of street-level activities. Conversely, the positive effects of the Visual Proportion of Street Furniture (VPSF) and Visibility Graph Analysis (VGA) underscore the importance of open spaces and well-planned street furniture in enhancing urban vitality. These elements appear to facilitate more engaging and active street environments, thereby boosting the overall liveliness of the area.

Methodological innovation

This study presents a significant methodological innovation in the calculation of urban vitality by integrating traditional Location-Based Service (LBS) data with emerging data sources from the Xiaohongshu platform, including urban hotspots and sentiment data. This innovative approach provides a more comprehensive and nuanced understanding of urban vitality, capturing not only the spatial distribution of population activities through LBS data but also the qualitative aspects of these activities reflected in social interactions and emotional expressions.

The inclusion of Xiaohongshu data is particularly innovative because it captures the spontaneous and subjective experiences of city residents and visitors, which are often overlooked in conventional urban studies. By analyzing check-in data and sentiment values from Xiaohongshu, this study gains insights into the popularity and emotional resonances of different urban areas, offering a more dynamic and human-centered perspective on urban vitality.

Furthermore, this methodological advancement leverages the strengths of machine learning in processing large datasets and in extracting meaningful patterns from complex urban data. The combined use of quantitative LBS data and qualitative social media data enhances the accuracy and relevance of the Urban Vitality Index, making it a powerful tool for urban planners and policymakers seeking to understand and enhance the liveliness of urban environments.

Future research could expand on this innovative approach by integrating additional data layers, such as real-time traffic data or weather conditions, to further refine the vitality index. Moreover, the methodology could be adapted to other social media platforms and urban settings worldwide, broadening its applicability and facilitating comparative urban studies.

Limitations & next steps

Despite the robust methodological framework, this study has some limitations that suggest directions for future research. One limitation is the exclusion of certain street segments due to zero values in urban vitality or morphological indicators, which could potentially skew the understanding of urban dynamics by omitting areas that are either underdeveloped or not adequately captured by the data sources. Additionally, the reliance on data from specific platforms like Xiaohongshu may limit the generalizability of the findings across different urban contexts or cultural settings.

Future studies could address these limitations by incorporating a more diverse array of data sources to capture a wider spectrum of urban activities and by expanding the analytical framework to include other cities or historical districts. Furthermore, longitudinal studies could be conducted to assess how

interventions in urban design influence vitality over time, providing more dynamic insights into the efficacy of urban planning strategies.

Acknowledgements

We would like to express our sincere gratitude to Professor Ye Yu from the College of Architecture and Urban Planning, Tongji University, for his invaluable guidance and insightful advice on this research.

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A century of saturnino de brito's plan for santos city: an urban morphological analysis

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ABSTRACT

The following guidelines provide instructions to format your full paper, specifically on the way how text should be formatted, table and figures captioned, and references cited. The conference proceedings will be published in an electronic format. The paper should be submitted in a Word document (.doc or .docx) and shall be written in accordance with instructions of Urban Morphology Paper Submission Guidelines. The Brazilian city of Santos, located in the state of São Paulo, Brazil, is home to largest port in Latin America, its history is directly related to the urban project designed and executed by engineer Saturnino de Brito at the beginning of the 20th century, which, due to its scale, was one of the first and most original planned cities in Brazil. The urban morphological study of the territory bequeathed by this project highlights the components of the urban landscape preserved from the original project that promoted (or not) the urban development of areas adjacent to those preserved from the original plan. Its analysis also highlights (emphasizes) the process of formal recognition and its project genesis established by its author, from an urban-sanitary nature. The city of Santos in Brazil, located in the state of São Paulo, is home to the largest port in Latin America. Its history is closely tied to an urban project developed and implemented by engineer Saturnino de Brito at the beginning of the 20th century. This project was one of the earliest and most innovative planned city initiatives in Brazil due to its large scale. An analysis of the urban layout left by this project highlights the elements of the urban landscape that have been preserved from the original plan, as well as how they have influenced the development of surrounding areas. Therefore, by applying the British school of urban morphology, the historical narrative explicitly revealed the existing morphological regions after a century. With this knowledge, especially in the highlighted region of the research, the Orchidarium Park, in confluence with the seaside garden, original and also previous morphological characteristics of Saturnino's plan. Another concept of the Conzenian tradition has been identified: the burgage cycle. This has also led to the identification of likely models of ongoing urban expansion that extend beyond the island, involving both vertical growth and the merging of neighboring coastal cities. This transformation is turning Santos into the metropolitan capital of its region. This article aims to explore the paths, streets, and buildings developed as part of Saturnino de Brito's Plan for Santos over a century. It seeks to deepen an understanding of the urban landscape, tracing its evolution from the initial planning stages to the eventual saturation of the originally designated area. This saturation occurred between the subsequent master plans implemented in 1968 and 2005.

Keywords: urban morphology, urbanism, new cities

INTRODUCTION

In the study of urban expansion, a single city can have diverse and changeable formal compositions. Cities are also understood by the results of their constant process of spatial evolution, thus giving them a certain spatial character. When combined with urban morphological analysis, research on these characteristics becomes a broader field of investigation. This is defined by M.R.G. Conzen (1969: 03) as "a combination of City Plan, the pattern of built forms, and pattern of urban land use" within a certain "urban landscape".

Urban morphology can be understood in two definitions adopted here. According to Anne Vernez Moudon (1997:1), "Urban morphology is the study of the city as a human habitat.". The second approach, which this article closely aligns with in terms of time, was conceptually defined by Stael de Alvarenga Pereira Costa and Maria Manoela Gimmeler Netto as follows: "Urban Morphology is the study of urban form, considering it a physical product of society's actions on the environment, which build it over time".(2015:29-31).

The morphogenesis of planned cities as a design intention.

The choice of the analysis is justified as it is essentially a project for a new city. Due to its projected and partially constructed dimension, it is considered part of the urban development movement known as Sanitary Urbanism. "It is essentially summarized in the work of Saturnino de Brito" (Villaça, 1999: 179). This choice further supports the hypothesis, as evidenced by Karl Kropf's research:

"The analysis of planned cities can help understand their origins by considering urban form as a physical representation of a specific cultural context. Urban morphology can address the emergence of different forms and why certain forms persist or spread". (Kropf, 2011: 159).

Therefore, the hypothesis that the urban evolution of Santos had at its origin the design intention of the author to implement an urban layout that manifested a certain cultural context. Furthermore, this hypothesis begs the question of "[...] how those forms shave been generated in terms of the elements they are made of, the internal relationships between the elements, the relationship of the whole with the larger structures of which they are part, and the generic processes involved in their formation?" (Kropf and Malfroy,2013:130).

I The inicial routes

To conduct an urban morphological study in the city of Santos, located on the coast of São Paulo. The study will focus on the evolution of the Urban Plan created by Saturnino de Brito, also known as 'A planta de Santos', starting from its origins." - integrating port, city, and coastline - until the creation of the first Participatory Master Plan in 2005. This study (Araújo, 2023) uncovered existing implicit pathways leading to the proposed city design and the preservation of part of the same plan.

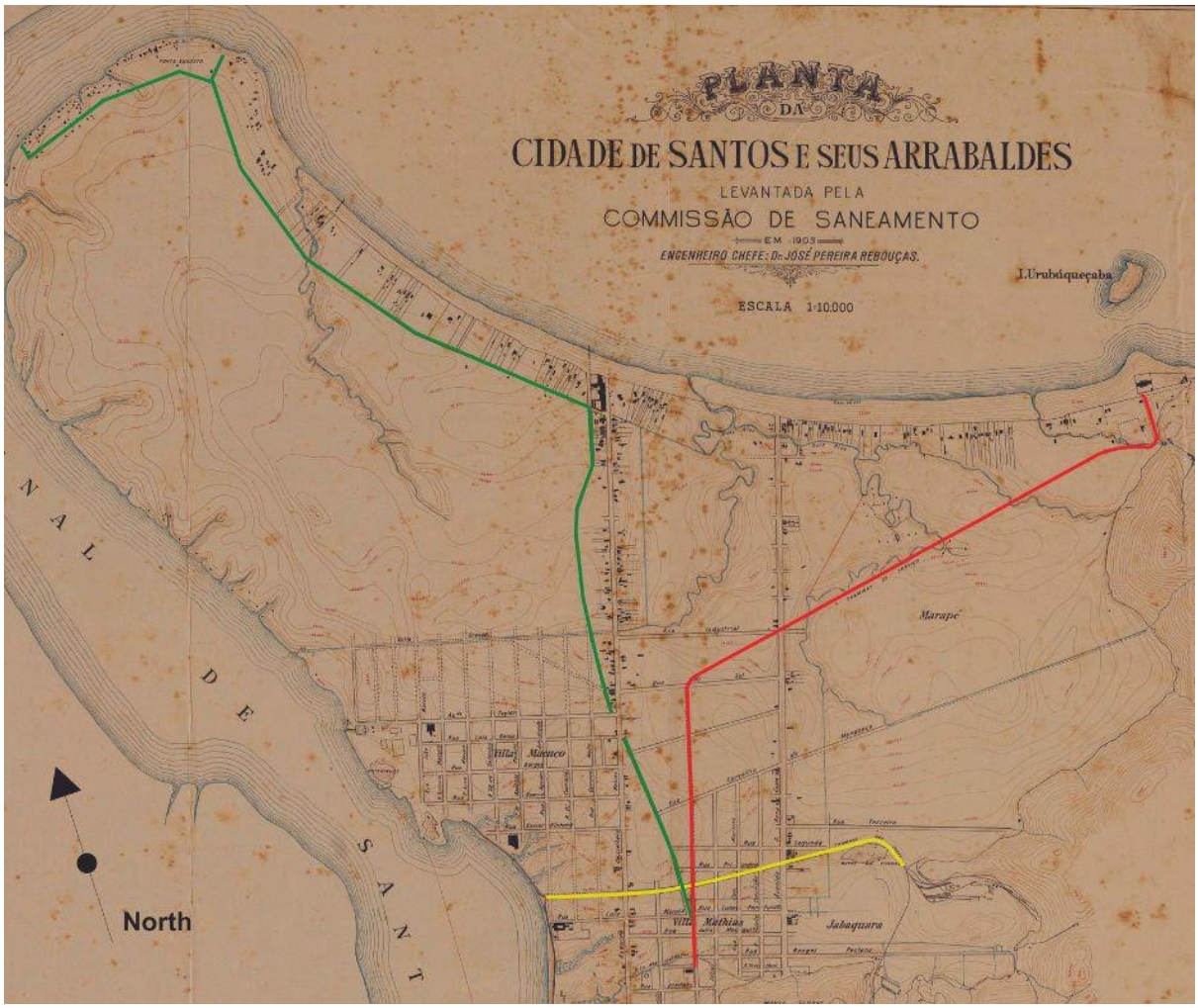

Figure 1 – Generational paths of the Saturnine Plan finding in the 1903 cadastral survey of Santos prepared by the Santos Sanitation Company (CSS).Scale 1:10,000. Source: Prepared by the authors based on CSS. São Paulo, ISUF 2024.

The survey points and axes established the basis for the urban and sanitary plan of the “Planta de Santos”, which was created by its author in 1910. This intention is evident in the choice of the meeting point for transportation routes and the primary sanitation network (red line), old preserved routes from the 16th century include (green line) the “Caminho da Barra dos Fortes Militares Augusto e da Barra do Estuário”, along with landfills built with borrowed material for port expansion (yellow line) – Tramlines for cargo have shaped the current neighborhood, giving it a toponymy similar to "Encruzilhada", Crossroad.

Background – From a Village to a port city

No more than three levels of headings should be used. When mentioning and referencing specific work, please use author and year in parenthesis (Surname, 2003). If you are citing several works at the same time, all relevant surnames and years should be included in parenthesis chronologically (Surname, 2010; Surname, 2014). Citations of works by two authors should have ‘and’ (not an &) between the names (Surname and Surname, 2015). Citations of works by three or more authors should have the first author followed by et al in italics (Surname et al., 2021). Furthermore, “When

you include a quote in the text, this should be in italic, contained quotation marks and listing in the reference author(s), year of publication, as well as page number or page range” (Surname, 2020: 5-8).

The hereditary captaincies were a system established by the Portuguese empire during the 16th century to make the occupation and exploration of Brazil financially viable. This system was inspired by feudalism and was continued by King João III, who succeeded King Manuel I and upheld the mercantilist project.

In 1532, Dom Martim Afonso, the grantee of the hereditary captaincy of São Vicente, disembarked his fleet at the port of ships. This port is in the current neighborhood of Ponta da Praia. He brought his first settlers and the sugarcane seedlings, which quickly spread throughout colonial Brazil. (Ribeiro, 2006:273). The "Vila do Porto de Santos" was officially founded in 1543 by Brás Cubas, a Portuguese member of the same fleet. He was tasked with building a new port on the banks of the Enguaguaçu estuary, located north of the island of São Vicente. This was a strategic and defensive choice, as it concealed the village from the sight of pirates dispatched by other cities. Pirates were sailing along the southern coast of Brazil at that time. In the same area, there were small hills where the village center was located (Ornelas, 2008: 22). This site was selected to protect it from frequent flooding caused by tides and long rainy periods, which are common in the coastal region of São Paulo. The site is situated in the Mangrove Forest, which formerly encompassed almost the entire island. This colonial cycle lasted for three centuries, coinciding with the conquest and founding of numerous villages in the interior of Brazil, while the village of Santos saw little expansion in terms of urban planning. Its port lost significance due to the inland region's pursuit of mineral wealth.

The first port on this route was São Paulo, elevated to city status in 1711. In 1790, the expansion of coffee production led to the construction of a paved road connecting it with the port of Santos. “Calçada de Lorena” was a winding route that wound its way up the steep slope of the Serra do Mar. Two critical factors led to the recovery of the port economy and the expansion of both cities at the beginning of the 19th century. One significant factor was the general opening of the ports in 1808 by

D. João VI, as part of his reorganization of Brazil's infrastructure and economy. In 1867, the São Paulo Santos – Jundiaí Railway (S.P.R.S.J) was implemented, and the port was expanded from 1890 onwards by the newly formed Santos Port Authority (“Companhia Docas de Santos”). This expansion involved creating a landfill to gain more space for logistics. When sanitation measures were introduced, endemic diseases were eliminated and the urban land value in the area was enhanced. In addition to attracting the elite of the coffee-growing elite, this also led to increased settlement on the Santos coastline, and in 1836 Santos was finally granted city status.

METHOD

An analysis of the urban layout left by this project highlights the elements of the urban landscape that have been preserved from the original plan, as well as how they have influenced the development of surrounding areas. Therefore, by applying the British school of urban morphology, the historical

narrative explicitly revealed the existing morphological regions in the city of Santos, after a century, as elaborated upon more fully in our previous research (Araujo,2023).

The urban morphological analysis of Saturnino de Brito's Plan for Santos (Figure 3), proved to be an efficient methodology for understanding urban evolution, especially regarding the description of its historical periods, in identifying the paths taken by the project's author from its initial point. Such a historical-geographical description sheds light and sharpens the focus on every detail that occurred in various areas of the city, at different times, even those before and after its implementation.

The theoretical foundation of this research was complemented by Carriço (2002), essential for understanding the Morphological Periods through the explanation derived from the existing legal framework in the city, and the construction of the historical-geographical narrative.

The Urban Plans and Legislation of Santos, which determined the evolutionary periods and their reflection on the physical planning of the city, revealed a more assertive historical-geographical narrative regarding the formation and correct identification of its morphological periods, and, in particular, the knowledge of its territory.

In her research on the interaction between the city and the law, specifically regarding urban policy and the formation of territories, Raquel Rolnik (1997:13) states: "... law ostensibly functions as a template for the ideal city, yet it dictates only a minor portion of the built environment. The resultant city is not a product of the model enshrined in law, but rather of the interplay between legal frameworks and real estate production, which simultaneously delineates territories both within and beyond the city limits." (Translated by the authors).

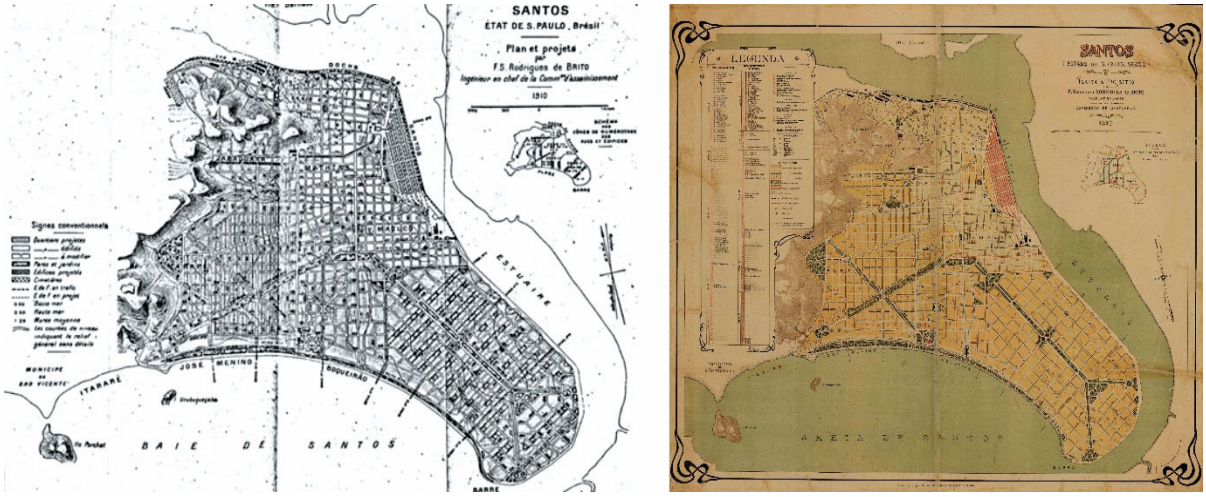

Figure 2. "Planta de Santos" with plots (Brito, 1944a) and its 1910 his final urban-sanitary project (Brito, 1944b). Source: Brito (1944a and 1944b). São Paulo, ISUF 2024..

RESULTS AND DISCUSSIONS

Provide a concise, clear and precise description of the results and their interpretation. You may use tables, drawings, figures, and diagrams to illustrate your findings. Make sure to dedicate enough space for discussing your results and to reflect on how they can be interpreted from previous studies' perspectives and the working hypotheses/research questions. The findings and their implications should be discussed in the broadest context possible, and the limitations of the work should be highlighted.

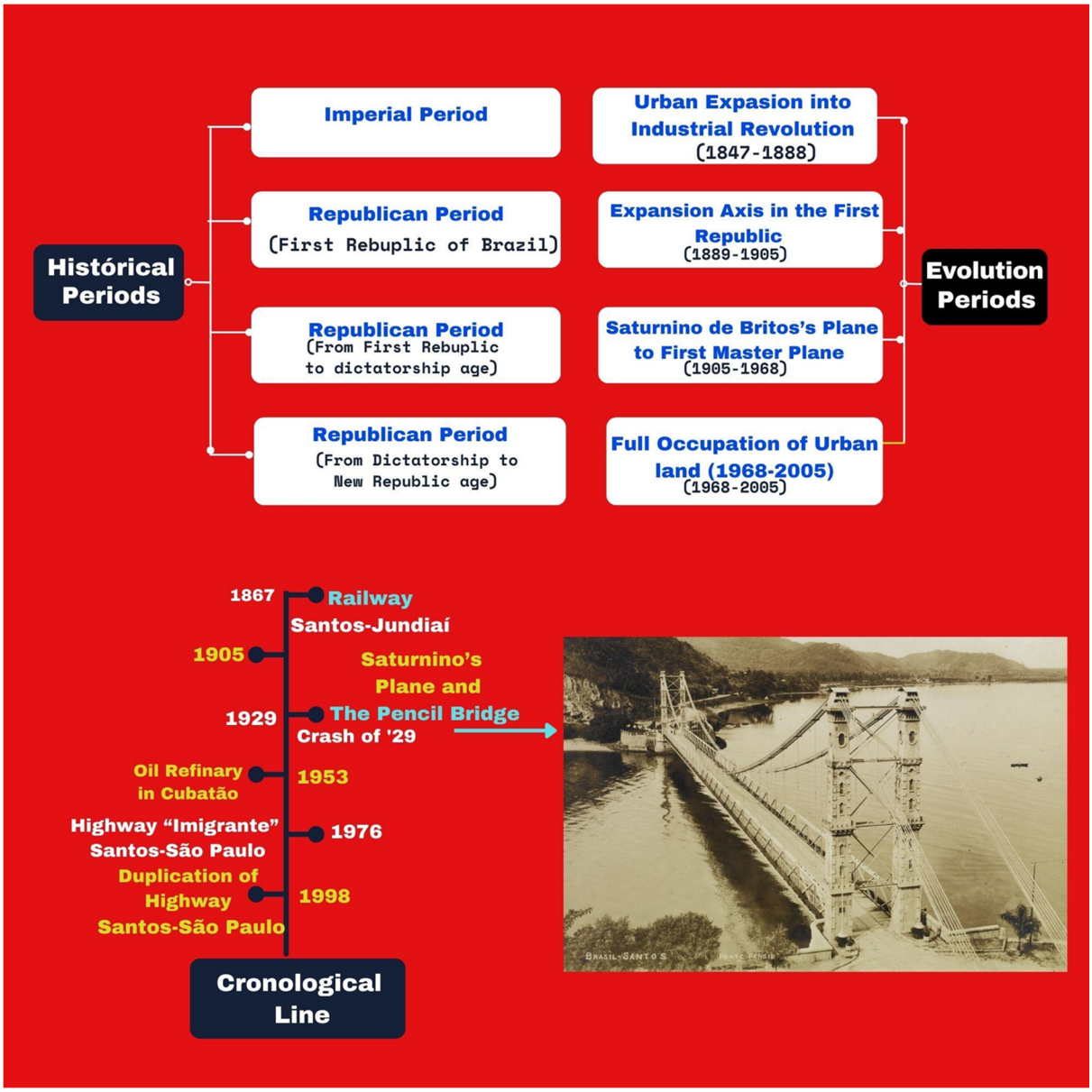

Figure 3. Resulting flowcharts of Historical Narrative method defined in research: Historical and Evolution Periods. Above, in the chronological line, and its events, with particular emphasis on the Pencil Bridge, designed by Saturnino de Brito to carry the sanitary sewage pipeline and connect São Vicente Island to its final destination—the old outfall located in the Isthmus of Itaipu, in the neighboring city of Praia Grande on the mainland. Photo credit: Prepared by the authors based on the Public Archives of the State of São Paulo. São Paulo, ISUF 2024.

Two results are obtained in a place delimited by urban expansion. First, the constructive interferences for the complex drainage system of the city ended up generating the interconnection of the island to the continent on its south coast, as well as for the continuation of the route with the largest city in South America: São Paulo. The use of existing systems prior to Saturnino's plan, which were taken advantage of, collaborate with this hypothesis. They are present from the axis adapted to the initial sewage system found in 1903, which formed the large diagonal avenue, which the author named "Avenida Sanitária" (Sanitary Avenue), in reference to his ideas from the school of positivism founded by Auguste Comte, which at the time influenced all engineering schools in Brazil. Therefore, in this research, this morphological period was named: Expansion Axis in the First Republic (1889-1930).

These and other periods are also motivated by the increase in urban legislation, which shapes the territory, giving it a characteristic physiognomy of place over time. The second result can be seen in the outcome of the laws and plans developed for Santos, which will - before and after the century analyzed here - create a conurbation on the coast of São Paulo, in which Santos will become the main urban nucleus. This result is exemplified by the actions of the subjects found in the legislative sphere and the consequent reaction - which renames the evolutionary period, as seen in Table 1 below.

Table 1. Principal Legislation and Historical Narrative Process of Santos City. Source: Prepared by Authors based in (Carriço, 2002).

Item	Legislation form	Number- Data	Subject	Evolution Period	Historical Period
1	Municipal Law	03/07/1847; 04/24/1857	City Hall conduct regulation	Port Expansion in the Industrial Revolution (1847-1888)	Imperial Period
2	Municipal Law	217 – 03/15/1897	City expansion Project	Town-Atlantic Sea Expansion Axis in the First Republic (1889-1905)	Republican Period (First Republic of Brazil)
3	Municipal Law	Lei 217 01/11/1906	Building Code	Saturnino de Britos' Plane to First Master Plane (1905-1968).	Idem
4	Municipal Law	675 - 07/28/1922	Building Law and Usage	Idem	Idem
5	Municipal Law	Lei 403 09/15/1945	Idem	Idem	Republican Period (Vargas Age)
6	Municipal Law	3.529 / 04/16/1968	First Municipal Master Plan	Idem	Republican Period (Militar Dictatorship Age)
7	Complementar Law	311/312 de 11/13/1998	Second Municipal Master Plan	Full Occupation of Urban land (1968-2005)	Republican Period (From Militar Dictatorship to New Republic Age)
8	Complementar Law	551- 12/27/2005	Municipal Law under Federal Land Policies of Urban Developed Instruments (10.257-07/10/2001)	Idem	Republican Period (New Republic Age)

This second results establishes a correlation between the knowledge of the original plan's preserved territory from the Subsequent Evolution Period and its level of legal protection. This correlation is evident in the morphological regions presented in Figures 4 and 5, designated as morphological region A (Saturnino Plan's preserved) and B (Burgage Cycle).

Lastly, the interplay between the aforementioned results suggests another factor influencing the continuity of the highlighted regions: the underlying intention of its author behind the urban sanitation project. This intention, rooted in both Sitte's principles of urban aesthetics and the Comtean positivist ideal of personal reform, manifested through a morphogenetic process of adapting and remodeling the existing urban fabric.



Figure 4. Aerial view of the first flight over the Santos beachfront and drainage canals in 1921 (left) and a current image of the Santos beachfront gardens (right). Source: Prepared by the authors based on the Public Archives of the State of São Paulo and Santos City Hall publications. São Paulo, ISUF 2024.



Figure 5. Aerial view of the Orchidarium (7a), between Marapé Hill and the small island of Urubuqueçaba in 1936 and the opposite aerial view of the same area in 1956 (7b), with the first taller buildings in beachfront including, in the background of the photograph, the old emissary located in the isthmus of Itaipu, in the neighboring city of Praia Grande (photo b). Source: Brazilian Institute of Geography and Statistics (IBGE). Credit: Thomas Somilo.

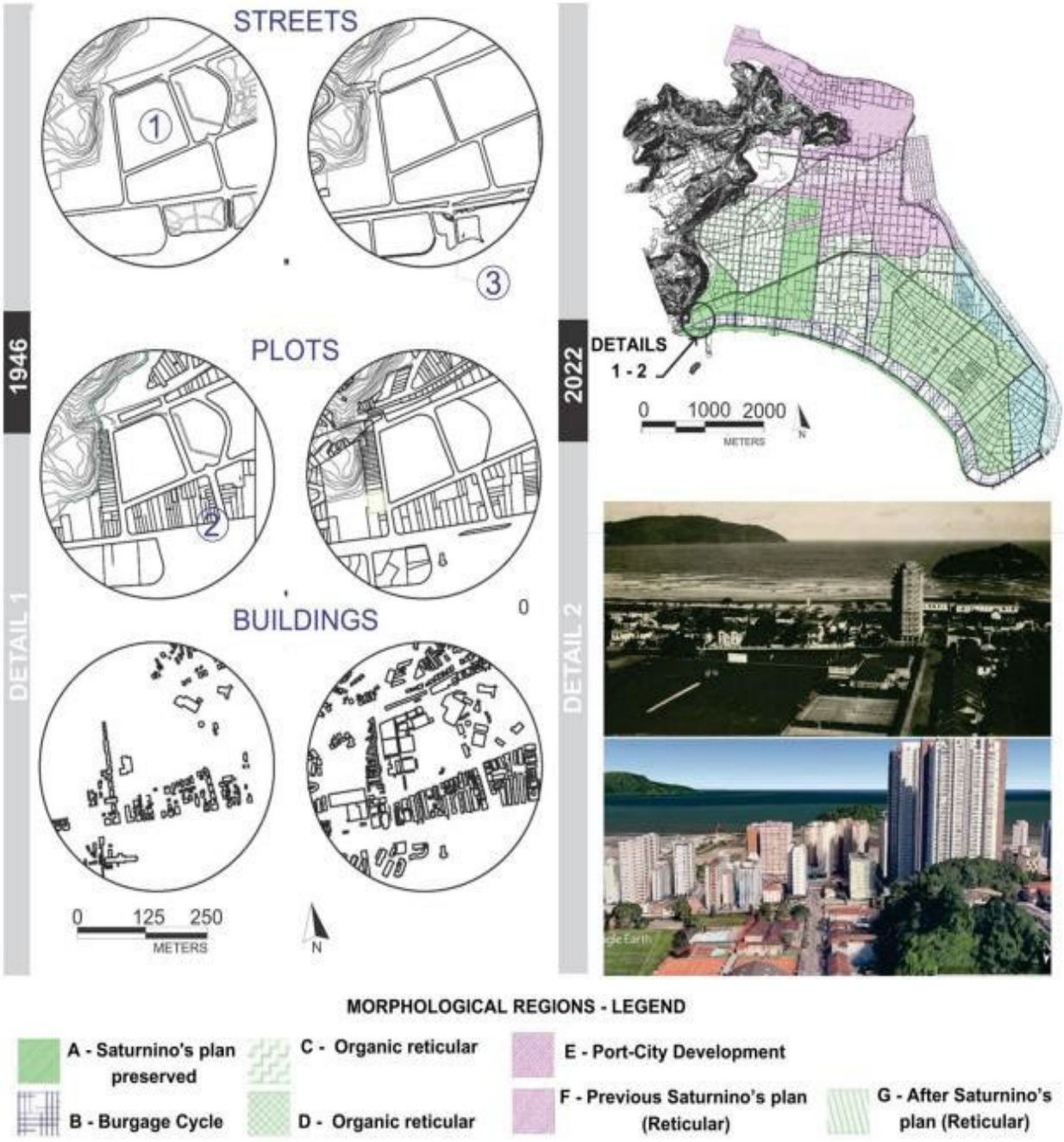

Figure 6. (Left) Detailed study of the "Climax" stage in the Burgage Cycle. (Right) Morphological regions of Santos. View over Marapé Hill: Orchidearium Municipal Park and Urbuqueçaba Island (1943-2022). Source: Authors, based on Santos Municipal Urbanism Secretary GIS Database and Google Earth (Street View).

CONCLUSIONS

With this knowledge, especially in the highlighted region of the research, the Orchidearium Park, in confluence with the seaside garden, original and also previous morphological characteristics of Saturnino's plan. it was possible to identify another Conzenian tradition concept: the burgage cycle.

In designing his open drainage canals, his plan doubled the existing waterways, adapting them to the natural processes of the area on the southern coast of São Paulo. This created an integration with nature, in line with his ideological principles, which became a model and prerogative for public sanitation policies throughout Brazil, a fact that he personally helped to propagate by adopting the same system in several cities where he worked. By opting for complete planning, Saturnino de Brito transformed the city of Santos into a Sitte-like city, where the stage conducive to broad interaction of the population found its common and natural place in at least one large urban space, interconnected by public facilities: the beachfront garden. This also laid the foundation for new mobilities and interactions of its inhabitants with the entire urban area, on an island with equidistant locations from its new central geometric point. The intensification of tram transport, in conjunction with the drainage canals, enabled the interconnection between the historic center and the beachfront during the period described here as: Saturnino de Brito's Plan to First Master Plan (1905-1968). As a consequence, its elongated lots are visibly occupied by taller buildings (Figure 6b), at the beginning of what became known as "the sea wall," with a clear reference to the process of "climax and replacement" present in burgage plots, according to the Conzenian methodology. Nevertheless, it boasts a wide array of public amenities that, over time, multiplied throughout its entire length, becoming the largest urban park in the world, tree-lined and by the sea. The Sittean ideal (Sitte, 1903) thus continued, with a large garden integrated amidst monuments and small support buildings, entirely dedicated to the population.

In her study for another Brazilian city, Vila Rica, Stael Pereira Costa and Manuela Gimmler Netto (2015:18) confirmed this analogy when then affirmed: "The other variety of secondary accumulation is the overspill of the burgage cycle, or the gradual densification of the rear of plots by new buildings, which will involve the subdivision and subletting of the backlands of these plots. This process also has its origins in the medieval period, but it became more prominent during the industrialization era, in the form of a cycle with a succession of phases: institution, overspill, climax, and recession; culminating in the eradication of slums. This cycle is based on the introduction of units at the back of plots, without direct access to the streets, defined as the prototype for the densification of burgage plots" (Translated by the authors).

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Research on the "interface-space" analysis method of urban street space

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ABSTRACT

Space syntax is an analytical tool based on visual perception to understand local space and connect it with broader spatial cognition. Traditional methods often overlook the visual experience of physical boundaries, while the "surface partition" and "endpoint partition" methods proposed by scholars such as John Peponis incorporate the visibility of spatial physical boundaries into the analysis. This paper extends the method from the analysis of interior spaces to urban street spaces, and from two-dimensional to three-dimensional, while also considering the limitations of paths and visible ranges on spatial cognition. Through empirical research on three streets in Nanjing City, this study uses the method of quantity, variance, and path analysis to examine the quantity, set relationships, continuity, and differences of spatial division, revealing the spatial perception characteristics of different interface streets. The results show that the method is convenient for spatial division and index analysis, and can significantly distinguish the spatial perception characteristics of streets. Future research will consider the impact of natural elements, develop automated programs, and combine VR and AR technology to provide a more intuitive spatial experience and assist in design decision-making.

Keywords: space division, physical boundary, street space, visual perception analysis

INTRODUCTION

Vision is the primary way we perceive architectural and urban spaces, providing the foundation for experiencing architectural effects. Space syntax, as an analytical tool, focuses on how people understand local spaces visually and connect them with a broader spatial cognition through movement. By decomposing continuous space into analyzable parts and dividing it into the most basic small-scale spaces, the three fundamental spatial methods are axial, convex, and isovist (Figure 1).

Isovist analysis, on the one hand, is based on the two-dimensional level where Benedikt (1979) introduced it for the analysis of architectural space (Figure 2-a). Later, Batti (2001) transformed Benedik's illustrative method to define the spatial isovist characteristics from multiple angles, such as average distance, area, perimeter, etc., quantifying the visual perception of spatial geometry (Figure 2-b). On the other hand, based on the three-dimensional level, Teller (2003) proposed a new measurement for complex open spaces, using spherical projection to analyze urban open spaces with

a spherical view (Figure 2-c), and Fisher-Gewirtzman (2003) introduced the concept of Spatial Openness Index (SOI). Isovist analysis is also used to quantify the visual implications contained in Kevin Lynch's elements of urban imagery (Morello & Ratti, 2009), as well as the Sky View Factor (SVF) which expresses the degree of sky visibility (Ratti 2004, 2005; Yang, 2007). At the same time, some studies only focus on the boundaries or interfaces that enclose space. Tucker (2004) explored how to visually analyze street landscapes through digital image processing technology, and Freitas (2022) designed interactive interface tools (SFMLT) through visual technology, providing visual feature visualization effects.

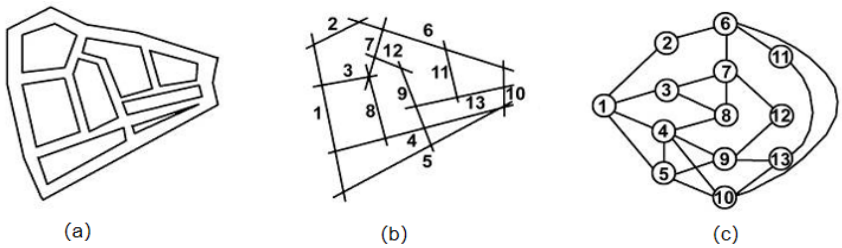

Figure 1 .Spatial syntax analysis of the axial lines in urban open spaces and its "spatial configuration". (a) axial (Jiang, B., 2002) ; (b) convex(Jiang, B., 2002) ; (c) isovist (Jiang, B., 2002)

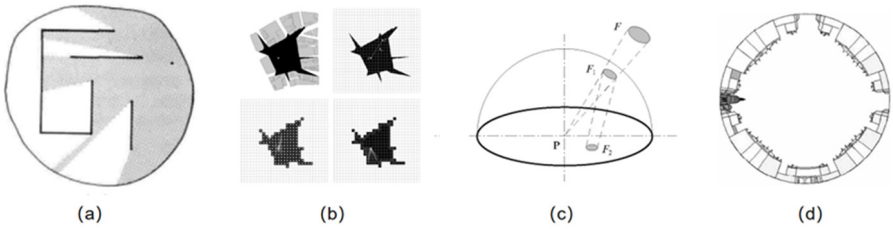

Figure 2 .Schematic diagrams of two-dimensional and three-dimensional isovist analysis. (a) Planar viewshed analysis (Benedikt, M. L., 1979) ; (b) Viewshed quantification analysis (Batti, M., 2001) ; (c) Measuring the visible sky range using the sky view factor projection method (Teller, J., 2003)

However, most spatial division methods focus solely on the space itself, often neglecting the close connection between vision and the physical interface in spatial perception. The effectiveness of spatial perception fundamentally depends on the observer's recognition of the substantive elements that define the space, namely endpoints, edge lines, and interfaces. These elements define the physical boundaries of space and play a key role in visual perception.

Thus, in the 1990s, scholar John Peponis innovated upon the analytical framework of space syntax, developing a new spatial division method based on "convex space" and "isovists." This method, known as "surface partition" and "endpoint partition," combines the visibility of the physical boundaries of space with spatial division methods. The specific approach is illustrated in Figure 3, where A represents a single interface that one must cross the extension of to see the space behind it; B represents an intersecting interface where pedestrians at positions 1 and 3 can only see one interface, while those at position 2 are at the intersection of the extensions of two interfaces, meaning they can see both interfaces at the same time; C is a schematic of intersecting interfaces and endpoints, where observers at positions 5 and 6 can see the endpoints on the opposite side, whereas in the area to the left of position 6, the extension of the endpoint is obstructed, preventing the observer from seeing the endpoint on the opposite side.

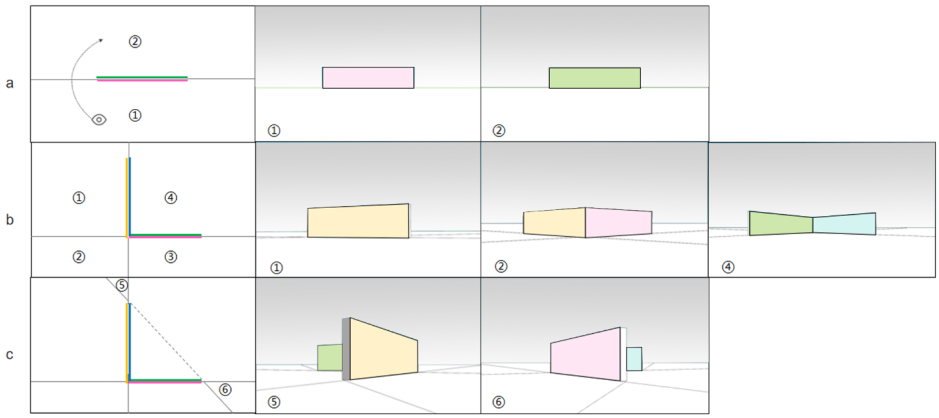

Figure 3 .Schematic diagrams of surface partition and endpoint partition. (a) Single interface; (b) intersecting interfaces - surface partition; (c) intersecting interfaces - endpoint partition, photo credit: Author's own drawing.

This method links the human perception of space with visual interfaces, providing a way to concretize spatial analysis and project it onto the surfaces of human activity. This projection not only aids in understanding how people move and perceive their surroundings in space but also facilitates spatial analysis.

Regrettably, this method has not received sufficient attention and development. This limitation mainly stems from several aspects: the restriction of application scope: it is primarily applied to the analysis of indoor spaces and has not been used in urban external spaces like other spatial division methods; the insufficiency in dimensional development: current analyses mostly focus on the planar dimension, lacking discussion on the vertical or longitudinal dimensions of space; the limitation of static analysis: it usually analyzes a planar feature from a static perspective, lacking the integration of human movement and dynamic viewpoints into the analysis.

Based on the limitations of current methods, this paper aims to further develop and refine the spatial perception analysis method that combines "space-interface."

METHOD

Material Selection

This study selects the Xinjiekou area in Nanjing as the case study object for the analysis of urban spatial form. As the commercial center of Nanjing City, the street space structure of the Xinjiekou area is not only typical in urban morphology but also shows significant complexity and diversity in architectural environmental studies. The street system of this area is composed of multi-level roads, including main urban roads, secondary roads, and branch roads, which together weave a hierarchical and functionally composite traffic and social network.

Specifically, this study focuses on Shigu Road, Fengfu Road, and Zhongshan South Road, the three main streets, which provide an ideal research window for exploring the morphological characteristics of street space due to their regular spatial layout and rich local visual dynamics. In addition, the even distribution of high-rise buildings in the area provides favorable conditions for line-of-sight analysis and spatial configuration research (Figures 4 and 5).



Figure 4 .Samples of three roads in Xinjiekou, Nanjing City. (a) Shigu Road; (b) Fengfu Road; (c) Zhongshan South Road , Photo credit: Baidu Map.



Figure 5 . Line drawing of the Xinjiekou block area in Nanjing City .

Material Reduction

During the process of material simplification, this study adopted a series of strategies aimed at enhancing the efficiency and accuracy of the analysis while ensuring the universality and applicability of the model. The following is an optimized description of the simplification methods for existing buildings and roads: Concave-convex feature simplification: A quantitative assessment is made of the local protrusions or recesses of buildings. If the size of these features is less than 3 meters and parallel to the main facade of the building, they are ignored in the model to reduce complexity; if the size exceeds 3 meters, they are considered to have a significant impact on the spatial form and are retained. Corner feature integration: Multiple small curved surfaces at the corners of buildings are geometrically integrated to form a unified geometric body. For large arc buildings at intersections, right angles are used to replace rounded corners to simplify the model and maintain its key visual and functional features. Building height standardization: According to the podium and tower parts of the buildings, this study has set a set of standard height levels, which are 24 meters, 50 meters, 100 meters, and 200 meters, respectively. This standardization process helps to maintain consistency and comparability in spatial analysis of different scales (Figure 6).

By employing these simplification strategies, the aim of this study is to highlight key spatial morphological features, facilitating in-depth analysis and intuitive understanding. It enhances computational efficiency to ensure the completion of high-quality research within limited resources and time. Furthermore, it strengthens the universality of the model, enabling it to meet the needs of spatial analysis of different scales and types.

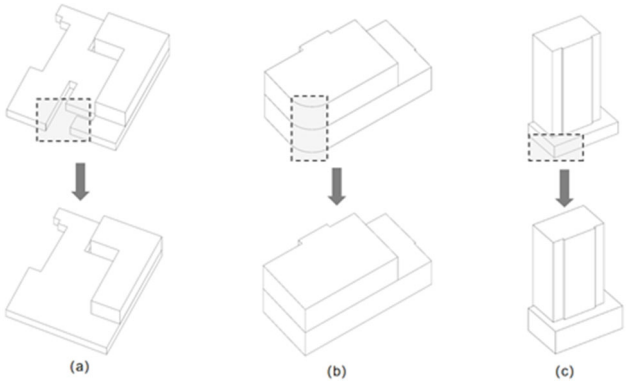

Figure 6 .Three methods of simplification. (a) Concave-convex simplification; (b) Corner integration; (c) Height standardization, Photo credit: Author's own drawing.

Partition Step

Drawing podium s-partitioning and e-partitioning

This step begins with surface partitioning (s-space) of the podium structure, extending the outer wall surface of the podium to define the spatial boundaries. Subsequently, endpoint partitioning (e-space) is implemented, identifying the corners of the podium and extending the partition lines to the limit of the line of sight, selecting only the partition lines that display a single visible corner to accurately divide the visual information units of the space (Figure 7).



Figure 7 .Podium s-partitioning and partitioning illustrations.(a) Podium interface partitioning; (b) Connections between podium endpoints; (c) Valid connection lines of podium endpoints, Photo credit: Author's own drawing.

Drawing Tower S-partitioning and E-partitioning

For the tower portion, the same surface partitioning (s-space) as the podium is performed to establish the three-dimensional spatial form of the tower. Considering that the endpoint partitioning (e-space) of the tower has limited visual perception for people at the ground level, this step omits the endpoint partitioning of the tower and focuses on implementing surface partitioning to simplify the analysis process (Figure 8).

Drawing the E-partitioning of Tower and Podium Corners

The interaction of the corners between the podium and the tower is perceptible directly at the ground level. Identify the corner points of both the tower and the podium, and then draw straight lines to connect the corresponding corner points, extending to the limit of the line of sight. In this process, only the partition lines that can reveal a single corner are drawn. (Figures 9-a, 9-b)

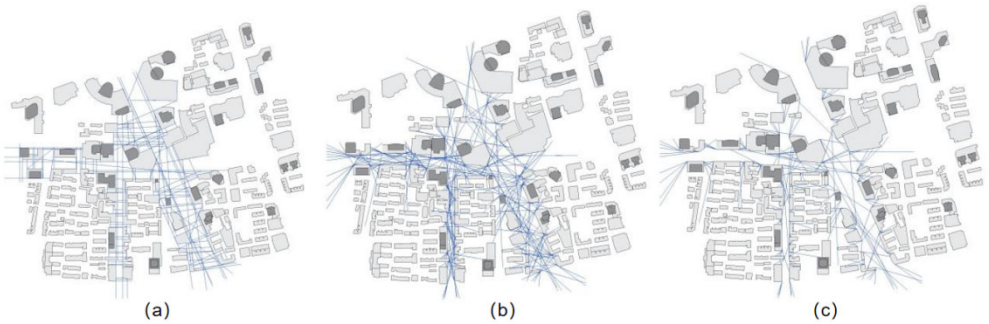

Figure 8 .Tower S segmentation and E segmentation.(a) Tower interface segmentation; (b) Tower endpoint connection lines; (c) Effective connection lines of podium endpoint, Photo credit: Author's own drawing.



Figure 9 .Corner segmentation of the tower and the podium at point e. (a) Connection line between the podium and the tower's endpoint; (b) Effective connection line between the podium and the tower's endpoint; (c) Vertical segmentation of the tower's endpoint, Photo credit: Author's own drawing.

Drawing the vertical segmentation of the tower at point e

This step focuses on the mapping relationship between the tower and the podium in the vertical dimension. By connecting the horizontal boundary line of the tower with that of the podium, an extended connection line is formed that extends to the ground. This line not only visually defines the spatial relationship between the two but also determines the visual perception of the observer at the ground level. When the observer is within the range of the connection line, the podium is obscured by the tower's boundary line and is not perceived; when outside the range of the connection line, the podium is clearly visible. (Figure 9-c)

After completing the above four steps of drawing the connection lines, we synthesize these lines to form a comprehensive spatial analysis drawing of the material. Based on these synthesized overlapping lines, the subsequent research will proceed to an in-depth discussion of the spatial structural characteristics and an analysis of the factors affecting visual perception (Figure 10).

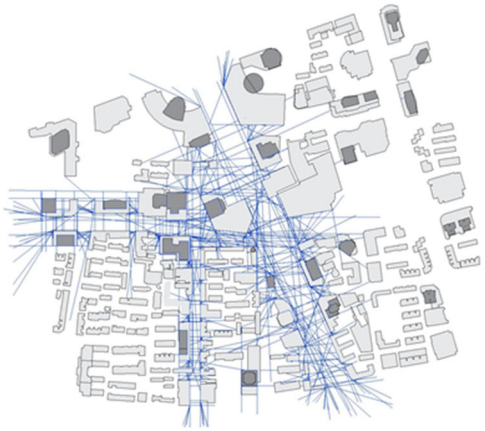

Figure 10 . Spatial segmentation result diagram. Photo credit: Author's own drawing.

Analytical Method

The structure and characteristics of urban external spaces are primarily determined by the street interface, which is jointly formed by urban roads and the buildings along them. The form of these spaces is not only defined by the physical width of the roads but is also greatly influenced by a series of characteristics of the street interface, including key parameters such as the porosity and continuity of the interface. These characteristics play a crucial role in shaping the visual perception and functional distribution of urban spaces.

Surface segmentation and endpoint segmentation serve as a method for understanding the composition of spatial structures and have certain applications in visibility analysis. Peponis has developed some variables for measuring local visual attributes, such as using the e-space's visible turning points and divergence, as well as the expansion coefficient of s-space (Peponis, 1997), to quantify and study issues such as the centrifugal and centripetal arrangement of architectural spaces, the clarity and vagueness of sub-space definition, and the diversity and discreteness of enclosure (Figure 11).

In light of this, the present study aims to employ three quantitative analysis methods to conduct an in-depth data analysis of the subspaces obtained through surface segmentation (s-space) and endpoint segmentation (e-space). To ensure the comparability and fairness of the analysis results, the selected street samples will be evaluated based on the same length of 200 meters. Through this method, it is expected to reveal how the characteristics of street space division interact with the characteristic factors of the street interface and affect the overall urban spatial form.

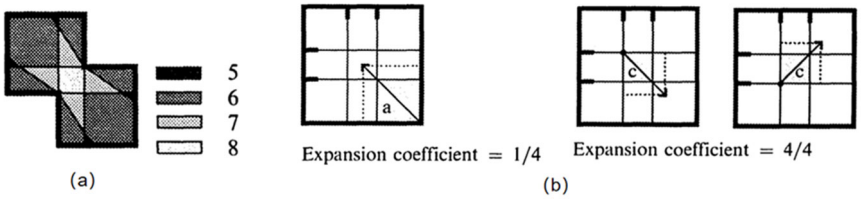

Figure 11 . Segmentation method. (a) Analysis of the visible turning points in e-space (Peponis J, 1997); (b) Analysis of the expansion coefficient in s-space (Peponis J, 1997).

The analysis method will also involve corresponding indicators, and the following will first introduce the definitions of the relevant indicators. The average road width refers to the average value of all

road widths within the 200m limited range of road length, and this indicator is used to quantify the overall level of the overall road width in the area. It is one of the key parameters for assessing the scale, openness, and visual perception characteristics of the street space. The number of junctions refers to the number of branches or intersections in the road, including crossroads, T-junctions, irregular intersections, etc., and is an important indicator for measuring the complexity of the road network and the efficiency of traffic flow organization.

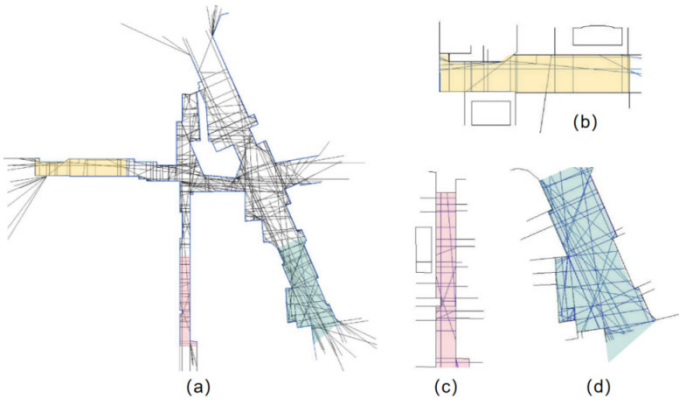

Figure 12 . Selection of street scope. (a) object distribution; (b) Shigu Road section; (c) Funghu Road section; (d) Zhongshan South Road section, Photo credit: Author's own drawing.

The number of building corners refers to the number of corners formed at the junction of the outer walls of buildings and the street within the research area. A corner is defined as a position where the building's outer wall surface undergoes a significant change, reflecting the complexity of the street space form and the diversity of visual perception. The number of interfaces refers to the total number of all street interfaces within the research area, including both the visible faces of the towers and the visible faces of the podiums. These interfaces are directly adjacent to the street, forming the visual boundary of the street space. The porosity rate is the proportion of the street space not occupied by the building interface, which can also be understood as the proportion of open spaces or gaps between the street interfaces. It reflects the openness and permeability of the street space and has an important impact on aspects such as ventilation, lighting, and visual communication of the street. Streets A, B, and C correspond to the interval streets as shown in Figure 12, with the yellow area b being Shigu Road, the horizontal road, the red area c being Funghu Road, and the blue area d being Zhongshan South Road.

Quantitative Method

The quantitative method primarily focuses on the number of regions obtained through segmentation for analysis. The key to this method is to count and compare the total number of regional units obtained through surface segmentation and endpoint segmentation on different streets. By employing this approach, we can quantify the complexity and diversity of street spaces and further assess their impact on spatial perception.

Variance Method

The variance method emphasizes the assessment of the degree of area variation among segmented regions. By measuring the area of each region and calculating its variance, this method can reveal the uniformity or irregularity of street spaces. A higher variance may suggest that the space has richness and dynamism, while a lower variance may indicate consistency and static nature.

Path Method

The path method is concerned with the differences in traversing segmented regions along continuous paths. This method simulates the walking path of people on the street, recording the changes in experience as they pass through different areas. The path method takes into account not only the physical characteristics of the space but also integrates the dimension of time to evaluate the changes in spatial perception during movement. The analysis involves selecting three routes on each of three streets to analyze the path conditions of the three streets at the same distance along the street (analysis a-1, b-1, c-1), as well as analyzing the path conditions of three routes on a single street (analysis a-1, a-2, a-3).

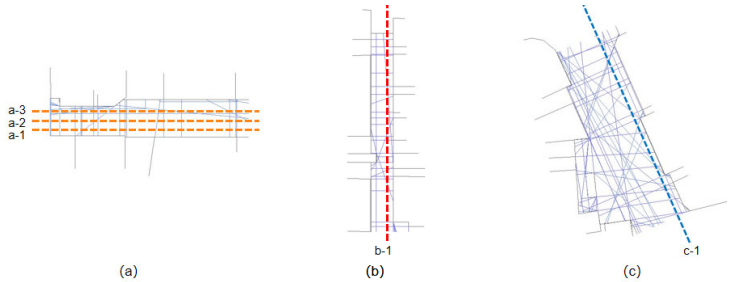

Figure 13. Selection of routes for each street (a-1, b-1, c-1 at a distance of 5m from the building edge). (a) represents the selection of three routes on Shigu Road; (b) represents the route selection on Funghu Road; (c) represents the section of Zhongshan South Road, Photo credit: Author's own drawing.

RESULTS AND DISCUSSIONS

Quantitative method: space division number and building Angle

In the study using the quantitative method, we conducted an analysis of three streets, each with a length of 200m. Through the division by building boundaries and building corners, these three streets respectively formed 105, 98, and 445 subspaces (Table 1).

Table 1. Statistical count of the number of subspaces divided by the three streets.

Parameter	Street A	Street B	Street C
The average width [m]	37	22	55
Number of forks	6	9	8
Building rotation	19	14	24
Subspace quantity	105	98	445
Voidage	0.31	0.24	0.22

From a professional data perspective, the number of subspaces divided shows a significant positive correlation with the number of building corners, which are 19, 14, and 24 respectively. It should be specifically noted that the number of building corners mentioned here includes both the podium and tower corners. We used the number of corners as the independent variable and the number of divisions as the dependent variable for a linear regression analysis, and ultimately derived the regression equation as $y=34.7x-443.3$, where y represents the number of divisions, and x represents the number of corners. Further analysis of this model shows an R^2 value of 0.7651 and a p-value of 0.0345. Given that the p-value is less than 0.05, this proves that there is a very significant linear relationship between the number of building corners and the number of subspaces. It is clear that an

increase in the number of corners will lead to an increase in the number of subspaces divided by the road. This conclusion is not only clearly reflected at the data level, but also, from the perspective of perceptual analysis, the more corners there are, the more likely they are to connect with other building corners, thereby achieving a more refined division of space(Figure 14).

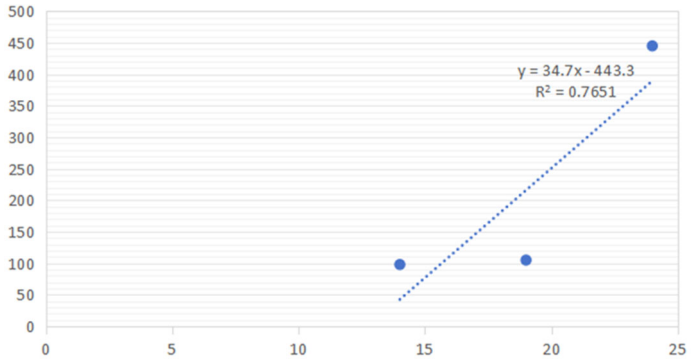

Figure 14. presents the regression equation and data for the number of corners versus the number of divisions, where y represents the number of divisions and x represents the number of corners , Photo credit: Author's own drawing.

Variance Method: Spatial Homogeneity and Interface Stability

After the street space is divided by boundary lines and corner connection lines, multiple subspaces are formed. Different subspaces correspond to specific areas. By summarizing the spatial area for streets A, B, and C (Table 2).

Table 2. Statistical summary of the areas of subspaces divided by the three streets

Parameter	Street A	Street B	Street C
The average width [m]	37	22	55
Number of forks	6	9	8
Subspace quantity	105	98	445
Average size[m]	67.3379	47.1161	31.5279
Variance	25140	4291	2191
Fluctuation condition	Max	Medium	Min
Fragment interface average [m]	30.51	19.13	20.77
Fragment interface maximum subtract minimum value [m]	78.48	48.8	55.2
Segment interface variance	23.81	14.93	14.36

The corresponding average areas are 67.3 square meters, 47 square meters, and 31.5 square meters, respectively. At the same time, the total area of all subspaces contained in each is counted, and the corresponding variance is calculated to measure the fluctuation of the subspaces' areas. The variances are 25,140, 4,291, and 2,191, in that order. It can be seen that Street A has the most intense fluctuation (Figure 15), Street B has moderate fluctuation (Figure 16), and Street C has the least fluctuation (Figure 17).

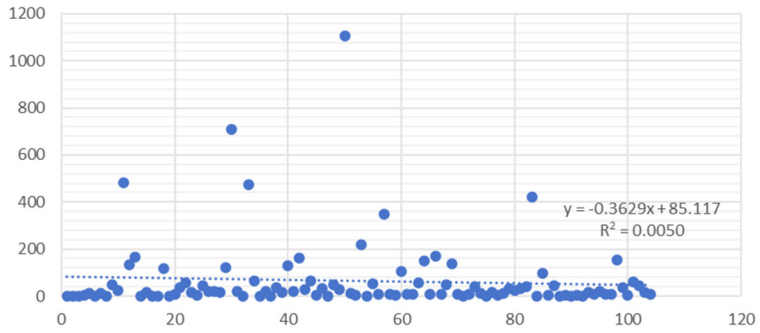

Figure 15. shows the distribution of subspace areas for Street A, where y represents the area of the subspace and x represents the sequence of subspaces, Photo credit: Author's own drawing.

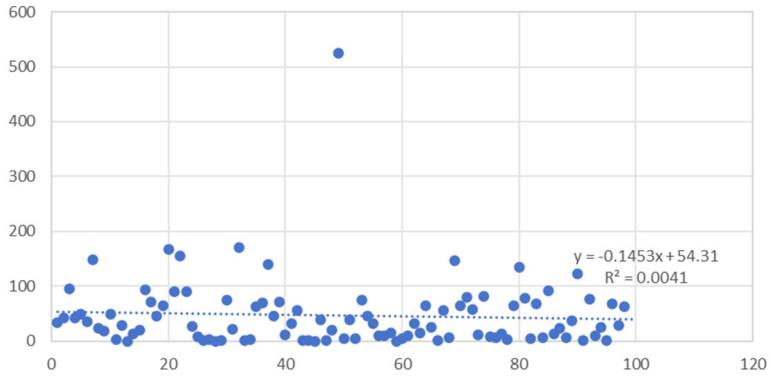

Figure 16. illustrates the distribution of subspace areas for Street B, with y denoting the area of the subspace and x indicating the sequence of subspaces, Photo credit: Author's own drawing.

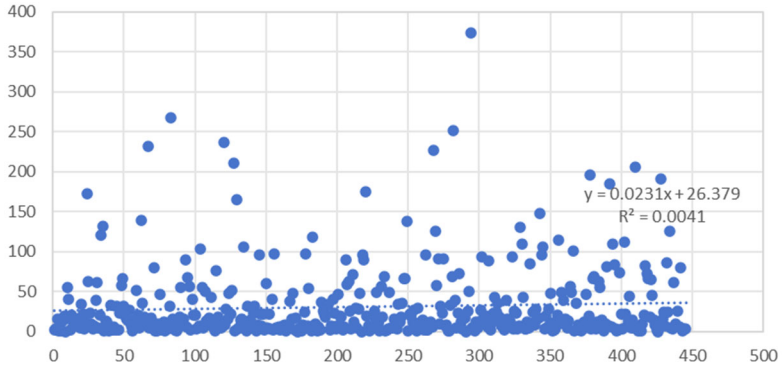

Figure 17. depicts the distribution of subspace areas for Street C, where y represents the area of the subspace and x signifies the sequence of subspaces, Photo credit: Author's own drawing.

When investigating the correlation between the fluctuation of subspace areas and potential causes, we find that the fluctuation is not related to the planar area. The average area is influenced by factors such as the width of the street, but the street width is not a constant variable. At the same time, further analysis of the area fluctuation reveals that streets are actually composed of solid building interfaces and void interfaces. Therefore, we further explore whether the fluctuation of street area is affected by the balance of interface widths. The widths and corresponding variances of the three interfaces (including building interfaces and road cross-sections) are 23.81, 14.93, and 14.36, respectively.Street A has a relatively larger variation in interface amplitude, while Street C has the smallest. The variation in interface amplitude is positively correlated with the fluctuation of the spatial area. It is also easy to understand from a perceptual perspective that if a street is evenly divided, the

road width and area will also be uniform, and the fluctuation of its space will be minimal. Therefore, it is obviously reasonable to infer the fluctuation amplitude of the road subspace area through the variation amplitude of the road interface, and it is positively correlated (Figure 18).

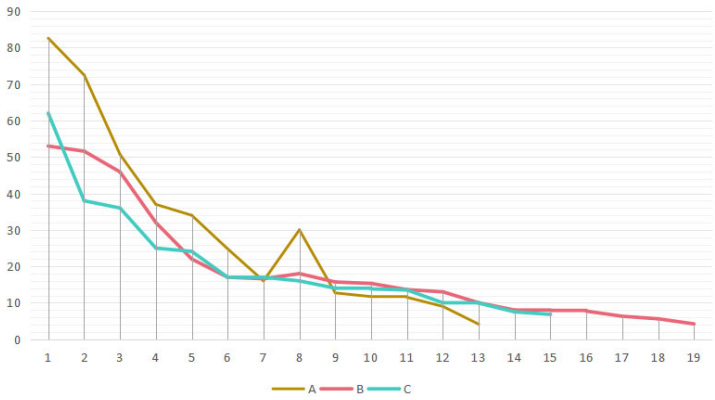

Figure 18. presents the numerical statistics of interfaces for the three streets ABC, where y represents the interface value and x represents the sequence number of the interface, Photo credit: Author's own drawing.

Path Method: Perceptual Richness

Three paths, each 5 meters from the right building interface of the three streets, were selected as the research subjects (Table 3). The corresponding paths of the three streets pass through 18, 26, and 30 subspaces, respectively. Each subspace has a certain difference in the number of tower and podium interfaces and corners seen, creating visual richness in different subspaces. Therefore, the more subspaces a path passes through, the more intense the visual experience is on the path.At the same time, the three paths of Street A, namely a-1, a-2, and a-3, were analyzed. The number of subspaces they pass through are 18, 18, and 21, respectively. It can be seen that the visual experience of a-3 is more intense, and through the variance value, it can be seen that the variance of the a-3 path is the smallest, indicating that the fluctuation of subspaces on this path is relatively small compared to a-1 and a-2. The variance of subspaces reflects the gentleness or abruptness of the spatial change experience during the walking process on the path.

Table 3. Statistical summary of the areas of subspaces divided by the three streets.

Parameter	Street A	Street B	Street C
The average width [m]	37	22	55
Number of Spaces traversed	18	26	30
Corresponding space area [㎡]	6.7, 199.7, 346.8, 128.2, 18.6, 160.5, 107, 63.4, 480, 120.5, 32.7, 710, 170, 421, 1107, 118, 21, 220	93, 78, 524, 135, 22, 25, 65, 15, 74, 76, 48, 123, 81, 37, 147, 90, 80, 155, 65, 91, 147, 167, 64, 56, 42, 63	80, 35, 376, 232, 14, 126, 18, 90, 191, 212, 67, 26, 165, 91, 83, 148, 135, 227, 236, 104, 74, 143, 41, 12, 2.5, 3.8, 185, 267, 19.7, 237

Table 4. Analysis of the three pathways for Street A

Parameter	a-1	a-2	a-3
Number of Spaces traversed	18	18	2

Corresponding space area [m²]	6.7, 199.7, 346.8, 128.2, 18.6, 160.5, 107, 63.4, 480, 120.5, 32.7, 710, 170, 421, 1107, 118, 21, 220	6.7, 200, 346, 128, 19, 160, 30, 63, 480, 120, 33, 710, 170, 422, 1107, 118, 21, 220	1.2, 38, 56, 14, 15, 3, 45, 20, 48, 56, 25, 6, 152, 20, 49, 165, 473, 95, 65, 13, 136
Variance	76227.4491	77729.04423	8578.626941

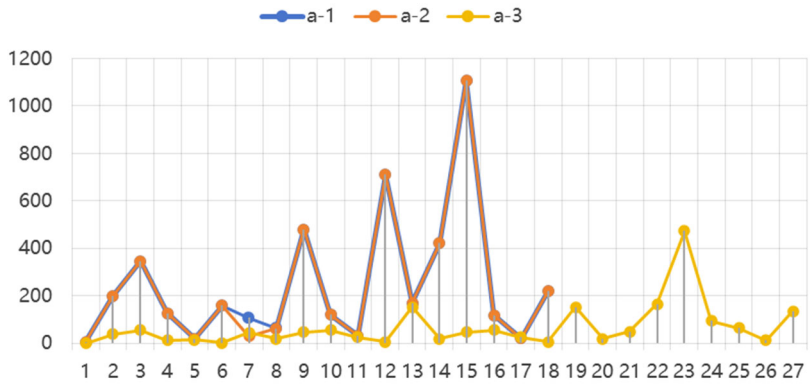

Figure 19. illustrates the selection of three paths on Street A, namely a-1, a-2, and a-3, where y represents the area of the subspace and x represents the sequence number of the subspaces, Photo credit: Author's own drawing.

Some Prospects

In this study, we explored the relationship between street space richness and building corners through 2D and 3D spatial segmentation methods. We simplified the model initially by reducing complexity and highlighting key characteristics. However, to better simulate the real world, future research should consider external factors like roadside trees. Currently, our research relies on manual data statistics which is time-consuming and subjective. We'll develop automated programs for more efficient and objective analysis. Also, when analyzing podium-tower mapping, we ignored different observer heights. Future research should include this as a variable. Finally, we believe combining VR and AR technologies will expand and deepen the application of space syntax. These technologies offer immersive experiences and help designers and planners optimize spatial design. They can help decision-makers understand spatial impacts

CONCLUSIONS

This study conducted a quantitative analysis of the spatial structure of three streets in Nanjing City via the extended application of space syntax. Using quantitative, variance, and path methods, we accurately described and differentiated the visual perception characteristics such as corners and interfaces of street spaces.

In terms of quantitative methods, we found a significant positive correlation with the number of building corners by calculating the number of subspaces. Specifically, an increase in the number of subspaces directly reflects an increase in the number of building corners, a finding that was verified at the data level through linear regression analysis. The quantitative method effectively revealed the complexity and diversity of street spaces, with Street C showing the highest spatial complexity due to having the most building corners and subspaces.

In terms of variance methods, the variance method reveals the uniformity or irregularity of street spaces by measuring the fluctuation of the area of segmented regions. The results show that Street A has the greatest fluctuation in the area of subspaces, indicating the richest and most dynamic spatial form; while Street C has the least fluctuation, indicating a relatively consistent and static spatial form. The variance method highlights the differences in spatial homogeneity among different streets.

In terms of path methods, we focus on the walking paths of people on the streets, recording the changes in the experience of passing through different areas. The analysis indicates that the more subspaces a path passes through, the richer the visual experience it provides. For example, the a-3 path on Street A, while passing through more subspaces, also shows a smaller variance, meaning that the experience of spatial change on this path is more continuous and gentle.

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Research on urban micro-update from the perspective of urban micro-morphology and agents: a case study of Chaotian-Gong district in Nanjing

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ABSTRACT

In China, urban renewal has entered a new phase of optimizing existing stock, with "acupuncture-style" micro-updates gradually being applied and bottom-up resident participatory updates gaining increasing attention. However, there is a lack of focus on the micro-morphology of urban micro-renewal and its relationship with stakeholders from the perspective of urban morphology. This paper adopts a micro-urban morphology perspective, using the historical Chaotian-Gong District in Nanjing as a case study, to explore the relationship between spatial morphology and social dynamics. Given the complex situation of mixed historical, commercial, and residential districts, the study categorizes the stakeholders involved in urban renewal, focusing on the conflicts between commercial and residential functions due to the predominance of ground-floor businesses. It examines the different roles of various stakeholders in the micro-morphological changes of urban space. Building on this, the paper explores a bottom-up urban micro-renewal mechanism based on entities such as business associations and resident councils, and the concept of "multi-partner cooperation." The goal is to summarize a participatory renewal mechanism for mixed-use historical districts and its connection with urban spatial micro-morphology, providing a reference for future community-based urban micro-renewal projects.

Keywords: urban micro-renewal, micro-urban morphology, agents, multiple stakeholders, mixed-use commercial and residential districts

INTRODUCTION

Research background

China's urban development has transitioned from incremental growth to a new phase of stock renewal. The traditional model of large-scale demolition and reconstruction is no longer applicable; urban development increasingly focuses on micro-scale updates. This paper adopts a perspective from urban morphology to explore the changes in historical district morphology, emphasizing a more targeted micro-morphological study and examining the relationship between agents and urban micro-morphology in urban renewal. Urban morphology has a long history, with the Conzenian School, represented by M. R. G. Conzen and J. W. R. Whitehand, advocating for the analysis of urban form

through the division of independent plan units. This approach considers plan units, building types, and land use, combined with historical map data to infer the process of urban form development. Since 2007, Whitehand has progressively conducted urban morphology research in China (J. W. R. Whitehand and Gu, K, 2021), and several university teams have since conducted a series of studies on the localization of urban morphology (Duan, J., 2003; Duan, J. and Qiu, G. C., 2008). This paper applies the methods and concepts of the Conzenian School to the study of urban morphology in the Chaotian-Gong district of Nanjing, focusing on the micro-morphology in urban micro-updates and its relationship with agents.

Urban micro-morphology

J.W.R. Whitehand has identified micro-morphology as an independent branch of urban morphology research. He argued that researchers need to incorporate more granular spatial analysis elements to complement and enhance the structural study of urban plans, particularly emphasizing the formation and development of public spaces that cross property boundaries, such as public walkways, permeability pathways, and alleyways. These "capillary" spaces play a structural role in the organization of land use and social activities. This research method, which starts from the micro-scale of urban morphology and delves into the internal structure of space, provides additional spatial analysis elements beyond the "planar" structure of land use. It enriches the research dimensions of urban morphology and has become an important direction in the study of urban space.

Research on urban morphology and agents

In the 1970s, Whitehand explored the changes in the morphology of urban centers and their relationship with the characteristics of agents by studying building plan applications in the UK. Inspired by Whitehand's research, Rackham examined the built and newly constructed forms within historical and cultural conservation areas, confirming the significant impact of agents on architectural form innovation and dissemination. Rackham categorized agents into direct and indirect types. Analyzing the behavior of agents within different socio-cultural contexts has led to a deeper understanding of their role in urban morphology. The book Shapers of Urban Form: Explorations in Agency (2014) provided new perspectives for future research in urban morphology. Recent studies have also focused on the reconstruction of church buildings, the preservation of urban historical and cultural resources, and the morphological changes in suburban residential areas.

Current research status and limitations

In recent years, extensive research has explored urban renewal mechanisms and methods from a morphological perspective. Most of these studies focus on urban material spaces, investigating urban historical districts and residential space renewal strategies and mechanisms. For example, Garcia-Perez and Sergio examined urban morphological changes in residential area renewal in France and summarized their implications for urban renewal in Spain (Garcia-Perez and Sergio,2021). Wang Fang combined the study of block morphology changes with street network changes, focusing on the historical street morphology of Beijing (Wang F,2018). Additionally, numerous studies categorize block morphology or establish databases to better address future urban renewal. For instance, Dantas investigated the morphological conditions of the ninth district in Budapest and established a database

to improve quality of life while preserving historical information in future urban renewal (Dantas et al.,2023).

Existing urban morphology research predominantly focuses on medium to large-scale urban forms, such as street patterns and road networks, with limited attention given to the integration of micro-scale urban morphology and urban renewal. For example, Huang Kai conducted a micro-scale analysis of street cross-sectional morphology in the historical and cultural district of Xijie in Quanzhou, Fujian Province, quantifying street interface morphology and proposing measures for street protection and renewal (Huang K et al,2024). Macro-scale urban morphology research offers limited practical value for the stage of urban stock renewal; therefore, the study of micro-scale urban morphology and renewal mechanisms remains insufficient. Only a few studies address social relations in urban renewal contexts, such as Zhai Yuqi, who investigated historical urban morphology changes in the Guizhou West community in Shanghai, elucidating the interactive evolution of lane space structures and internal community changes, involving land ownership relationships (Zhai, Y. et al,2023). However, existing research lacks exploration of the role of urban renewal participants, i.e., agents, in the changes of micro-scale urban morphology.

Site introduction

The study site is located in the Chaotian-Gong Street of Qinhuai District, Nanjing, Jiangsu Province, China. Situated in the southwestern quadrant of the commercial and business center of Xinjiekou, the Chaotian-Gong Street is bordered by Zhongshan South Road to the east, the Outer Qinhuai River to the west, Shengzhou Road to the south, and Hanzhong Road and Shigu Road to the north. It comprises 11 communities and has historically been a crucial commercial and residential area.

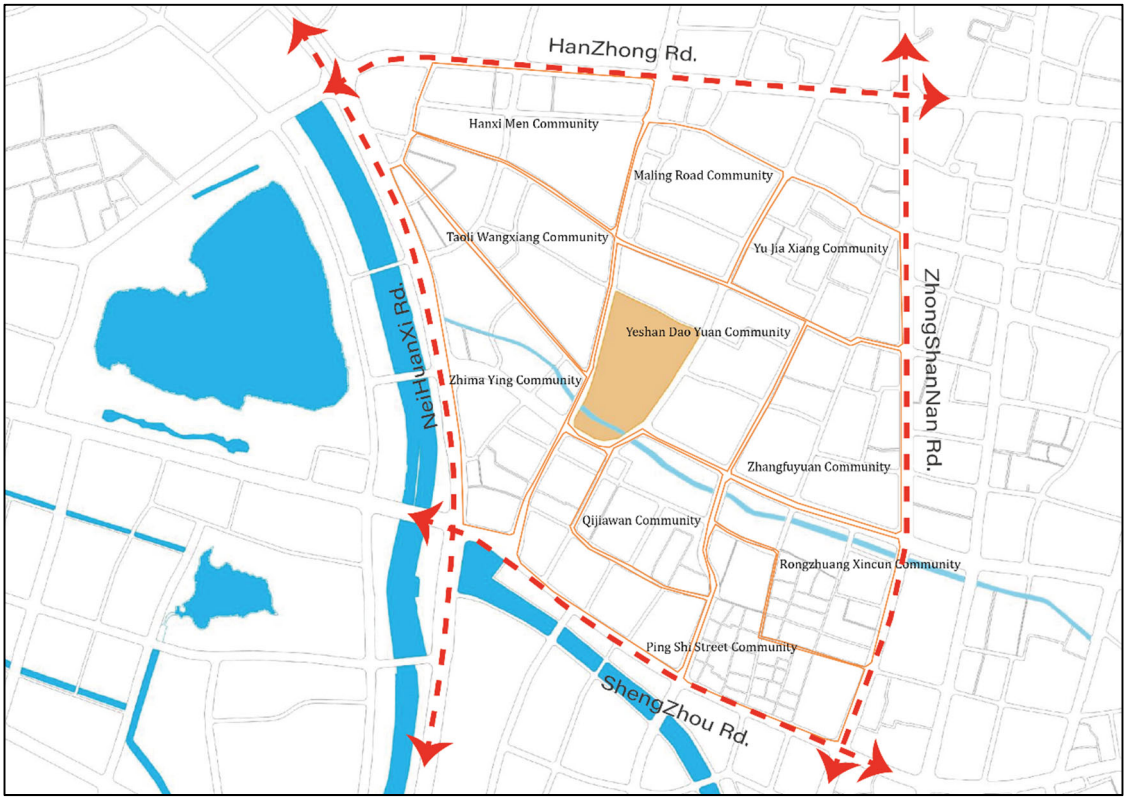


Figure 1. the community map of Chaotian-Gong District.

Named after the "Chaotian-Gong," the district has a rich history. As early as the 5th century BCE, the site where the Chaotian-Gong now stands was home to one of the earliest settlements in Nanjing. The Chaotian-Gong, constructed later, has undergone several fires and restorations. The most significant renovation in modern times occurred during the Tongzhi era of the Qing Dynasty, preserving its main layout and architecture, which is now housed in the Nanjing Museum. The district not only serves as one of the origins of Nanjing's historical culture but also represents a key intersection between modern urbanity and traditional culture. Therefore, conducting urban morphological research in this district holds significant importance for the preservation and renewal of historical districts.

In recent years, Chaotian-Gong Street has leveraged its unique comparative advantages to develop modern service industries, including finance and insurance, information technology, and cultural creativity. It has established a financial cluster along Zhongshan South Road and Jianye Road, with Wangfu Street, Mingwa Lane, Shigu Road, and Xinanli forming core areas featuring dining, shopping, and entertainment. Recently, the Chaotian-Gong district has focused its renewal efforts on the Chaotian-Gong Seven Lanes area, initiating a series of urban micro-renewal projects. This involves exploring a "multi-partner collaboration" mechanism for bottom-up urban micro-renewal, with trade associations, residents' committees, and other entities as key carriers, addressing the complex mixed nature of historical, commercial, and residential areas, and resolving the commercial-residential conflicts prevalent in the district.



Figure 2. Plan of the Chaotian-Gong District.

Through methods such as historical map analysis and comparisons, further understanding of the patterns and underlying causes of the urban morphological changes in Chaotian-Gong can be achieved, facilitating focused analysis of the micro-morphology of urban public spaces in subsequent studies.

Importance and significance

This study addresses the gap in existing research regarding the micro-scale urban morphology and agents in China's urban micro-renewal. Micro-scale urban morphology research not only provides structural information for urban spatial analysis but also enhances the identification and extraction of multidimensional spatial elements and the study of morphological bases for social publicness. By integrating the analysis of micro-scale morphological changes with agents in urban renewal, this research establishes connections between spatial transformations, complex social activities, and the evolution of urban space, property, and usage rights across different historical periods. This approach effectively aids planners in understanding the processes underlying social and economic contradictions hidden beneath spatial conflicts, thereby providing valuable information for the fine-tuned management of urban spaces.

Outline

Existing research has paid insufficient attention to urban micro-morphology and rarely integrates the analysis of agents within the city. This study addresses the gap in existing research on urban micro-updates in China by examining the relationship between urban micro-morphology and agents.This paper analyzes the urban morphology of the Chaotian Palace district in Nanjing, China, using research methods such as historical map studies, field surveys, and interviews. It examines the medium-scale changes in urban morphology and the evolution of social relations, focusing on fagents influencing road network and parcel division changes. The study then shifts to a micro-scale analysis, exploring the relationship between agents and urban micro-morphology in the context of urban micro-renewal. It investigates the participatory micro-renewal mechanisms involving diverse stakeholders in Chaotian-Gong and assesses the applicability of urban morphology and agent-based research to urban micro-renewal. The study aims to provide insights and lessons for participatory urban micro-renewal mechanisms.

METHOD

Study of the historical spatial morphology evolution of the Chaotian-Gong district

Late qing dynasty

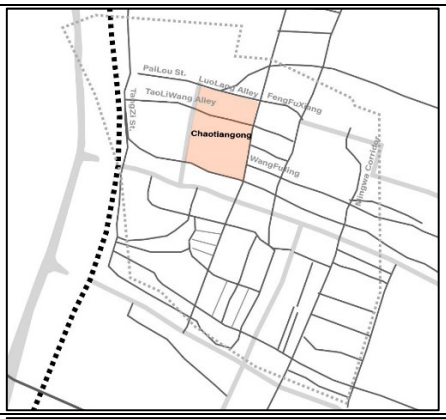
In the late Qing Dynasty, there is relatively little recorded data on the maps of the study area. For this research, the more valuable references include the "Jiangning Provincial City Map," the "Jiangning Prefecture City Map," and the newly surveyed "Complete Map of Nanjing Province" from the Lushi School (Table 1). The 1853 Jiangning Provincial City Map does not precisely depict spatial positions but reflects the positional relationships between different land parcels. During this period, the overall spatial layout was centered around Chaotian-Gong, with key areas extending to the Hanxi Gate in the northwest and the Tianhou Palace and Shuixi Gate in the southwest. The map shows a network of waterways within the Chaotian-Gong district, with numerous bridges.

By 1898, the Jiangning Prefecture City Map provided a more accurate depiction of the internal street network, revealing an initial "five horizontal and five vertical" grid pattern. The road network was generally parallel and perpendicular to the water systems and Chaotian-Gong. Main streets and lanes radiated from the Shuixi Gate and Hanxi Gate nodes, converging at Chaotian-Gong. During this period,

the land parcel shapes were characterized by diagonal grids and a radial structure extending from the city gates to the west.

The 1910 Lushi School's newly surveyed "Complete Map of Nanjing Province" more accurately presents the spatial relationships and road networks. It shows many scattered waterways within the area, most of which have now disappeared. The northern street pattern remains relatively unchanged due to the presence of Chaotian-Gong and the surrounding mountains. In contrast, the southern street pattern experienced significant changes, with the road network becoming notably denser. This indicates that the natural base and land parcel attributes and uses during this period had a considerable impact on the changes in urban morphology.

Table 1. Compilation of Historical Maps of Chaotian-Gong District During the Late Qing Dynasty, Drawn by the Author

Time	Map Source	Map
1853	the Jiangning Provincial City Map	
1898	the Jiangning Prefecture City Map	
1910	New Survey Complete Map of Jinling Provincial City by Lushi Academy	

From the republican era to the present

Following the formulation of the capital city plan in 1927, the urban morphology of Nanjing underwent significant changes. This period is well-documented, with one of the most impactful developments being the construction of Zhongzheng Road (now Zhongshan South Road) starting in 1929. According to the 1948 Nanjing map (Table 2), the most significant change in the block morphology compared to earlier periods was the introduction of the new grid layout in Xinjiekou following the capital city plan. The north-south roads in Xinjiekou intersected with the existing grid system, creating numerous irregular land parcels. The road networks on both sides of the waterways were slightly denser than before, largely defining the current spatial morphology of the Chaotian-Gong District.

Overlaying maps of the Chaotian-Gong District from different periods reveals that, similar to the planning period, the street pattern in the northern part of the district changed little, with minimal alterations near Chaotian-Gong and the surrounding mountains. In contrast, the road network in the southern part experienced substantial changes and continuous updates. The modifications to the waterways, along with the disappearance of city walls and gates, had a significant impact on the overall morphology of the district. Additionally, the new roads constructed under the capital city plan drastically altered the district's layout in a very short time, highlighting the role of agents in the transformation of urban morphology.

Table 2. Compilation of Historical Maps of Chaotian-Gong District from the Republic of China to Present, Drawn by the Author

Time	Map Source	Map
1948	Detailed Street Map of Nanjing City-University of Wisconsin	

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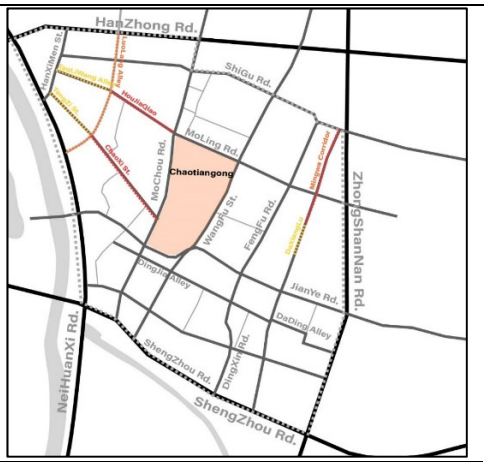

Research on the relationship between diverse agents and urban micro-update morphology

Analysis of agents in the Chaotian-Gong district

Based on the specific functions and roles of agents in the formation, change, and development of urban morphology, agents can be categorized into indirect agents, direct agents, and evaluative agents (see Figure 3). In the Chaotian-Gong District, indirect agents include government approval agencies such as the District Construction Bureau, Urban Management Bureau, and Landscaping Bureau, as well as the Chaotian-Gong District community departments and neighborhood committees.

Direct agents are primarily of two types: one type consists of builders, specifically White House Property Maintenance Co., Ltd. in the context of the Chaotian-Gong District urban renewal; the other type includes planners, architects, and designers, represented by the Southeast University design team and the Nanjing Creative Design Center.

Evaluative agents include consumers and users. In the Chaotian-Gong District, significant evaluative agents are merchants, residents, and staff from public institutions or government departments.

Agents exercise agency through various actions such as decision-making, design, supervision, and feedback, directly or indirectly shaping and transforming urban morphology. Due to differences in their roles, objectives, modes of influence, resources, and socio-economic backgrounds, agents play different roles in the process of urban morphology formation, resulting in a diverse range of urban forms. Conversely, urban morphology impacts aspects such as the economy, culture, and environment, which in turn affects the agents.

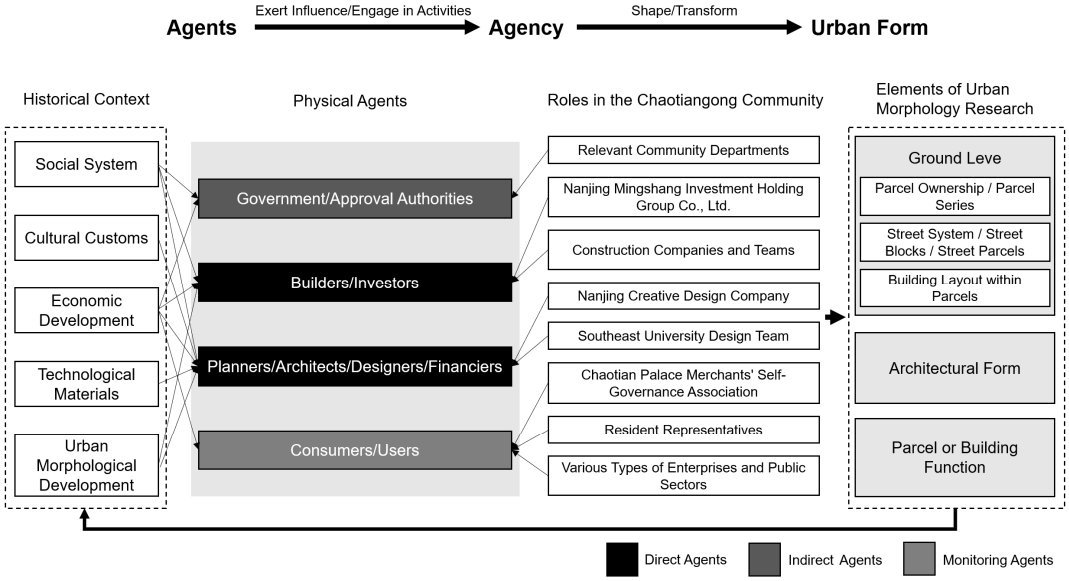

Figure 3. Types and Impacts of Agents in the Chaotian-Gong Area.

Analysis of the relationship between urban micro-morphology and agents in the Chaotian-Gong district

This study focuses on the Chaotian-Gong District, specifically from the Mingwulang area to the Daxing Furnace area (see Figure 3), to analyze the relationship between urban micro-morphology and agents. The area under examination involves a diverse range of agents influencing urban morphology. By observing and documenting the existing urban micro-morphology and conducting interviews with agents in this region, it has been found that evaluative agents, such as users and consumers, have a significant impact on the morphological changes of public corridors, permeable streets, and alleyways, which can be considered as the "capillaries" of urban space. This impact is particularly evident in issues related to the delineation of boundaries between different attributes and the utilization of grey spaces at boundary intersections.To further investigate, four representative plots within this area have been selected as case studies to analyze in detail how these agents affect urban micro-morphology.



Figure 4. Key Research Area for Urban Renewal in the Chaotian-Gong District.

Plot One is located at the boundary between the China Bank Campus and the residential area in the Mingwulang region (Figure 4-1). Plot Two is situated at the boundary between the Nanjing Overseas Business College and the residential area (Figure 4-2), with individual shops lining one side of the street. Both plots feature narrow pedestrian pathways and residential entryways. From the perspective of agents, institutional users such as banks and schools require spaces with strong enclosure, larger scales, and distinctive or ceremonial entrances. In contrast, residents need spaces that cater to social interactions, relaxation, parking, and the collection of deliveries. Merchants, on the other hand, prefer spaces that are open to the public to ensure customer flow. The behaviors and feedback of these agents shape similar micro-morphological characteristics in the two plots. First, institutions and departments create well-defined boundaries and spaces that are inaccessible to others, with large, conspicuous features such as flowerbeds and stone lions encroaching on some of the passage areas. Second, the residential alleyways are narrow, leading to the creation of overlapping spaces with ambiguous boundaries to accommodate various needs. Due to spatial constraints, some impromptu activities spill over into the permeable streets (Figure 5).

Plot Three is located at the entrance of the Chengmei Campus of Nanjing Fifth Junior Middle School (Figure 4-3). Key agents here include teachers, students, and parents. This plot exhibits notable temporal variation in use; during school start and end times, there is a significant influx of people, leading to a relatively wide passage space with designated waiting areas. However, the high building density in the Chaotian-Gong district still results in issues like parking difficulties and queue congestion. Plot Four is situated at the entrance space of the Daxing Furnace residential area, flanked by shops along the street. Compared to Plots One and Two, this plot features a larger entrance space with more ambiguous boundaries between different user areas. Functional spaces are often shared, highlighting the considerable impact of various agents on the micro-morphology of boundaries.

Overall, the Chaotian-Gong District is characterized by high building density and narrow passage spaces. The residential area entrances are typically narrow alleys. The mix of historical, commercial, and residential characteristics creates significant differences in the needs of agents in adjacent smaller areas, resulting in various types of boundary conditions. For instance, spaces occupied by institutional employees, government staff, and students have clear boundaries, are usually larger, and support relatively singular activities. These spaces undergo minimal changes and are less adaptable in urban renewal contexts. In contrast, spaces used by residents and merchants generally feature ambiguous boundaries with overlapping functional areas. Due to limited space, the study area frequently experiences temporary usage phenomena, such as flowerbed edges being used as seating, and open areas serving various functions like parking, queuing, and placing urban furniture at different times.



Figure 5. Recording of Chaotian-Gong District Urban Micro-Morphology.

In urban micro-renewal involving multiple stakeholders, different types of agents influence the boundaries, permeability, and other aspects of urban micro-morphology in various ways. The previously mentioned evaluative agents, such as users and consumers, modify and update the urban micro-morphology through their daily usage and feedback, aiming to meet their activity needs. During the micro-renewal process, indirect agents, such as government departments and planning agencies, guide and regulate the block's morphology through policies and regulations. Their decisions and management actions typically shape planning at a macro level, but in the case of Chaotian-Gong, regulatory bodies have detailed their efforts to address the micro-level aspects of the block, such as street improvements, landscaping, and public facility arrangements. These measures also align the morphology more closely with the needs of users and consumers. Direct agents, such as developers and architects, affect the physical morphology of the block through construction and renovation projects. Their actions are primarily influenced by design concepts, construction methods, and aesthetic goals. Through design and construction, direct agents have a tangible impact on the urban micro-morphology.



Figure6. Recording of Chaotian-Gong District Urban Micro-Morphology.

RESULTS AND DISCUSSIONS

Research conclusions

Applicability of urban microform studies and actor research in urban micro-updates

Based on the above research, this project targeted specific plots with prominent contradictions for focused micro-updates. For example, in Plot Three, analysis of the agents revealed that parents picking up and dropping off students lacked waiting space. In the renovation, the flower bed was redesigned into a node for waiting and resting. For nodes with high demand but limited space, multifunctional equipment can be appropriately installed to flexibly meet users' needs. This also illustrates how direct agents, such as architects, actively shape the physical form of the district through construction and renovation projects.

Overall, studying urban microform helps to identify the "capillaries" of urban spaces—such as public corridors, alleys, and green spaces—that are small but important spatial units. These units often become the focus of renovation in micro-updates. Detailed study of their form and usage allows for more precise renovation strategies, improving the efficiency and quality of urban spaces. The impact of agents on urban form helps better align user needs with physical forms during urban updates and

aids in understanding the interaction among various stakeholders in policy-making and implementation. By optimizing policy design and promoting active participation from diverse agents, it facilitates joint involvement of government departments, developers, architects, community residents, and merchants in urban micro-updates. Coordinating these relationships fosters collaborative efforts and ensures the smooth implementation of update projects.

Summary

In the study area of the Chaotian-Gong District, the activities of agents have a significant impact on the urban microform, particularly regarding the boundaries and alleyways. User and consumer agents, as evaluative agents, notably influence the shaping of boundary forms and alleyway configurations. Their daily activities and behavior patterns, such as pathways, waiting spaces, and interaction nodes, directly affect the layout and changes in the district's micro-spaces. These agents, through their roles and responsibilities, continuously update and optimize the district space, driving the dynamic development of the overall district form. In the study case, the passage roads are generally quite narrow, yet they still serve numerous functions beyond traffic. This is primarily due to the lack of public activity spaces within the district, causing the social activities of agents to temporarily shift onto these passage roads, occupying part of the space. Public corridors and alleyways between plots of different natures are gradually being squeezed, and the varying needs of agents result in different boundary forms on either side of these corridors and alleyways. A thorough study of these agents' activities and their impacts provides valuable references for urban micro-updates and promotes sustainable urban development.

Implications and limitations of the study

This study addresses the gaps in research on urban microform and urban agents in the context of urban updates, offering a new perspective on urban micro-updates. By exploring how urban microform is influenced by different agents, this paper reveals the complex relationships between microform and agents and expands understanding of the details and mechanisms in urban micro-update practices. This perspective helps identify and analyze the specific roles and interactions of various stakeholders in urban updates, providing theoretical support and practical guidance for formulating more precise and effective micro-update strategies.

While the paper briefly mentions the impact of users' temporary activities on urban microform in the Chaotian-Gong district, it does not fully summarize their mechanisms and research methods. Many countries and regions are now in the "second half" of urbanization, where space updates and functional transformations are very common. Exploring how to apply the frameworks of urban morphology and agency studies to phenomena such as industrial-to-commercial conversions, temporary land use, and the segmented use of living spaces in time and season warrants further consideration.

CONCLUSIONS

This study explores the historical urban morphology changes in the Chaotian-Gong District and their underlying causes from the perspective of urban micro-morphology and agents of change. It analyzes the relationship between the current micro-urban morphology of the Chaotian-Gong area and the

various agents involved. The identified conflicts and deficiencies in this analysis have been applied to the practice of urban micro-renewal. Through this application, the research provides valuable insights into the role of urban micro-morphology and agent dynamics in informing and guiding urban micro-renewal projects. The findings suggest that understanding the interactions between agents and urban micro-morphology can enhance the effectiveness of micro-renewal initiatives, ensuring that the needs of diverse stakeholders are met while improving the spatial quality and functionality of urban environments.

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Study the effect of urban morphology on micro climatic comfort of public open spaces using genetic algorithm. Case study: Tehran, Iran

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ABSTRACT

As urban areas continue to expand rapidly, there is an increasing imperative to integrate microclimate considerations with urban morphology to enhance thermal comfort at the pedestrian scale. This study aims to optimize climate comfort indices—specifically solar radiation, daylight factor, and the Universal Thermal Climate Index (UTCI)—to identify effective urban morphology patterns for pedestrian environments in urban streets. Utilizing a quantitative approach, the research employs computational modeling in Grasshopper, enhanced by a genetic algorithm, to explore optimal density and occupancy levels for urban morphology in Tehran's streets. The study focuses on two primary land uses, residential and commercial, analyzing the impact of density and occupancy levels as key morphological parameters on the microclimate. Findings indicate that density exerts a more significant influence on thermal comfort with a fixed street network pattern than occupancy. These insights provide essential data for urban morphology and climate modeling, advancing the development of climate-responsive urban designs.

Keywords: urban morphology, urban climate, climate comfort, pedestrian scale, urban streets

INTRODUCTION

The rapid urbanization and concentration of populations in cities amplify their vulnerability to climate change, highlighting the need for strategic adaptation to address the evolving weather patterns linked to global warming. Projections indicate that average annual temperatures could rise by 1°C to 5°C by the 2080s (Harrs et al., 2024). In response, policymakers and urban planners prioritize sustainable and energy-efficient development strategies to cultivate resilience within urban environments (Monteiro et al., 2024). Urban expansion is evident in the projected increase of cities with populations between

500,000 and 1 million, expected to rise from 598 in 2016 to 710 by 2030 (Salmanian et al., 2024). This growth altered urban morphology, resulting in new multifunctional spaces and intensified energy demands while exacerbating environmental challenges, including the urban heat island effect (Ma et al., 2024). Urban areas, which host approximately 50% of the global population, account for two-thirds of primary energy consumption and contribute 71% of global greenhouse gas emissions (Salmanian & Ujang, 2021). As urban populations are anticipated to reach 68% by 2050, the strain on material and energy resources will only increase (Li et al., 2022).

In the context of escalating climate change impacts, urban areas have experienced a significant rise in temperatures, with global averages increasing by 0.8°C over the past century, alongside rising atmospheric CO2 concentrations projected to double by 2100 (Davis, 2017). Given the critical role of cities in addressing these challenges, frameworks such as the Paris Agreement and the Sustainable Development Goals have highlighted the importance of urban resilience and adaptive strategies (Bikomeye et al., 2016). Nevertheless, challenges remain regarding the equitable implementation of urban improvements. To tackle the adverse effects of climate change, it is essential to understand how urban morphology affects local climates and outdoor thermal conditions. Research indicates that design parameters such as green cover ratios and building heights significantly impact microclimatic variations (Shaikh Salim et al., 2020; Galal et al., 2020). Consequently, integrating climate-responsive urban design into planning strategies is vital for enhancing thermal comfort and reducing energy demands linked to cooling systems (Abd Elraouf et al., 2022). This paper aims to strategically model the interplay between urban morphology and climate in Tehran, utilizing computational techniques to establish effective urban design strategies that foster sustainable and resilient urban environments.

Literature review

Outdoor thermal comfort

Thermal comfort refers to the level of satisfaction or indifference experienced by individuals concerning their thermal environment. Definitions of thermal comfort vary among institutions and scholars, with the most widely accepted definition provided by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). ASHRAE defines thermal comfort as a mental state reflecting satisfaction with the thermal environment. The glossary of terms related to thermal physiology describes it as a subjective indifference to temperature conditions. Gagge et al. points out that while "comfort" is a recognizable emotional state, it does not correlate with a specific sensory organ like the traditional five senses (Wang et al., 2018). Outdoor thermal comfort is a multifaceted concept influenced by various environmental, individual, and psychological factors. Environmental elements, including solar radiation, wind speed, air temperature, and humidity, directly impact the human body's thermal balance and sensation. Individual characteristics, such as age, gender, and physical activity levels, influence the body's capacity for thermal regulation and adaptability. Additionally, psychological factors—such as past experiences, expectations, and the purpose of activities—also play a role in determining thermal satisfaction and preferences. Consequently, a comprehensive examination of outdoor thermal comfort must account for the interplay among these factors (Han et al., 2024).

Given the complex nature of thermal comfort, no single factor can adequately capture individuals' subjective experiences in different thermal environments. To address this complexity, thermal comfort indices integrate various environmental parameters and human body responses into a unified

metric for a more accurate and convenient thermal comfort assessment. Since ASHRAE introduced the first thermal comfort index, Effective Temperature (ET), in 1923, research on thermal comfort has evolved significantly, leading to the development of approximately 165 different thermal comfort indices. These indices can be categorized into two main types: empirical thermal comfort evaluation indices and theoretical thermal comfort evaluation indices (Su et al., 2024).

Outdoor thermal comfort factors

Studies have shown that numerous direct and indirect factors influence outdoor thermal comfort. These include geographical and seasonal variations, climatic conditions such as temperature, thermal radiation, wind, humidity, individual physiological differences, social and cultural factors, and personal behavioral habits (Yongga et al., 2024). Empirical thermal comfort evaluation indices were primarily developed in the early stages of thermal comfort research. These indices assess heat and cold risks by examining the relationship between the physical environment and human thermal sensation. Typically, they focus on estimating the combined effects of air temperature, humidity, and velocity on individuals at rest. Empirical indices are generally divided into two categories: hot empirical indices and cold empirical indices. Hot empirical indices evaluate thermal comfort in high-temperature environments, while cold empirical indices are used for low-temperature settings. The main advantages of empirical indices are their simplicity in calculation and ease of understanding. However, these indices have notable limitations, disregarding individual physiological factors, activities, clothing, and personal characteristics such as height, weight, age, and gender. Additionally, their applicability can be constrained by geographical and climatic conditions. It is essential to supplement empirical indices with other indices, such as dynamic and adaptive indices, to enhance the accuracy and applicability of thermal comfort evaluations. This integrated approach helps address the shortcomings of empirical indices and provides a more comprehensive assessment of thermal comfort (Liu et al., 2023).

As the understanding of thermal comfort mechanisms has deepened, the focus has shifted from merely assessing the physical environment to incorporating individual physiological and psychological factors and dynamic balances. Consequently, theoretical indices have emerged. These indices are numerical models derived from the human body heat-balance equation, comprehensively considering environmental conditions and human body parameters. Theoretical indices exhibit diverse development due to different research institutions' varying methods and models. Based on their application scope, they can be classified into steady-state and dynamic indexes. Steady-state indices evaluate thermal comfort under constant environmental conditions, while dynamic indices account for fluctuating conditions. Theoretical indices offer a more objective evaluation of human thermal comfort in complex environments, resulting in more scientifically robust assessment outcomes (Hughes et al., 2018).

Steady-State Thermal Comfort Evaluation Indices

The steady-state model posits that human thermal comfort results from the continuous heat transfer between the human body and its environment, leading to a thermal equilibrium over time. In 1923, Houghton and Yaglou conducted pioneering experiments, defining the Effective Temperature (ET) as the temperature at which individuals in standard clothing perceive similar thermal sensations across

environments with differing temperatures and humidity. However, ET primarily accounts for air temperature and humidity (Chen et al., 2023). In 1971, Gagge et al. enhanced the concept of ET by introducing skin moisture into the equation, coining the term New Effective Temperature (ET) to incorporate the body's evaporative heat dissipation. In 1972, Gagge et al. proposed the New Standard Effective Temperature (SET) at a seminar, which integrates activity levels and clothing thermal resistance based on ET. This index adapts to varying physiological conditions and clothing scenarios, although its calculation complexity poses challenges. Most of these indices have been traditionally applied indoors, which may not accurately reflect outdoor thermal comfort due to differences such as solar and infrared radiation (Savi & Romero, 2024).

In 2000, Pickup and de Dear introduced the Outdoor Mean Radiant Temperature (OUT_MRT) and established the Outdoor Standard Effective Temperature (OUT_SET) to tailor the SET model for outdoor contexts. By comparing actual measured values with predictions, the OUT_MRT model effectively characterizes the outdoor radiation environment and calculates the total radiation absorbed by the human body. During the 1960s and 1970s, Danish scholar Fanger developed the Predicted Mean Vote (PMV) model, which utilizes a seven-point scale based on the human body's heat-balance equation to predict the average thermal sensation of individuals. The PMV model is widely adopted for indoor thermal comfort assessments. Concurrently, Fanger introduced the Predicted Percentage of Dissatisfied (PPD) index, reflecting the proportion of individuals feeling too hot or cold. However, since the PMV model is primarily designed for stable air-conditioned environments, it often yields significant errors in dynamic outdoor settings (Li & Zhao, 2023). Mayer and Höppe (1987) developed the Physiologically Equivalent Temperature (PET) model, based on the Munich Energy-balance Model for Individuals (MEMI) steady-state two-node model. PET remains relevant today, conceptualizing outdoor climates as effective indoor environments with comparable expected air temperatures (Keshavarz & Bahrami, 2023). Furthermore, Matzarakis et al. introduced the RayMan model in 2007 to facilitate PET calculations, enhancing its utility for outdoor thermal comfort assessment (Matzarakis & Amato, 2024).

Dynamic Thermal Comfort Evaluation Indices

The steady-state model assumes that heat exchange between the human body and the thermal environment remains constant, requiring stable environmental conditions and prolonged exposure. This model is typically applicable when individuals are exposed to outdoor environments for extended periods. However, because outdoor thermal conditions frequently fluctuate, the human body's heat load also varies. To address this limitation, dynamic models were developed to account for varying heat storage rates, recognizing that thermal comfort can be achieved even when heat storage is not zero. An example of such a dynamic model is the Universal Thermal Climate Index (UTCI), initiated by Commission 6 of the International Society of Biometeorology. The UTCI evaluates outdoor thermal conditions across various human biometeorology contexts. The UTCI is derived from the equivalent temperature calculated through over 100,000 thermal physiological simulations using the multi-node dynamic thermal physiology UTCI-Fiala model. This equivalent temperature reflects the environmental conditions required to produce the same physiological response observed in the natural environment. Although the UTCI accurately assesses outdoor thermal comfort across different climates and is applicable worldwide, its complex model structure is characterized by its complex model structure (Yongga et al., 2024; Steadman, 2023).

Morphological Aspects of Thermal Comfort

Thermal comfort in urban environments is significantly influenced by various morphological aspects, which play a critical role in shaping the microclimate experienced by pedestrians. This sub-section delves into the key variables pertinent to urban morphology and their impact on thermal comfort, mainly focusing on density, block dimensions, and spatial configuration as analyzed in the context of Tehran.

- Urban Density

Density is a crucial morphological parameter that affects thermal comfort. Higher urban density can increase heat retention and the urban heat island effect, impacting outdoor temperatures (Guan et al., 2023). Research indicates that higher-density areas experience elevated ambient temperatures due to reduced green space and increased impervious surfaces, which hinder natural cooling processes (Zhou et al., 2023). Consequently, optimizing density levels can enhance thermal comfort by balancing heat retention and dissipation in urban spaces.

- Block Dimensions and Internal Configurations

Block dimensions, including the height-to-width (H/W) ratio, significantly influence solar exposure and wind flow, which are critical for thermal comfort. A lower H/W ratio is associated with increased solar access, leading to higher surface temperatures during the day and affecting overall thermal comfort levels (Erell et al., 2023). Furthermore, internal block configurations can create microclimates that enhance or mitigate heat stress. For instance, more extensive internal courtyards can facilitate air circulation and provide shaded areas, thus improving thermal comfort for pedestrians (Lee & Loughnan, 2024).

- Spatial Configuration

The spatial arrangement of urban elements, including streets, buildings, and public spaces, is vital in determining thermal comfort. The buildings' orientation and streets' layout can influence wind patterns and solar gain. Optimal spatial configurations that promote natural ventilation can reduce reliance on mechanical cooling systems, thereby enhancing thermal comfort in densely populated areas (Wang et al., 2024). Moreover, integrating mixed-use developments can foster a pedestrian-friendly environment that encourages outdoor activity, further influencing perceived comfort levels (Kumar et al., 2023).

METHOD

The research methodology employed in this paper utilizes a quantitative approach coupled with computational modeling to enhance urban morphology for improved thermal comfort. A thorough literature review initially identifies key morphological characteristics that impact microclimatic conditions. This review emphasizes various urban morphology components, including building density, layout, and height-to-width ratios. These directly influence critical thermal comfort indices such as solar radiation, daylight factor, and the Universal Thermal Climate Index (UTCI).

Following the literature review, an urban model will be developed using Grasshopper, a visual programming language that facilitates dynamic simulation and analysis. The model will leverage genetic algorithms to iteratively optimize urban form configurations based on predefined thermal comfort criteria. Three distinct types of urban networks—12m, 18m, and 24m—will be incorporated into the model, allowing for flexible adjustments of block dimensions and internal divisions. This grid-system configuration is specifically tailored to the unique context of Tehran, enhancing the model's relevance and adaptability. Data collection will occur through simulations that evaluate the thermal performance of varying urban configurations. The analysis will focus on how changes in density and occupancy levels influence outdoor thermal comfort, providing valuable insights into optimal design strategies for sustainable urban development. Ultimately, this methodology aims to integrate microclimatic considerations into morphological configurations, promoting energy efficiency and enhancing pedestrian comfort in urban environments. Consequently, this analysis expands the urban planning workflow to incorporate inputs from climate models, as illustrated in Figure 1.

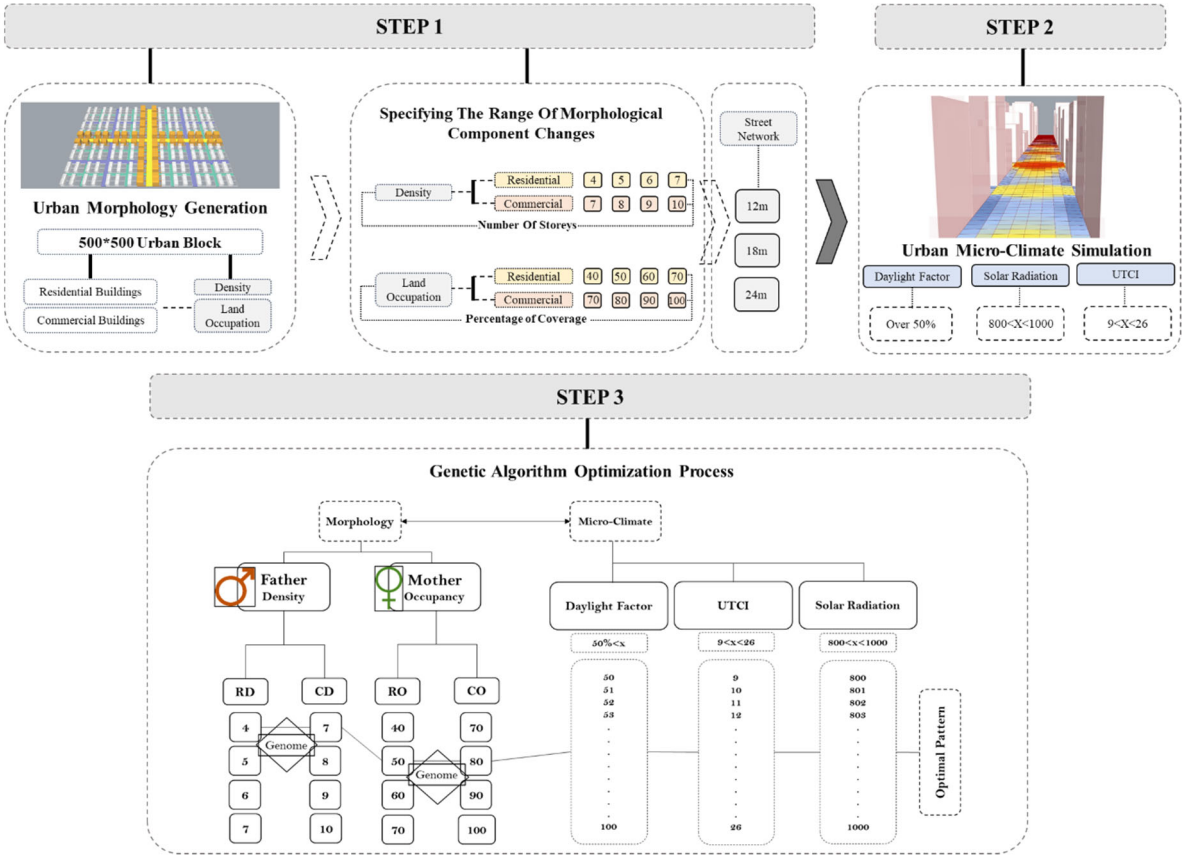

Figure 1. The study's workflow is in three main steps: urban morphology generation (Step 1), urban micro-climate simulation (Step 2), and the genetic algorithm optimization process (Step 3).

Generating urban morphology

The initial step involves developing an urban model capable of dynamically adapting to changes within the city's context while accurately representing Tehran's morphological characteristics, including its urban patterns and density. Depending on the context, this model should be flexible enough to adjust block dimensions, internal divisions, and other morphological properties.

To refine the analysis further, the subsequent step is to select an appropriate hierarchy within the urban network, which will facilitate more precise processing of the model. Currently, three distinct types of urban networks—12m (Fig. 2), 18m (Fig. 3), and 24m (Fig. 4)—have been integrated into the

urban block model using a visual programming language. Given the area and city being studied (Tehran), the network has been configured as a grid system.

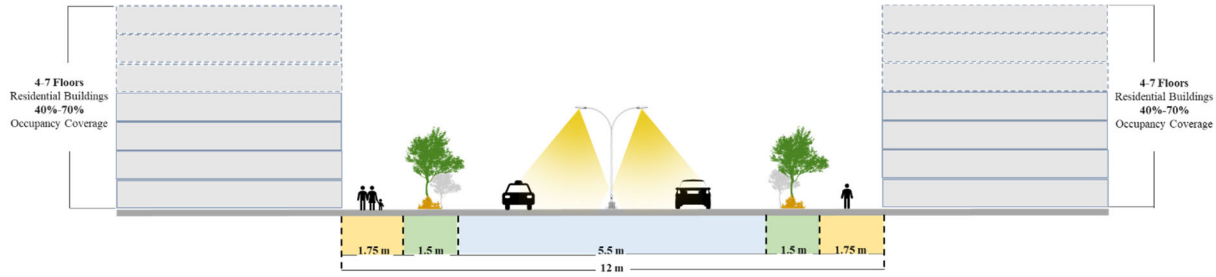

Figure 2. Cross Section of Urban Street Type 1 (12m)

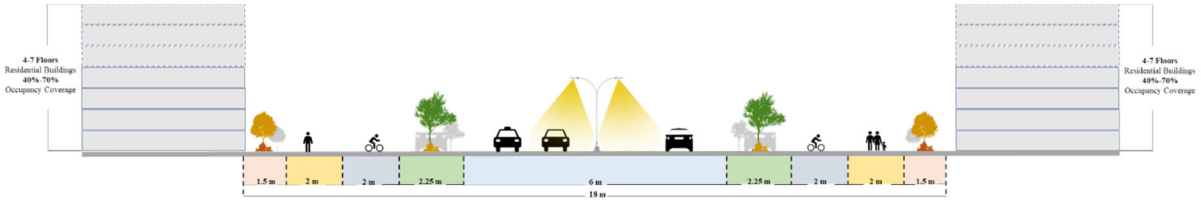

Fig. 3. Cross Section of Urban Street Type 2 (18m)

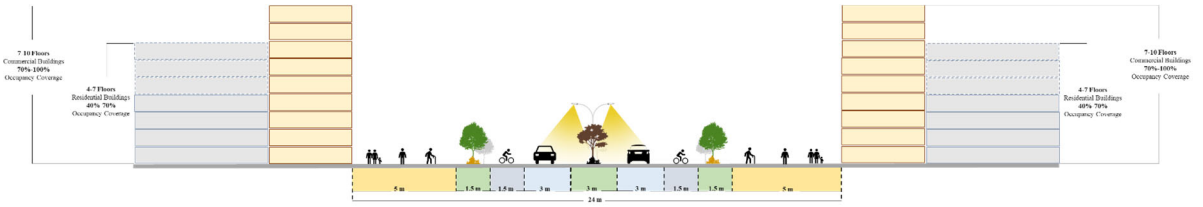

Fig. 4. Cross Section of Urban Street Type 3 (24m)

Urban micro-climate simulation

To begin the climate and microclimate analysis essential for future research, Tehran-specific climatic data is imported into the appropriate software as an EPW (EnergyPlus Weather) file. This foundational step establishes the groundwork for subsequent stages of the study, ensuring that the analysis is grounded in accurate and relevant climatic conditions. The data collected will be crucial in informing the various simulations and evaluations conducted throughout the research process. Following the data import, the subsequent steps involve a series of systematic analyses and simulations to understand urban morphology's impact on thermal comfort. Each phase is designed to refine the model and enhance its applicability to Tehran's unique climate, ultimately guiding the development of effective urban design strategies that prioritize occupant comfort and environmental sustainability:

Daylight Factor

Daylight calculations traditionally rely on the daylight factor, which does not consider prevailing weather conditions. While effective for overcast skies, this method falls short for clear-sky scenarios. In urban canyons, reflected sunlight from surrounding buildings and surfaces can significantly boost structure illumination. Early-stage design calculations, though simplistic, are vital for avoiding decisions that may degrade daylight quality.

Urban canyons can act like photometric integrators, where light becomes more uniform after multiple reflections, reducing dependence on the angle of incidence. This principle forms the basis for calculating the average total daylight factor, especially for sunny conditions, incorporating reflected light from urban environments (Brotas & Wilson, 2007). More recent studies confirm the importance of reflected light and highlight the need to integrate site-specific climatic data for better accuracy in urban settings (Konis & Selkowitz, 2023).

In daylight analysis using the Grasshopper plugin, the process begins by generating test points on a geometric model. To ensure accuracy, three fundamental parameters are defined: test geometry, grid size, and distance from the surface. Once set, the simulation proceeds with inputs such as test points, vectors, and a uniform sky model. These simulations consider morphological conditions and integrate climatic data, ensuring that results are more representative of real-world conditions. The results are then displayed in a color spectrum and can be exported to Excel for detailed analysis, aiding in visualizing daylight performance under various conditions (Reinhart et al., 2024). These recent methodologies provide a comprehensive approach, moving beyond traditional daylight factor calculations by incorporating local weather and urban morphology data to ensure optimized daylight performance in complex urban environments.

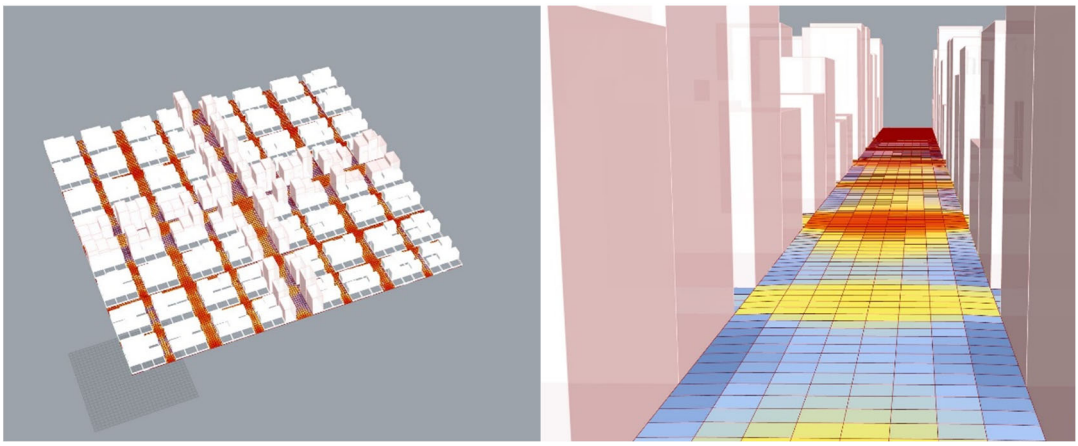

Fig. 5. The results of the daylight factor analysis in the Grasshopper plugin

Universal Thermal Climate Index (UTCI)

The Universal Thermal Climate Index (UTCI), developed to assess outdoor thermal comfort, is recognized as one of the most comprehensive tools for evaluating heat stress in urban environments. Originating from biometeorological research, UTCI is grounded in a multi-node thermoregulation model that simulates the body's ability to regulate core temperature despite external climate variations. Recent advancements in UTCI applications emphasize its importance in urban planning, particularly for addressing the challenges of rising global temperatures and urban heat islands. The UTCI reflects an equivalent environmental temperature that produces the same physiological strain on an individual as a reference temperature in a controlled setting. This makes it especially useful for accurate thermal assessments under diverse climatic conditions (Shen et al., 2024).

In urban climate analysis, tools like the Grasshopper plugin integrate local weather data into simulations, such as Tehran's EPW (EnergyPlus Weather) file. By incorporating essential inputs such as dry bulb temperature, mean radiant temperature, wind speed, and relative humidity, the UTCI index can be calculated more precisely. For example, the "Outdoor Solar Temperature Adjuster" simulates the mean radiant temperature, a critical factor in UTCI calculations, ensuring that all climatic and morphological variables are accurately represented. Once the inputs are established, the simulation provides a visual spectrum and detailed quantitative outputs, helping urban designers

evaluate thermal comfort more effectively in dense urban environments (Ryu & Kwon, 2023; Chen et al., 2023).

Table 1 illustrates the distinct characteristics of the Universal Thermal Climate Index (UTCI) compared to previous indices, especially in how it reflects comfort levels throughout the day. When considering monthly averages, the index shows no indication of thermal comfort at 9:30 am and 3:30 pm, whereas 9:30 pm presents a more accurate reflection of comfort conditions. For example, during winter (January, February, and December), the average values at 9:30 am and 3:30 pm show no thermal stress, suggesting comfortable conditions. However, at 9:30 pm, the data indicates slightly colder conditions. Similarly, in November and December, while the average values at 9:30 am and 3:30 pm suggest no heat stress and comfortable conditions, the evening values at 9:30 pm indicate a slight chill, highlighting the variation in thermal comfort across different times of the day.

Table 1. Evaluation of human comfort using the UTCI index

UTCI	9:30	15:30	21:30	Monthly Average
January	No thermal stress	No thermal stress	Slight cold stress	Slight cold stress
February	No thermal stress	No thermal stress	Slight cold stress	Slight cold stress
March	No thermal stress	No thermal stress	Slight cold stress	No thermal stress
April	No thermal stress	No thermal stress	No thermal stress	No thermal stress
May	Moderate heat stress	Moderate heat stress	No thermal stress	No thermal stress
June	Moderate heat stress	Strong heat stress	No thermal stress	Moderate heat stress
July	**Strong heat stress**	**Very strong heat stress**	**Moderate heat stress**	**Strong heat stress**
August	**Strong heat stress**	**Strong heat stress**	**No thermal stress**	**Strong heat stress**
September	Moderate heat stress	Strong heat stress	No thermal stress	No thermal stress
October	Moderate heat stress	Moderate heat stress	No thermal stress	No thermal stress
November	No thermal stress	No thermal stress	Slight cold stress	No thermal stress
December	No thermal stress	No thermal stress	Slight cold stress	Slight cold stress

Based on the data presented, July and August are identified as periods of reduced climate comfort due to the highest recorded temperatures in Tehran, as shown in Figure 6. These months consistently experience the peak heat, particularly at Mehrabad station, making them critical indicators for assessing thermal stress and identifying the comfort threshold. On the opposite end, January registers the lowest average temperatures, offering a stark contrast. Therefore, focusing on these months is essential to create an optimal climate model for Tehran. July and August represent critical points for evaluating the impacts of extreme summer heat on comfort.

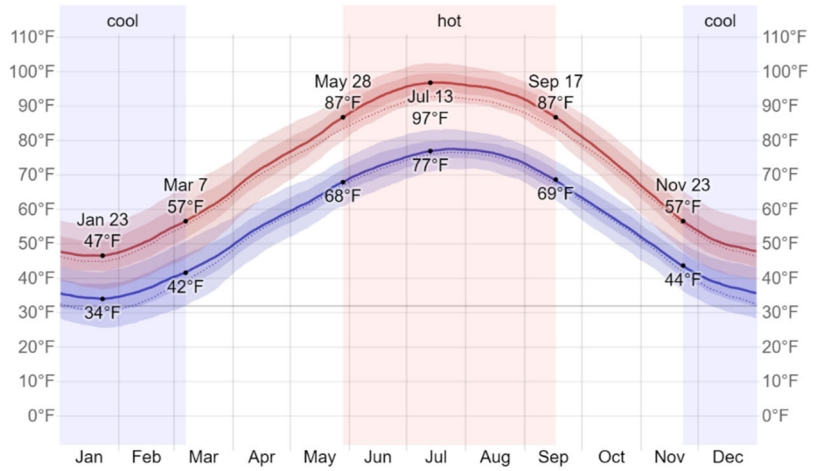

Fig. 6. The daily average high (red line) and low (blue line) temperature, with 25th to 75th and 10th to 90th percentile bands. The thin dotted lines are the corresponding average perceived temperatures (Source: weatherspark.com)

Solar Radiation

Shortwave radiation, which includes visible light and ultraviolet radiation, exhibits significant seasonal fluctuations in Tehran. The brightest period spans approximately 3.4 months, from May 9 to August 22, during which the average daily incident shortwave energy exceeds 7.4 kWh per square meter, peaking in June at 8.4 kWh. In contrast, the darker period, also lasting 3.4 months from October 31 to February 11, sees the average daily incident shortwave energy drop below 4.0 kWh, with December being the darkest month at just 2.9 kWh (Fig. 7). The calculation of this index is based on climatic data specific to Tehran. It uses a sunlight simulation tool that requires geometry, context, grid size, distance from the surface, and a selected sky matrix. The numerical output generated from this analysis will be used to inform a genetic algorithm developed with the Grasshopper plugin, aiding in the creation of an optimal model for micro-climate-driven urban morphology (Rocca & Morabito, 2024; Khan & Sinha, 2023).

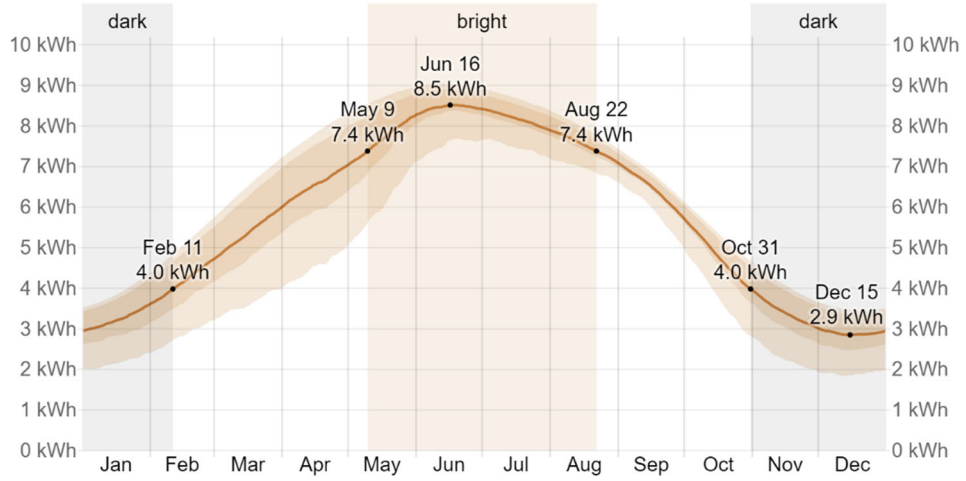

Fig. 7. The average daily shortwave solar energy reaching the ground per square meter (orange line), with 25th to 75th and 10th to 90th percentile bands (Source: weatherspark.com)

Genetic algorithm optimization process

Evolution-based heuristic techniques, such as Genetic Algorithms (GAs), represent a powerful class of algorithms for solving complex problems. Recent research has focused on enhancing the adaptive nature of GAs, showcasing their effectiveness across various applications (Jalal & Kaur, 2023; Kaur & Narula, 2024). These algorithms utilize a chromosome-like data structure and apply recursive recombination or search techniques. For a given set of sample points, denoted as $u= \{u_1, u_2, u_3,\ldots, u_n\}$, GAs can derive an optimal set through effective recombination and selection processes based on semantic analytics. From this initial set, subsets can be identified, such as $\{u_1, u_2,\ldots,u_i\}$ with similar properties and another subset $\{u_j, u_k,\ldots, u_n\}$ with distinct characteristics.

GAs operate on five fundamental principles:

1. **Initialization**: This phase defines the complete sample points or population set. Initialization can be achieved using database tables or direct input from real-world scenarios. Semantic analysis is transformed into statistical models through random number generators that create density functions when employing database tables. In cases involving real-time data, the process begins with natural language processing, followed by statistical methods (Hasan, 2014; Jalal & Kaur, 2023).

2. **Selection**: Grounded in Darwin's principle of survival of the fittest, selection involves choosing a subset from the initial population that logically connects at a specific time. This subset can represent various domains, such as customer shopping behavior or complaints, ensuring the selected data is relevant and meaningful (Kaur & Narula, 2024).

3. **Crossover/Recombination**: Crossover is a critical operation that distinguishes GAs from other methods. This process involves combining a gene representing an individual member of a set with a gene from another set. The recombination fosters the exchange of behaviors and trends, creating logical relationships while minimizing randomness. Typically, crossover occurs between two genes, while the rest remain unchanged (Hasan, 2014; Kaur & Narula, 2024).

4. **Mutation**: Mutation introduces genetic diversity within the population by altering specific gene properties (alleles) during crossover. This mechanism helps preserve individuality within the population and can lead to the emergence of significant alleles by combining different genes (Jalal & Kaur, 2023).

5. **Acceptance**: New offspring are generated as candidates for the next iteration after mutation. However, not all candidates are suitable for advancement. The percentage of beneficial features within each gene is assessed during the elimination phase. Like an activation function in neural networks, a threshold determines which genes advance to the next level. This iterative process continues until the differences between successive generations are minimal, ensuring the algorithm converges toward optimal solutions (Jalal & Kaur, 2023; Kaur & Narula, 2024).

By leveraging these principles, GAs can efficiently explore large search spaces, optimizing solutions for various complex problems in fields ranging from computer science to bioinformatics (Jalal & Kaur, 2023; Kaur & Narula, 2024).

RESULTS AND DISCUSSIONS

The output model is highly adaptable, allowing for customization through parametric components to meet specific analytical needs. In the next phase, as detailed in the Genetic Algorithm (GA) section, morphological components are treated as variables, while micro-climatic standards function as fitness measures. Various factors—such as space geometry, building height, occupancy, and open space ratio—are analyzed as variables. In contrast, climatic parameters, including Universal Thermal Climate Index (UTCI), Daylight Factor, and other relevant indicators, serve as the fitness functions within the algorithm. By employing Grasshopper alongside the GA, these morphological components act as "parents," guiding the selection of optimal solutions for the chosen genomes. Concurrently, the objective functions consist of micro-climatic standards that enhance the inherited traits from the morphological parameters. The result is an urban morphology that remains flexible and responsive to changes in the micro-climate.

Once the algorithmic process concludes, the output is an active city-scale platform capable of integrating various components—either default or customized—based on specific micro-climatic measurement requirements. This platform generates corresponding data that informs decision-making. To finalize the optimization process, the data produced by the Genetic Algorithm should be saved in an Excel file in CSV format and uploaded to the Design Explorer website for further exploration and analysis. This approach streamlines data management and facilitates a deeper understanding of how urban morphology can adapt to and enhance local micro-climatic conditions (Feng et al., 2023; Gupta et al., 2024) (Fig. 8).

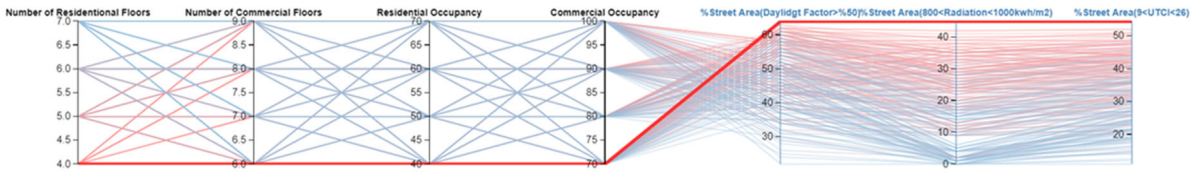

Fig. 8. Regulating the parameters (genomes) resulting from the Genetic Algorithm

The parametric model developed for this study exhibits high adaptability, allowing customization through various morphological variables. These variables, including space geometry, building height, occupancy rates, and open space ratios, were analyzed alongside key climatic parameters such as the Universal Thermal Climate Index (UTCI), Daylight Factor, and Solar Radiation. Using a Genetic Algorithm (GA) in combination with Grasshopper, the morphological variables served as "parents," guiding the selection of optimal solutions for the generated genomes. The objective was to optimize urban morphology responsive to micro-climatic conditions.

- Upon completing the optimization process, the resulting model was integrated into a city-scale platform capable of incorporating default and customized micro-climatic components. The data generated from this model was exported for further exploration and analysis, allowing for a deeper understanding of how urban morphology can enhance micro-climatic comfort (Feng et al., 2023; Gupta et al., 2024). From the 256 potential configurations generated by the algorithm, four optimal alternatives were selected based on their performance against climatic comfort criteria.

- Optimal Alternative No. 1 demonstrates a residential occupancy rate of 40%, indicating moderate utilization of residential spaces, while the commercial occupancy rate stands at 70%, reflecting a strong predominance of commercial activities. This alternative features a medium-density residential environment with buildings averaging four storeys, contrasted by commercial structures averaging six storeys. The micro-climatic performance shows an average Daylight Factor of 48.23%, peaking at 64%, which suggests that the area benefits from substantial natural light. However, variations exist in illumination levels across different zones. Solar radiation is recorded at an average of 18.58%, with a peak of 45%, suggesting that shading from surrounding building heights affects sunlight exposure. The UTCI averages 33.41% and peaks at 54.5%, indicating moderate thermal comfort but highlighting variability in comfort levels across different areas.

- In Optimal Alternative No. 2, the residential occupancy remains at 40%, similar to the first alternative, while commercial occupancy also holds steady at 70%. This alternative maintains a residential density of four storeys, but commercial buildings rise to an average of seven storeys. The Daylight Factor averages 48.23% with a peak of 62%, suggesting adequate natural light but highlighting the potential for improvement through design adjustments. The solar radiation metrics mirror those of Alternative No. 1, with an average of 18.58% and a peak of 42%, indicating limited direct sunlight exposure in shaded areas. The UTCI here also averages 33.41%, peaking at 52.5%, reflecting moderate thermal comfort.

- Optimal Alternative No. 3 shows a consistent residential occupancy rate of 40%, but the commercial occupancy rises significantly to 80%, indicating a commercially dominant area. The residential density remains four storeys, while commercial structures maintain an average height of six storeys. The Daylight Factor averages 48.23%, peaking at 62%, indicating that natural light is moderate, although some areas may experience reduced access due to the urban fabric. Solar radiation averages 18.58%, peaking at 42%, indicating limited exposure to direct sunlight. The UTCI results average 33.41%, peaking at 52%, signifying varying thermal comfort levels throughout the area.

Optimal Alternative No. 4 maintains a residential occupancy rate of 40% and commercial occupancy at 80%, reflecting a solid commercial focus in the area. The residential density remains four storeys, while commercial buildings average seven storeys, indicating a vertically developed commercial zone. The Daylight Factor averages 48.23%, with a peak of 61%, suggesting that although the area generally receives moderate to high levels of natural light, variations in daylight access occur based on building design. Solar radiation metrics show an average of 18.58%, peaking at 41%, indicating potential shading effects from taller commercial structures. The UTCI averages 33.41%, peaking at 51%, indicating moderate thermal comfort levels across the area.

The analysis of these four optimal alternatives reveals essential insights into the relationship between urban morphology and micro-climatic conditions. Each alternative demonstrates distinct characteristics, underscoring the need to balance commercial and residential uses while optimizing environmental quality. Across all alternatives, residential occupancy remains stable at 40%, while commercial occupancy ranges from 70% to 80%, indicating a predominantly commercial land use

pattern. Such patterns suggest strategies to integrate residential spaces into urban designs better to promote mixed-use development and enhance urban vibrancy (Smith et al., 2023; Johnson & Patel, 2024).

The moderate Daylight Factor across alternatives (48.23%) highlights the importance of building design in maximizing natural light. Improving daylight access could reduce energy demands and improve occupant well-being (Fernandez et al., 2023; Yang et al., 2024). The relatively low Solar Radiation (18.58%) suggests that shading from taller buildings affects sunlight exposure. Optimizing building orientation and enhancing vegetation can improve solar radiation and thermal comfort (Nguyen et al., 2024). The UTCI values (33.41%) indicate moderate thermal comfort, with variations suggesting the need for targeted interventions, such as implementing green roofs or strategic shading to enhance thermal conditions. Research supports that urban greenery and reflective materials can significantly improve overall climate comfort (Khan et al., 2024; Mansouri et al., 2024).

Implications for Urban Planning:

Analyzing the four optimal alternatives highlights significant insights into the studied area's urban morphology and micro-climate conditions. Each alternative presents distinct characteristics that underscore the importance of balancing commercial and residential spaces while optimizing environmental quality.

1. Morphological Parameters Across Alternatives:

- Residential and Commercial Occupancy: Across all alternatives, residential occupancy remains stable at approximately 40%, while commercial occupancy ranges from 70% to 80%. This suggests a consistent pattern of predominantly commercial land use, which could lead to potential challenges in residential integration. Studies indicate that urban environments with mixed-use developments promote higher livability and reduce travel demand (Smith et al., 2023; Johnson & Patel, 2024).

- Building Density: The residential density of four stories and commercial density varying from six to seven stories reflect a strategic approach to urban development. Higher commercial density, particularly in Alternatives 2 and 4, underscores the commercial significance. Recent research emphasizes that building height can impact urban energy efficiency and social interactions, influencing economic activity and community cohesion (Lee et al., 2023).

- Balancing Land Use: Given the predominance of commercial spaces, urban planning should strive to integrate residential areas more effectively. This could involve policies encouraging mixed-use developments, enhancing vibrancy, and reducing the risk of urban sprawl (Zhao et al., 2023).

- Optimizing Micro-Climate Conditions: The results indicate a critical need for urban design strategies to maximize daylight and solar radiation while improving thermal comfort. Implementing reflective materials and increasing green spaces can significantly mitigate heat and improve UTCI, ultimately leading to a more pleasant urban environment (Johnson & Patel, 2024; Fernandez et al., 2023).

- Enhancing Urban Layout: Future developments should prioritize the strategic placement of buildings to reduce shading effects and enhance solar access. Studies suggest that optimizing building layouts can significantly improve daylight access and energy performance (Lee et al., 2023; Yang et al., 2024).

2. Micro-Climate Indices:

- Daylight Factor (D.F.): The averages across the alternatives indicate a moderate Daylight Factor around 48.23%, peaking at 62%. Although the area generally receives sufficient natural light, variations exist due to building design and spatial configuration. Enhancing daylight access through thoughtful design can significantly improve energy efficiency and occupant well-being (Fernandez et al., 2023; Yang et al., 2024).

- Solar Radiation (S.R.): Solar radiation averages 18.58%, with peaks at 42%. This suggests limited direct sunlight in some regions, often attributed to shading from taller commercial structures. Addressing these challenges through optimized building orientation and spacing can improve solar exposure, enhancing thermal comfort (Nguyen et al., 2024).

- Universal Thermal Climate Index (UTCI): The UTCI values reveal moderate thermal comfort levels, averaging 33.41% and peaking at 52%. Variations in comfort across the area highlight the need for targeted interventions, such as implementing green roofs or strategic shading to improve thermal conditions. Research supports that urban greenery and reflective materials can enhance overall climate comfort (Khan et al., 2024; Mansouri et al., 2024).

CONCLUSIONS

This research underscores the critical importance of urban structure and form in enhancing climatic comfort within public spaces, particularly in Tehran's unique climate challenges. The findings demonstrate that strategic modifications to urban morphology—through geometric properties, density, and building orientation adjustments—can significantly mitigate thermal stress and improve overall environmental quality. By adopting a climate-based urban design approach, urban planners and designers can make informed decisions that leverage natural climatic advantages, ultimately leading to more comfortable and sustainable urban environments. The application of computational methods, particularly algorithmic programming and genetic algorithms, has proven to be a transformative tool in this study, facilitating the analysis of complex climatic and morphological data. These methodologies provide insights into the interactions between urban design parameters and climate comfort and establish a dynamic platform for future research. As highlighted, the ability to adapt this approach across various scales—from individual buildings to extensive urban developments—opens new avenues for integrating microclimate considerations into urban planning practices.

Moving forward, researchers and practitioners must explore the capabilities of genetic algorithms and other algorithmic tools to expand the scope of morphological and climatic variables. This will enhance the understanding of climate-responsive urban design, enabling the creation of public spaces that are not only aesthetically pleasing but also resilient and responsive to the needs of their inhabitants. By fostering collaboration across disciplines and embracing innovative technologies, urban designers can significantly contribute to developing sustainable cities, prioritizing ecological integrity and human comfort. In summary, this study lays a foundational framework for integrating urban design and climatic considerations, paving the way for future advancements in the field. Continued research is essential to refine these methodologies and their applications in diverse urban contexts, ultimately

leading to a more profound understanding of the interplay between urban morphology and climate comfort.

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The association between public space layout and vitality in metro station area： A case study of Shanghai, China

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ABSTRACT

The strategic organization of public spaces in Transit-Oriented Development (TOD) areas is increasingly recognized as a crucial factor for enhancing urban vitality and optimizing space utilization. This study investigates the distribution and organizational characteristics of public spaces in TOD areas, focusing on 18 metro station precincts in Shanghai's central district. Through a quantitative analysis of key organizational indicators, the research examines three types of public spaces: plazas, green spaces, and pedestrian malls.To assess the relationship between these organizational features and public space vitality, activity surveys were conducted in 146 public spaces within the case study areas. Data on activity density were gathered through field observations and behavior mapping techniques. By analyzing both spatial layout and activity patterns, the study identifies distribution trends and evaluates the efficiency of various public space configurations.The results reveal critical spatial organization indicators for different types of public spaces, uncovering notable differences in the organizational requirements for plazas, green spaces, and pedestrian malls. Factors such as metro connectivity, walkability, and proximity to residential areas were found to significantly influence public space vitality.

Keywords: TOD area, public space, layout efficiency

INTRODUCTION

Metro station areas are not merely extensions of urban transportation infrastructure but essential hubs of public life, with public spaces playing a central role (Thammaruangsri, 2003; Bertolini, 1996). In recent years, global cities have increasingly acknowledged the symbiotic relationship between public spaces and transit nodes, recognizing their potential to enhance both urban vitality and transportation efficiency. In Transit-Oriented Development (TOD) areas, public spaces serve dual functions: efficiently managing passenger flows and creating venues for social interaction and leisure.

However, China's rapid urbanization has often prioritized high-density real estate development around transit stations, overlooking the holistic integration of public spaces (Yuan, 2015; Yang, 2023).

This imbalance has led to inefficient passenger dispersal and underutilization of spatial resources in metro station areas (Luo et al., 2024). Peter Calthorpe's introduction of the TOD model in the 1980s emphasized the organic integration of residential, commercial, office, and public spaces around transit nodes (Calthorpe, 1993). The model's concentric "commercial-office-residential" structure became widely accepted as a TOD blueprint. While this framework provides a general outline for public space distribution, it fails to distinguish between different types of public spaces and does not fully address the complexities of urban renewal in Chinese cities.

As China's major cities shift from rapid expansion to urban renewal, the improvement of existing built-up areas through transit infrastructure has become a key strategy. However, TOD theories grounded in Western urban expansion may not fully apply to the context of urban renewal in China's metro station areas.

This study seeks to conduct a quantitative analysis of the relationship between public spaces and the built environment in transit areas within Shanghai's central district, leveraging multi-source data. It examines the distribution characteristics of different public space types and assesses their vitality through behavioral mapping. Using quantitative modeling, the research identifies the impact and relative importance of various spatial layouts on public space vitality, offering recommendations to optimize public spaces in metro station areas.

RESEARCH DESIGN

Definition

Public spaces are typically defined as outdoor areas accessible to the public 24 hours a day, such as plazas and green spaces (Low, 2006). However, in many cases, public-private partnerships or privately developed open spaces also function as vital spaces for citizens' daily activities. For the purposes of this study, any space accessible without the need for specific identity verification is considered a public space. This definition primarily encompasses three types: plazas, green spaces, and commercial spaces.

In this paper, the term "metro station area" refers to the area influenced by a metro station. Defining the spatial scope of such an area involves determining the reasonable extent of its influence. Both domestic and international scholars generally consider an 8-10 minute walking distance to be the radiation range of a rail transit station. Calculating at a walking speed of 1-1.2 meters per second, the space influenced by a rail transit station is typically represented as a series of overlapping circular areas, each centered on a station entrance or exit with a radius of 500 meters (Pan et al., 2007).

The study of public space layout patterns mainly focuses on analyzing the relationship between the built environment of station areas and the organization of public spaces. Spatial vitality serves as an external indicator of how well public space resources are aligned with urban development needs. Previous research has shown that the topological characteristics of road networks at spatial nodes, as well as the accessibility of nearby retail facilities, are strongly correlated with spatial vitality (Peimani et al., 2020). For example, the ease of access to surrounding retail areas and enhanced motorized accessibility can attract more visitors to public spaces. In contrast, poor accessibility from residential areas, unfavorable road network structures, or proximity to major highways can hinder the vitality of these spaces.

Numerous studies have confirmed the relationship between public space organization patterns and spatial vitality from various perspectives. However, research specifically focusing on metro station areas remains relatively limited, and a deeper understanding of the relationship between public space organization and spatial vitality in these areas is needed. Additionally, there is a lack of comparative studies that assess how the same organizational indicators differentially impact the vitality of various types of public spaces. This gap underscores the need for further research in this area.Case Selection

Eighteen metro station areas were selected from Shanghai's central area(Figure 2), and 146 public spaces (51 plazas, 49 green spaces, and 46 commercial spaces) were screened as research subjects. The selection criteria for station areas were:1) well established built environment and mature urban development. All selected areas are located within Shanghai's Middle Ring Road, with long-established stations in well-developed urban districts. This criterion minimizes the impact of incomplete urban construction on public space vitality.2) High metro passenger flow and rich public activities. All selected stations have an average daily metro passenger flow of over 50,000, with most samples being hub areas where multiple metro lines intersect. This criterion reduces the impact of insufficient activity population density in station areas on public space vitality.3) Diverse urban function types. The selected station areas all include various urban functions such as commercial, office, and residential, avoiding the impact of insufficient urban functional mix on spatial vitality.

Additionally, public spaces with relatively enclosed boundaries or those requiring appointments for entry were excluded from the analysis to mitigate the influence of micro-environmental quality and space operation management on spatial vitality.

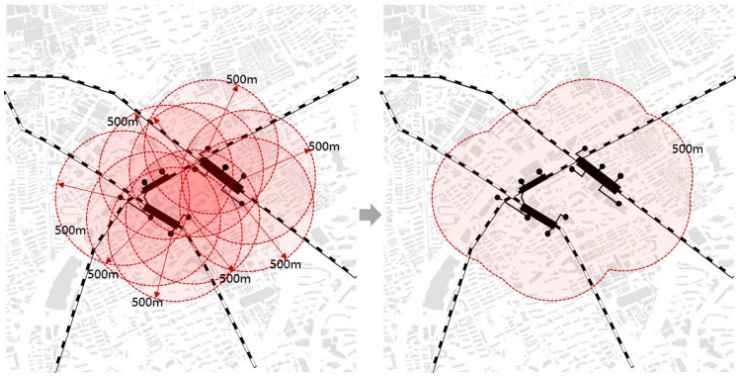

Figure 1. Definition of Metro Station Area

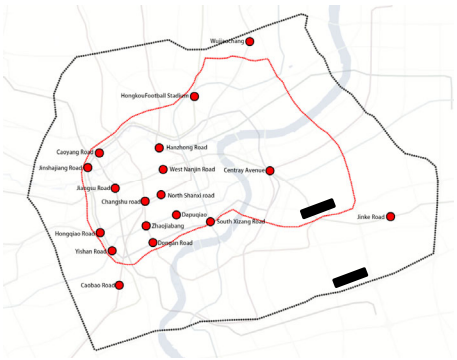

Figure 2. Case Study Selection

all figures in this paper are drawn by authors

Data Collection

Data collection was divided into two parts: public space layout and vitality. Public space layout data, were obtained through field surveys and mapping. This data was then integrated with open-source data from Gaode Maps(), including metro facility entrances and exits, building volumes, plot functions, and road networks, to establish a geographic information model of the metro station areas.

Spatial vitality data were collected by Public Space Public Life (PSPL) survey method proposed by Jan Gehl. Surveys were conducted for each public space on both a workday and a non-workday with

favourable weather conditions. Using the snapshot method and behaviour mapping, the number of people engaged in activities in public spaces was recorded across six time periods from 7 AM to 9 PM.

Layout And Vitality Indicators

This paper focuses on discussing the spatial organizational relationships between public spaces and transportation facility elements, street network elements, and functional area elements. ① Transportation facilities: The dense passenger flow brought by rail transit facilities is one of the main drivers of vitality in station areas. This study mainly focuses on the impact of the path distance from metro stations to public spaces (rail transit connectivity) on spatial vitality. ② Street network: The insertion of rail transit facilities affects regional walking and vehicular networks, often elevating the grade of motorways around stations. Public spaces located at network nodes with good connections to surrounding street segments (represented by betweenness) or easily accessible (represented by closeness) contribute to enhancing spatial vitality. This study primarily concerns the topological performance of walking and vehicular road networks at public space nodes and the grade of motorways. ③ Functional areas: Rail transit facilities often influence the distribution of urban functions in surrounding areas. Functional areas represent locations of different population attributes, such as commercial and leisure crowds, office workers, and community residents. Placing public spaces in locations easily accessible to potential activity groups can effectively enhance their spatial vitality. This study mainly discusses the proximity relationship between public spaces and surrounding urban functional areas.

Spatial vitality is often measured using activity intensity, activity diversity, and activity fluctuation amplitude. Previous studies have found that activity diversity is more influenced by the micro-environmental quality of public spaces, while the fluctuation amplitude indicator is mainly affected by the free time of the active population. Therefore, this study selects activity density (number of activities / public space area) as the quantitative indicator of vitality.

Table 1. Public space layout indicators.

Category	Indicator	Code	Formula	Description
Station	Proximity to Station	PtS	/	The route length between a public space and its nearest station entrance
Road Network	Pedestrian Network Closeness	PC	/	sDNA modelled the pedestrian network and measured MED500, BTE500,Div 500 values at R=500 for the street segment where the main entrance to the public space is located
	Pedestrian Network Betweenness	PB	/	
	Pedestrian Network Deviation	PD	/	
	Motorway Network Closeness	MC	/	sDNA modelled the motor way network and measured MED500, BTE500 values at R=500 for the street segment where the main entrance to the public space is located
	Motorway Network Betweenness	MB	/	
	Motorway Level	ML	/	The main entrance of the public space is adjacent to the motorway level
Urban Function	Proximity to Residential area	PtR	$\frac{\sum_{i=1}^{n} A_{ai} \cdot d(x,a_i}{\sum_{i=1}^{n} A_{ai}}$	Where Aa/Ab/Ac is the area of residential/office/commercial area, d(x,ai) d(x,bi) d(x,ci)is the distance from public space to residential/office/commercial area entrance
	Proximity to Office building	PtO	$\frac{\sum_{i=1}^{n} A_{bi} \cdot d(x,b_i}{\sum_{i=1}^{n} A_{bi}}$	
	Proximity to Shopping centre	PtC	$\frac{\sum_{i=1}^{n} A_{ci} \cdot d(x,c_i}{\sum_{i=1}^{n} A_{ci}}$	
Spatial Vitality	Activity Density	SV	$\frac{N_w+N_e}{2A_x}$	Where Nw and Ne is the number of activity people in weekday and weekend day, Ax is the behavior survey area of public space

Research Approach

This study includes three steps: basic data collection, spatial indicator quantification, and correlation mechanism analysis. 1) Identify public spaces within station areas, establish a sample database, and obtain spatial vitality data through field surveys and behavioral notation. 2) Integrate open-source map data and public space locations using GIS to build a geographic information model, and calculate spatial indicators through sDNA and network analysis tools. 3) Employ correlation analysis and regression models to explore the association mechanism between spatial layout and spatial vitality, determining core indicators and their impact weights.

ANALYSIS RESULTS

Public Space Layout Characteristics

To understand the coupling relationship between public spaces and the built environment around transit stations, we conducted a quantitative analysis of organizational indicators for public space samples and summarized their layout characteristics.

Plaza spaces are relatively evenly distributed, mostly concentrated within a 100-400 meter walking distance from subway stations. The average transit facility connectivity is 251.58. These nodes frequently intersect with surrounding pedestrian streets and vehicular roads, with average pedestrian betweenness and vehicular betweenness of 305.05 and 1369.32, respectively. They are closer to commercial areas and furthest from residential zones.

Green spaces are mainly distributed in the outer circle of the station area (average transit connectivity of 371.71), often located beside secondary and tertiary city roads, with the closest proximity to residential and office functions.

Commercial spaces are mostly situated around subway entrances, with an average transit connectivity of 101.44. However, their nodes intersect with surrounding streets the least, making pedestrian access difficult, and they are often located next to major city roads.

Table 2. Public space layout indicators.

Category	Indicator	Plaza	Green Space	Commercial Space
Station	PtS	251.58	371.71	101.44
Road Network	PC	329.7	331.98	398.31
	PB	305.05	246.51	201.24
	PD	1.38	1.41	1.54
	MC	1369.32	1369.97	1397.89
	MB	645.7	393.02	447.07
	ML	2.48	3.04	2.19
Urban Function	PtR	515.29	430.63	411.41
	PtO	367.89	637.54	204.07
	PtC	538.53	515.63	492.958

Key Indicator Selection

Core indicators for public space layout in station areas were identified through the analysis of the correlation between spatial vitality and public space organizational indicators. The analysis results

indicate that plazas with high vitality tend to be located near transit facilities and close to commercial areas, with good connectivity to pedestrian networks and minimal intersections with vehicular networks. Green spaces exhibit higher vitality when situated near residential areas and with few intersections with vehicular networks. Commercial spaces achieve optimal vitality when located close to transit facilities, with well-connected pedestrian networks, easy pedestrian access, and proximity to residential areas.

Table 3. Correlation between Public space layout and vitality.

DV / IV		Plaza Vitality	Green Space Vitality	Commercial Space Vitality
Station	PtS	-0.620**	0.232	-.417**
Road Network	PC	0.022	0.084	0.07
	PB	0.485**	-0.048	0.440**
	PD	-0.291	0.162	-0.284
	MC	0.17	-0.091	0.06
	MB	-0.376**	-0.281*	0.162
	ML	-0.016	-0.076	0.101
Urban Function	PtR	0.265	-0.321*	-.382**
	PtO	-0.521**	0.123	-0.16
	PtC	0.217	-0.141	0.099

**At the 0.01 level (two-tailed), the correlation is significant. *At the 0.05 level (two-tailed), the correlation is significant.

Correlation Mechanisms Between Public Space Layout and Vitality

Correlation analysis found that the vitality of plaza, green space and commercial space was significantly correlated with several spatial organization indicators. Therefore, multiple regression models of three types of public space were constructed with key organizational characteristics indicators as independent variables, station area energy level indicators as control variables, and spatial vitality as dependent variables.

The results of the fitting model reflect the different effects of different organizational indicators on vitality in the same public space. In the plaza model, the impact degree of each organizational indicator is ranked as: PtS > PB > MB> PtC, which indicates that the activity density of plaza space is mainly promoted by the pedestrian potential and the accessibility of rail transit facilities, and inhibited by the vehicle potential. In the green space model, the order of spatial organization index is as follows: PtR > MB, and the influence degree of the two is similar. In the commercial space, the degree of impact of each spatial organization indicator is sorted as follows: PB> PtS > PtR, indicating that the vitality of commercial space in the case station area is most affected by its relationship with the pedestrian network organization, and the relatively weak impact of rail connection degree may be due to the fact that commercial space in the selected station area is mainly clustered within 150 meters around the station area. There is little difference in the index of rail intersection degree.

The results also show that there are significant differences in the influence of different accessibility indicators on the vitality of public space, and the control variables have a positive impact on the vitality of three types of space. First of all, the degree of rail connectivity has a significant impact on the vitality of plaza and commercial space, and the good connection with rail transportation facilities plays a role in promoting the vitality of plaza and commercial space, with the degree of impact ranking as follows: plaza > commercial space. The topology performance of the pedestrian network at the node where the space is located is closely related to the vitality of the plaza and commercial space. The plaza is mainly affected by the walking intermediateness, while the commercial space is comprehensively

affected by the walking proximity and intermediateness. In terms of spatial and vehicular network organization relationship, high vehicular intermediateness inhibited the vitality of plaza and green space, and the inhibition degree was similar. In terms of functional area proximity, the proximity of residential area has a positive effect on the vitality of commercial and green space. The detailed analysis is as follows.

1) Public Space and Proximity to Metro Station

The correlation analysis and regression fitting model reveal a significant relationship between transit connectivity and the vitality of plazas and commercial spaces, while there is no clear correlation between green space vitality and transit connectivity. Proper planning and organization of the connection between public spaces and transit facilities can effectively enhance the vitality of public spaces in station areas.

Firstly, plazas with high vitality are often located within a 250-meter walking distance from transit stations. Plazas located beyond 250 meters exhibit vitality below the average (Figure 12). Plazas serve as transitional spaces between transportation facilities and the urban environment, helping to manage high-density passenger flows, improving public transportation efficiency, and providing waiting and resting areas for transit passengers, thus enhancing the service level of the public transportation system.

Secondly, although there is no statistical correlation between green space vitality and transit connectivity, only 37% of green spaces within 100 meters of subway stations have vitality above the average. Green space boundaries are often defined by vegetation and trees, with strongly defined internal paths that limit free passage for transit passengers, reducing the appeal of green spaces. Additionally, placing overly large green spaces around transit entrances can increase the distance for transit passengers to access other urban facilities, leading to detours. It is recommended that green spaces be located on the periphery of transit stations, while the core areas around stations should have green spaces with carefully designed environments to meet the needs of transit users for travel and gathering.

Lastly, 90% of commercial spaces located more than 150 meters from the subway have vitality below the average (Figure 14). It is recommended that commercial spaces be closely connected to transit facilities. The shopping, dining, and leisure services they provide can meet the needs of transit passengers during their journeys.

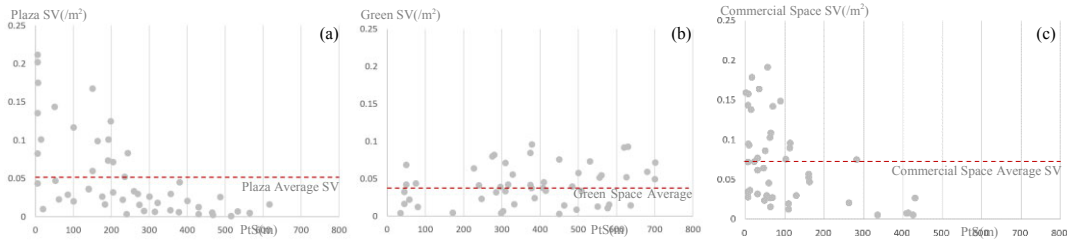

Figure 3. Relation between *Public Space Vitality and Proximity to Metro Station:(a)plaza SV and PtS (b)Green space SV and PtS (c) Commercial space SV and PtS*

2) Public Spaces and Road Network

The interaction between public spaces and the pedestrian street network significantly promotes the vitality of various spaces. Pedestrian betweenness measures the degree of connectivity between public space nodes and surrounding streets, and this indicator has a significant impact on the vitality of plazas and commercial spaces.

Firstly, pedestrian betweenness enhances the vitality of plazas, with only 5% of plazas having a vitality above the average when pedestrian betweenness is below 300 (Figure 15). Plazas generally have weak boundaries, a low sense of territory, and good permeability and inclusiveness. Therefore, placing them at nodes with high pedestrian betweenness can enhance their vitality.

Secondly, the results of multiple regression analysis indicate that pedestrian betweenness is the dominant factor influencing the vitality of commercial spaces. Among commercial spaces with a pedestrian betweenness higher than 250, 57% exhibit high vitality, compared to only 28% of samples with a pedestrian betweenness lower than 250 (Figure 16). Additionally, compared to green spaces and plazas, commercial spaces have the weakest connection with pedestrian streets, often resulting in an "island effect." Thus, integrating commercial spaces with the pedestrian network is a key strategy for further enhancing their vitality.

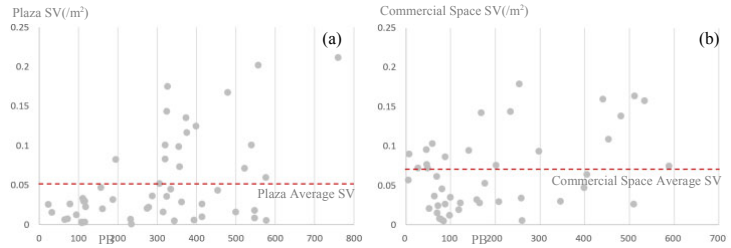

Figure 4. Relation between *Public Space Vitality and Pedestrian network betweenness:(a)plaza SV and PB (b)Commercial space SV and PB*

The organization of public spaces and motorway networks also affects spatial vitality, primarily through its negative impact on the vitality of plazas and green spaces. Excessive connectivity between public space nodes and vehicular networks can reduce pedestrians' sense of security. Dense traffic also brings noise pollution and air pollution, with these factors collectively contributing to the negative impact of vehicular betweenness on public space vitality.

Although the boundaries of green spaces often include vegetation as a buffer, this is insufficient to fully mitigate the negative effects of high vehicular betweenness.

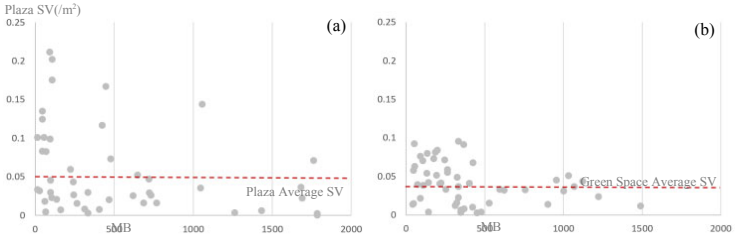

Figure 5. Relation between *Public Space Vitality and motorway network betweenness:(a)plaza SV and PB (b)Commercial space SV and PB*

3) Public Spaces and Urban Functions

Strategically integrating public spaces with various urban functional areas can effectively enhance their spatial vitality. The proximity to commercial areas has a significant positive impact on plaza activity density. When plazas are integrated with commercial areas, commercial facilities infuse plazas with a vibrant commercial atmosphere, attracting more activities. The open nature of plaza spaces showcases the vitality of commercial facilities to the city, further attracting surrounding crowds and creating a mutually reinforcing effect.

Additionally, the proximity to residential areas significantly enhances the vitality of green spaces, indicating that the primary users of green spaces are nearby residents. Therefore, the spatial organization relationship with residential areas is the foremost consideration for the layout of green spaces.

Besides green spaces, the vitality of commercial spaces is also related to their proximity to residential areas. This indicates that the activity in commercial public spaces near transit stations includes not only the passenger flow brought by transit facilities but also the population from nearby residential areas. Easy access from surrounding residential areas can enhance the overall service efficiency of commercial public spaces, helping to establish the transit station area as a center of vitality.

It is recommended to integrate plazas with commercial spaces and green spaces with residential areas while considering the proximity of commercial spaces to residential areas as needed.

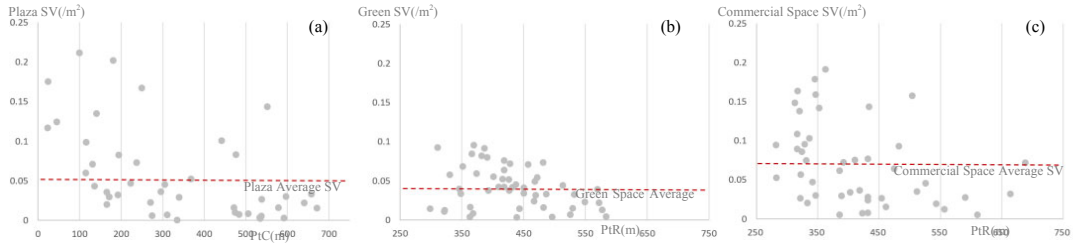

Figure 5. Relation between *Public Space Vitality and proximity to urban function:(a)plaza SV and PtC (b) green SV and PtR (b)Commercial space SV and PtR*

CONCLUSIONS AND DISCUSSION

This study explores the organizational patterns of plazas, green spaces, and commercial spaces around transit station areas in the central city of Shanghai and their impact on spatial vitality. The results indicate significant differences in location requirements for different types of public spaces, leading to the following optimization recommendations:

Rationalize the Spatial Relationship between Public Spaces and Transit Facilities: It is recommended to place plaza and commercial spaces at nodes closely connected to transit facilities to meet the needs of transit passengers for rest, passage, shopping, and entertainment.

Enhance the Interaction between Public Spaces and Pedestrian Networks: Ensure that the nodes where plazas and commercial spaces are located have good connectivity with surrounding pedestrian street segments, thereby increasing the likelihood of spatial activities. Avoid placing green spaces and

plazas at nodes with high vehicular traffic to reduce the negative impact of dense traffic on the vitality of public spaces.

Coordinate Accessibility between Public Spaces and Urban Functions: Integrate Plaza spaces with commercial buildings, ensuring high accessibility of green spaces to residential areas to promote spatial vitality. While maintaining good connectivity between commercial spaces and transit stations, it is suggested that they be positioned where they are easily accessible on foot from surrounding residential areas.

Although this study has identified the differential impact of organizational characteristics of plazas, green spaces, and commercial spaces within transit station areas on their vitality, it is necessary to expand the number of case samples. This expansion would allow for more precise quantitative methods to explore the suitable value ranges of indicators for different organizational patterns. Additionally, spatial vitality is influenced by multi-scale and multi-level environmental factors. Beyond the meso-level organizational patterns, the effects of micro-level environmental quality factors such as site scale and activity facilities on spatial vitality should also be examined in further research.

Acknowledgements

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The heritage research on Macao's pier buildings from the perspective of morphological typology

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ABSTRACT

As an important support for the economy and livelihood of the island, Macao's inner harbour have an extremely close interaction with the development of the city, and along with the booming international trade, Macao's inner harbour has become the earliest space for exchanges between Chinese and Western cultures. However, with the rapid development of the economy and the structural changes of the city, the number of piers in the inner harbour is now declining, and the gradual unification of functions and the fact that some of the pier buildings are in an unused state make the style and function of the Macao inner harbour pier buildings clearly reflect the trend of disjointedness and exhaustion in the process of urban development. By using maps, old photos and other facts as the objective data, this paper takes the 35 existing pier buildings along the west coast of Macao Island as the research target, integrating the perspectives of history, architecture, human geography and sociology, and trying to sort out the important time points of the inner harbour piers at different stages of development, as well as their relationship with Macao's urban development, such as economy, trade, society and people's livelihood. This paper successfully analyses and summarises the physical conditions of the inner harbour pier buildings, such as their forms, characteristics and materials, and categorises them according to their relationships, with a view to adding a more detailed and systematic theoretical basis for the revitalisation and regeneration of Macao's inner harbour city.

Keywords: Macao, inner harbour, pier buildings, values, morphological typology.

INTRODUCTION

In the early sixteenth century, with the development of ocean voyages and the intermingling of different industries, the Portuguese embarked on a voyage to the Orient. Due to its favourable geographical location, climate, hydrology and sea and land transport conditions, Macao became the first window for trade, ethnic and cultural exchanges between the East and the West during the Ming Dynasty (Jie, 1961).Gradually, Macao has evolved into a cosmopolitan city, however, as in many international high-density cities (Wang et al., 2019), the contradiction between economic development and cultural heritage has slowly emerged with the rapid development of the society. Due to the existing rapid urban construction and the single rise of the tertiary industry, the architectural styles, cultural landscape systems, and historical view corridors of Macao's historic

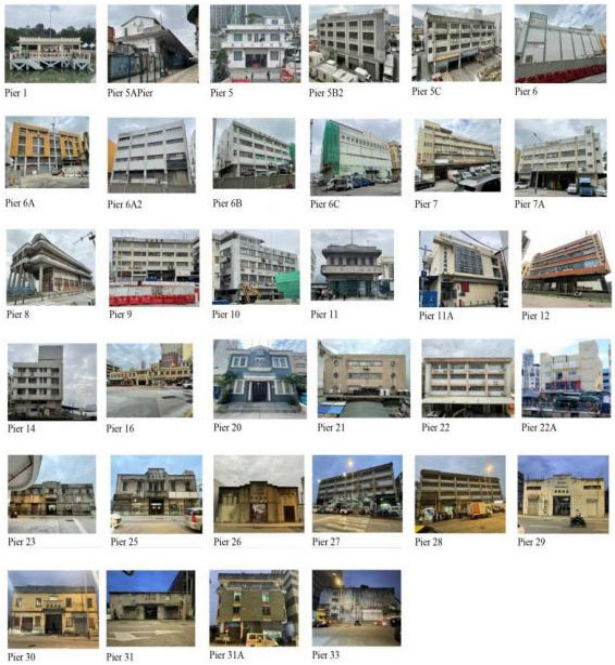
districts, which were originally part of the early city's development process, are showing a tendency to become disjointed and depleted. Macao's inner harbour is included in this trend of depletion (Zheng et al., 2018).

Since the Ming and Qing dynasties, studies on Macao have begun to deal with the inner harbour of Macao (Jie, 1961; Shi, 1995; Long, 1997; Yan, 2006), and the number of these studies has been increasing over time. In addition to categorising Macao's inner harbour as a single study of Macao's urban history, these studies have also explored Macao more comprehensively through aspects and perspectives of political history, economic history, intellectual history, archaeological history, geopolitics, as well as the relationship between Hong Kong and modern China (Wu, 1998; Ye, 2013; Shi, 2019).

However, in the so-called 'Macao in a Global Perspective', there is no systematic analysis of the architecture of Macao's inner harbour from an architectural point of view, and little focus is placed on the pier buildings of Macao's inner harbour itself, and there is still a lack of systematic research on the evolution of its architecture and built environment.

METHOD

The research scope of this thesis mainly focuses on the inner harbour buildings (Figure 1), and the spatial scope is defined as the 35 waterfront buildings of the piers, including Pier No. 1 to No. 33 (Figure 2). It is mainly based on the latest information of the piers published in the Macao Online Map of the Macao SAR Mapping and Cadastral Bureau, combined with the Inner Harbour Reorganisation Plan of Macao Instruction no. 218/90/M, the Coastal Map of the Macao SAR approved by the Chief Executive no. 184/2018, the Macao Peninsula CAD map of 2010, and the field surveys.



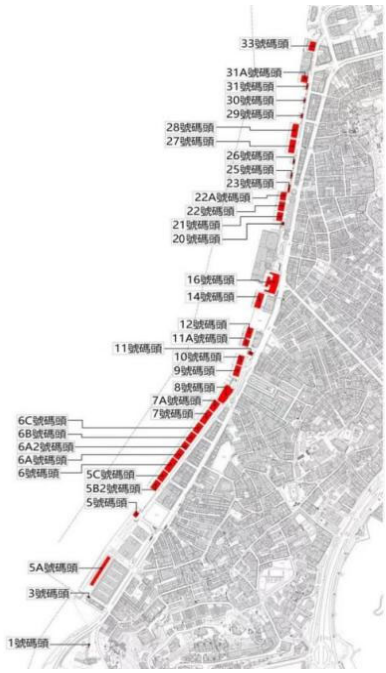


Figure 1. Current status of the 35 piers, photo credit: Author's own drawings.

Figure 2. Map of the current status of the 35 piers, photo credit: Author's own drawings.

As a new try, it is highly recommend to combine several research methods together, including online and offline research, to comprehensively integrate scattered information and make up the research gap in this area.

Firstly, the article adopts the document analysis method. By combing through the current relevant ancient books, public opinion maps and old photographs and paintings circulating in the community about the inner harbour. Due to the special historical reasons of Macao, some of the early historical materials are in Portuguese or mixed Chinese-Portuguese documents that need to be screened and organised. Secondly, the documents and periodicals and newspapers in Macao Archives, Macao Museum, Maritime Museum and other related units were searched and collected, as well as information from Macao Yearbook, Chronology of Macao, Macao Economic Yearbook, Chinese Commercial News, so as to comprehensively obtain information about the inner harbour.

Secondly, this paper adopts the field research method. From the perspective of architecture, we understand, confirm and record the pier building types and characteristics, topography, landscape and ecology as well as the usage conditions, and analyse and summarise the characteristics of the pier buildings in terms of building types and style characteristics. At the same time, according to the needs, we visited relevant libraries, archives, museums and planning museums to collect data and enrich the research content of human geography of piers.

Thirdly, comparative interpretation method is also used. Based on the comparative study between the current situation of the pier buildings and the early pier design plans, the veins, symbols and elements of the pier buildings in the early planning and construction are sorted out, and the inner harbour piers are placed under the dual vision of ‘time-space’, so as to deepen the interpretation of their cultural connotations and historical characteristics.

Lastly, the use of morphological typology plays an important role. To provide a theoretical basis and design entry point for specific planning and architectural design work. In the actual operation process, in the face of the aspirations and contradictions of different subjects, the design strategy based on Morphological Typology will also provide reasonable suggestions for the policy formulation and working mechanism for the protection and regeneration of historical lots. Morphological type interpretation is a comprehensive presentation of historical data and on-site research results. Through the process of morphological evolution and the classification of building and component types, it interprets and presents the Macao inner harbour from different levels. The study will provide a typological interpretation of the history and status quo of the pier architecture at different levels, as well as an analysis of the causes of the evolution, and will start to recognise and interpret the pier architecture from two aspects, namely, the evolution of the physical and spatial morphology, and the changes in the mode of production and life brought about by the changes in the socio-political and cultural environments.

Combining these four research methods together provides a comprehensive way to take a close look at the changes and current situation of Macao’s pier buildings, which can work as a useful tool for further researches related to this area.

RESULTS AND DISCUSSIONS

The formation and development of Macao's inner harbour

As the location where the Portuguese first landed in Macao, the inner harbor area has witnessed the rise and fall of the city and is a microcosm as well. Pier buildings have been constantly changing along with the changes of Macao's inner harbor, so sorting out the historical changes of Macao's inner harbor is a necessary prerequisite for analyzing pier buildings.

The initial development of Macao's inner harbour mainly began during the mid-Ming Dynasty (Deng and Huang, 1991), with the exact date dating back to 1557 to 1840 (Zheng, 2017). With the development of social productivity at that time, China gradually began to possess an objective demand for a commodity money economy. From the earliest plan of Macao found by the author, at the beginning of the opening of the port of Macao, the Portuguese focused on the construction of houses, Macao's inner harbour was only used as a docking area for ships and an auxiliary area for disembarkation. For this reason, at this stage of the Macao inner harbour coast presented the irregular shape, is its most primitive state(Figure 3).



Figure 3. Map of the city of Amacao, circa 1598 (the first geographical map of Macao), photo credit: Vatican Pontifical Library.

Figure 4. Reclamation of the inner harbour of Macao from 1831 to 1889, photo credit: Das cabanas de palha as torres de betão：assim cresceu Macao (first from left) and Macao Archives (seco-nd from left and first from right).

In the context of the Portuguese monopoly of trade and the "one-lipped" trade, the Macao inner harbour gradually took shape as a result of the monopoly of trade, which led to the frequent landing and disembarkation of merchant ships and fishing boats. The Macao inner harbour Pier in its infancy was relatively simple in form, with no specific harbour buildings, only stone steps and a wooden plank pier made of wooden piles, with extremely rudimentary facilities. According to historical records, this part of the pier should belong to the original style of the pier in Macao.

After the Second Opium War, the port of Macao was marginalised by the natural harbour of Hong Kong. The Portuguese and Macao governments, through a number of policies and projects, made it possible for complete architectural entities and construction systems to emerge in the inner harbour, and the pallet-type piers were gradually abandoned. The reclamation and expansion of the inner harbour and the prototype construction of the Macao inner harbour pier were thus initiated (Figure 4). This stage proved that the Portuguese and the government of Portuguese Macao began to pay attention to the development of the inner harbour of Macao, and carried out the construction of facilities and repair of venues. The construction of the inner harbour was based on the expansion of the inner harbour form. Afterwards, the inner harbour shoreline was extended again and the location of the inner harbour was shifted westwards. However, the inner harbour in the formative period had

not yet formed a complete construction engineering system and specific building entities, and were still mainly in the form of pontoon pallet bridge piers, and the waterways were not yet able to adapt to the needs of modern large-scale ship transport.

In 1912, Macao started to reclaim the sea again, and by 1935, the reclamation and expansion of the inner harbour had completed the shape of the two ends of the inner harbour moving closer to the middle (with the emergence of Rua do Almirante Sérgio), and the planning of the new harbour had already taken shape. The widening of the inner harbour streets created favourable conditions for the planning of piers, and the construction of specialised piers also took shape and scale during this period (Figure 5).

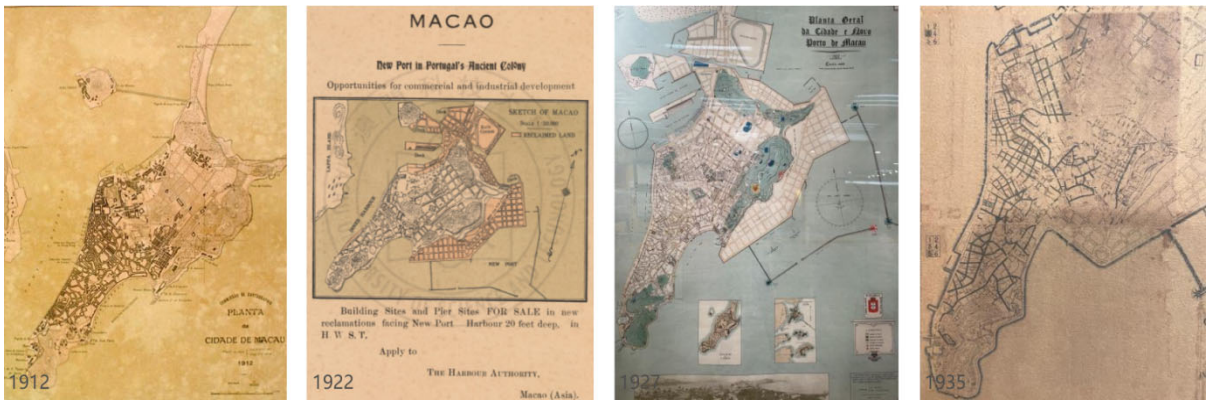


Figure 5. The Evolution of Macao's Planar Map, 1912-1945, photo credit: Macao University of Science and Technology.

Around 1940, the volume and scale of professional pier construction in the inner harbour began to be determined and the first round of construction peak began. Therefore, around 1940, the professionalisation of pier construction in the inner harbour began to take shape and scale, and the first round of construction peaked, and the modernisation of pier construction began. The reconstruction, new construction and restoration of pier buildings during this period almost laid the material foundation for the development of the inner harbour area and even the entire Macao port economy in the next few decades.

Later, due to the United Nations General Assembly Resolution 500 in 1951, which imposed a total embargo on China, Macao became the only window for China to break the embargo. The development of Macao's inner harbour once again reached a climax, which was also a special background for the prosperous phase of the inner harbour. The emergence of the demand and the gradual development of the industry put forward higher requirements for transport, which led the Macao-Portuguese government to promulgate a number of policies in order to comprehensively improve the status quo of the inner harbour. The complementary relationship between the inner harbour and the new area's transport facilities is gradually being highlighted. The inner harbour is now enjoying a period of prosperity (Figures 7).



Figure 7. Macao inner harbour port in 1932 (left) and 1950 (right), photo credit: Macao Guide.

With the transformation of traditional industries into manufacturing, the economic model of Macao, which was based on fishing and traditional handicrafts, gradually collapsed in the late 1960s. In the face of the ever-increasing number of people and goods, and under the challenge of the new trade situation, the inner harbour of Macao has become tired, which has put forward higher functional requirements for the construction of the inner harbour pier buildings. The pier buildings constructed in the middle of the formation of the inner harbour were mainly made of wood and concrete structures. The platform of the pier was basically made of wood. Due to the corrosion of the sea winds and the long time of construction, it has become dilapidated in many places and is unable to cope with the rapid increase in the volume of freight transport and the loading and unloading of containers. At the same time, there is a lot of unused space between the old wharves, mostly used by boats and sampans as berthing places, resulting in a waste of land use, the early old wharves are in urgent need of improvement.

As time passes by, the inner harbour area has been in decline since the late 1980s because of both external and internal reasons. Externally, Hong Kong's advantages of being a deep-water port and a free port have tempted businessmen to leave Macao and move to Hong Kong. Internally, the Macao-Portuguese government started to plan the construction of the outer harbour and the port of Kau O in 1989, and the functions of the inner harbour pier buildings were subsequently shared, which to a certain extent also diverted passengers and port cargo from the inner harbour area. In addition, as the processing and manufacturing industries moved to the Pearl River Delta during the same period of time, the industries in the inner harbour area shrank, and the inner harbour area lost its original commercial core function in the new round of economic restructuring, and was reduced to a marginalised old area in the industrial relocation and spatial competition.

At the same time, as the inner harbour is located at the mouth of the Pearl River, the river channel has been seriously silted up and is getting narrower, making it impossible for the inner harbour to accept ships with deep draught and large carrying capacity, and reducing the significance of shipping. What's more, the elevated water level of the inner harbour, coupled with the support of the astronomical tidal wave, makes it impossible for the accumulated water on the surface to be discharged through the city's drainage system in the case of extreme weather conditions such as rainstorms or typhoons, thus resulting in flooding, which has an adverse impact on the business environment. As a result of the above factors, the inner harbour area is in a state of decline.

Formal analysis of Macao inner harbour pier buildings

Form analysis

Due to the construction time, material characteristics, functional requirements and different design ideas of the designers, the architectural styles of the Macao inner harbour buildings are different from each other, and the most intuitive feeling of the architectural style is the façade of the pier buildings. The most intuitive feeling of the architectural style is the façade of the pier buildings. There are two more important periods in distinguishing the façade of the pier.

The first is the period between the 1930s and the 1950s, when the Macao government realised that the pier could be leased out for huge profits after refurbishment, and therefore undertook a large-scale renovation and reconstruction of the pier. The designers, led by João Canavarro Nolasco, used different colours of paint, geometries and lines to decorate the façades in a clear Art Deco style. The appearance and massing of these buildings are adapted to the function of the building. In addition, the piers constructed in this period also paid great attention to the design of the symmetrical composition of the doorways and the daughter walls, which are highly symbolic, characteristic and recognisable, and at the same time have a distinctive private design style. Today there are ten pier buildings of this style: Nos. 5, 8, 11, 16, 23, 25, 26, 29, 30 and 31.

However, almost half of the piers restored, rebuilt or newly constructed in the first period were wooden piers, which were susceptible to natural erosion. Therefore, in the second period (from the 1980s to the end of the 20th century), the government started the inner harbour Restructuring Programme, which led to the reconstruction of many piers. At this time, the Portuguese and Australian governments required the reconstructed piers to be uniformly 4-storey, and there were strict regulations on the total height and the height of each storey. As a result, the construction of inner harbour piers became uniform during this period. At this time, the pier building to get rid of the door as the centre, the sense of line as the decoration of the symmetrical composition of the facade, mainly to the column network, the horizontal and vertical wall surface for simple art treatment. The reconstructed piers are all modernist style pier buildings with only minor differences in the colour of the facade and the arrangement of the windows and doors. There are 22 existing buildings in this style: No. 5A, No. 5B2, No. 5C, No. 6, No. 6A, No. 6A2, No. 6B, No. 6C, No. 7, No. 7A, No. 9, No. 10, No. 11A, No. 12, No. 14, No. 21, No. 22, No. 22A, No. 27, No. 28, No. 31A, No. 33. The use of paint or tiles, aluminium windows and simple façade decoration are the characteristic language of the style.

In addition, there are only two other Portuguese eclectic style pier buildings, No. 1 (Cultural Building of Immovable Property of Macao) and No. 20 (Former Marine Police Inspectorate). The top of the main façade is decorated with the Portuguese coat of arms, lattice fencing and architectural decorative symbols such as the Portuguese Caravelle cross of the Age of Sail. In addition, the mixture of different styles mentioned above is also one of the characteristics of the buildings of the inner harbour.

The Macao inner harbour pier building is a combination of public and private property rights, which imposes certain restrictions on its use and repair. The last major renovation of the inner harbour buildings in Macao was organised in the 1980s under the Inner Harbour Reorganisation Plan, which imposed strict controls on the construction of the buildings. Since then, the 34 buildings along the inner harbour have complied with the four-storey maximum (with a few owners illegally adding up to five storeys), namely Nos. 5B2-7, 9, 10, 12, 14, 21-22A, 27, 28, 31A, 33, a total of 20 buildings. The

buildings have different functions, but they are all in the form of a regular cube and in the style of a clean and modernist style, with only some differences in the colours and decorative lines of the façade.

Compared with the pier buildings around the 1950s, the existence of different batches of piers can be distinguished very clearly. In the past, the wharves were much smaller and lighter in form, with no more than two floors, and were mainly used for loading and unloading of cargo ships and small boats. And from the facade will be more complicated, complex, varied graphics and façade decoration, rich in obvious identity and the designer's personal style.

Material analysis

The study of the basic materials of inner harbour piers focuses mainly on the finishing materials of the building's exterior, which are summarised and categorised into three main types: paints, mosaic tiles, and brushed stone (Figure 8). Firstly, the piers constructed around the 1950s were mostly made of paints. As the piers were located along the long coastline, the colours of the paints were more vibrant, mainly yellow and white, for easy identification and differentiation. However, due to the pier's coastal location, the objective factors of sea breeze erosion, water wash and sun exposure made it clear in the field study that the colours of the painted pier buildings that had not been refurbished were slightly grey and not as good as they had been in the past. In contrast, brushed stone materials with weather resistance and durability were used depending on the location of the piers. Piers 8, 11, and 31, for example, use brushed stone as a finishing material, and the surface of the brushed stone usually has a stone-like texture, giving a natural, rough feeling. This material creates a rustic and natural feeling, which makes the appearance of the building at the beginning of the construction is basically the same as that of today's survey.

In the piers built in the 1980s, mosaic tiles were used in most of the piers to achieve a colourful effect through the patchwork of colours, and because of the glazed colour of the tiles, they were brightly coloured and of a high specification, and were not easily eroded by sea winds. It is generally used by owners with better financial means and under the guidance of the government.



Figure 8. Elevation facing tiles (first from left, Pier 31A), coating practice (second from left, Pier 16), water-brushed stone practice first from right, Pier 25), photo credit: Author's own drawings.

Type analysis

From the pier platform characteristics (Table1), pier buildings have 6 wooden pier (Table 2), reinforced concrete pier platform 27, no specific pier platform form 1 (Pier 20). From the classification of the number of floors (Table 3), low-storey that is, the ground floor to two-storey pier building 13, basically built in the 1950s; multi-storey that is, three to five-storey (five-storey that is, four-storey + rooftop

illegal additions) 21, basically constructed in the 1980s of the twentieth century. After the formation of the inner harbour, Macao has only carried out two large-scale renovation plans for the inner harbour pier building. The first one was in the 1930s-50s of the 20th century, and the piers constructed at this stage generally had two storeys; the second one was in the 1980s of the 20th century, and the Macao-Portuguese government had a clear height restriction of 15 metres and a four-storey requirement for the pier buildings constructed at this time. Thirdly, in terms of building structure, there are 26 reinforced concrete structures and 8 brick structures (Table 4).

Overall, the styles of pier buildings showed a large time span in terms of platform features, number of storeys, scale and building structure. This co-existence of old and new pier buildings is the result and testimony of the needs of the times, and brings a valuable and diverse visual sense to the inner harbour shoreline.

Table 1. Classification of Pier Platforms.

Classification.	**Pier Number**
Wooden Pier	23、25、26、29、30、31
Reinforced concrete piers	1、5A、5、5B2、5C、6、6A、6A2、6B、6C、7、7A、8、9、10、11、11A、12、14、16、21、22、22A、27、28、31A、33

Table 2. Classification of Timber Pier Platforms.

Pier Number	**Construction Time**	**Redevelopment Time**	**Construction**	**Remarks**
23	1948	-	Reservation	Retention of wooden platforms
25	1942	-	Reservation	Retention of wooden platforms
26	1939	-	Reservation	Retention of wooden platforms
29	1949	-	Reservation	Retention of wooden platforms
30	1948	-	Reservation	Retention of wooden platforms
31	1940	-	Remould	Compared with the original design, the later phase of the renovation is bigger. However, the wooden platform is still retained.

Table 3. Breakdown of Pier Levels.

Classification.	**Pier Number**
Two-storey pier buildings and below (i.e. ground floor to first floor)	1、5A、5、11、16、20、23、25、26、29、30、31、33
Pier buildings above two storeys (i.e. three to five storeys)	5B2、5C、6、6A、6A2、6B、6C、7、7A、8、9、10、11A、12、14、21、22、22A、27、28、31A

Table 4. Classification of Pier Building Structures.

Classification.	**Pier Number**
Reinforced concrete structures	1、5A、5B2、5C、6、6A、6A2、6B、6C、7、7A、8、9、10、11、11A、12、14、16、21、22、22A、27、28、31A、33
Brick and mortar construction	5、20、23、25、26、29、30、31

From the on-site comparison, the author summarises, classifies, compares and concludes the current status of the buildings of the inner harbour in terms of their form, material and type. It can be found that although both were initiated by the government, there are two distinct periods.

They are the 30s-50s of the 20th century and the 80s of the 20th century for the reconstruction of the pier buildings in Macao. In the 30s-50s of the 20th century, due to the existence of the demand and profit, the pier buildings went from the simple forms of 'Shun Shui type' and 'Pallet type/pontoon type' to the simple forms of the pier buildings and the pontoon type. Demand and profit led to a shift from the simple form of 'down the bank' and 'palisade/pontoon' to the combination of pier and platform, with the two-storey symmetrical composition as the basis and the timber pier being the usual handiwork of João Canavarro Nolasco, the designer at the time. Combining the popular Art Deco style, Portuguese colonial colours, and the technology of the time, the decoration of different colours, geometries, and lines focuses on the design of the doorway and the nursery wall, which is highly symbolic and recognisable, and also has a distinctive private design style. However, due to the lack of weather resistance (e.g. paint and wooden platforms), some of the piers have become dilapidated.

In the 1980s, Macao organised the last major renovation of the inner harbour buildings, which on the one hand was a purely maintenance and management exercise, and on the other hand was an attempt to revitalise the Macao inner harbour. This phase of the renovation of the Macao inner harbour was subject to very strict regulations and controls, and combined with a modernist style, the four-storey concrete buildings with a total height of 15 metres were erected along the coast of the Macao Peninsula in the form of a very solid architectural 'box', with the only difference coming from their external colours and decorative lines. Although practicality (glass windows and mosaic tiles) was the first consideration in this phase of pier building, and the climatic characteristics were taken into account, the degree of match between aesthetics, style and functionality was not as good as it was in the 1930s-50s of the 20th century. Fortunately, in the 1980s, as the original pier owners had to invest in the reconstruction of the inner harbour piers, the Government granted land to the pier owners for the construction of standardised superstructures on the extension lots. However, due to the different interests of some pier owners, not all of them were able to do so. Therefore, judging from the present situation, most of the pier buildings are from the 1940s to 1950s.

The majority of the pier buildings are the early pier buildings constructed in the 1940s and 1950s and the modern new pier buildings rebuilt in the 1980s. They are arranged high and low along the waterfront from Avenida da Misericordiau de Sinares in Fa Wong Parish to Avenida do Lagoa do Sai Van in Fung Shun Parish on the Macao Peninsula, constituting the architectural landscape of the inner harbour piers nowadays.

Current use and protection of Macao's inner harbour pier buildings

After witnessing the prosperity of Macao's inner harbour area, these pier buildings gradually fade away from people's memory, which means that the current use and protection of these pier buildings are not that ideal.

The pier buildings that are still in operation mainly concentrates on the first half of the extension of the pier building from the A-Ma Temple to the north, and most of them were built in 1980s with

modern equipment. According to the field research, it is found that some of the pier buildings are not being used. However, others are in good use. Eight of the pier buildings in the Inner Harbour area are still used for fisheries (fish ponds or fish products), 12 are used for various commercial trading companies, and two are used as passenger harbour, partially for catering and warehouses, etc. The section encompassing this area is also one of the largest in Macao. The road it encompasses is also one of the busiest and most congested roads in Macao, from which many seafood products and daily necessities are wholesaled to the various markets in Macao, and the basic internal demand in Macao makes the use of the pier continue steadily but not as much as in the past.

In terms of conservation, the second half of the Macao inner harbour pier extends in the direction of the Saritou Market and the ground in front of the Land Temple to the south. The pier buildings are basically those constructed in the 1940s, and are the most poorly protected and visibly damaged part of the pier; the gradual idling of the pier at the end of the 20th century has left the pier space unmaintained and unrepaired, and this portion of the pier was mainly rented out to small shipping companies in the past. For this iron door and east-west ventilation makes the building facade skin erosion due to sea winds, coupled with the age of repair, the colour block peeling obviously, the wall in many places cracking, corrosion, mouldy, the internal structure of the part of the exposed, increasing the building safety hazards. And this part of the pier is mostly wooden platforms, and there is no weather-resistant nature of the existence.

CONCLUSIONS

This thesis is based on the Macao government's intention to renovate and revitalise the inner harbour area and the gap in the development research on the history of the inner harbour pier buildings. Firstly, a morphological typology is used to sort out and analyse the timeline of the development of the inner harbour pier buildings, assisted by the objective morphology of the relevant maps. The study aims to identify and summarise the historical causes and influences on the development of the inner harbour pier buildings in different periods (four major stages: the Macao inner harbour before its formation, the reclamation and expansion of the inner harbour, and the construction and development of the inner harbour piers), and to judge their overall orientation on the development of the piers. Secondly, field research on the inner harbour pier buildings was conducted from the perspective of preserving the existing inner harbour pier architecture. The architectural form, material and type that appeared in different periods were categorised and summarised to arrive at two main periods of pier construction and restoration (1930s-1950s and 1980s).

The causes, influences and time phases of these changes in building forms are explored through a combination of both of the above (representation of the current situation and narration of historical information). This will not only provide some theoretical support for the subsequent revival of inner harbour piers, but also provide insights into the academic and regional values of such buildings.

As for the limitations of this research, firstly, the historical value of Macao's inner harbour is not only limited to the pier buildings themselves, but also the ancillary buildings (such as warehouses) that complement the pier buildings should be discussed together in order to understand Macao's inner harbour in a more comprehensive manner. Secondly, the internal spatial arrangement of the pier buildings is a mapping of the functions and needs of the inner harbour buildings in different periods. If further consideration is given, the study of the inner harbour can be more in-depth.

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Typo-morphological studies of Stockholm and Shanghai: Tracing a typological methodology for comparison of Swedish and Chinese cities

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ABSTRACT

Many European neighbourhoods particularly in Sweden were designed specifically for individual mobility and today are dominated by private cars and excessive automobile travel. In many new Chinese neighbourhoods, there is rapid motorisation and increase in car traffic followed by major investments in road infrastructure that results in wide road that create fragmentation and often make it very difficult for pedestrians to move along. This paper compares the neighbourhoods in Stockholm and Shanghai as typologies to discuss morphologically informed international urban design guidelines for Transit-Oriented Development (TOD) with mobility hubs. TOD is a development alternative to urban sprawl as suburban car-oriented model by synchronising urban form with public transport. Mobility hubs are new transport infrastructure aiming to boost the accessibility (the so-called last mile) by offering on-demand mobility systems as shared bikes and electric cars at public transport stations and in surrounding neighbourhoods. Suburbanization processes are very rigid that there is a strong momentum to develop car-oriented neighbourhood and transport infrastructures that favour the private car. The investments in infrastructure are enormous and the return on investment for the stakeholders are small if the surrounding urban area is not designed for or does not promote public transport or micromobility. It is important to identify typo-morphological methodologies in local and global contexts that could contribute to developing urban design guidelines for more sustainable urban form and climate-responsible mobility. The transport sector is a major contributor to climate change and there are various typological methods that can be used. There are long typo-morphological traditions in Sweden and China with different understanding of the types of neighbourhoods and methodologies to analyse them.

Keywords: typo-morphology, neighbourhood typology, Transit-Oriented Development (TOD), sustainable transport

INTRODUCTION

Achieving sustainable mobility is a major challenge in cities today and Transit-Oriented Development (TOD) is an urban planning and design policy that seeks to improve walking and better integrate public transport in neighborhoods. Research on urban morphology is pivotal in advancing Transit-Oriented

Development (TOD) and sustainable urban development, while also enhancing urban life quality. Urban morphology provides a framework for understanding the spatial relationships, structural composition, and interactions between elements within the physical urban environment. Numerous studies in transportation planning and urban design have explored the relationship between urban spatial elements and public transit stations (Batty, 2008; Oliveira, 2014; Fleischmann et al., 2021). This research emphasizes the development of compact, high-density, mixed-use, and pedestrian-friendly urban forms around transit stations to encourage green travel behaviors (Calthorpe, 1993). TOD has also been closely linked to studies examining the interaction between land use and travel behaviors at the neighborhood scale, with a particular focus on walkability, walking radii, and D-variables that define land use (Cervero, 1989; Cervero & Kockelman, 1997; Ewing & Cervero, 2010; Boarnet, 2011; Stojanovski, 2018). Various models, such as the place-node model, have been developed to assess the integration of station areas as nodes within neighborhoods, both as transit hubs and as places of activity (Bertolini, 1996; Papa & Bertolini, 2015).

The literature on the relationship between urban form and transportation is extensive (Anas et al., 1998; Kasraian & Maat, 2016). It is widely accepted that areas closer to transit stations are more attractive to residents and businesses, as they offer convenient services, access to employment, and enhanced customer reach (Redding & Turner, 2015; White, 1999). Consequently, development density is typically higher in proximity to transit stations compared to other urban areas. Moreover, areas with greater functional diversity and street connectivity around stations tend to better support walking behavior (Noriko Otsuka et al., 2021). The mix of urban functions near transit stations leads to increased walking activity, drawing attention to pedestrians' perceptions and experiences. Therefore, creating high-quality built environments and public spaces has become an increasingly important focus in urban design research (Schlossberg & Brown, 2014)

This principle seems broadly applicable to transit station areas across various contexts. However, the urban form around different transit stations is not uniform. Scholars of urban morphology contend that the variations in urban form are due to the complexity of cities and their gradual evolution over time (Scheer, 2016). Different phases of urban development have resulted in distinct urban areas, such as historic districts, urban centers, new districts, and expansion zones, each with unique interactions with transit stations (Adolphson & Fröidh, 2019). For instance, built-up areas like historic districts and old city centers face the challenge of integrating subway stations into their existing urban fabric while managing the influx of subway passengers through urban renewal. Conversely, new and expansion districts use subway stations as catalysts for shaping sustainable urban forms.

This study adopts the theoretical and methodological framework of urban morphology, particularly emphasizing walkability, to analyze the urban form characteristics around subway stations. By comparing typical urban areas in Shanghai and Stockholm, this research evaluates the urban form around transit stations from distinct cultural and developmental backgrounds. This comparative analysis enhances the understanding of the integration between urban form and subway stations in different socio-cultural contexts, providing a scientific foundation for the planning and construction of pedestrian-friendly transit station areas. Furthermore, the study discusses the differences between typo-morphological approaches, which take a historical perspective, and spatial analyses that prioritize morphological indicators and variables (so-called morphometrics, Venerandi et al., 2017; Fleischmann et al., 2021; 2022; Wang et al., 2023).

METHOD

The methodology starts with case selection and creation of a generic typology in Stockholm, Sweden, and Shanghai, China and description of morphological indicators and variables. A data collection and spatial analysis is executed to compare the cases for variables that are important for TOD. This paper seeks to compare and discuss typo-morphology as historical approach and spatial analyses. The typological tradition in urban morphology looks at urban history and emergence of architecture and urban forms as a process of creating types. Types are abstractions about urban forms (e.g. apartment block), the representative exemplar or prototype. Society creates types (of streets, buildings, neighbourhoods and so on) to simplify communication and promote values (Franck 1994, p.345). The spatial practices of any society both structure and are structured by the activity of creating and classifying types (Franck & Schneekloth, 1994). Similar to concepts in linguistic terms, a type packs much information into one icon: a set of architectural or environmental attributes; a set of rules for construction and for organisation of space; a set of behaviours and defined roles that take place within it; and a set of qualities it should exhibit (Schön, 1988; Robinson, 1994). The types have history, and they tell histories (Southworth, 2005). Types are not static. They change over time and vary considerably between cultures and between different groups within the same cultures. Even though the typologies vary across cultures, the activity of creating types exists within all societies (Schneekloth & Franck, 1994). Sweden has a long tradition in typo-morphology (Abarkan, 2009; 2013; Stojanovski, 2019a). Many architects, planners, architectural and urban historians, and geographers have created urban models of typical cities and typologies of buildings, streets, spaces between buildings and neighbourhoods. Gregor Paulsson (1950) in cooperation with the architectural historian Elias Cornell and a group of scholars, students and professionals wrote two tomes of Swedish city (or Svensk stad) describing the development of Swedish cities and urban lifestyles. Greger Paulsson introduced the Weber's (1949 [1904]) concept of "idealtype" as abstractions. Type is a construct to abstract characteristic features in reference to an idea and the ideal-type does not exist in reality, but it is useful to understand and describe the historical process and social construction of idea into building type, typical family, neighbourhood type and social stereotype. In the tomes of Swedish city Paulsson describes an ideal-typical Swedish city with ideal-typical houses and social classes (high and low bourgeoisie and working class) with ideal-typical floor plans, furniture and cutlery (Figure 1).

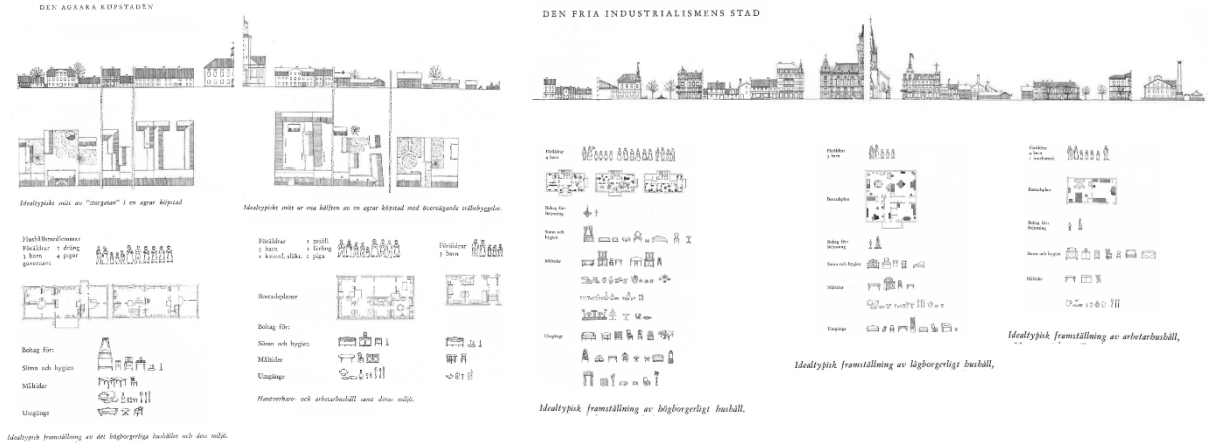


Figure 7: A section of an ideal-typical Swedish city with ideal-typical houses and social classes with ideal-typical floor plans, furniture and cutlery

The writings of Greger Paulssen, Elias Cornell and Björn Lynn inspired new typo-morphological research and conceptualizations in the 1980s aimed not only to contribute to urban history, but also to understand and guide urban planning and design practices. Terms such as, “typområde” (“typical places”, “place types” or even “area types”, in Engström et al., 1988), “stadstyper” (“urban types” in Rådberg, 1988; Rådberg and Friberg, 1996), “stadskaraktär” (“urban character” in SSBK, 1997; 2000; 2022;) were used to describe types of neighbourhoods and city blocks (as configurations of buildings). Since the 1980s, typologies have been developed according to building types and architecture styles specific for historical periods (Björk et al., 2003 [1983]; 2009; 2018 [2000]); planning and development paradigms (Rådberg, 1988; Rådberg & Friberg, 1996); and industrialization epochs (Engström et al., 1988). The trilogy Så byggdes staden, … (translates Thus was built in English) includes books that focus on apartment buildings, houses and cities (Björk et al., 2003 [1983]; 2009; 2018 [2000]). These books aimed to illustrate typical Swedish architecture and present it as part of the urban history by every decade (Figure 2).

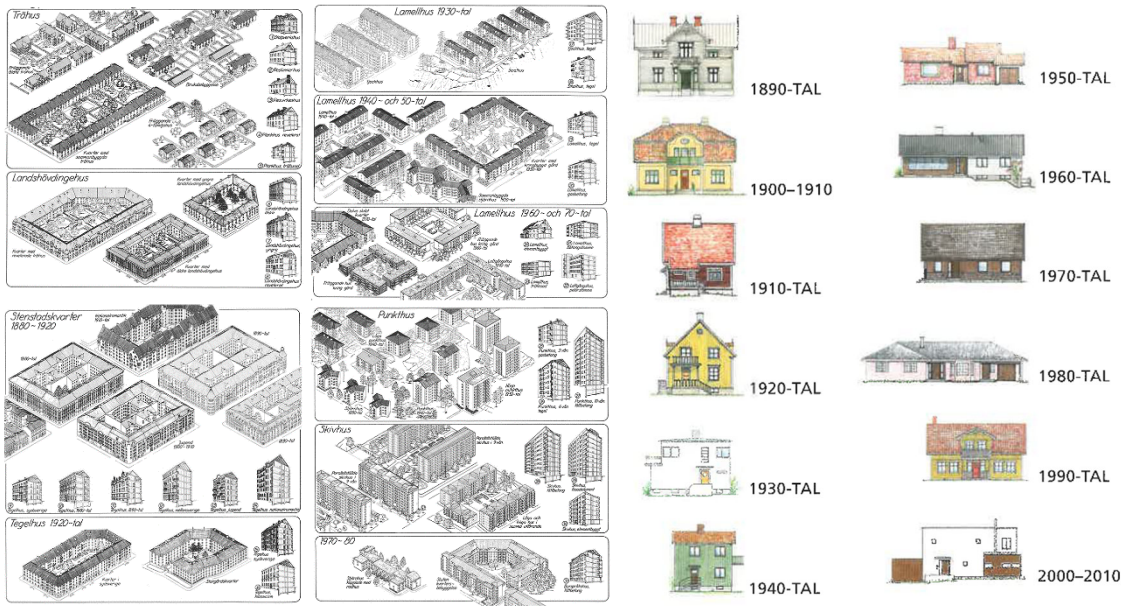


Figure 8: Typical apartment buildings presented as representative exemplars and in city blocks (Björk et al., 2003 [1983]) on the left and typical villas for each decade (Björk et al., 2003) on the right.

To show the historical expansion of the ideal-typical Swedish city, Figure 3 illustrates four major cyclical changes: the pre-industrial, industrial, modern and postmodern city (Stojanovski, 2019b). The y-axis shows historical timeline that includes changes in economy and society along with transportation revolutions and the emergence of new technologies. The x-axis indicates distance from the city center with cores and peripheries for each urban development cycle.

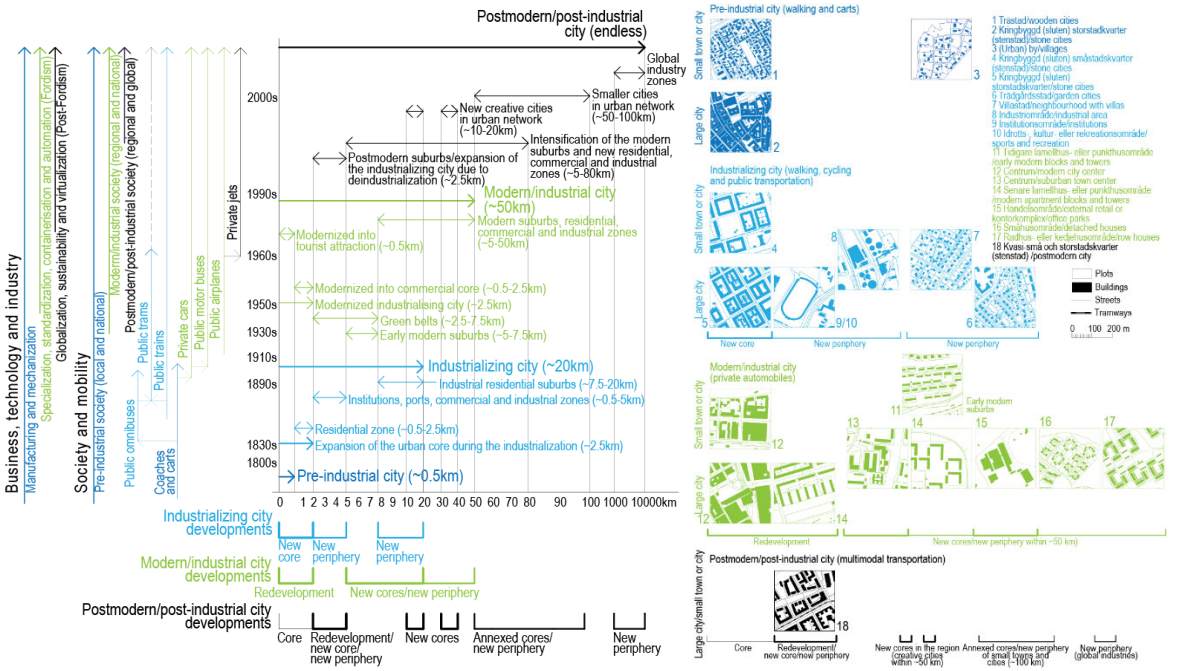


Figure 9: Cyclical changes and morphogenesis of Swedish cities during periods of industrialization of society, together with the urban cores and peripheries and urban patterns

Case Selection

Shanghai, China and Stockholm, Sweden have rich historical evolution, with urban morphology characterized by historic districts, old town centres, and new urban areas. Shanghai's old town development was influenced by Western planning concepts, creating similarities with Stockholm's old town. However, there are significant differences between the two cities, particularly in terms of urban scale and population density. The urban area of Shanghai (664 km²) is three times that of Stockholm (approximately 188 km²), and its population density (20,000 people/km²) is five times that of Stockholm (4,200 people/km²). Furthermore, the cities differ in their histories. Shanghai is prioritizing its metro network as a main mode of transport. that is largest in China (with an operational length of approximately 800 kilometres, over 500 stations, and a daily passenger volume exceeding 10 million), however, the new urban planning is primarily driven by rapid car-oriented development, lacking strong guidance for green transport planning. Stockholm developed historically along suburban railways and from the middle of the 20th century started to decentralize rapidly. Many new suburbs are dominated by cars, but there are new town developments that follows Western community planning TOD concepts. Stockholm is considered as "transit metropolis" (Cervero, 1996), but public transport remains an option for majority. In Shanghai, public transport is the default.

This paper seeks to create a basis for typo-morphological comparison between Sweden and China. The Swedish generic typology has around 20 neighborhood types where each type can have additional subtypes (Figure 3), whereas there are no detailed typological studies of Shanghai (except detailed analyses of its historical core, Whitehand & Gu, 2007; Whitehand at al., 2014; 2016). To explore the similarities and differences in the development of these two cities with different cultural backgrounds, population densities, and development models, a generic typology was developed to abstract similar historic districts, old town centres, and new urban areas as metro station areas and TOD case studies.



Figure 10: Satellite maps of the study areas in Shanghai and Stockholm, (photo credit: River Map, a software) ***Historic Districts:*** *Xintiandi in Shanghai and Gamla Stan in Stockholm are selected. Xintiandi is influenced by Western urban planning concepts, featuring a grid street network and building morphology influenced by Western row houses and enclosed block formations. This area has recently undergone extensive renovation, creating a juxtaposition of old and new urban textures. Gamla Stan is a well-preserved medieval district and the origin of Stockholm's development.* ***Old Town Centers:*** *Nanjing East Road and T-center are selected as examples. These areas are characterized by prosperous commercial activities and diverse mixed-use functions. Nanjing East Road has also been influenced by Western planning concepts and has undergone multiple rounds of renewal and reconstruction.* ***Old Town Residential Areas:*** *Changshu Road and Odenplan are representative cases.* ***New Urban Centres:*** *Lujiazui in Shanghai and Kista in Stockholm are selected as examples of new urban centers. These areas are hubs for high-tech enterprises and companies, with Lujiazui having a stronger commercial and business atmosphere, while Kista is a comprehensive development zone that integrates residential, commercial, and high-tech industries.* ***New Urban Residential Areas:*** *Century Avenue and Tensta are chosen as case studies.* ***New Urban Shopping Centers:*** *Jinke Road and Vällingby are selected as examples.*

Morphological Indicators

There is a long tradition in analyzing D-variables defining land use (Cervero, 1989; Cervero & Kockelman, 1997; Ewing & Cervero, 2010; Boarnet, 2011; Jiao, et al., 2017; Stojanovski 2018) that exist as a place-node model (Bertolini, 1996; Papa & Bertolini, 2015). To quantitatively describe the urban form around metro stations, this study identifies key morphological indicators from four aspects: land use, block patterns, public spaces, and building morphology, (Table 1).

Table 2: Morphological indicators to describe the characteristics of urban forms. Land Use: The Shannon Diversity Index is used to represent the diversity of urban functions. A higher value of this index indicates greater functional diversity and convenience in neighborhood life (Jun et al., 2015). Block Patterns: Indicators include average parcel size, street network density, and street node ratio. Smaller parcel sizes help reduce walking detours, making navigation easier. Low street network density can lead to higher vehicle speeds, which can negatively impact pedestrian safety. Additionally, low street network connectivity implies a higher number of dead-end streets, limiting walking route options (Emily Rose Hennessy, 2023). Public Spaces: Indicators for public spaces include the density and average area of green spaces and plazas. An appropriate number and size of public spaces support walking activities and enhance neighbourhood vitality (Carr et al., 1993). Building Morphology: Indicators include the average building footprint area, building density, and building frontage ratio. High-density building layouts and continuous building facades are generally associated with increased pedestrian activity and improved walking environment experiences.

Category	Indicator		Code	Formula	Description
Land use	Shannon Index(-)	Diversity	SDI	$-\sum_{i=1}^{n} P_i \ln P_i$	Where Pi is the percentage of land use and n is the number of land-use types.

Block/ Street	Average area of blocks (ha)	AAB	$\frac{\sum_{i=1}^{n} A_i}{n}$	Where Ai is the area of each block and n is the number of blocks.
	Street length density (km/km²)	SD	$\frac{\sum_{i=1}^{n} L_i}{\mathrm{A}}$	Where Li is the length of each street segment and A is the sample area.
	Link node radio	LNR	$\frac{\mathrm{L}}{N}$	Where L is the number of links and N is the number of nodes.
Public Space	Number of plaza per sq. kilometre (-/km²)	NP	$\frac{\sum_{i=1}^{n} P_i}{\mathrm{A}}$	Where Pi is the number of plazas and A is the sample area.
	Average area of plaza(ha)	AAP	$\frac{\sum_{i=1}^{n} A_i}{n}$	Where Ai is the area of each plaza and n is the number of plaza.
	Number of green space per sq. kilometre (-/km²)	NG	$\frac{\sum_{i=1}^{n} P_i}{\mathrm{A}}$	Where Pi is the number of green spaces and A is the sample area.
	Average area of green space (ha)	AAG	$\frac{\sum_{i=1}^{n} A_i}{n}$	Where Ai is the area of each green space and n is the number of green space.
Building	Build to line radio (%)	BLR	$\frac{\sum_{i=1}^{n} A_i}{\mathrm{n}}$	Where Ai is the length of each continuity street wall inerfaces and n is the length of all street.
	Average ground area (m²)	AGA	$\frac{\sum_{i=1}^{n} A_i}{n}$	Where Ai is the area of each building and n is the number of buildings.
	Ground Space Index	GSI	$\frac{\sum_{i=1}^{n} A_i}{\mathrm{A}}$	Where Ai is the area of each building and A is the sample area.

Data Collection

The calculation of the above indicators relies on urban mapping data provided by Tongji University and KTH, including satellite imagery, land use maps, parcel boundary maps, street network maps, public space distribution maps, and building footprint maps. Satellite imagery serves as the foundational map data, used to verify the accuracy of the other maps and to make necessary corrections. Land use maps illustrate the functional attributes of different parcels, reflecting the degree of land use diversity in the area. Parcel boundary maps, street network maps, public space distribution maps, and building footprint maps represent the physical attributes and organizational relationships of various urban form elements within the district. Given the differences in measurement methods for the foundational urban morphology data of the two cities, this study standardizes the calculation of indicators as follows (Figure 5):

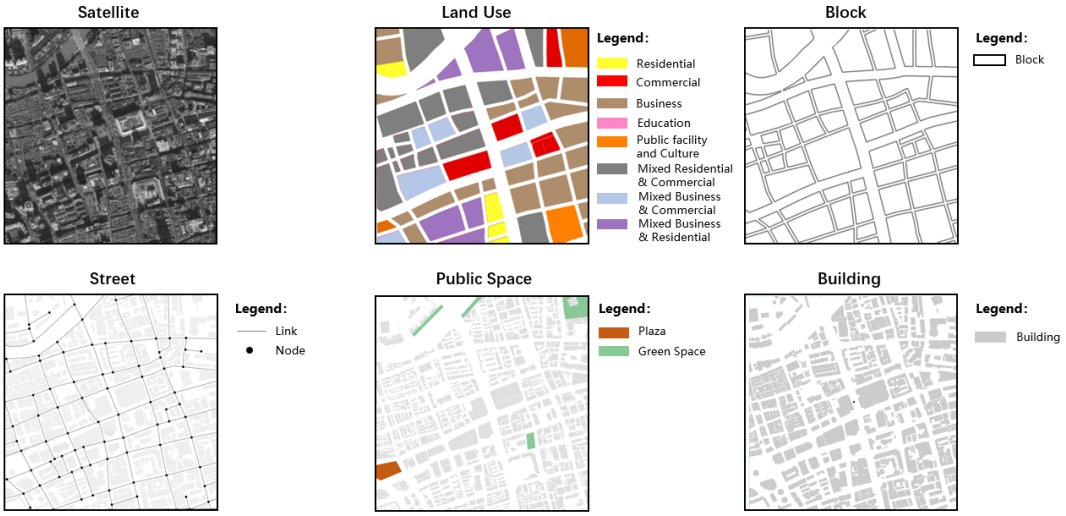


Figure 11: Six maps of study area: satellite map, land use map, block map, street map, public space map and building footprint map. ***Land Use:*** *Land uses are categorized into residential, commercial, office, educational, and cultural types.* ***Block:*** *Block are primarily defined using major urban roads as reference points.* ***Street Network:*** *The analysis focuses on major roads and excludes internal secondary roads within parcels.* ***Public Space:*** *The distribution maps are used to calculate the number and average area of plazas and green spaces.* ***Building:*** *Building density and footprint area are derived from building footprint maps, while the building frontage ratio is calculated in conjunction with parcel boundary maps.*

All foundational map corrections, overlay analyses of urban morphology elements, and calculations of physical attributes are conducted using GIS platforms.

RESULTS AND DISCUSSIONS

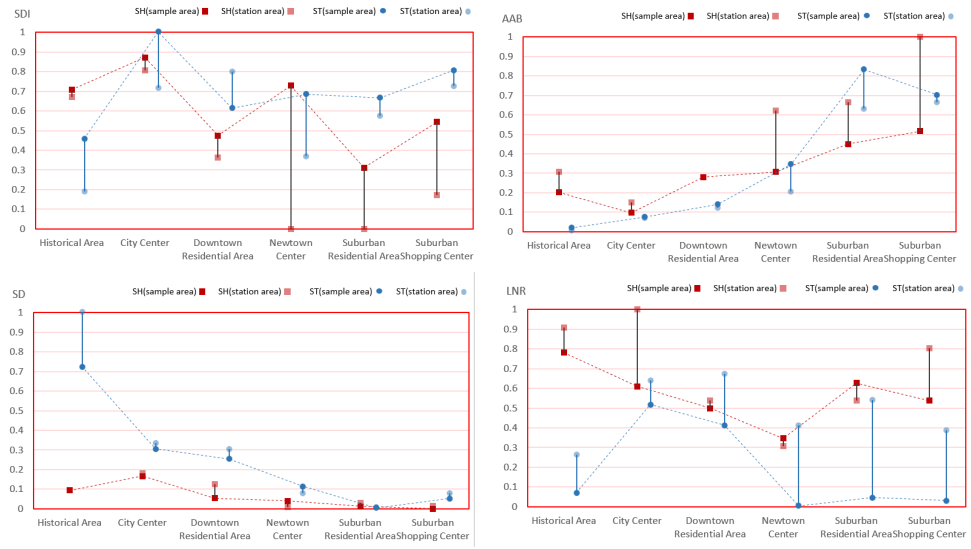
Shanghai and Stockholm have different histories and different morphology. This paper created generic typology that is applied in China and Sweden to analyze a set of morphological indicators: land use, street/block patterns, public space, and building forms. The urban morphological characteristics of the overall areas and core zones of 12 samples were computed, with the results presented in Table 2. To observe overall data trends, the results were normalized to ensure that all values fall within the range of 0 to 1.

Table 3: ***Morphological indicators for 12 cases area and core station area.***

Land Use		**Street/Block**			**Public Space**			**Building**			
Area	**SDI**	**AAB**	**SD**	**LNR**	**NP**	**AAP**	**NG**	**AAG**	**BLR**	**AGA**	**GSI**
SH-XT	1.29 (1.22)	1.7 (2.50)	8.8 (8.8)	2.26 (2.40)	2 (8)	0.31 (0.31)	1 (0)	3.88 (0)	0.90 (0.89)	282 (314)	0.35 (0.35)
SH-NJ	1.58 (1.46)	0.9 (1.31)	11.7 (12.3)	2.08 (2.50)	1 (0)	1.03 (0.00)	4 (4)	0.88 (0.21)	0.94 (0.98)	350 (457)	0.39 (0.44)
SH-CS	0.86 (0.66)	2.3 (2.3)	7.2 (10.1)	1.96 (2.00)	1 (0)	0.42 (0.00)	3 (4)	0.22 (0.09)	0.75 (0.87)	258 (289)	0.35 (0.36)
SH-LJ	1.32 (0.00)	2.5 (4.9)	6.6 (5.4)	1.79 (1.75)	6 (20)	0.62 (0.62)	5 (0)	4.44 (0)	0.15 (0.25)	572 (919)	0.18 (0.19)
SH-CA	0.56 (0.00)	3.6 (5.2)	5.5 (6.2)	2.10 (2.00)	3 (8)	0.43 (0.32)	3 (4)	0.42 (0.36)	0.12 (0.43)	440 (676)	0.24 (0.34)
SH-JK	0.99 (0.31)	4.1 (7.8)	5.0 (5.6)	2.00 (2.29)	6 (24)	0.22 (0.22)	2 (8)	0.24 (0.24)	0.06 (0.05)	686 (1338)	0.23 (0.30)
ST-GT	0.83 (0.34)	0.3 (0.2)	33.9 (45.15)	1.49 (1.70)	5 (0)	0.19 (0.00)	4 (0)	0.32 (0.00)	0.95 (0.98)	195 (200)	0.36 (0.43)
ST-TC	1.82) (1.30)	0.7 (0.6)	17.1 (18.3)	1.97 (2.00)	5 (12)	0.45 (0.49)	2 (4)	0.89 (0.87)	0.91 (0.97)	713 (1044)	0.39 (0.55)

ST-OP	1.11 (1.45)	1.2 (1.0)	15.0 (17.1)	1.86 (2.14)	4 (12)	0.17 (0.16)	5 (0)	1.81 (0.00)	0.94 (0.89)	312 (326)	0.33 (0.36)
ST-KT	1.24 (0.66)	2.8 (1.7)	9.4 (8.0)	1.42 (1.86)	2 (8)	0.26 (0.26)	5 (0)	1.40 (0.00)	0.62 (0.54)	560 (888)	0.30 (0.46)
ST-TS	1.20 (1.04)	6.5 (5.0)	5.0 (5.2)	1.46 (2.00)	2 (8)	0.11 (0.11)	5 (4)	1.95 (1.15)	0.52 (0.58)	423 (510)	0.18 (0.25)
ST-VB	1.46 (1.31)	5.5 (5.2)	6.9 (7.4)	1.44 (1.83)	1 (4)	0.46 (0.46)	3 (4)	1.76 (1.63)	0.45 (0.53)	373 (568)	0.20 (0.25)

*Figure 6 shows all the For **land use** the functional mix in urban core areas (such as the old city center, new city center, and shopping centers) is higher compared to residential neighborhoods and historical districts. Within historical districts, ST-GT shows a significantly lower functional mix compared to SH-XT. The land use in ST-GT is predominantly residential with commercial elements (residential buildings with ground-floor shops) and cultural facilities (such as churches and palaces), resulting in a lower degree of functional diversity. Conversely, SH-XT, originally similar in land use to ST-GT, has undergone multiple rounds of urban renewal and redevelopment, incorporating commercial and office functions and significantly enhancing its functional mix.In residential neighborhoods, while the functional mix in Shanghai's cases is notably lower than in Stockholm's, the underlying reasons differ. The old town area in Shanghai (SH-CS) lacks the mixed-use developments with ground-floor shops found in ST-OP, whereas SH-CA is deficient in park and green space compared to ST-TS. A comparison between core and overall area functional diversity reveals that the core areas generally exhibit a lower degree of functional mix than the broader regions, with this trend being particularly pronounced in Shanghai's new city areas. The high population density in Shanghai has increased the demand for commercial and office services around metro stations, leading to a predominance of commercial and office land uses in the core areas. In contrast, the new city districts in Stockholm, with their relatively lower population density, feature smaller commercial and office areas. These core areas often include educational and mixed-use developments, catering to the diverse needs of metro users and pedestrians, and providing a more comfortable and convenient neighborhood environment for residents.*



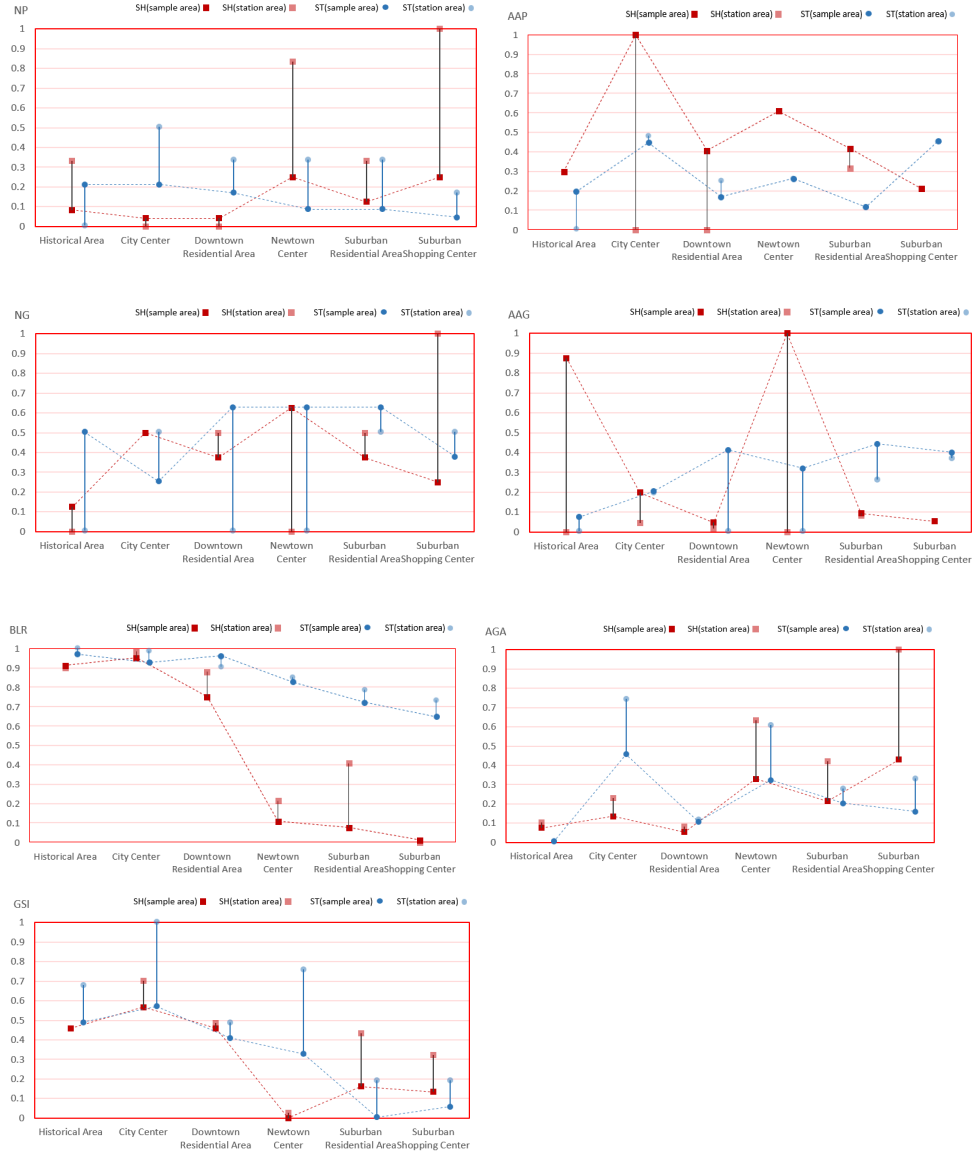


Figure 12: Comparison of morphological indicators

The block/pattern analyses reveal a clear trend of increasing AAB (Accessibility and Activity Buffer) and decreasing SD (Street Density) from old town to new town areas, indicating that the cost of walking trips is gradually rising. This change is attributed to differing urban development models. In Shanghai's new cities, the development is oriented towards motorized transport, with larger land parcels and sparse road networks facilitating rapid vehicle movement. Conversely, Stockholm's new city developments follow Clarence Perry's "neighborhood unit" concept, featuring sparse road networks and larger parcel sizes to mitigate the impact of motorized traffic on the pedestrian environment. This approach also includes non-continuous dead-end streets or circular paths within parcels (as seen in Figure TENSA and VB's road networks). Comparing the AAB indicators for core and overall areas, it is evident that cases with significantly increased AAB are found in Shanghai's new city areas. This is due to the high population density, which leads to the concentration of commercial service facilities. The government encourages the development of large commercial complexes to boost economic growth and enhance urban image, often resulting in large development parcels near metro stations. In contrast, while Stockholm's new city areas also feature commercial developments, the lower population density results in smaller commercial parcels, better aligning with pedestrian-

friendly urban design principles. When comparing the SD indicators for core and overall areas, cases with significantly increased SD are ST-GT, ST-OP, and SH-CS, all located in the old town areas. The higher SD values are attributed to the metro station location strategies. The ST-GT station, located adjacent to a dense grid road network, is relatively distant from sparse road networks near the church and palace clusters. Meanwhile, the ST-OP and SH-CS stations in old town residential areas are positioned at the core of radial road networks, providing strong connectivity to surrounding areas. The variation in LNR (Land Network Ratio) between Shanghai's old and new towns is relatively small due to the consistent use of grid network patterns. In Shanghai, the SH-NJ and SH-CS areas, influenced by Western urban planning models, show LNR indicators similar to those of the historical areas ST-TC and ST-OP in Stockholm. Stockholm's historical, old, and new urban districts exhibit distinct LNR characteristics: the historical districts feature spontaneous medieval street networks with a fishbone-like structure, high spatial privacy, and low connectivity; the old town areas are characterized by homogeneous, dense grid networks with high connectivity; and the new town areas, influenced by garden city and neighborhood unit planning concepts, exhibit sparse road networks with low connectivity. This highlights the limitations of LNR as it primarily reflects the structural characteristics of road networks and their public-private nature but does not fully represent the walkability of a district. For example, the ST-GT historical district, despite its low connectivity, reflects convenient walking conditions due to its high road network density. Therefore, the walkability of street networks should be assessed using multiple indicators. Comparing LNR indicators between station core areas and overall areas, it is noted that Stockholm's new town cases, despite showing lower overall road network connectivity, exhibit higher connectivity within station areas, reflecting a strong public nature. This is due to different planning patterns in functional zones; in Stockholm's new town cases, the station core areas feature relatively dense and accessible road networks to ensure the public nature of commercial, office, and public service functions, while the surrounding residential communities have more sparse road networks to maintain vehicle-pedestrian separation and privacy.

The public space analyses show that the NP (Number of Public Spaces) in Shanghai's new towns is higher than in the old town areas, while the opposite is true for Stockholm. This result reflects the influence of social, cultural, and construction models. Shanghai's old town areas, despite Western urban planning influences, still retain a more inward-looking spatial structure with fewer public squares. In contrast, new town areas around Shanghai's metro stations often feature large commercial complexes, which include multiple public squares. In Stockholm, the number of squares decreases from old to new town areas. In Western cultural contexts, squares are seen as central to urban public activities. In historical districts like ST-GM, squares are located at key nodes such as churches, palaces, and major road intersections. In old town areas like ST-TC and ST-OD, squares are positioned at intersections of major streets and public transport routes, often near commercial centers. In new town areas, public activity spaces shift from squares to green spaces, leading to a decrease in square density. Additionally, apart from suburban commercial centers like SH-JK, Shanghai's squares are significantly larger on average than those in Stockholm, mainly due to population density differences. Shanghai's daily metro ridership (approximately 13 million) is about ten times that of Stockholm (around 1.26 million), necessitating larger public squares to accommodate passenger flow. Comparing NP and AAP (Average Area of Public Spaces) indicators for station core areas and overall areas reveals that many cases in both Shanghai and Stockholm show higher square density in metro core areas. This

is due to the inclusion of public squares within commercial complexes adjacent to metro stations, serving both metro passengers and commercial customers. However, in the old town cases of SH-NJ and SH-CS, the metro core areas lack sufficient square spaces. The SH-NJ station, located in the old town and adjacent to a wide commercial pedestrian street, relies on this street to handle passenger flow from the station, resulting in less new square space in the surrounding redevelopment areas. Except for the core area with missing squares, the difference between core area and overall AAP is minimal, with squares typically concentrated in the core station areas. For instance, the SH-NJ area includes a large urban square (approximately 160 meters by 70 meters) located in the center of a commercial pedestrian street, which is not closely related to the metro station, resulting in a lack of square space within the metro core area. The metrics for NG (Number of Green spaces) and AAG (Average Area of Green spaces) in Shanghai exhibit no clear pattern, while in Stockholm, AAG increases from the old town to the new town. This variation in Stockholm is influenced by urban development models: the old town, characterized by compact block arrangements, has limited green space often associated with churches and educational buildings. In contrast, new town development in Stockholm, guided by community planning principles, incorporates large green spaces within residential areas to facilitate daily recreational activities for residents. Comparing the metrics for station core areas and overall areas reveals that in Stockholm, half of the station core areas lack green space, with most green spaces located in the peripheral areas around the stations. In some Shanghai cases, the density of green spaces in core areas increases, often consisting of landscape-type green spaces that are difficult to traverse (see photos). Additionally, both in Shanghai and Stockholm, the green spaces present in the core areas are relatively small.

The building form analyses illustrates that the BLR (Building Line Ratio) in Shanghai’s and Stockholm’s old towns are quite similar and both have high frontage ratios. This similarity is due to the historical development contexts of the cities. Shanghai’s colonial history has led to a blend of Eastern and Western architectural forms in the old town, with traditional lane houses arranged in a manner similar to European row houses, creating a “clustering + row” type with commercial areas on the periphery. Stockholm’s old town, in contrast, features typical enclosed block structures. Although building line ratios in both cities' new towns have decreased compared to the old towns, Shanghai’s new construction practices, moving away from Western planning influences, have favored enclosed residential districts with boundary walls, resulting in a significant drop in building line ratios and less defined street frontages, thus negatively impacting the walking experience. In contrast, Stockholm's new town construction, while differing from the old town, maintains a relatively high building line ratio, contributing to more intimate street spaces. Comparing the BLR metrics for station core areas and overall areas, it is observed that in cases such as SH-CS, SH-CA, and SH-JK, there is an increase in building line ratios within the metro core areas. The buildings near metro stations with high frontage ratios create continuous commercial facades to attract the dense passenger flow brought by the metro, enhancing the walking experience. AGA (Average Gross Area) increases from old to new towns, while GSI (Gross Space Index) decreases. This trend is attributed to changes in urban cell unit forms. Both cities’ old towns feature high-density low-rise residential areas, such as Shanghai’s Shikumen lanes and garden villas, and Sweden’s enclosed blocks and multi-storey row houses. New town residential areas in Shanghai include multi-storey worker villages and high-rise modern residential districts, while Stockholm predominantly features multi-storey apartment buildings (see base maps and photos). Additionally, the centre of Shanghai’s new town, SH-LJ, has extremely low building density due to the development of motorways, skyscrapers, and large urban parks. The wide, high-

level motorways, setbacks created by skyscrapers, and multiple urban parks contribute to a dispersed and fragmented urban texture. Comparing the AGA and GSI metrics for station core areas and overall areas, both Shanghai and Stockholm show an increasing trend in these indicators in metro core areas. This is particularly notable in central-type districts (old town centers, new town centers, and suburban shopping centers), where the increase in AGA is significant due to the high density of metro passenger traffic, necessitating large-scale buildings to meet commercial and office needs. Additionally, the proximity of the new town residential area SH-CA to the new town center SH-LJ results in a high metro passenger density, leading to a notable increase in AGA.

DISCUSSION

This study compares the urban morphological characteristics of metro station areas in typical districts of Shanghai and Stockholm from a walkability and TOD perspective. The cross-cultural comparative study reveals how metro stations interact with urban morphology under different social contexts. Analysis shows that in both Shanghai and Stockholm's new urban area, metro station core areas generally exhibit increased plaza density, higher building density, and larger building scales compared to peripheral areas. This indicates a common practice of high-density development around metro stations to efficiently manage passenger flow through plaza spaces, enhance urban vitality, and increase surrounding commercial value. In contrast, in the old towns, due to constraints such as land ownership and historical preservation, the overall morphological changes in metro station core areas are less pronounced. However, some Shanghai cases demonstrate that selecting metro sites in areas with higher road network density and better connectivity, combined with urban renewal and redevelopment, can improve the capacity and functional mix of metro core areas.

Urban development models significantly influence walkability around metro stations. Over the past 30 years, Shanghai's rapid urbanization has been driven by motor vehicles and road construction. This development model has impacted metro line planning and station layout, leading to metro stations often being situated alongside major roads with large land plots and lower road network density, which results in significant interference with pedestrian movement due to high-speed traffic. Conversely, Stockholm's new district development model, influenced by the neighbourhood unit concept, features a sparser road network and larger land plots. This increases the detour distance for pedestrians reaching metro stations, but the use of cul-de-sacs and loop roads within large plots helps separate pedestrian and vehicle traffic, enhancing walkability and safety.

The difference in population density between the two cities leads to distinct commercial development models near metro stations, which in turn affects the pedestrian environment around these stations. Although large-scale commercial complexes can meet the high-density passenger flow needs and their accompanying large plazas can handle metro passenger dispersal, this often results in larger land plots and reduced road network density in the core areas, further decreasing functional diversity and increasing walking distances. This reduces the opportunities for accessing diverse services on foot and can lead to increased car traffic, which encroaches on pedestrian spaces and raises the risk of traffic accidents. In Stockholm, the lower population density results in smaller commercial facilities near metro stations and a more mixed-use core area, facilitating the creation of urban micro-centers that attract residents to visit on foot.

In the end, the generic typology of six neighborhood types serves as good proxy for comparison, but it does not reflect the urban development trends (neighborhhod type 18 in Figure 3) and favourite car-oriented typologies (neighborhhod type 16 and 17 in Figure 3) that dominate in Swedish suburbs but are seldom developed in China. The typical gated community as a Chinese predominant type (exempliefied as Vällingby in Sweden) experienced several variations from the 1970s and still dominates as preferred type in Shanghai. Figure 7 on the left shows a luxurious gated community in the suburbs of Shanghai (Hongqiao) with an access to a metro station and western supermarkets. Figure 7 on the right illustrated experiments with neotraditional neighborhoods (so called waterfront cities) in Stockholm with a mix of buildings and traditional main street with a light railway (Hammarby Sjöstad) supported by car pools, automated supermarkets and indoor farms. These new experimental sustainable neighborhoods in Stockholm are rooted in Swedish traditions and do not exist in China. They are excluded from the comparison, but they are testbeds for sharing vehicles and mobility hubs. the generic typologies do not grasp the detail typo-morphological development that is typically captured by typomorphological studies. In Sweden, there are detailed typologies (Paulson, 1950; Rådberg, 1988; Engström et al., 1988; Rådberg and Friberg, 1996; SSBK, 1997; 2000; 2022; Björk et al., 2003 [1983]; 2009; 2018 [2000]; Stojanovski, 2019b; Stojanovski et al, 2022; 2023), whereas in China typologies are typically used for analyzing historical areas (Whitehand & Gu, 2007; Whitehand at al., 2014; 2016).

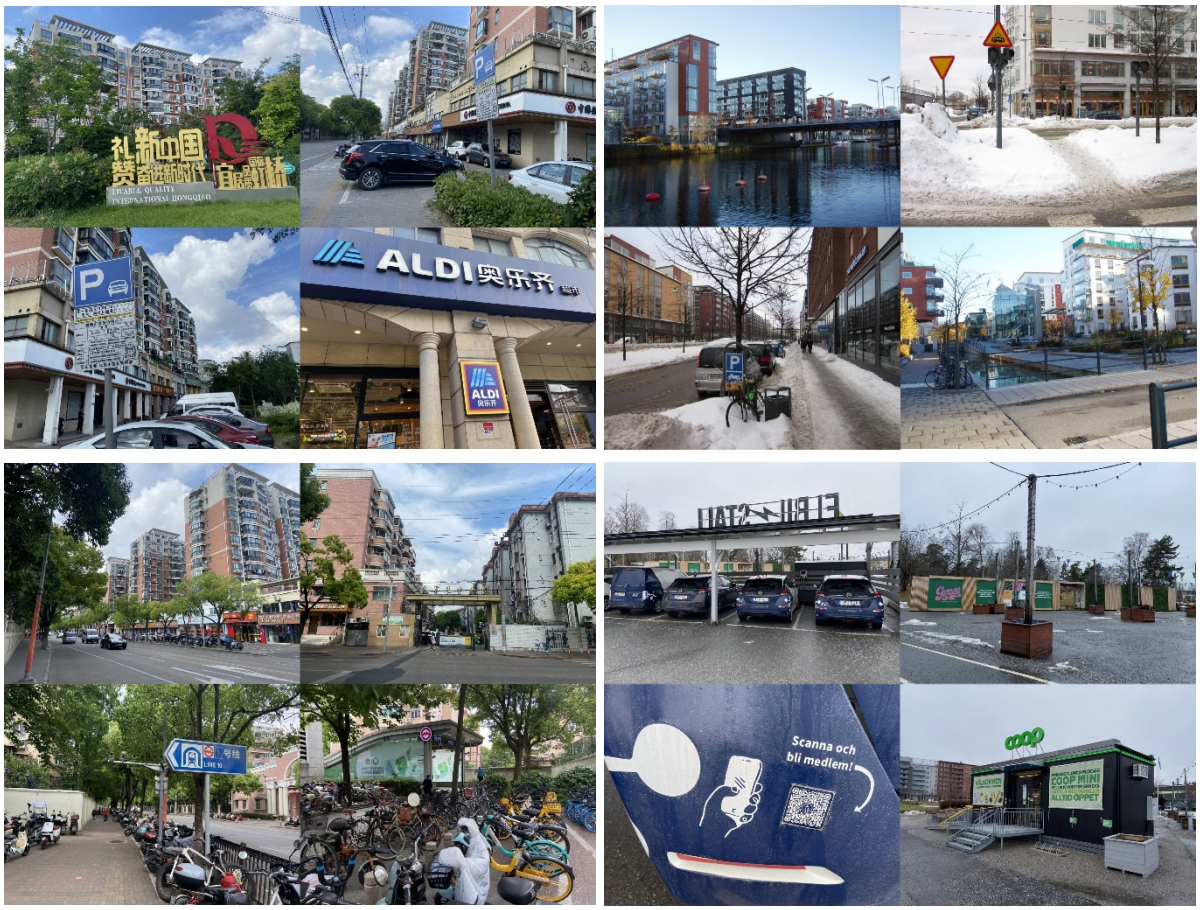


Figure 13: A typical gated community in Shanghai (Hongqiao) on the left and a typical new waterfront development in Stockholm (Hammarby Sjöstad as a prototype on the up right and Täby park on the bottom right where experiments with mobility hubs and shared electric cars are at place).

CONCLUSIONS

The discussion about application of typo-morphology and typologies and spatial analyses with morphological indicators is perpetual in morphological research. This paper presents generic typologies in Sweden and China and compares variables. However, the generic typologies do not grasp the detail typo-morphological development that is typically captured by typomorphological studies. A combination of refined Chinese typologies and morphometric analyses can offer a more detailed perspective, not only in the indicators for walkability and TOD, but also in preferences and (typological and morphological) evolution of Chinese and European cities. In the end, there are limitations in using typo-morphology in urban design practice that requires critical understanding and application of typologies. Typologies are usually historical facts, whereas the future is here to be invented. If a historical pattern of a neighbourhood is replicated today, the neighbourhood type will be different in the historical context. This might only has meaning if the typologies are based on historic information without considering the present conditions.

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Urban metabolism: a morphological approach to promote regeneration in São Paulo's central region

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ABSTRACT

The presented work was awarded at a competition for the requalification of the surroundings of São Paulo's municipal market, a representative figure of the city's socioeconomic role as a strategic hub between the state's productive hinterland and the port of Santos. Currently, the territory is characterized by a convergence of flows, creating idiosyncratic spatial conditions. While the region has a strategic role in the state's trade and supply chains, the logistics behind the retail operation has precluded the occupation of the area for leisure (green areas) and created infrastructure issues which are manifested through acute pollution, heat islands and flooding episodes. Given this scenario, the competition required transversal planning strategies, capable of outlining interventions in a contained perimeter while fostering vectors of urban requalification in a long-term scenario. Given the complexity and challenges of the context, we needed to better understand the intricate dynamics at play in the region to enable a mora targeted and effective intervention. We conducted a series of exercises to anaçyse the impact of the city's form on its economic and productive dynamics, assessing whether urban morphology acts as a driver for the transition from a linear to a circular economy. The study is based on a morphological analysis that connects the built environment with the virtual space, where flows of extraction, production, consumption, and disposal operate. These flows were examined across two distinct periods, within the same productive land framework, in a territory yearning for transformation. The results of this analysis allowd us an in-depth exploration of the complexities within the central region, highlighting spatial weaknesses and potentialities while enhancing synergies between the socioeconomic agents and flows of the consolidated territory of São Paulo.

In this way, we were able to outline strategies and create design proposals that will enhance existing value chains and prompt a transition to a circular economy. The research presents a valuable opportunity to reflect on process of urban regeneration which begin from morphological concerns, and which can be materialized through concrete and spatial interventions

Keywords: urban regeneration; urban metabolism; green infrastructure; spatial clusterings; consolidated territories

INTRODUCTION

This paper discusses the metabolic analysis methodology developed to investigate the surrounding of the Municipal Market area, located in the central region of São Paulo. This site was the subject of a national competition organised by the Instituto de Arquitetos do Brasil and Associação Escola da Cidade in December 2023. The investigation was essential for a deep understanding of the territory, enabling the development of evidence-based regenerative strategies, as it turned to be highly praised by the technical jury, resulting in the highest awarded prize in the competition.

The action perimeter defined by the competition brief has been subject of public debate for decades. While the Market itself has a significant presence – shaping, transforming, and conditioning the territory, the brief invited proposals to investigate the area, agents, and dynamics around it, designing possibilities to overcome the programmatic and spatial super specialization that hinders an effective transformation of the area. Furthermore, the perimeter of the region holds a critical role in affordable housing production, flood mitigation, and green and road infrastructure, leading factors in our argument for the necessity of regeneration.

Context

Strategically located north of São Paulo's historical core and bounded by the Tamanduateí River and its historic floodplain, the immediate context of the São Paulo Municipal Market turned into a commercial hub for food products. While it emerged as a critical commercial nexus, connecting productive inland regions to the coastal areas (Prado Jr., 1998) through railways and roads, now represents as a gastronomic centre, offering specialty goods and raw products, establishing itself as a important tourist and cultural establishment.

Since the Market's inauguration in 1933, the area around it has consistently reinforced its commercial identity, catalysing urban development. This progress has been further spurred by industrialization and immigration, especially with the efforts of the Varzea do Carmo's floodplain reclamation, straightening Tamanduateí River, while attempting to mitigate flooding and facilitate urban expansion along the riverbanks, while it was not served anymore as a logistic modal of transport.

During this period, immediate neighbourhoods develop around the railway infrastructure and close to the Municipal Market. With the downturn of the global economy and the subsequent decline in coffee exports created a favourable condition for industrialisation to thrive as a domestic supplier of São Paulo's market. This process was accelerated by the settlement of European immigrants, who brought valuable expertise in industrial activities. The manufacturing industry and specially the textile industry were important remarks back in the area, which the last one, remains significant to this day.

The São Paulo Municipal Market accommodates more than 1,500 employees who collectively manage approximately 350 tons of food daily, and it attracts around 50,000 visitors per week. The competition's redevelopment proposal encompasses an area of approximately 53 hectares. This preset is a promising opportunity to enhance the tourism-cultural circuit beyond a diversity of economic cluster. However, despite its vibrant daytime activity – more than 2 million people move through its area- it exhibits a sparse residential density, making its atmosphere empty and unsecured for passersby at the end of business time.

Historically, public investments in this area have prioritized mobility and logistics infrastructure, overshadowing other important dimensions of the urban life, leaving little to no space for other uses that are considered relevant, and which are central to the competition's brief. In our understanding, the lack of success of previous projects and proposals for the area, were caused by the lack of depth in studies not considering certain topics for the area's maintenance.

The numerous interventions and transformations projects that took place at this territory, which many ended in failure, prompting us to question what factors these proposals considered and why, despite its well-documented challenges, the region continues to stand out as the largest and most important open-air market in the country. These idiosyncrasies spurred us to conduct a thorough investigation of the area, allowing us to envision desirable future scenarios for its development.

System Thinking

Currently, the industrial framework located in São Paulo's central region configures a decentralized production network, whereas resources and labour do not depend on proximity with the consuming public (Leite, 2012). The lack of industrial policy led incentives led industries to install outside the urban environment. The growth of flexible productive sectors and outsourcing of the means of production created the need for a vast network of suppliers and distributors. São Paulo faces a challenge in decentralizing its production while recentralizing its consumption (Figure 01).

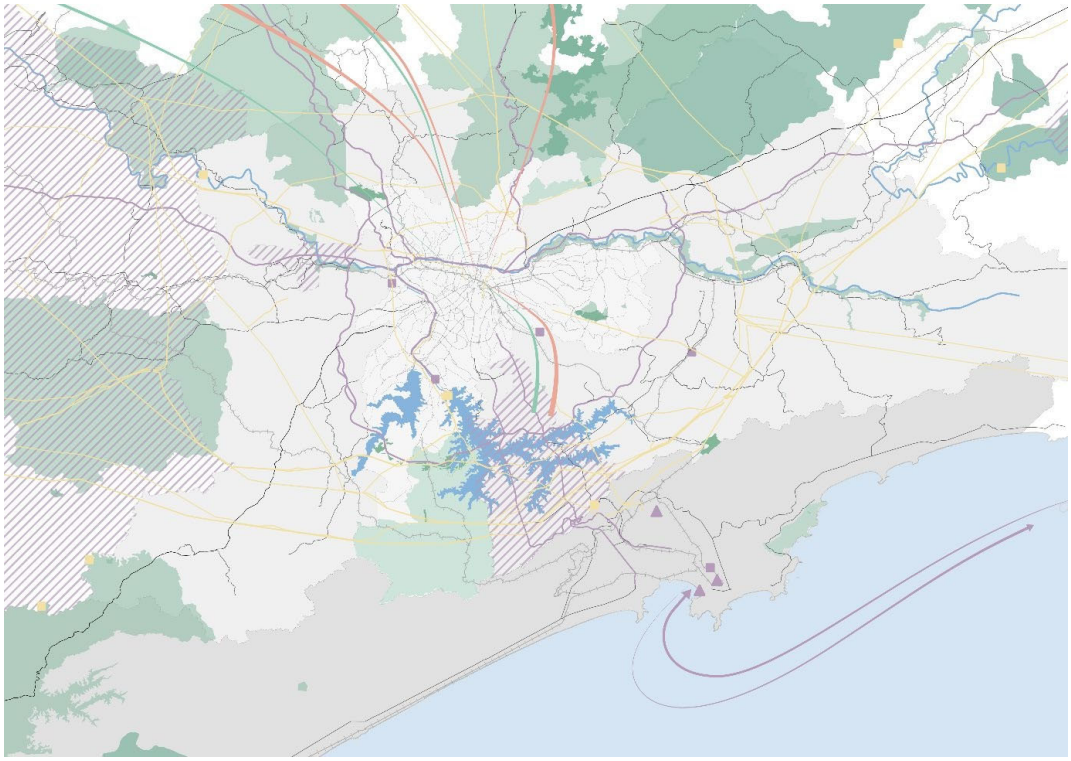

Figure 1. São Paulo's metropolitan area in 2023, showing economic activities that start, end or cross its urban area. In purple: logistics and transportation of goods; In yellow: energy supply; In blue: water basins; In green: food production; in Pink: Residues, Water Treatment and Solid disposals. Image made by author

The presence of various active economic clusters within the defined area, within the encompassed area, which were notably thriving, as evidenced by the inauguration of new commercial infrastructure hubs of retail, tech manufactures, food and other goods, were the first potential identified for the proposal.

The initial question raised by the project was to understand the flows and dynamics occurring within this territory, which did not begin or end within its boundaries, the concept of extended urbanization (Brenner N. and Katsikis, N, 2020) that points how city and non-city landscapes are dialectically co-produced under modern capitalism, systematically connected, though tangible and intangible layers. To this end, we introduced the concept of urban metabolism as a framework to conduct an in-depth analysis and comprehend the physical and non-physical dynamics at play in the area.

The region's historical context served as a reference point for a productive city that grew and developed based on its economic potential. Neighbourhoods that emerged during the industrialisation period retained their building structures and have continued to prosper, maintaining their commercial but no longer productive vocation. Thus, the second question that arose was to understand which spatial transformations may have contributed to this shift in vocation and whether it is still possible to regenerated it.

The concept of system thinking illustrates how productive and economic activities can serve as leverage for regeneration. We defended that it is crucial to first structure and enhance other activities to increase liveability, social safety, and connectivity to make the territory more attractive for its residents. The idea of urban metabolism, argue that it is possible to do so by increasing and redirecting value captured with the existing economic activity, which is at the core of this region's character. In this sense, the current economic clusters, can begin to engage with other stages of manufacturing process, such as research, design and prototyping, amongst others. A similar process was observed in the Brussels Canal Zone, as demonstrated by the project Cities of Making (CoM, 2018).

In this sense, the questions brought up in this exercise expected to create a base ground or foundation of a system thinking approach that could properly design in such a complex territory configuration, enhancing existing value chains, preserving local value and mitigating impact and externalities, such as mismanaged economical logistics and flooding risk.

Spatial Investigation

The exercise involved a comparative morphological analysis of the same territory, focusing on the area defined by the competition, across two distinct periods: 1930, at the Coffee Metropolis era, and 2023, the Consumer Metropolis. The aim was to identify small or large alterations in the urban fabric, with a particular focus on water and green infrastructures and transportation networks, that have undergone transformations in their configuration.

Following this comparative analysis, an economic study of the material and product flow from both periods was proposed to understand the strengths and weakness of the dynamics within the competition's defined perimeter. The next phase of the study sought to identify the spatial potential of the current territory using the Space Syntax methodology. This approach would provide region demarcation of high degree integration and connectivity within the area, ensuring that the groups proposal could be focused on zones with the greatest potential for impact and effectiveness.

The final stage of the exercise involved synthesising and cross-referencing all collected data to identify similarities or discrepancies that could provide a deeper understanding of the territory's transformation. This comprehensive approach aimed to develop a new methodology for proposing

urban interventions in complex urban areas, that would consider both the spatial transformations and the economic dynamics emerging from the use of those spaces, to provide better interventions for a desired city of tomorrow.

METHOD

To understand the territory through its morphology, the study aimed to analyse the region defined by the competition, comparing it across different temporal scenarios. The selection of time periods for analysis was based initially on the availability of data and cartographic records, and subsequently on the economic context of each era. As such, the study focused on the periods of 1930 and 2020, within a framework of territories seeking transformation, following moments of industrialisation and urban development. The first period represents a scenario poised for significant alteration in the coming years, while the second reflects the present-day context, allowing for the projection of a desired scenario rooted in the potential reindustrialisation of the area's functional activities, coupled with the (re)development of its territory.

The methodology is composed of four stages:

1. Morphological Urban Analysis: involving morphological analyses of the urban fabric within the defined areas across the two selected periods.

2. Metabolic Flow Mapping: focusing on mapping the metabolic flows and key products associated with the Municipal Market and its surroundings, using a qualitative approach.

3. Spatial Analysis, examining the region through Space Syntax methodology, using the Depthmap.exe software.

4. Cross-Referencing Spatial and Metabolic Data, the final stage of the study, where spatial data from cartographies and diagrams developed in the previous stages are cross-referenced.

Morphological Urban Analysis

The development of the morphological analysis consisted of comparing the two scenarios: The Coffee Metropolis in 1930 and the Post-Industrial Metropolis in 2020. In the first case, we analysed the city of São Paulo, which was still characterized by its coffee export economy and already displaying a significantly developed urban spatial configuration. It was also the stage for industrial development, which ultimately transformed and consolidated the urban fabric in the city centre. In the second case, we analysed the city in its current stage, using cartographies and data from 2020, where São Paulo is characterized as a commercial metropolis, with trade and services as key elements of its economic configuration, alongside the exodus of industrial activities to peri-urban contexts. In both temporal frameworks, we identified the region as being in a status prior to an imminent transformation, which in this case refers to a potential return to its industrial and productive vocation.

Using geospatial cartographic data from 2020, acquitted through public domain portals and presented in computer-aided design (CAD) software, along GIS software, a working file was created to organise and display relevant information for the study (figure 2). This included elements such as the road network, urban blocks, building structures, green and open spaces, hydrographic features, railway infrastructure, public urban equipment (metro and bus terminals), and bridges and crossings.

Elements such as land plots were excluded to this exercise, due to the lack of this information in historical cartography in some places within the region perimeter.

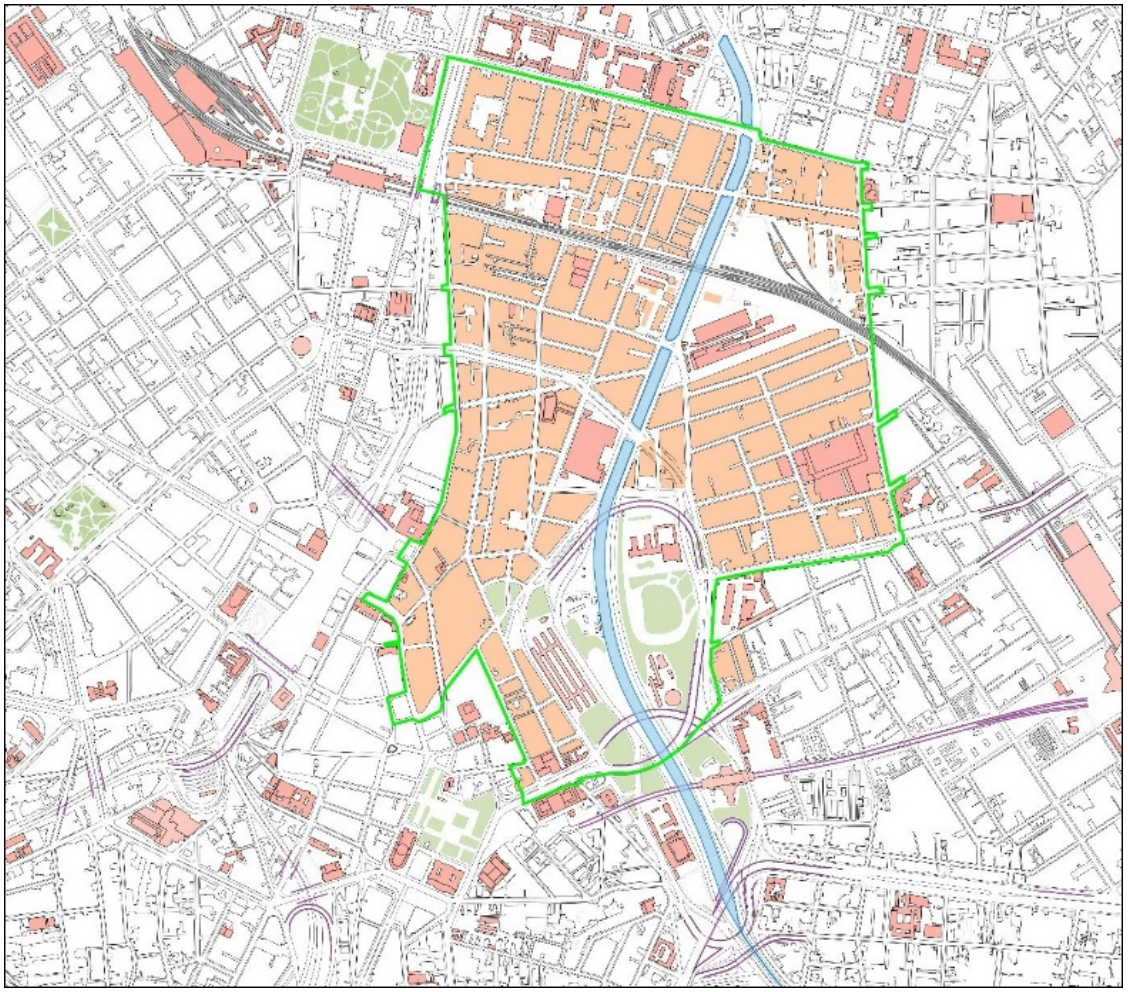

Figure 2. São Paulo's central urban context in 2020, in green the outlined perimeter of the competition. Image made by author

The 1930 cartography, named SARA Brasil 1930, was georeferenced using GIS software to ensure greater compatibility with modern territorial representations (figure 3). This allowed for the elaborations of roads, blocks and buildings present at the time. However, the representation of the built-up area could not be fully translated within the available timeframe. Therefore, only significant alterations in blocks and urban fabric were considered. Information on mass transit systems, specifically the tram network, was not represented in this cartography for clarity and visibility purposes but was considered in subsequent analyses.

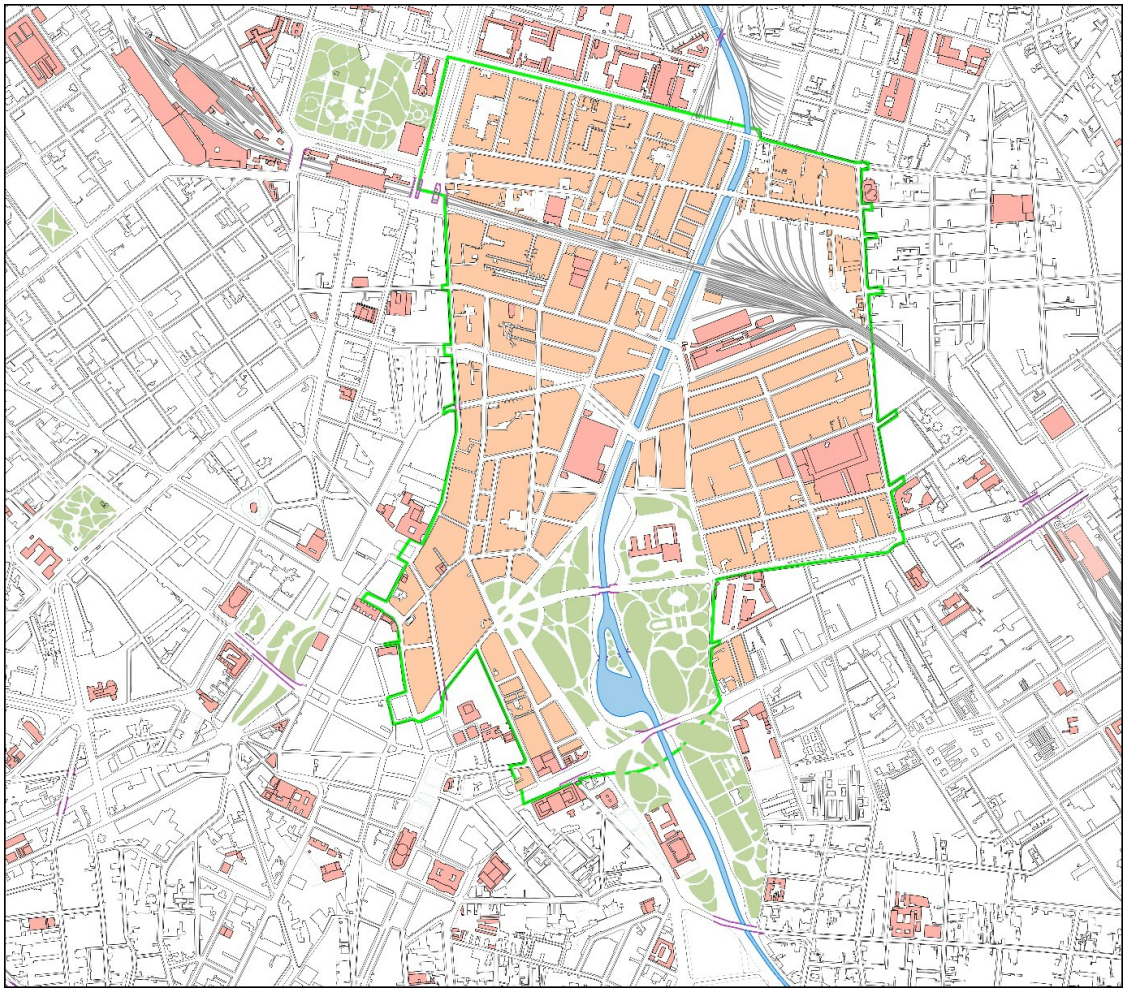

Figure 3. São Paulo's central urban context in 1930, in green the outlined perimeter of the competition. Image made by author

Metabolic Flow Mapping

The second step of the methodology was the metabolic analysis. We looked at the Urban Metabolism publication by the IABR – Project Atelier Rotterdam (Fabrications, n.d.) as a reference. Their understanding of the urbanized territory in sync with natural cycles as part of other widespread systems provided a practical framework to define our starting point for this exercise.

To conduct the "Metabolic Flowchart", we incorporated the concept of extended urbanization, discussed by Neil Brenner and Nikos Katsikis (2020), that pointed out how city and non-city landscapes are dialectically co-produced under modern capitalism, thus, the field of urban studies should treat them as a systematically connected.

> From this point of view, cities are supported by diverse metabolic inputs (labor, materials, fuel, water, and food) and engender a range of metabolic byproducts (waste, pollution, carbon), the vast majority of which are produced within, and eventually, absorbed back into non-city zones. (Brenner and Katsikis, 2020, p. 25)

In this exercise we tracked flows, from origin to its destination, most of the flows initiated in contexts out the urban limits and ended in the urban context. The flow analysis considered topics such as air, waste, energy, biota, housing, transportation logistics of raw materials, food, and manufactured goods, along with their result byproducts, including waste and economic implications. This metabolic

analysis seeks to deeply understand the intrinsic relationships and synergies between these inputs and how they interact with the built urban fabric.

In the case of the current situation of São Paulo, we faced with the dispersion and absence of certain data for the defined perimeter, a limitation which researches of the Global South often contend. While we couldn't assure quantitative precision, it was also an interesting exercise to work with these flows through their qualitative properties, resulting in a diagrammatic scheme (figure 4) that was suitable to present the concept.

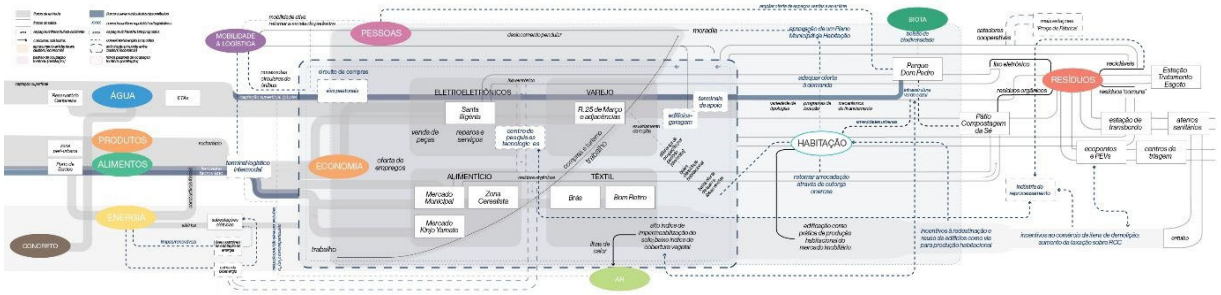

Figure 4. Metabolic Flow Map of São Paulo's economic activities in current and desired situation. Image made by author

The diagrammatic scheme of this concept presents information on flows and assets, illustrating the current situation while indicating a desired scenario of improved efficiency in these flows and their potential outcomes.

Thus, we were able to conduct a study of the qualitative properties of the system in another historical period, this allowed us the creation of a comparative case in which both periods could be analysed on the same level. The information collected to support the Metabolic Flowchart for the year of 1930 (figure 5), came from archives of public domain and historical records, authenticated by reliable institutions with certified dates.

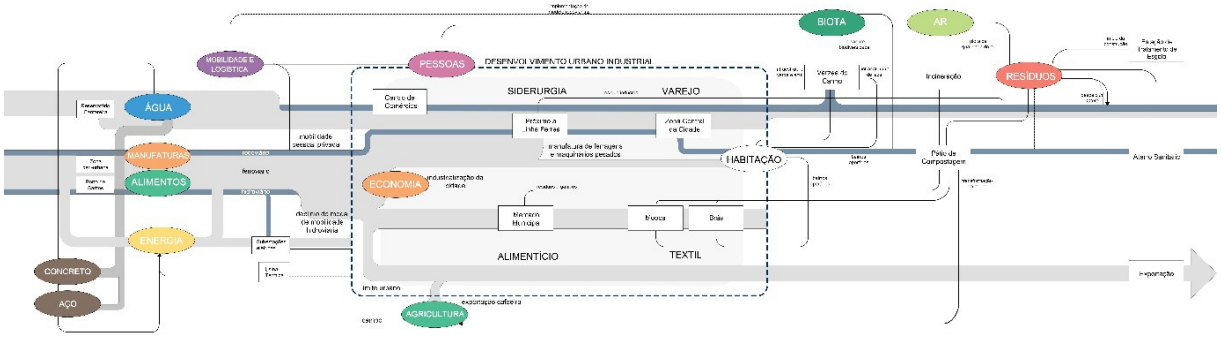

Figure 5. Metabolic Flow Map of São Paulo's economic activities in 1930. Image made by author

In this configuration, we were able to gather a significant amount of data, as a substantial amount of literature produced during São Paulo's urbanization process following the establishment of the infrastructure and energy provider, *The São Paulo Tramway, Light and Power Company Limited*. During the same period, the railway system managed by *The São Paulo Railway Company Limited*.

Was already well-established as the main route for exporting coffee production that was developing in the hinterland of the state, to its destination to the coastal area at the *Port of Santos*. Additionally, the concentration of new infrastructure projects for water supply and sewage in São Paulo's city centre were crucial factors that enabled prosperous and enduring industrial urban development.

Spatial Analysis

In the third stage of our work, we conducted a study of walkable pathways using Space Syntax analysis. The purpose of this analysis was to understand the hierarchical structures that compose the system within the limits defined by the competition, enabling us to identify spaces and urban fabrics that should concentrate interventions and design practices, supported by spatial validation that could enhance our project proposal.

To produce this analysis, we developed a cartography in the style of the Noli Map of Rome, depicting the current situation of the central region, which is the focus of the competition. In this cartography, we redrew the boundaries of the public realm, also considering walkable spaces such as galleries, passages, and squares that have defined opening and closing hours, in addition to areas like streets and avenues that do no present clear physical barriers but are not optimally utilized for public purposes. This cartography allowed for a more detailed execution of Space Syntax and understanding of different spatial manifestations occurring in the area, within a new layer of the perceived space.

After developing this cartography, we created axial maps using the depthMapX application of Space Syntax, allowing us to extract new cartographies and results for interpretation. The results for Connectivity (figure 6), Integration (figure 7), and Choice (figure 8) were used to interpretate the territory from a qualitative perspective.

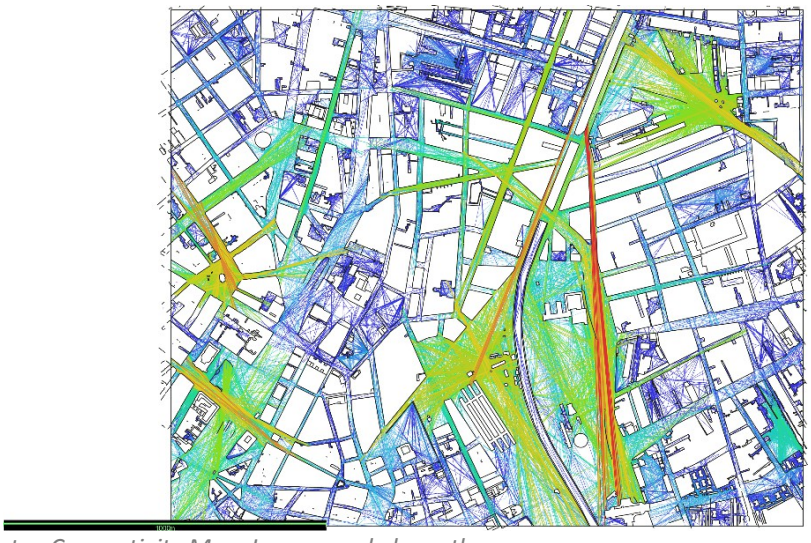

Figure 6. Space Syntax Connectivity Map. Image made by author

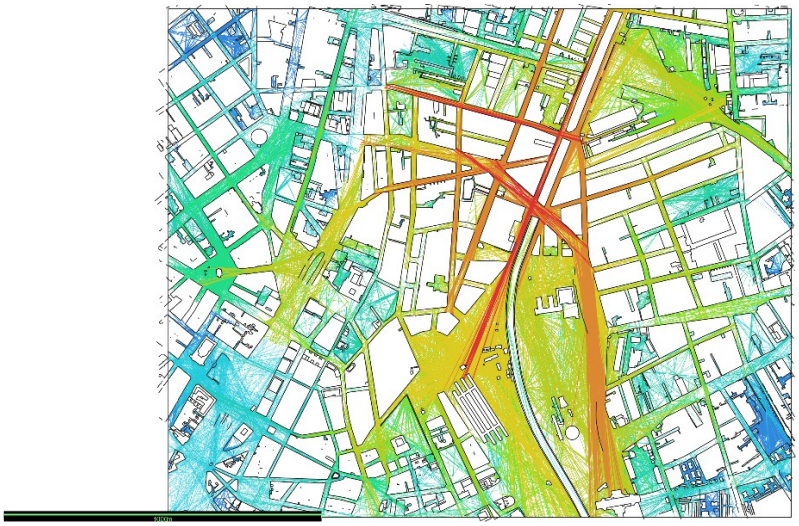

Figure 7. Space Syntax Integration Map. Image made by author

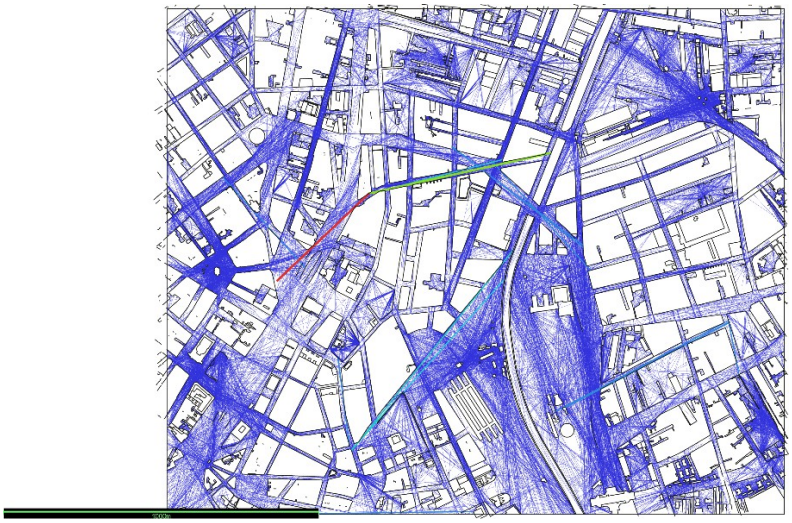

Figure 8. Space Syntax Choice Map. Image made by author

A high degree of integration and connectivity values were identified in the areas that are currently occupied by the road infrastructure, Avenida do Estado, that borders the Tamanduateí river. The spatial potential identified in this region, served as a foundation of a series of strategic design guidelines presented in the final proposal, with the most relevant in this scope, to propose a division of the roadway on both sides of the river bank, into two distinct routes: a local road with reduced speed limits happening above ground, and the structural avenue with reduced number of lanes, running underground along the same path as before, enabling the appropriation of the spaces above ground near the river, for public and collective use.

However, it was still necessary to ensure that these interventions, beyond improving spatial quality for the public, would not overburden the traffic network of São Paulo's central region. To this end, a new analysis was conducted using Space Syntax methodology, but now, based on an axial map of the city's road system, with a 2km analysis radius centred on the Municipal Market. The cartography compared two situations, one as a current state, and the other a desired scenario, considering potential impact on the redirection of the Avenida do Estado on the system.

The test conducted at this macro scale provided data on Connectivity (figure 9), Integration (figure 10), and Choice (figure 11), obtained through the application of the Space Syntax method using the Depthmap. exe software.



Figure 9. Space Syntax Macro Connectivity Map. Image made by author



Figure 10. Space Syntax Macro Integration Map. Image made by author



Figure 11. Space Syntax Macro Choice Map. Image made by author

The results did not indicate significant negative impacts, as it didn't display any degradations in the system's territory, regarding connection, integration, and choice themes. By that, it allowed us to assertively work upon the Avenida do Estado Road structure, thus supporting the interventions strategies in the proposal.

Cross-Referencing Spatial and Metabolic Data

The final stage of this study involved cross-referencing the data and information obtained though the previously mentioned methods. The findings were grouped according to their respective time periods. This allowed us to elucidate the morphological conditions present in each era, as well as their economic and market dynamics, with the aim of addressing the two hypotheses posed at the beginning of the study.

RESULTS AND DISCUSSIONS

Starting with the analysis of the 1930s, we were able to understand the economic and spatial conditions that propelled the area's industrial and productive activities. These conditions were not only defined by the physical aspects of the urban morphology but also by the logistical flows of the elements highlighted in the Metabolic Flow Map, which provided a basis for testing the initial hypotheses of the experiment.

Two main factors emerged from this analysis: the river and the railway line served as crucial foundations for the region's industrial development, supporting both logistics and supply chains. Although no definitive evidence of industrial waste disposal into the river during this period was found, it remained a point of consideration in our dissertation. Another key aspect was the Green and Blue Infrastructure of Parque do Carmo, or the later Varzea do Carmo floodplain, which played an

important spatial role in the growth of central neighbourhoods. In addition to providing recreational spaces for the population, it was the only mechanism for flood control available at that time.

The methodology allowed to highlight key issues, which were organized into the following spheres: logistics and mobility, sustainability, and economics.

In terms of logistics and mobility, the analysis revealed a prioritization of road transport in urban transformations, which remains the most utilized mode for the movement of goods and people. The proximity of a underutilized railway infrastructure near the Municipal Market presents a potential opportunity to improve goods transportation in this specific area.

In the realm of sustainability, there is a noticeable reduction in public green spaces near the Tamanduatei River.

To enhance biodiversity in the region and potentially restore the Varzea do Carmo floodplain area for recreational use and a infrastructure of flooding mitigation, the results of the Space Syntax analysis demonstrated the integrative potential this region offers to the system, should it be made accessible to the public.

From an economic perspective, waste treatment and transportation continue to be a weakness in the system. Economically, it would be valuable to consider the spatial conditions of the region to repurpose waste and reintegrate it into the production chain, with the Municipal Market itself serving as a focal point.

CONCLUSIONS

The study for the competition allowed an in-depth exploration of the complexities in São Paulo's central region. The team developed tools, outlined spatial strategies, and showed how reallocating resources could promote regeneration, in environmental, mobility, heritage, infrastructural, and economic aspects through a circular economy perspective.

The economic flow perspective, as an additional layer of analysis was introduced to the territory. This layer allowed the identification of spatiotemporal changes that either hindered or contributed to the degradation of the urban landscape, such as the underutilization of railway infrastructure and its decline due to road network investments. This shift led to the deterioration of green areas and the river, particularly where avenues were constructed in floodplain areas, restricting the river's natural course.

By identifying the spatial weaknesses and economic impacts, and analuzing them through the Space Syntax method, the study highlighted the potential for uban and landscape recovery in areas dominated by the avenue. These analyses (Figure 8, 9 and 10) enabled the anticipation and evaluation of the impacts that a potential reconfiguration of road network would have, both locally and at a metropolitan scale.

The methodology applied proved effective in identitying hidden potentials and elucidating the region's complexity graphically, presenting a proposal that connects public and collective spaces with existing economic infrastructures. This approach promotes new dynamics and perspectives for interconnected urban interventions that foster urban regeneration.

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The role of typification in phenomenology and urban morphology

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ABSTRACT

The world we live in is manifold, full of surprises, and constantly changing. Fortunately, it also offers a range of recurring and typical situations, thereby enabling us not to get lost, to experience the novel through the lens of the familiar and hence to develop a sense of feeling at home in the world. The study of typical situations in the built space has been a central contribution of Italian architects and urban researchers in the second half of the twentieth century. More than a century ago, the Austrian philosopher and founder of phenomenology Edmund Husserl applied the notion of type to denote a fundamental structuring element of human experience. Meanwhile, such related questions as the role of typification in human cognition and orientation have been underdeveloped within architecture and urban studies in general, and urban morphology in particular. The ability to recognise what kind of things are involved in any situation and to hold something new as an instance of a certain type is a fundamental human achievement that deserves to be focused on in urban morphology. As a newly formed team with a common interest in the interdisciplinary exchange between phenomenology and urban morphology, we aim to sharpen the understanding of the underlying notion of type as a fundamental structural property of the human lifeworld from two complementary viewpoints: architecture, urban morphology and heritage studies on the one hand, philosophy, phenomenology and research on experience and artefacts on the other. The paper presents the results of a workshop held at Husserl Archives Cologne in April 2024, which included a number of activities that enhanced the discussion on the role of typification in human experience and the studies of urban form. This question touches on fundamental, philosophical issues regarding the relationship between subject and object, and taking it seriously imposes a broader approach, including research on orientation, affordances, and memory.

Keywords: phenomenology, urban morphology, human experience, typification

INTRODUCTION

As a newly-formed team with a common interest in phenomenology, urban morphology and well-being, at our first workshop in Spring 2024 we sought to refine our understanding of the underlying

notion of type as a fundamental structural property of the human lifeworld from complementary perspectives: urban morphology, architecture and heritage studies on the one hand; philosophy, phenomenology, and research on experience and artefacts on the other. This complementary perspective on type and typical situations and the associated terms, concepts and topics was at the heart of this workshop. This paper begins with an examination of the core tenets of two foundational methods employed in this research: phenomenology and urban morphology. It delineates the formative inaugural event, presents the work process and discusses intermediate results. After that, it highlights the potential benefits of synergizing the two approaches and demonstrates how, starting from the exploration of type, we can go further. The paper concludes with a presentation of the main research areas that will be explored further, along with suggestions for future plans and perspectives.

METHOD

The tradition of urban form studies, or urban morphology, links architecture, urban history, planning and design through form, uniting a vast and growing community of researchers originally coming from such diverse disciplines as architecture, urban design, geography, history, anthropology, heritage studies and so on. The field encompasses several complementary approaches that are collaborating within the framework of the International Seminar on Urban Form (ISUF). One of them is rooted in the method of process-based typology founded by the Italian architect Saverio Muratori and has been further developed, among others, by Gianfranco Caniggia. It stands apart from other typological approaches in its emphasis on process and the history of the development of local urban palimpsests, which is particularly attuned to historical and cultural context. Another approach striving to link urban morphology to the phenomenology of human spatial perception is space syntax. This configurational approach to the study of urban form has been developed in the 1970s by Bill Hillier, Julienne Hanson and colleagues at the Bartlett, University College London. It examines the relationship between human behaviour and spatial configurations, comparing patterns of activity with patterns of space.

On the other side, phenomenology provides an understanding of the human experience of the world that is methodologically rigorous (Gallagher and Zahavi, 2012). In contrast to empirically-oriented disciplines, such as ethnology or psychology, it focuses on the structures of lived experience and shows (and reflects on) the ways in which things appear. The phenomenology of architecture (Seamon, 2023) offers comprehensive and in-depth investigations of the most fundamental concepts, terms and ideas in architecture – such as space and place (Casey, 2009; Malpas, 2018; Figal, 2020), dwelling, building and atmospheres (Bollnow, 2011; Böhme et al., 2014; Dodd, 2017), embodiment, environment and lifeworld (Harries, 1988; Seamon, 2018) as well as actions, perception and affordances (Rietveld and Brouwers, 2016). The experience of the lifeworld, or more precisely, of our home-world, is shaped by intentional attitudes including perception, movement, perspectivity, orientation, familiarity, historicity, and so forth (Dzwiza-Ohlsen, 2022). The concepts of typicality and habituality are profoundly relevant to urban morphology as they have a strong influence on how we perceive, interact with and inhabit our built environments.

The two-day event ‘Typical Situations’, held in Cologne, was an inter- and transdisciplinary workshop to foster the dialogue between urban morphology and philosophy. It took place at the Husserl Archives Cologne, and was collaboratively organised by Daria Belova, Thiemo Breyer, Sylvain Malfroy, Erik Norman Dzwiza-Ohlsen and Urs Primas. The workshop brought together participants from different research cultures and disciplines related to philosophy and architecture, such as

phenomenology, anthropology, enactivism, landscape architecture, urban planning and design, architectural history, and literature. The interests of the participants covered a wide range of topics and areas, including – but not limited to – phenomenology and philosophical anthropology; applied phenomenology with a focus on orientation, embodiment and ageing; phenomenology of architecture; architectural history; philosophy with a focus on metaphysics and ontology; affordances and landscape architecture; European avant-garde and architectural typology; terminology in morphology; phenomenological psychology; cognitive sciences; typological-processual as well as configurational approaches to urban morphology.

Table 1. The program of presentations of the workshop.

Day one: 12.04.2024 (11.00–19.00 CET)
11.00–11.45 Introduction of the speakers and the idea (Thiemo Breyer, Erik N. Dzwiza-Ohlsen, Sylvain Malfroy, Urs Primas and Daria Belova)
11.45–12.30 Sylvain Malfroy (Neuchâtel): "Situations: What They Do with Us and What We Do with Them. About Agency and Structural Tendencies"
12.30–13.15 Federico Vercellone (Torino): "Glossary of Morphology"
14.30–15.15 Erik N. Dzwiza-Ohlsen & Daria Belova (Cologne): "Bridging Phenomenology and Urban Morphology: The Case of Situational Typification"
15.15–16.00 Tina Röck (Dundee): "Types of Ideas and Essences – From Being to Becoming"
16.00–16.45 Irene Breuer (Wuppertal): "The Sublime Experience of Architectural Space Morphology"
16.45–17.30 Joint discussion with coffee on the way to Kolumba Museum
17.45–19.00 Guided architectural tour at Kolumba Museum
Day two: 13.04.2024 (10.00–18.00 CET)
10.00–10.30 Short introduction of the day
10.30–11.15 Julian Kiverstein & David Habets (Amsterdam): "Trusted Urban Places"
11.15–12.00 Penny Lewis (Dundee): "Arendt, the World and Architecture"
12.00–12.45 Urs Primas (Zurich): "On Typical Streets"
14.00–14.45 Luca Lanini (Pisa): "The Permanence of Type. Mies van der Rohe's Patio Houses"
14.45–15.30 Fabio Tommy Pellizzer (Venice): "The Interplay of Familiar and Unfamiliar"
15.30–16.15 Gabriella Cianciolo Cosentino (Cologne): "A-typical Situations"
16.30–19.00 Concluding discussion



Figure 1. The workshop team at "Kolumba". The Kolumba Museum in Cologne is an urban palimpsest that has been in perpetual renewal for some 2,000 years. It was converted into a space for contemplation after the Second World War by Gottfried Böhm and then in 2007 by Peter Zumthor. The varied atmospheres it provides for aesthetic experience interact with the artefacts on display in temporary exhibitions. Kolumba is a veritable laboratory for the phenomenological study of the experience of space. Photo credit: Associate of the Kolumba Museum.

RESULTS AND DISCUSSIONS

Overview

Thiemo Breyer, professor of philosophy and anthropology at the University of Cologne and director of the Husserl Archives Cologne, opened the workshop with an overview of the concepts of type and habit in Husserlian phenomenology: Our engagement with the world is not limited to isolated acts of consciousness. Rather, it is characterized by a continuous flow of habitual actions and practices structuring everyday experience. These habits are acquired through repeated engagement with the world and then become sedimented in our embodied being.

Federico Vercellone (University of Turin), co-editor with Salvatore Tedesco of a valuable Glossary of Morphology (2020), then looked at the roots of morphology. Johann Wolfgang von Goethe's process-based approach reads the evolution of form poetically, as an open-ended, non-deterministic process. His underlying idea of structural homologies between mind and nature might provide a way into an investigation of the relationships between human experience and urban form.

After these conceptual preliminaries, Sylvain Malfroy (retired at ZHAW Winterthur) addressed the typification of emerging situations. By way of example, he dissected the historical process that gave shape to the Tournay estate on the outskirts of Geneva currently undergoing a trend towards the fragmentation of land ownership and the disarticulation of its original functional structure. To characterise a part that cannot exist outside a relevant whole, Husserl had introduced the notion of 'moment', as opposed to 'piece'. Drawing on this distinction, Malfroy advocated an approach to changes of use and indices of constructability of land that is more attentive to the 'moments' that characterise each situation. In short, obsolete urban ensembles challenge us to make explicit the 'moments' and interdependent relationships that persist between different levels of scale: The politically crucial question is whether types of situations possess their own evidence, or whether they remain ultimately arbitrary.

Therefore, and according to the following presentation by Daria Belova, architect, and Erik Dzwiza-Ohlsen, philosopher (both researchers at the Husserl Archives Cologne), situational typification lies at a crucial intersection of materiality with human action, perception and affection. Both urban morphology and Husserlian phenomenology understand types in a dynamic way, involving processes of foundation, sedimentation and reactivation. Urban morphology does address the socio-cultural dimension of typical situations, albeit indirectly, through an investigation of invariant structures and typical processes underlying urban form. To this, the investigation of invariant structures of lived experience offered by phenomenology constitutes a fitting and necessary counterpart, especially when it comes to the persistent challenge of linking the individual-centred perspective of the micro-scale to the societal and institutional perspective of the macro-scale.

Then, the time had come to shake things up by exposing the audience to the backside of what we had been looking at so far. This vital role of philosophy was taken on by Tina Röck (University of Dundee, UK) by means of a summary of Martin Heidegger's critique of the Husserlian concepts of type and familiarity. Heidegger had been concerned by the ways in which immediate typification might prevent us from seeing what is actually present. Remaining within the comfort zone of the familiar, we all too easily limit ourselves to seeing how things surrounding us might serve our aims and needs. The related, crucial question of how to address the necessarily uncomfortable shift from a paradigm of

understanding to a paradigm of action and change kept occupying the participants during the remainder of the symposium.

The notion of the unfamiliar was also at the heart of the following contribution. Irene Breuer (Bergische Universität Wuppertal) introduced the aesthetic concept of the sublime: A bodily-felt emotion aroused by an excess of the sensual over the conceptual. While body and space are affectively intertwined, this co-belonging is characterized by conflicts, tensions and the suspension of meaning. Breuer exposed how contemporary architecture stages disruptive experiences by unsettling bodily habits and suspending institutionalized ways of reading space. In a fitting way, her contribution was followed up by a visit to the Kolumba complex, an urban palimpsest of some 2000 years of stratified urban artefacts, fascinating both from an architectural and morphological point of view, and as a phenomenological experience of atmospheres emerging from architectural interventions by Gottfried Böhm, in the 1940s and 1950s, and Peter Zumthor, in the 2000s.

The next day started with the introduction of a concept that might turn out crucial to our understanding of the interplay between typical urban situations and human habits: basic trust. Referring to the notion of affective scaffolds in psychology, Julian Kiverstein (University of Amsterdam) and David Habets (Amsterdam Medical Center) showed how people habitually draw upon environmental resources to sustain, amplify or dampen affective states. In this way, habits may be understood as nested in places. The city turns into a constellation of “trusted places” that are visited because of the effects they have on our bodies. It becomes clear that these places are not “outside” of us: Rather, our very existence is rooted in them.

Drawing on the work of Hannah Arendt, Penny Lewis (University of Dundee) singled out yet another perspective to the unfolding debate. Arendt’s work revolves around a central aspect of the human condition: we exist alongside each other, in plural. Therefore, the question of how we appear to each other takes centre stage. Arendt introduced a strong distinction between the twilight of the private realm – where one is concerned with one’s own life and well-being and that of friends and family – and the bright light of the public stage in which people take action concerning the affairs of the world. Obviously, this distinction is intimately related to formal properties of urban and architectural space facilitating mutual presence and visibility, but also withdrawal and seclusion.

Interestingly, there is one strand of urban morphology that explicitly addresses urban space in terms of relationships of visibility and movement. Urs Primas (ZHAW Winterthur) introduced the configurational approach of space syntax to investigate situational types of a central stage of public life: the urban street. Such a differentiation of street types according to their situation within a network can then be linked to the evolutionary typification of streets according to the processes of their formation that had been introduced in urban morphology by Gianfranco Caniggia and Gian-Luigi Maffei.

Turning the page from mutual visibility to seclusion, Luca Lanini (Università di Pisa) then focused on a crucial episode of modern architectural history by exploring the permanence of type in Mies van der Rohe’s patio house projects. While referring to the ubiquitous tradition of enclosing a place embodied by the Graeco-Roman patio house, Mies seems to attempt a cancelling of traditional domestic ideas as well as of any contextual middle-ground relating the house to its urban environment and to nature,

apparently liberating the destiny of the house and its owner from the rest of the world and from any constraints of social life.

Fabio Tommy Pellizzer (University of Cologne, Husserl Archives) then succeeded in the unlikely task of providing a preliminary synthesis of many topics that had been touched on before. Focusing on the interplay of the familiar and the unfamiliar, he started out with a discussion of the entanglement of generality and salience to move on to highlight the temporal constitution of typicality and sedimented meaning along the notions of perceiving, remembering, and expecting. Crucially, according to him, patterns of familiarity are embodied in artefacts – we never start from scratch. This leads to another important concept that needs to be added to the toolbox linking phenomenology and urban morphology: affordances. Affordances are understood as refractions of possibilities: what things have been for me, for others, and what they might or will afford.

Finally, Gabriella Cianciolo Cosentino (University of Cologne) closed the rich panoply of viewpoints with a surprising and unsettling take on the subject. She presented the results of a four-year research project investigating the transformation of prison spaces from different eras through graffiti. The marking of prison spaces with personal, devotional or political inscriptions is an age-old and recurring habit, possibly contributing to some sort of familiarity and feeling at home in a hostile environment designed to control both body and mind.

Perspectives

The workshop identified a range of bridging terminologies as well as several areas of common interest between participants that may facilitate synergies between disciplines. These areas should be further developed. On the one hand, the clarification of typomorphological concepts such as type, process, spontaneous consciousness or territory along insights from Husserlian philosophy may extend the pertinence of morphological concepts and methods beyond the study of physical urban form and lead the way towards a more comprehensive understanding of physical urban form as interlocking with social or cultural form. On the other hand, phenomenological approaches that are recently gaining traction in various areas of social or medical sciences are likely to benefit from the body of knowledge on the spatial structure and the temporal evolution of urban environments that has been accumulated within urban morphology.

A cross-examination of the notion of type both in phenomenology and in urban morphology promises to open new perspectives to both fields. In Husserlian phenomenology, the concept of “typification” refers to anticipations arising when we recognize beings, things or even situations. We tend to expect them to be alike to a certain type of beings, things or situations we are already familiar with. As these anticipations are strengthened or weakened depending on the way they are confirmed or disconfirmed by experience, typification is strongly related to habituality. Urban morphology, on the other hand, generally understands types as invariants underlying the spatial organization of artefacts such as buildings, urban fabrics or territorial structures.

But how do types emerge, and how do they change in time? And how can we build environments that connect different people by means of types? Regarding these questions, Husserl proposes the notion of generativity, referring both to the process of “generation” and to a process that occurs over the “generations” (Steinbock, 1995, 55). Some approaches to urban morphology have already attempted to go beyond the mere empirical observation and classification of types by postulating mental, social

or cultural “templates” (Deetz, 1967, 45) underlying their generation. For instance, Muratori conjectured that each development phase in the emergence of territorial structures goes along with a unique way of translating topographical features into “image concepts”. In his view, these invisible “mental labels” can be reconstructed through an analysis of regularities in landscapes reshaped by human activity (Muratori, 1967, 216). When it comes to the spatial-structural configuration of buildings, such regularities have been termed “a posteriori types” by Muratori and his followers, implying the presence of “a priori types” underlying their formation (Caniggia and Maffei, 1979, 49).

In an entirely different context, questioning the emergence of stable, socio-spatial patterns, space syntax pioneers Julienne Hanson and Bill Hillier have interpreted observable, “social-functional phenotypes”, such as typical floor plans or urban street network configurations, as indicators of underlying ordering principles, which they refer to as “social-functional genotypes” (Hillier and Hanson, 1984, 38). Regarding the further investigation and development of such conjectures, the phenomenological concept of generativity might prove crucial.

As far as the study of part-whole relationships is concerned, which is required to deepen our understanding of the city both as an “urban fabric” and as a “large-scale composition”, the conceptual pair moment/piece theorised by Husserlian philosophy is very enlightening (Smith et al., 1982; Malfroy, 2014). Muratori had already drawn our attention to this when he proposed a method for measuring the ‘degrees of organicity’ that qualifies an assembly of parts. In Husserl’s Logical Investigations, the “moment” is a property of a whole that cannot be detached (except by a process of abstraction). For example, in the case of a landscape garden, the typological character of “being landscaped” (rather than “being a kitchen garden”) cannot be isolated from the garden, but can only be verified as a “moment” concretised in the choice of planting, in the determination of the garden’s extent, in the layout of paths, in the treatment of boundaries and transition zones, and so on.

The possible and desirable convergence between the morphology of built forms, the management of historical heritage and phenomenology becomes immediately apparent when we ask ourselves whether a “composite object” can survive the loss of a “moment” as well as the loss of a “piece”. This question is generally treated under the heading of the “conditions of persistence” of artefacts (Haslanger, 2006). If we halve the area that embodies the ‘landscape moment’ of a garden, we destroy it more surely than if we remove a fountain, a bench or an arbour that are “pieces” of it. In other words, the existence of things of a certain type is entirely based on certain “moments”, whereas the detachable parts, i.e., the material parts of it, can be largely interchangeable. But a symmetrical issue to that of the conditions of persistence concerns the ‘conditions of emergence of artefacts of a new type’ (De Monticelli, 2008). Indeed, it may be that when an object of a certain type (for example, an aristocratic country manor) is deprived of its constituent moments (for example, its pleasure grounds) and thus ceases to exist as such, objects of another type take its place (for example, a hospital or a tourist hotel). The question then arises as to whether there is a rationally elucidable genetic chain linking the initial type of manor house to the successive types of hospital or tourist hotel. In other words, was it more probable that one transformation would occur than another? Husserlian phenomenology is driven by a realist aim, and it endeavours to show that the substratum of our actions is not an inert, passive reality, but a structured reality with which we can collaborate more or less intelligently.

Affordances provide another crucial notion to be included in the toolbox linking phenomenology to urban morphology. James J. Gibson (1904 - 1979), a pioneer of ecological psychology, coined the noun "affordance" from the verb "to afford" to capture how the environment provides opportunities for action (Gibson, 1977, 1979). According to him, affordances describe a relationship between the abilities of an organism and the environmental features of a situation (Marcus et al., 2016). Gibson argued that when we perceive a situation, we observe its affordances rather than its particular qualities. This viewpoint is of central importance to morphological analysis: While it is possible to objectively describe the physical properties of urban form, such a description would be of little use if it would not consider the activities, behaviours and uses that these physical features afford. Therefore, we may understand affordances as refractions of possibilities, thereby going beyond the physical layer of form.

For instance, the discussion on prisons as highly typified architectural environments paradoxically generating extremely unfamiliar situations prompted a consideration of the role of boundaries and limits as affordances. An important role of graffiti in prisons is to transcend the boundaries, to expand the physical and mental boundaries of the enclosed space. Furthermore, graffiti serves the function of an immaterial wall – a protection from demons and a sign of belonging to the group. Therefore, it has a dual function of transcending existing boundaries and creating new ones. Thus, affordances can manifest in different dimensions and belong to different layers of existence, ranging from the physical to the mental or spiritual. This leads to the question of material and immaterial forms and their interrelation. How can immaterial form transcend or alter the limits of physical form?

The phenomenological understanding of architectural and urban experiences involves the typicality of the senses (Merleau Ponty, 1945) as a fundamental aspect. There is a "typological" character of multimodal perception based on the stability of intersensory relations. The body is a coherent sensory organ, organizing smell, taste, vision, and touch around a "milieu" of action; it establishes types of intersensory relations and equivalences that give depth and richness to what we perceive. Typicality, therefore, may be conceived as an "echo" of one sense into another, an echo that resonates in different sensory fields and reverberates in different segments of experience. This typicality of senses, along with the concept of synaesthesia – a condition in which stimulation of one sensory field correspond to the experiences in the other sensory field, should be considered in the projects of enhancement of built environments, especially when aiming at well-being for different generations.

The phenomenological concept of embodiment provides a complementary to studies of physical form and can be another one of the bridges connecting phenomenology and urban morphology. Embodied habits are of particular interest for the question of how to shape familiar living environments. Embodied habits are discussed as an important resource of personal identity, particularly in the context of dementia, and the potential of dementia-sensitive living space design, especially in urban areas, is by no means exhausted (Dzwiza-Ohlsen, 2022). Additionally, the method of space syntax implies typification and categorisation (Hillier et al. 1984) and relates patterns of activities to the patterns of space. Patterns of space generate potentials for vision and movement, thereby facilitating the allocation of density, shops or transport stops – the patterns of activities. Therefore, the principles of orientation and movement highlighted in phenomenology and the notion of embodied cognition can further enrich the methodological insights of space syntax.

Patterns of familiarity are embodied in urban artefacts – we never start from scratch. The bodily-conferred principle of gradual, consistent and continuous space formation, based on traditional bodily habits, advocates a natural integrity of architectural forms and can be related to the typological process. From a joined phenomenological and architectural perspective, the historical, continuously formed city can be seen as a constellation of trusted urban places, which affect our bodies in a certain way, fostering basic trust. Such places deserve careful morphological study, they organise our affective experiences and give form to feelings: This is where congruent social, emotional and urban forms emerge. The concepts of nesting and sedimentation are of particular interest here: One might think of habits in terms of nesting. When habits become embedded in the body, sedimented or incorporated, we begin to experience the world through that habit. Typical places and situations are therefore incorporated, we orient ourselves by habits. It would be interesting to link the concepts of trusted urban place and basic trust with Caniggian process-based typology, particularly with gradual typification processes. This may allow to define environments that have formed through the spontaneous adding of innovations to traditional types and instances as potentially familiar and trusted.

Finally, as Thiemo Breyer has put it, through the lens of phenomenology we aim to discern the underlying structure of perception and cognition that gives rise to our understanding of the typicality of diverse urban landscapes. Combining phenomenology and urban morphology allows us to go further. The innovative potential of the framing of this workshop lay in the investigation of the complex interplay between human experience, urban environment and the nature of typical situations, focusing on how they shape our lived experience and define well-being in urban environments. Types allow for the emergence of legible and coherent urban environments, contributing to the formation of recognisable urban identities and fostering a sense of place and belonging. Habitual patterns of use and behaviour also play a crucial role in sharpening the usability of architectural spaces. Buildings contain elements that facilitate and support habitual activities, such as intuitive wayfinding systems and efficient circulation patterns. The concept of habit extends to the wider urban context, where the layout and configuration of streets and neighbourhoods influence daily routines and the relationship between rationality and experience. By aligning architectural design with habitual behaviour and routine, architects and urban designers may enhance the user's experience of the built environment.

CONCLUSIONS

The workshop identified a range of terminologies that require clarification and several areas of common interest among the participants that can facilitate the integration of disciplines and methodologies. Generally, a productive connectivity of (Husserlian) phenomenology, enactivism and anthropology with morphological methods such as the typological-processual or space syntax approaches can be established through the concepts of embodiment, familiarity, horizon, habit, and lifeworld.

We aim to develop research with the overarching objective of fostering inter- and transdisciplinary dialogue. Our goal is to identify methodologies for shaping urban environments in a manner conducive to enhancing the quality of life, well-being and to multi- and transgenerational transfers of meaning. We will facilitate the dialogue on the transformation of the meaning of place in time, with a view to

forming intergenerational environments for the present and future that are respectful of well-being. ‘Typical situations’ is an accepted umbrella term for our future collaborations.

The future plans of the team include, but are not limited to, several components aimed at exploring and refining key concepts and methodologies, such as a journal special issue and a glossary. To further promote dialogue and expand the group a wide variety of potential academic events is intended, such as workshops, conferences, open lecture series, art schools, design studios, and summer schools, for example on the topic of ‘intergenerational environments and meaning transfer’.



Figure 2. The workshop team, photo in front of the Husserl Archives Cologne. Photo credit: Daniel Galliano.

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Creating age-friendly public spaces in high heat vulnerable areas: the engagement of a spatial-morphological tool

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ABSTRACT

The disruptions in urban spaces and the population's quality of life caused by climate change phenomena urge a holistic interpretation. The funded research project CLIMATE ADAPTATION FOR OLDER PEOPLE LIVING IN VULNERABLE URBAN AREAS (CAOP, PTDC/GES-URB/2038/2021) aims to provide a Handbook for a Climate-Responsive and Community-Based Urban Planning/Design to deal with the effects of heat stress on health/quality of life through the development of a climate-sensitive and community-based urban planning and design methodology. Within the scope of a broader multidisciplinary team consisting of climate-change, health, and urban planning experts, the Faculty of Architecture (FAUP) researchers investigated the morphological and socio-urban conditions of two vulnerable urban areas located in the eastern part of Porto City, Portugal – the São Roque housing neighbourhood (1930s) and the social neighbourhood (1960s construction) and São Roque da Lameira Street (an ancient street). Consequently, an evaluation methodology was developed by this team to explore the spatial dimension of the vulnerability concept, recognising the role of public space in promoting inclusive, resilient, and sustainable communities with direct benefits for the well-being of older people. This paper primarily discusses the application of a methodology based on the “proxy attributes” of urban form and an understanding of older populations' practices and perspectives. Using morphological, ethnographic, and co-creation methodologies, it explicitly analyses the urban form's configurational and geometrical properties of the public spaces that promote healthier cities, and the public space uses and preferences of older residents. The findings suggest that some public space attributes can be considered for urban retrofitting measures by testing a tool to evaluate the relationship between urban spaces' spatial configuration with different thermal conditions and older populations' perceptions. These adaptive attributes are believed to safeguard the inhabitants during extreme heat events. Finally, the evidence presented in this paper shows that by exploring the potential of particular public space attributes design decisions can be better informed. Additionally, CAOP's multidisciplinary approach highlights the pressing importance of a comprehensive framework to support sustainable urban strategy development based on the multidimensional analysis of socio-morphological, microclimatic, and health issues.

Keywords: heat stress, older people, public spaces, urban form, healthy cities

INTRODUCTION

Nowadays, the climate adaptation issue is a cross-cutting challenge that presupposes developing an adjustment process to respond to actual and expected climate change and its effects (IPCC, 2014), particularly those of global warming. According to the IPCC (2023), warming will cause predictable increases in multiple climate hazards and present a variety of risks to ecosystems and human beings. The risks and dangers will be felt unevenly across different urban environments, according to their frequency and intensity. Against this background, adaptation measures are expected to protect the health and well-being of communities and the social fabric of public spaces (streets, squares, green and open spaces) (Foshag et al., 2020). Urban areas are more exposed and susceptible to the effects of climate change related to heat waves and extreme heat events, among others. Recognising the importance of this issue, the research project "CLIMATE ADAPTATION FOR OLDER PEOPLE LIVING IN VULNERABLE URBAN AREAS (CAOP). Designing a climate-responsive and community-based methodology" [PTDC/GES-URB/2038/2021] brings together a multidisciplinary group of researchers from the University of Porto and the University of Coimbra, supported by an international team of experts, in the pursuit of a plan that will contribute to mitigating and adapting to extreme temperatures.

The research project analyses two vulnerable urban areas – the São Roque da Lameira neighbourhood and the street of the same name in Porto, Portugal, considering that these study areas are at high risk of extreme temperatures in summer. A significant trend has been noted towards an increase in the number of days with very high temperatures (≥35°C) and tropical nights with high minimum temperatures of over 20°C, as well as in the annual rate of heat waves. Additionally, cold days and nights and the number of cold waves have decreased (CMP, 2018). In view of these changes, the CAOP focuses on investigating the impacts of extreme heat temperatures as, according to projections, their frequency is likely to increase. The CAOP research project seeks to ascertain the socio and spatial conditions that influence the adaptation capacity of the urban system to extreme heat and thus contribute to the thermal comfort and well-being of the people, particularly the elderly population. More specifically, it proposes (1) to analyse the morphological and socio-urban conditions of the selected areas, (2) to understand the practices, perspectives, and representations of older populations regarding these urban spaces, and (3) to create and evaluate a collaborative and integrative urban planning/design methodology.

The CAOP's multidisciplinary and holistic framework rests on a qualitative and quantitative approach to public spaces, along with studies, co-creation, and the participation of older people, with the ultimate goal of creating a Climate-Responsive and Community-Based Urban Planning/Design Manual. It is foreseen that this manual will assist the actions of local stakeholders with powers and functions in urban planning (municipalities, parish councils, companies, organisations, associations, and universities). Thus, the main goal of this paper is to present a proposal methodology consisting of a spatial-morphological analysis, thereby contributing to promoting age-friendly public spaces and the health and well-being of older people in the context of climate change. Facing the heat stress phenomenon, the analysis of the "proxy" attributes (an indirect measure of the desired outcomes, e.g. diversity, connectivity) (Feliciotti, Romice and Porta, 2016) of the public spaces, the observations of the physical characteristics and activities in the latter, and the co-creation process integrated into CAOP's methodology have enabled a more comprehensive understanding of the extreme heat

impacts. In turn, the socio-morphological perspective assesses how urban environments' social and physical structures interact to influence vulnerability to heat stress, i.e., exposure, sensitivity, and adaptability. Socio-economic factors with spatial and morphological characteristics are integrated into this approach to identify at-risk areas and populations and develop holistic mitigation and adaptation strategies.

More specifically, in CAOP's multidisciplinary framework, this line of approach, led by the Faculty of Architecture of the University of Porto (FAUP), proposes to address how urban form can minimise the impact of climate stress and to develop methods to assess the adaptability of form to climate impacts. To this end, selected configurational and geometrical properties will be operationalised using quantitative indicators and defined public space attributes will be qualitatively analysed using local observations, participatory sessions with older residents, and interview forms. This paper presents a holistic method of socio-spatial analysis that incorporates qualitative and quantitative approaches and focuses on evaluating the attributes of the urban form of two selected vulnerable areas, as well as the observations of the functional use and structure of their green/open spaces. The first section delves into framing the concept of vulnerability, users' vulnerability, and exposure in public spaces, which supports the theoretical approach to the spatial-morphological framework of public space adaptation to heat stress described in the second section (methodology). Section three (results) presents the application of the methodology with the operationalisation of the urban form attributes and the observation of their public space's characteristics and users' interactions in public spaces. Lastly, section four (conclusions) suggests possible guidelines to promote a more age-friendly public space by reducing exposure to high levels of heat.

Users' vulnerability, exposure in public spaces and adaptation strategies to heat stress

In this study, the analysis of the impact of high temperatures on public spaces focuses on users' vulnerability. The concept of vulnerability has been interpreted differently over time, however the CAOP project has adopted the idea proposed by the Intergovernmental Panel on Climate Change (IPCC) in its Third Assessment Report (TAR/AR3) (IPCC, 2001: 388). This interpretation understands vulnerability as the degree to which a system is susceptible to and unable to cope with the effects of climate change, including climate variability and extremes, which depends on the character, magnitude, and rate of climate change, the variation to which a system is exposed, and its sensitivity and adaptive capacity. Exposure refers to the contact between individuals and indoor or outdoor environments where environmental conditions, including air temperature, radiation load, atmospheric humidity and air speed represent a risk of increasing core body temperature or causing discomfort (IPCC, 2001: 373). Sensitivity, a property that determines the degree to which a system is affected (beneficially or adversely) by a given climate exposure is based on individuals' physiological state or behavioural response to changes in environmental temperatures. Adaptability is, therefore, a property that reflects the capacity or ability of a system, in this case, an urban system, to prepare for and respond to climate change, considering the continuous increase in greenhouse gas emissions.

Hence, when assessing the impacts of climatic phenomena, decreasing the vulnerability of older people to urban heat stress and promoting user-friendly urban public spaces involves considering parameters linked to exposure, sensitivity and the adaptive capacity of systems, i.e. (1) indicators related to climate variability; (2) indicators relating to the demographic, socio-economic profile that inform about the impact of extreme temperatures on human health and economic activities

(percentage of population exposed to several days of extreme heat) and (3) indicators related to the physical environment's capacity for adaptive change. In CAOP's research, the sociodemographic health profile indicators are related to particularly vulnerable groups, such as older people. According to the World Health Organization (WHO), older people are particularly vulnerable groups because of their physical and economic condition, and they are also susceptible to the outside temperatures in extreme heat (WHO, 2021). Works such as IPCC (2021) and Figueiredo, Midão et al. (2024) explain the direct correlation between high temperatures and the health problems experienced by this fringe of the population.

Creating attractive urban green and open spaces can help with this control. Public health needs to provide green spaces that encourage older people to be active while equally allowing for social interaction. For example, Owen et al. (2010) have shown that physical activity improves cardiovascular health, mental health, neurocognitive development, and well-being. Along with the quality of the green/open spaces, the quality of facilities and the outdoor thermal environment have an essential influence on the frequency and activities of residents in open spaces. Moreover, regarding the different outdoor thermal perceptions of older people, various authors (Yung et al., 2019) argue that they depend not only on physiological elements, but also on physical and individual factors (age, biological sex, education, economic level, and chronic illness). In this regard, studies such as that of Ma et al. (2021) highlight the importance of exploring the relationship between a number of influencing factors (age and chronic disease) and the thermal perceptions of older people.

Following this line of reasoning, CAOP's methodology incorporates the development of a socio-morphological approach, targeting identified areas within the urban environment that are more susceptible to high temperatures and the effects of heat waves. This approach is based on site-specific observations, questionnaire surveys and activity logs to investigate older people's spatial-temporal distributions and thermal perceptions (i.e., thermal sensation, thermal comfort, and thermal acceptability). At the same time, the configurational properties of public spaces are quantified to establish a correlation between the qualitative and quantitative analyses. The sensitivity of public spaces to extreme heat conditions depends on their physical, environmental, and sociocultural characteristics, and their adaptability and coping depend on their accessibility and inclusiveness. These characteristics affect thermal comfort within these spaces and the people using them (Quesada-Ganuza et al., 2023). Thus, in CAOP's research context, the socio-morphological approach is based on the analysis of "proxy" attributes directly related to promoting older adults' health and well-being through age-friendly public spaces in vulnerable areas: proximity, porosity, diversity, accessibility, centrality, and redundancy. For example, the analysis focuses on whether older people have access to age-appropriate health and recreational facilities close to their homes. The following section proposes a holistic methodology supported by different analysis tools for the varying scales of the case studies. This analysis aims to be used as a critical and comprehensive framing of the concept of users' vulnerability, exposure in public spaces, and adaptation strategies to heat stress.

METHOD

The proposed method aims to evaluate socio and morphological vulnerability, to select small typo-morphological units of the São Roque da Lameira study area located in the Campanhã parish of Porto and, according to this assessment, analyse their public spaces in detail, combining spatial analysis with the observations recorded by the FAUP research team and with the community of users, namely the

older residents. The parish of Campanhã, on the eastern side of the municipality of Porto, combines a higher concentration of older adults and municipal housing neighbourhoods, having recently been defined as an Urban Rehabilitation Area (ARU) to strategically promote its improvement (CMP, 2018). Additionally, this area is the hottest part of Porto: on days with this synoptic situation, the axis between Praça das Flores and São Roque is identified as a "thermal peak" (Monteiro, 1993). Within this broader heat concentration zone, although the urbanised areas such as São Roque da Lameira are in locations with slightly lower sun exposure, they present specific sociodemographic characteristics that increase their social vulnerability: In 2011, São Roque da Lameira ranked higher on the Ageing Index than other surrounding areas and also displayed the second highest Ageing Rate figure (257,3 %). As for the Dependency Ratio, calculated as the ratio between the dependent population (residents in the 0-14 and ≥ 65 age groups) and the active population (residents of working age), the São Roque area stands out negatively, with around 70 dependent people for every 100 working-age people. In population terms, São Roque emerges as the oldest area within the ARU, with 29.6% of its residents aged 65 years or over. At the same time, the rate of children (up to and including the age of 14) of its total resident population is also lower (11.5%) (CMP, 2018). This socio-dynamic continued until 2013, when such social neighbourhoods contributed to the high figures of the Ageing Rate and Dependency Ratio of the São Roque Area, approximately 304,4 % and 44,31%, respectively. Therefore, combining these climate and sociodemographic characteristics, two study areas were selected: São Roque da Lameira Street (an important and busy axis in this part of the city) and the São Roque da Lameira neighbourhood (a residential area with public housing blocks and private semi-detached houses) (Figure 1).

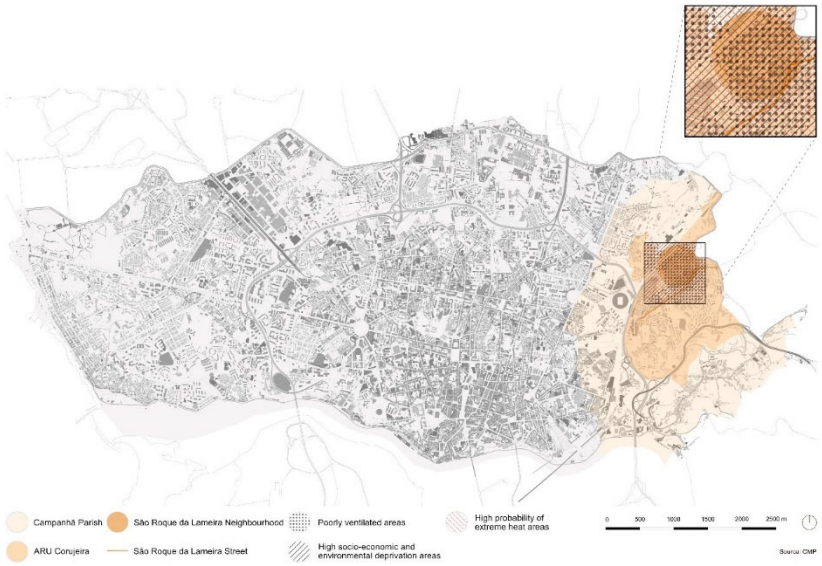

Figure 1. The study area: São Roque da Lameira climatic condition and the location of the study areas (street and neighbourhood). Porto: authors 2024, using municipal cartography.

The public spaces of the neighbourhood and street of São Roque da Lameira are heterogeneous as far as public space attributes are concerned. Both are indicative of the morphological and spatial diversity of the area (Figure 2). The neighbourhood presents a homogeneity of uses, pedestrianisation of the street network, and no maintenance of the public spaces, while the street displays a diversity of uses and disabled pedestrian paths. Acknowledging these neighbourhood characteristics, the study adopts

a multidimensional method comprised of several tools and tasks that seek to assess various aspects of the public space on different scales and from complementary perspectives. Therefore, the methodology includes a broader quantitative dimension and a local qualitative analysis.

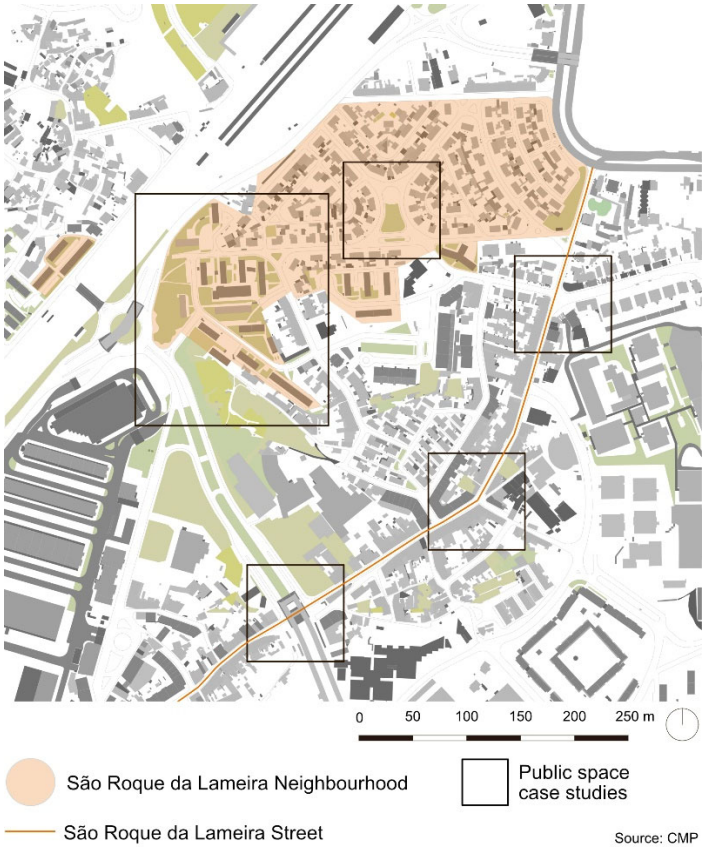

Figure 2. São Roque da Lameira case studies – public spaces of São Roque da Lameira neighbourhood and street. Porto: authors 2024, using municipal cartography.

As regards the quantitative dimension, the methodology is based on the analysis undertaken and tested by Monteiro and Pinho (2020), focusing on morphological units in the same geographical context (Porto). The adaptation of this method by the FAUP team to the CAOP project is explained in detail in a previous paper (Lameira, Fernandes, Ramos and Martins, 2024). It consists of the initial procedure of delimiting and characterising the morphological units and identifying the typological process for each. After defining the typo-morphological units, the physical and functional vulnerability analysis is conducted, evaluating the correlations between the urban form's configurational and structural characteristics of the different typo-morphologies and the classification of the typo-morphological units. It explores the physical and functional dimensions of vulnerability, which implies an intrinsic relationship with the social dimension. Firstly, physical vulnerability is evaluated based on the street system in order to gauge the degree of accessibility, centrality, and spatial redundancy of the units under study. Public spaces/green infrastructure (streets, squares, green spaces) are also subject to analysis, associated with proximity, porosity, and diversity. Secondly, functional vulnerability focused on the activities carried out in each typology is evaluated according to public service facilities, among other criteria - indicators such as the availability of primary and secondary activities.

In the qualitative approach of the next step, it is essential to coordinate the evaluation of the "proxy" attributes of the public spaces with the attributes ascertainable through observation of the materials, use of green spaces, presence of trees, and perceptions of the residents, mainly the older dwellers. This complementary study uses a qualitative, multiple-case approach to make the diagnosis. Empirical data, consisting of a participatory workshop, observations, a survey form, and informal conversations, were undertaken by the FAUP group of researchers and are currently being analysed. Walk-along interviews with users will also be undertaken in the near future as part of the ongoing process.

On the one hand, the participatory workshop brought together inhabitants, researchers, and representatives from local associations and the municipality in a working session to collectively map routines in the public spaces in this area and obstacles to a more comfortable usage. At this point, the aim was to gather data on dimensions associated with use and users, accessibility, amenities, urban furniture and artificial elements, comfort, safety, the image of the space, the environment, and social interaction, as well as to identify potential and co-create proposals for improvements. On the other hand, the observations were conducted systematically, mapping the public life and dynamics of the spaces in the neighbourhood and street, moving within the space to gather more information and different perspectives. These observations were undertaken in the case studies' major public areas (five squares in the neighbourhood and three crossings/squares in the street) on several summer days in August 2024. Late mornings and evenings of weekdays and weekends were the chosen periods. Each observation had a duration of 30 minutes, noting the people spending time in spaces (their activities and characteristics) and the passers-by (their trajectories and profiles), as well as the attributes of the space and their use (bus stops, benches, shade, trees, among other features).

A survey form was also used to collect georeferenced information on the location and conservation of urban furniture and green spaces, among other parameters. The development of this step is intended to generate a diagnostic report of the public spaces in the neighbourhood and street of São Roque, assessing not only the degree of friendliness but also the strengths and weaknesses of each area according to the older people's perceptions, as well as proposing actions for improvement. These actions can be applied in cases with similar vulnerabilities identified in the study area. This prospective diagnosis will be accomplished with informal conversations, where some older users may identify their choices, sense of belonging and well-being, sense of comfort and safety, their perception of the state of repair of the public space, well-being in hot and windy weather, accessibility, amenities, furniture, and urban equipment, in addition to their ideas and suggestions.

This collected and evaluated information will enable proposals to be drawn up with different levels of implementation which, together with the proposed methodology for the socio-morphological analysis, constitute the starting point for the preparation of the Measures and guidelines of the Climate-Responsive and Community-Based Urban Planning/Design Manual, the final output of the CAOP research project. Therefore, these qualitative and quantitative analyses are intended to classify types of urban form, relating the characteristics of form that support the resilience of the environmental, social, and health dimensions with the same stress.

RESULTS AND DISCUSSIONS

This section presents the preliminary results of the methodology and its different tasks. As previously stated, the analysis focuses on the operationalisation of the vulnerability concept in an urban system

- São Roque da Lameira area, relating to social, health and physical conditions, and systemic interaction, exploring the spatial dimension of vulnerability. With a previous morphological analysis, it was possible to identify different morphological units that emphasise the diversity of the São Roque urban area: continuous frontage (UM1), discontinuous frontage (UM2), fragmentation (UM3), exceptional (UM4) and rural nuclei (UM5) –, as can be seen in Figure 3. The preliminary results will then be presented, expressed in maps on factors related to urban form measures with a potential impact on the social interaction and health of the older people in this area. The study focused on the UM1, corresponding to São Roque da Lameira Street and the UM2-UM3, to the neighbourhood, since they are both predominantly residential areas within a compact tissue. However, the analysis will be conducted locally, given the nature of the spatial analysis parameters.

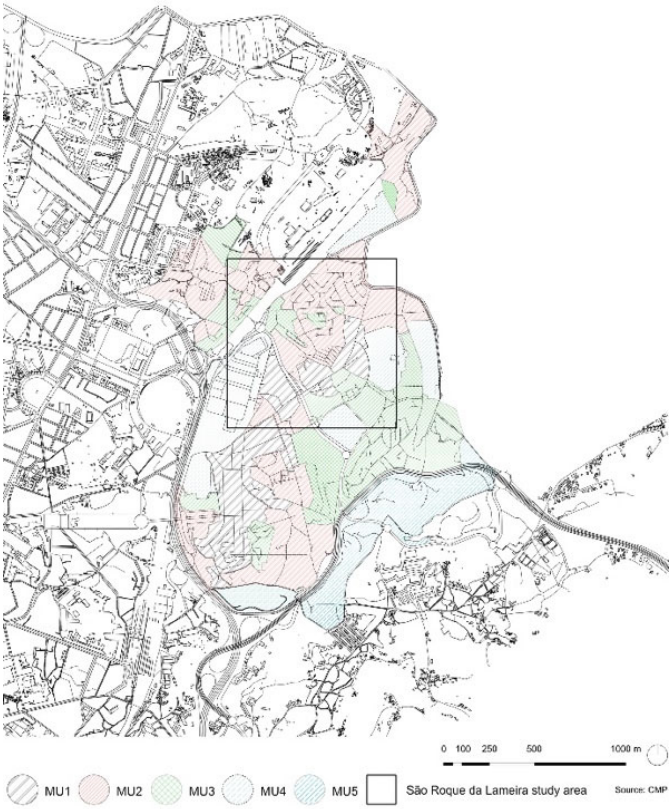

Figure 3. Preliminary identification of morphological units. Porto: authors 2024, using municipal cartography.

The factors mentioned above are related to (1) the measurement of the distance from different parts of the neighbourhood to key nodes along São Roque da Lameira Street, such as transportation hubs, commercial centres, and other activity points; (2) the measurement of the proximity of the neighbourhood to the nearest bus stations, an essential factor for public transit accessibility; (3) the assessment of the accessibility of essential indoor services, such as pharmacies and community centres for residents, (4) the evaluation of the amount of green space within the neighbourhood that is accessible to residents, especially considering factors such as proximity, slope, and pathways; and finally; (5) the evaluation of the slope gradient within the neighbourhood to assess accessibility challenges, especially for older adults or people with mobility impairments.

To measure these indicators, a walkable area was defined, i.e. starting from the central point of the São Roque neighbourhood (Origin Point, Figure 4), we established a 5, 10, or 15-minute walking, referring to accessibility to essential services, amenities, or infrastructure. Figure 4 illustrates the

covered area by the resident population over 65, considering a pre-determinate walking speed (V=0.8 m/s, CML, 2013; Alves et al., 2020), using the data obtained by Qqis Network Analysis. Within the walkable area of the São Roque da Lameira neighbourhood, access varies to green spaces, bus stops, facilities and the São Roque da Lameira street nodes (Figure 4).

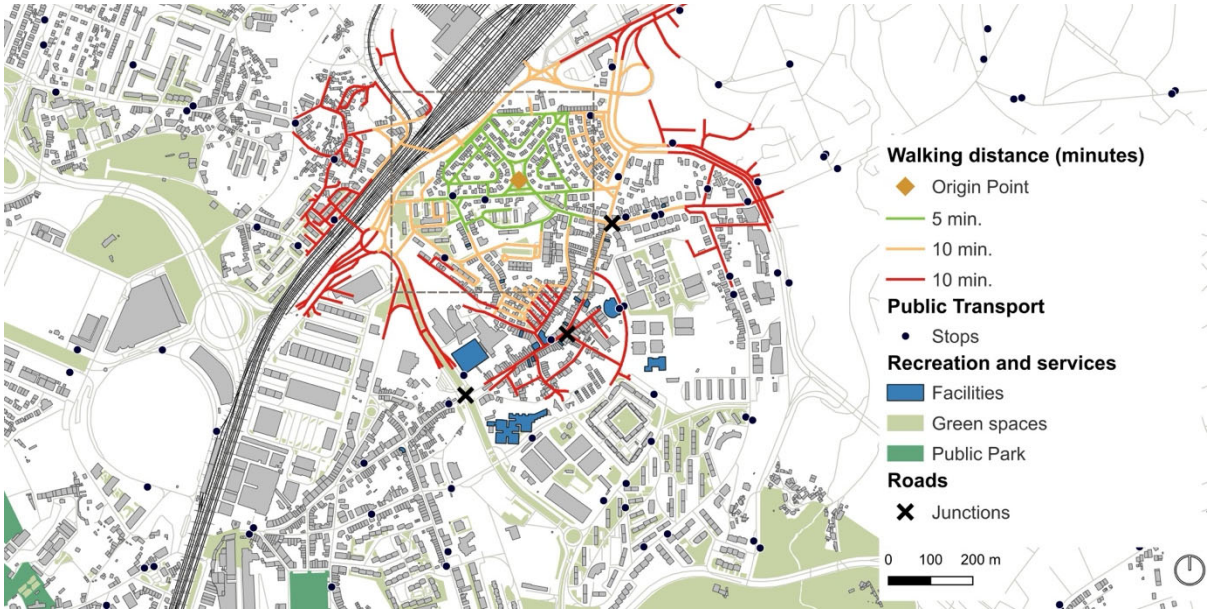

Figure 4. Walkable paths in the São Roque da Lameira neighbourhood. The characteristics of the pedestrian network and the characteristics of individuals influence the speed at which individuals travel and, consequently, the time taken to access a given point. As the characteristics of individuals influence speed, the circulation speed for adults with restricted mobility, such as the older population, was considered V=0.8 m/s (CML, 2013; Alves et al., 2020); São Roque da Lameira neighbourhood accessibility to a) São Roque da Lameira street nodes: central points of activity, transportation, or commercial hubs; b) public transport: bus stops; c) social facilities: pharmacy, social centre, healthcare centres, grocery store, bakery, butcher, supermarket, coffee shop, church. Porto: authors 2024, using municipal cartography and data obtained by Qqis Network Analysis.

The following observations were garnered on the afore mentioned parameters**.** Firstly**,** the distance between the São Roque da Lameira neighbourhood and the main São Roque da Lameira street nodes, central points of activity, transportation, and commercial hubs is a critical factor in urban planning, influencing both the quality of life for residents and the vibrancy of the area. Within a 10-minute walking distance, the older residents of the São Roque neighbourhood have access to one central node, with an additional 5 minutes needed to reach another junction. Upon analysing the access coverage and the distance from the São Roque da Lameira neighbourhood to nearby bus stops, we concluded that within a 5-minute walk, the older residents can only reach two bus stops, and within 10 minutes, they can reach four additional stops. While there is a relatively dense and comprehensive public transport network, physical barriers and the poor condition of pavements observed on-site reduce adequate accessibility. Furthermore, when evaluating the distance between the São Roque da Lameira neighbourhood and the facilities, essential services, and social infrastructures (shown in blue in Figure 4), it is evident that older adults must walk at least 15 minutes to access these resources. Lastly, regarding access to public green spaces, strategies are needed to improve overall urban liveability, ensuring that all residents, regardless of their mobility, can easily reach and enjoy these green spaces, as they are more than 15 minutes away on foot.

As illustrated by Figure 5, the slope is a critical factor influencing walking activity in the São Roque da Lameira area. In the study area, (1) most of the area consists of gentle to moderate slopes, shown in green in Figure 5, which can enhance physical fitness and introduce variety to walking routines, especially benefiting older people; (2) some areas are characterised by excessively steep slopes, depicted in red in Figure 5, which may discourage frequent walking due to the increased physical effort required and potential discomfort, leading older people to avoid these areas; (3) While the neighbourhood itself is relatively flat, the surrounding areas feature increasingly steep slopes and physical barriers such as traffic lanes, as seen on the left side of the neighbourhood. In the São Roque study area, there are specifically (1) gentle slopes (0 to 9%): from 0 to 5%, they are almost flat and comfortable for most pedestrians, including people with limited mobility, and from 5% to 9% slightly more noticeable but still manageable for walking, common in the residential streets and pavements; (2) moderate slopes (10 to 18%): from 10% to 12%, the range begins to feel more challenging for pedestrians, particularly those with mobility issues. Walking uphill becomes more effortful, and from 13 to 18%, slopes are noticeable and demanding, especially over longer distances.

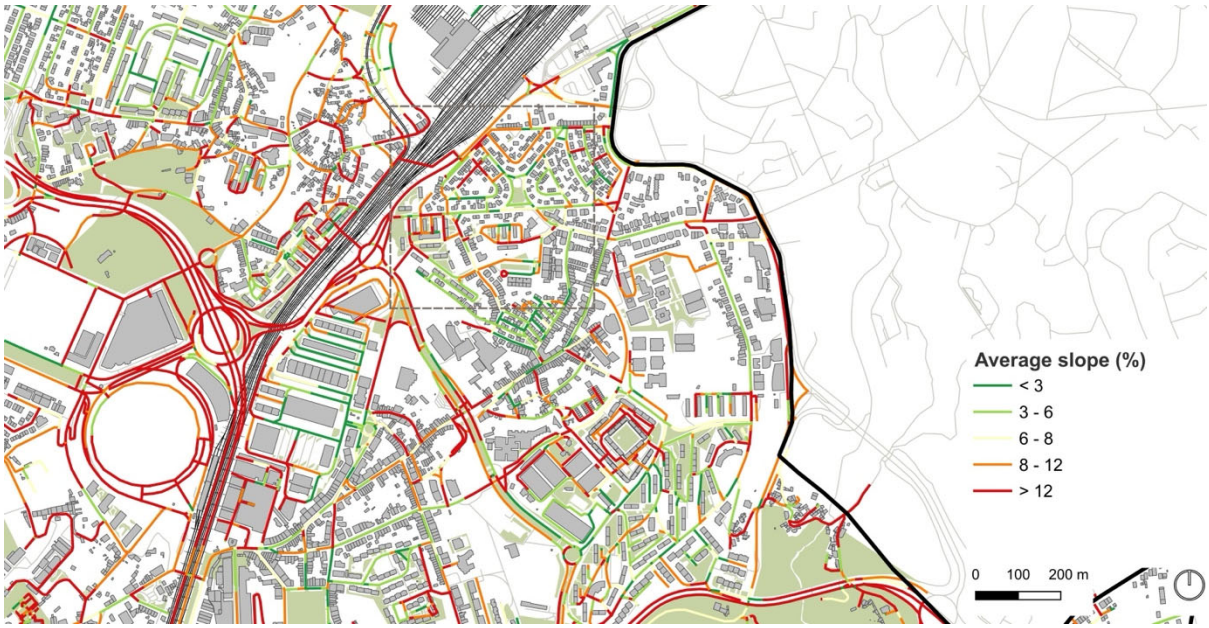

Figure 5. Slopes in the São Roque da Lameira neighbourhood, obtained from the digital terrain model made according to the available municipality data. Porto: authors 2024, using municipal cartography.

The use of public spaces depends significantly on the factors discussed above. However, it also depends on factors such as ease of walking, safety, and the specific needs of older individuals. Therefore, participatory sessions, informal conversations, and on-site observations served to establish a critical evaluation of the quality of São Roque's public space. Thus, the following observations are worthy of note. The participatory session and the informal conversations provided the opportunity to collect the perceptions of several residents and local users (Figure 6). Some of the aspects mentioned were, in particular, (1) public spaces with obstacles and uneven terrain that cause a sense of unsafety and discourage their use; (2) interventions to renovate public spaces that do not consider the needs of residents, particularly older adults (“it's got even worse”); (3) inadequate physical maintenance of spaces, which are deteriorating due to the breakdown or unsuitability of materials; (4) accumulation of solid waste, whether due to the actions of some users or to the lack of regular public cleaning; and (5) insufficient social facilities (such as nursing homes and daycare centres) and closed-down premises

(such as a daycare centre for people with special needs). The participant residents suggested increased vegetation, shade and rest furniture, and the improvement of pavements, lighting, and social facilities.



Figure 6. Photographs of the participatory session and one of the maps produced by the participants. Auditorium of Campanhã parish (Porto), photo credit: authors, 2024.

The observations in the neighbourhood (Figure 7) point to the use of public spaces by recurrent people, possibly related to their daily routines and personalities. Besides groups of children playing, teenagers and young adults, the older users were mainly couples, a lady strolling with her grandson (who, due to a lack of nursery placements, needs this support while his parents are working), individual older people walking their dogs, and a group of older women gathering for evening chats. The neighbourhood is also used by residents and non-residents, the latter relying on shortcuts, both through the existing public spaces and by creating informal paths on the green areas.

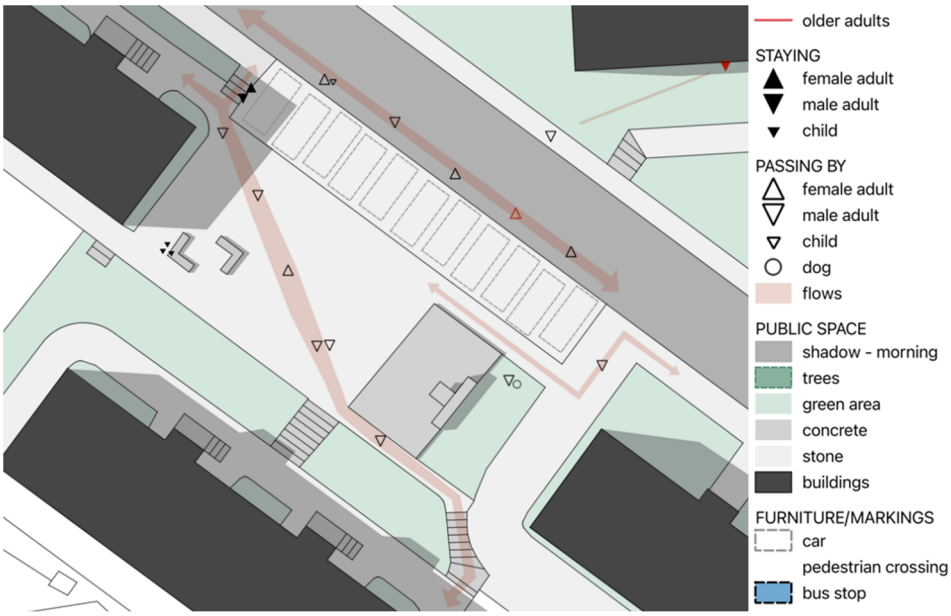

Figure 7. Diagram of one of the public spaces in the São Roque da Lameira neighbourhood, showing the characteristics of the space, user activities and routes. Porto: authors 2024, on municipal cartography.

The observations in São Roque da Lameira Street (Figure 8) revealed that most pedestrian movements occur within the scope of proximity routines and needs (such as buying hot bread, grocery shopping). Some older adults take short round trip routes and proximity circuits (taking a particular street in one direction and a different one to return), showing how daily chores are integrated in a broader stroll.

The bus stops, always crowded in this area and rapidly refilled after the departure of each bus, suggest insufficient or non-existent seating space and shading. Another frequently observed situation was that of older adults frequently having to stop to catch their breath along the routes, with no rest points or furniture available, requiring them to hold onto existing signposts or sit on low walls.

These observations show that, in line with the studies of other authors (Foshag et al., 2020), one of the most pressing issues regarding older people is their safety and accessibility needs. It is essential to understand the most valuable and frequent route that older people take in their daily lives in the neighbourhood and its level of safety and accessibility, analysing it from the perspective of older adults and their specific needs. For instance, bus stops in this area may appear to be easily accessible for many older adults (through the numeric distance indicators and area coverage), the routes to reach them remain challenging, making it essential to consider a finer network of rest points and better-equipped stops. However, this spatial-morphological study demonstrates that in addition to safety and accessibility needs, urban design must respond to increased overall comfort in terms of use (shading, furniture and equipment). In this regard, areas of sunlight and shade must be taken into consideration, based on the various users and respective uses, according to which different scales of design adjustments are proposed: climate-controlled seating and meeting areas, shared activities and pedestrian spaces, rest zones with gentle slopes, suitably positioned signage and lighting equipment , and cooling resources such as bodies of water or shaded areas, trees and vegetation, as well as the use of materials with high solar reflectance, and cooling façade and floor systems.

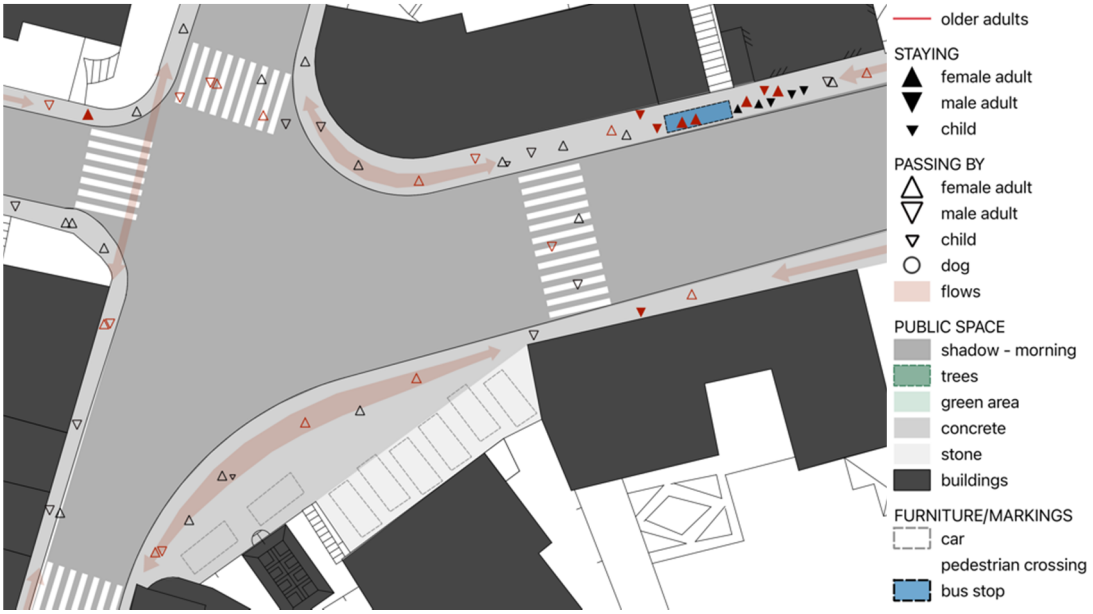

Figure 8. Diagram of one of the crossings in São Roque da Lameira Street, showing the spatial features, uses and routes. Porto: authors 2024, on municipal cartography.

CONCLUSIONS

From a socio-spatial perspective, in the context of urban public spaces vulnerable to high heat levels, promoting policies and processes for social inclusion and spatial rehabilitation in the study area is a challenge for the municipality. In the CAOP project, as in the Un-Habitat Policy (Martinuzzi and Lahoud, 2020), it is believed that inclusive design, well-managed and adequately maintained public spaces can significantly impact the communities' social and economic conditions, as well as the health

and well-being of the population, mainly the elderly. Also, urban form is believed to significantly affect heat stress, especially in the context of rising global temperatures and urbanisation (Emmanuel and Perera, 2017). To address the issue of urban climate mitigation and adaptation, this paper proposes a holistic approach, combining socio and spatial dimension analyses. Although this is a work in progress, it may be concluded that by integrating quantitative and qualitative tools into urban planning and design processes, cities can develop environments that protect vulnerable populations from heat stress and promote the health, well-being, and social engagement of older people. These tools help analyse and design urban environments, focusing on urban systems' spatial configurations and physical forms that involve urban form characteristics that are conducive to accessibility, safety, comfort, social interaction, and inclusion. From this perspective, the preliminary findings point to factors that affect how well public places work for older people. The width of pavements, the materials with which public spaces are made, how they are shaded, and creating connected and “cool islands” are factors that call for further consideration. In the next evaluation phase, the recommendations will be cross-checked with the information collected from the residents' interviews, which will be completed with information on users' public space observations. This analysis will contribute to the design of guidelines or “urban codes” that incorporate urban form measures to deal with climate change. In summary, the holistic approach designed by the FAUP team within the CAOP framework seeks to promote functional, inviting, and unique public spaces that support older people's health and well-being, identifying low-cost and low-scale intervention potential. Moreover, the socio-spatial vulnerability framework assessment proposed in this multidimensional study is intended to be replicable in urban areas or contexts with similar challenges.

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Analysis of urban expansion through Remote Sensing: an initial approach in the city of Arapiraca, Brazil

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ABSTRACT

This article aimed to analyze changes in the urban landscape over a defined time frame, utilizing remote sensing to examine urban expansion in a medium-sized city, using Arapiraca, Brazil, as a case study. To assess the Land Use and Land Cover changes (LULCC) in the city, this study employed data from the Landsat 8 satellite, which comprises two instruments: the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS); as well as the Landsat 5 satellite, which features the Thematic Mapper (TM) instrument. Both sensors were integrated into the Surface Energy Balance Algorithms for Land (SEBAL) to estimate surface temperature and energy balance components. Additionally, multi-spectral classifications and geostatistical analyses were applied to the MOD11A1.061 Terra Land Surface Temperature and Emissivity Daily Global 1km and MOD13Q1.061 Terra Vegetation Indices 16-Day Global 250m products. The Normalized Difference Vegetation Index (NDVI) was used to assess vegetation conditions, while Land Surface Temperature (LST) was considered for detecting local climate patterns. The analyses revealed substantial changes over the analyzed period, with a significant reduction in agricultural areas and a considerable increase in urban areas between 1987 and 2022.

Keywords: urban planning, Landsat, NDVI, LST, SEBAL

INTRODUCTION

The growth of global urbanization in recent decades has been particularly evident in developing countries. According to the United Nations report "World Urbanization Prospects: The 2018 Revision," the global urban population has increased significantly, especially in regions of Asia, Africa, and Latin America (United Nations, 2019). Since the 1970s, there has been a notable urban growth in these regions, especially when compared to developed countries (Nagendra et al., 2018), exacerbated by the disordered and chaotic manner of urbanization that creates a mismatch with the principles of sustainable development (Cabral and Cândido, 2019).

As a way to mitigate the impacts of changes caused by disordered urbanization, the proposal to implement public policies seems indisputable, with easy access to information emerging as an expression linked to governmental actions. In developed countries, academic communities,

researchers, and scientific associations participate in decision-making, regardless of the prevailing political position. However, in Brazil, the scenario still shows few advancements and many setbacks (Spink and Burgos, 2019).

In developing countries, disorganized growth results in changes in land cover use, capable of increasing thermal sensation, leading to changes in the microclimate that often result in a loss of environmental quality for the population (Li et al., 2018).

In this context, urban climate is an environmental derivative that can be understood as a sensitive phenomenon, thus exposed to various changes in climatic dynamics and their frequencies (Mendonça and Simões, 2012). It is important to highlight that urban climate is not only related to environmental issues but also to urban concerns, such as how cities are built and the elements inserted into urban spaces (Correia Filho et al., 2022). Therefore, it is observed that physical structures and dynamics in the city also influence the formation of urban heat islands (UHI).

In tropical countries, this phenomenon compromises the quality of life for residents (Silva and Ferreira, 2023). UHIs can be interpreted as the increase in air temperature at a given point, driven by factors such as obstacles to natural ventilation caused by excessive building density, lack of greenery, and changes in surface materials (Mendonça, 2015).

In Brazil, a significant aggravating factor for climate change is construction patterns. Urban planning rarely considers climatic factors as effectively determining aspects. Basic principles such as the thermodynamic characteristics of soil surface materials or building facades, wind permeability, and the maintenance of vegetation in urban spaces are not explored (Masiero and Souza, 2013).

Given this scenario, it is speculated that Brazil will undergo intense and rapid changes in climate patterns. The agricultural sector is expected to be the most affected, as well as poorer regions, such as the Northeast, whose extensive semi-arid area could become arid, forcing the resident population to migrate to other cities due to water scarcity and health issues (BIRD, 2023).

In this context lies the city of Arapiraca, located in the Agreste region of Alagoas State, situated in Northeast Brazil (NEB). The city's formation is directly linked to agriculture, fairs, and commerce, maintaining relationships with its surroundings, sometimes as a dependent and sometimes as a service provider (Santos, 2019). Between 1950-1980, the city cultivated 50,000 hectares of tobacco, the largest area cultivated in Brazil, exporting to other states and countries. Despite its rapid growth, the process of verticalization in the city is slow. The urban area is predominantly horizontal, with buildings occupying almost the entire lot (Silva, 2019).

The successive expansions of the city's perimeter, especially in the last 40 years, have resulted in the emergence of large urban voids, which, without proper planning, have driven real estate speculation and the occupation of peripheral neighborhoods due to lower land prices. Additionally, the increase in closed horizontal residential developments has fueled urban segregation, as this logic disregards the zoning established by the master plan, creating its own regulations (Neves, 2022). It is also worth mentioning the significant impact of housing programs like Minha Casa Minha Vida (PMCMV) on urban growth. In Arapiraca, a population increase of approximately 28.69% was observed from 1991 to 2010 (Correia Filho et al., 2022).

It can be asserted that Arapiraca exemplifies how medium-sized cities are important for the country's development, as they encourage a reduction in migration to capitals and metropolitan regions (Correia Filho et al., 2022). The municipality encompasses different functions, becoming central to the provision of commerce, administrative services, and industrial development. These types of cities polarize a region and reduce the need for displacement to other metropolises and states, playing an intermediary role between small and large cities (Santos, 2019).

Based on the above, this article aimed to discuss changes in the urban landscape from a temporal perspective, using remote sensing in the area of urban expansion in a medium-sized city, taking Arapiraca, Alagoas, Brazil, as a case study.

METHOD

Study area

The city of Arapiraca is located in the Agreste Alagoano mesoregion, in the central part of the state of Alagoas, Brazil, between latitude 9°75'25'' South and longitude 36°60'11'' West. It covers a territorial area of 345.65 km², with a population of 234,696 inhabitants and a population density of 678.99 inhabitants/km² (IBGE, 2022). The urbanized area corresponds to 52.07 km² and has only 12.2% of urban households on public roads with adequate urbanization (presence of drainage, sidewalks, paving, and curbs) (IBGE, 2019).

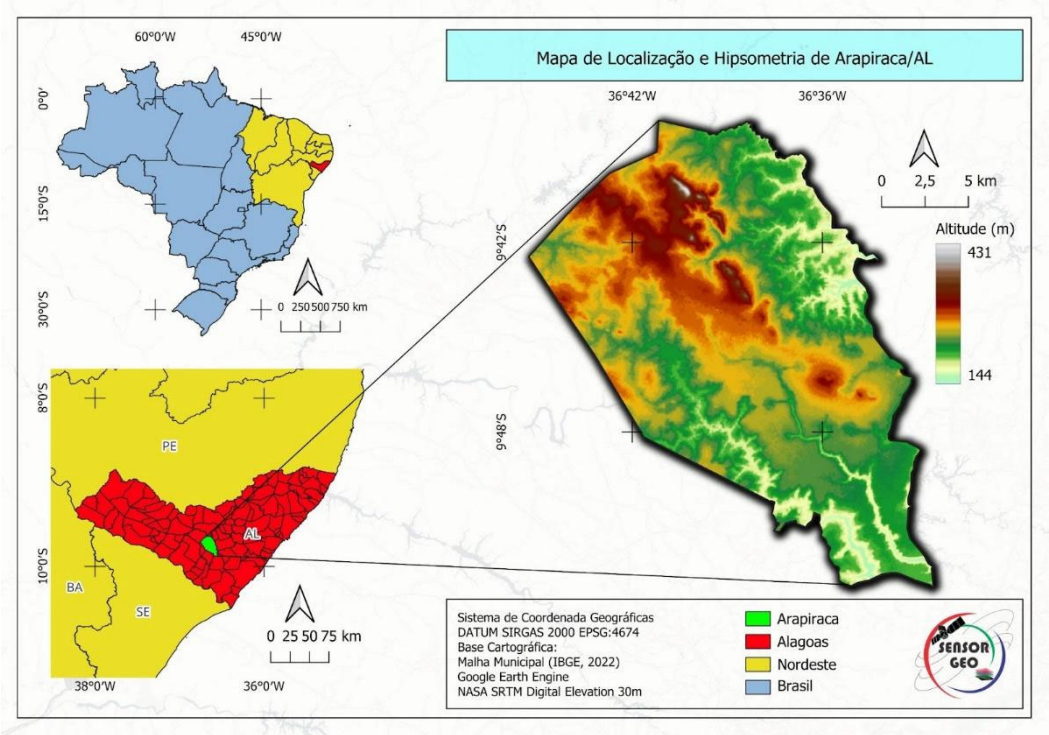

Figure 1. Location of the city of Arapiraca, located in the Agreste Alagoano, mesoregion of the State of Alagoas, Northeast Brazil. In the image, the urban perimeter was not separated from its rural area.

The city has a predominantly semi-arid climate (SILVA, 2019). The months from April to September have the lowest temperatures, with August being the coldest month, having an average minimum of 18.6 °C. From October to March, the highest temperatures reach 33.2 °C in December. In this sense,

its humidity shows values inversely proportional to temperature throughout the year, exceeding 80% during high-temperature periods and falling below 50% during cooler periods. There are two well-defined seasons: dry (warm and dry conditions during spring/summer) and rainy (autumn/winter) (Barros et al., 2012).

The sectors that employ the most in the city are agriculture, commerce, and industry (SANTOS, 2019). In 2021, the city's Gross Domestic Product (GDP) was R$ 25,248.44, and its Human Development Index (HDI) in 2010 was 0.649 (IBGE, 2024).

Methodological Procedures

To evaluate Land Use and Land Cover Changes (LULCC) in the city, this article used the Landsat 8 satellite, which consists of two instruments: Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS); and the Landsat 5 satellite, which has the Landsat Thematic Mapper (TM) as its instrument. Both sensors were implemented in the Surface Energy Balance Algorithms for Land (SEBAL) algorithm, estimating temperature and energy balance components of surface cover, along with multi-spectral classifications and geo-statistical analyses applied to the MOD11A1.061 Terra Land Surface Temperature and Emissivity Daily Global 1km and MOD13Q1.061 Terra Vegetation Indices 16-Day Global 250m products. The Normalized Difference Vegetation Index (NDVI) will also be used to analyze vegetation conditions. Additionally, Land Surface Temperature (LST) will be considered for detecting local climate.

Database

The images were acquired through Google Earth Engine (GEE)[79], based on scripts developed in JavaScript[80]. These scripts were designed to utilize time series and filtering functions, allowing for the quantification of images with a lower percentage of cloud cover. The geocentric projection system adopted was UTM DATUM SIRGAS 2000, with reference EPSG:4674. The time span of the images covered the entire period of the Landsat 8 and Landsat 5 satellites, with a temporal range of 37 years and a highlight on two images.

Surface Energy Balance Algorithm

The Surface Energy Balance Algorithm for Land (SEBAL) is a remote sensing processing model used in hydrological and agricultural studies to estimate evapotranspiration (ET). Using satellite images, such as those from Landsat, SEBAL provides a reliable approach to monitoring interactions between the Earth's surface and the atmosphere, contributing to a better understanding of hydrological cycles and sustainable management of water and agricultural resources (Allen et al., 2002).

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[79] Google Earth Engine is a free platform that can be used for scientific, academic, business and government purposes, and can be accessed through the website: https://earthengine.google.com/

[80] In this study, the scripts were run on Google Earth Engine, which is freely available on the GitHub website (https://github.com/JoaoAccioly/Arapiraca-Research.git).

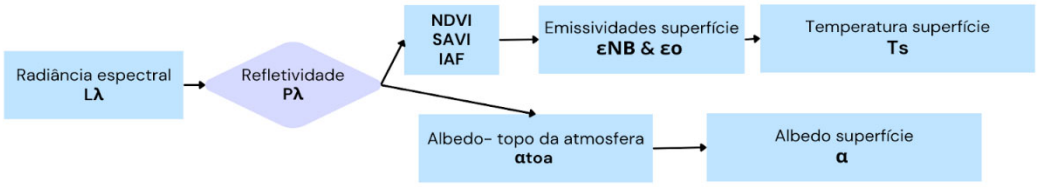

Figure 2. SEBAL flowchart used in matrix calculations (adapted from Allen et al., 2002)

Spectral radiance (Lλ)

According to Allen et al. (2002), the calculation of the spectral radiance of each band (Lλ) is performed using Equation 1, representing the radiation energy emitted by the observed band at the top of the atmosphere by the satellite. This radiance is determined using the following equation established for the Landsat 5 satellite, as follows:

$$L_\lambda = (\frac{LMAX-LMIN}{255}) \times DN + LMIN \quad (1)$$

where DN is the digital number, LMAX and LMIN are the calibration constants. The LMIN and LMIN values are calibration constants. The values of LMIN and LMAX are shown in table 2.

Table 2. Radiometric calibration values for Landsat 5 - TM (Allen et al., 2002).

After 15, Jan, 1984 (w*m-2*ster-1*ʜm-1)							
Bands	1	2	3	4	5	6	7
LMIN	-1.500	-2.800	-1.200	-1.500	-0.370	1.238	-0.150
LMAX	152.100	296.800	204.300	206.200	27.190	15.600	14.380

For Landsat 8, the equation for calculating spectral radiance is simplified, given by equation 2, according to Kamran (2005) and Allen et al. (2002).

$$L_\lambda = Gain * DN + Bias \quad (2)$$

where “gain” is the multiplicative factor and “bias” the additional factor for each band. The values are tabulated and found in the image metadata, for Landsat 8, for the scaled bands (2 to 7) Gain: 0.0000275 and Bias: -0.2; the thermal band (10) Gain: 0.00341802 and Bias: 149.

Reflectance (Pλ)

In this calculation, the fluxes represent the reflectance at the top of the atmosphere, at the sensor level, obtained through specific information from each pixel of the image. Thus, it was possible to calculate the reflectance’s corresponding to band 2 for Landsat 8 and bands 1 to 7 (excluding the thermal band) for Landsat 5, following the approach established by Chander, Markham, and Helder (2009). We quantified this by applying the following specific equation for Landsat images, allowing us to assess the proportion of reflected radiation in relation to the amount of radiation incident on the surface, as proposed in the equation below by Allen et al. (2002):

$$P_\lambda = (\frac{\pi - L_\lambda}{ESUN_\lambda * cos\theta * d_r}) \quad (3)$$

where dr is the Earth-Sun distance extracted from the metadata of the Surface Reflectance (SR) images from Google Earth Engine; Lλ is the radiance of each band calculated using equations 1 and 2 for Landsat 5 and Landsat 8, respectively; cosθ is the solar incidence angle, calculated by extracting the solar elevation angle (b) available in the image metadata and relating it as θ = (90° - b); the ESUN values correspond to the irradiance of each band, which varies for each sensor system, as described in tables 3 and 4 below.

Table 3. Irradiance values (ESUN) for Landsat 5 - TM (Allen et al., 2002)

	Band 1	**Band 2**	**Band 3**	**Band 4**	**Band 5**	**Band 7**
Landsat 5	1957	1829	1557	1047	219.3	74.52

Table 4. Irradiance values (ESUN) for Landsat 8 - OLI/TIRS (Ruhoff et al., 2015)

	Band 2	**Band 3**	**Band 4**	**Band 5**	**Band 6**	**Band 7**
Landsat 8	1982	1827	1540	932	234	79

Surface temperature (Ts)

After correcting the radiance for the thermal bands of the sensors, we calculated the surface temperature (Ts) using the following modified Plank equation as described by the SEBAL model:

$$T_S = \frac{K2}{ln(\frac{\varepsilon_{NB} * K1}{R_C} + 1)} \quad (4)$$

where NB is the emissivity; RC is the corrected radiance of the thermal band from the sensors; K1 and K2 are constants specific to Landsat images. For Landsat 5 (Band 6), K1 and K2 are 607.76 and 1260.56, respectively (adapted from Allen et al., 2002), and for Landsat 8 (Band 10), K1 and K2 are 774.89 and 121.08, respectively (Coelho and Corrêa, 2013).

Image Classification

The acquisition of land cover data was carried out through the MapBiomas platform, which provides annual data on land use and cover throughout Brazil for free (Available at: https://brasil.mapbiomas.org/). To cover the analyzed temporal space, two versions of MapBiomas were used: version 5 for the classification of 1987 and version 8 for the classification of 2022. The processing, clipping, and analysis of the classes included in the study area were performed using Quantum GIS software version 3.30.1.

The temperature classification process in the matrix data followed an analysis of anomalous temperature values within the urban mesh, discarding areas of exposed soil and considering only

inhabited areas. In GEE, the classification and data analysis steps are as shown in Figure 4, describing a geostatistical processing after the temperature calculation performed by the SEBAL algorithm has been completed, with a classification based on surface temperature fragmented into average temperature variations.

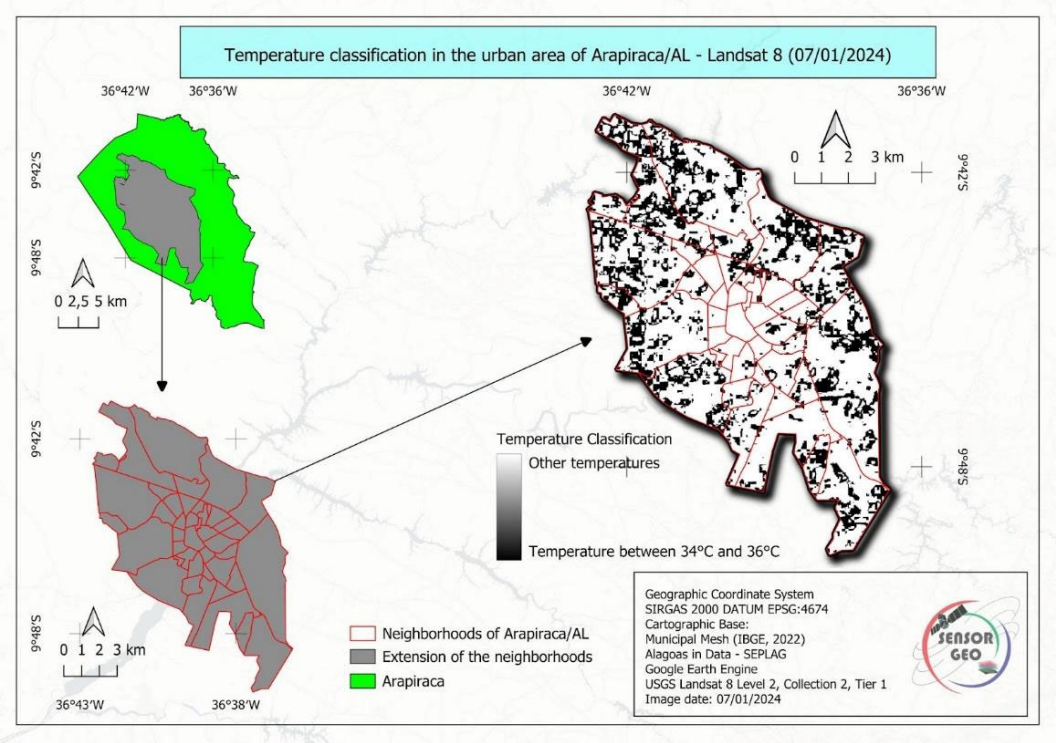

Figure 3. Temperature Classification for Landsat 8 Image.

RESULTS AND DISCUSSIONS

LULCC and its impacts

The evaluation of LULCC in the city of Arapiraca between the years 1987 and 2022 (Fig. 5) has changed substantially in just a few decades. There is a notable transformation in the city's landscape, with urbanized areas growing irregularly, creating large voids on the fringes of urban occupations. Furthermore, Neves (2022) points out that consolidated areas with urban infrastructure are not adequately occupied. The mode of occupation also results in segregation at three levels: spontaneous, with the creation of favelas and tenements; planned, when the population is displaced to the peripheries of the city without adequate facilities to meet their needs; and voluntary, with the establishment of high-end gated residential communities that end up functioning as islands surrounded by underprivileged populations.

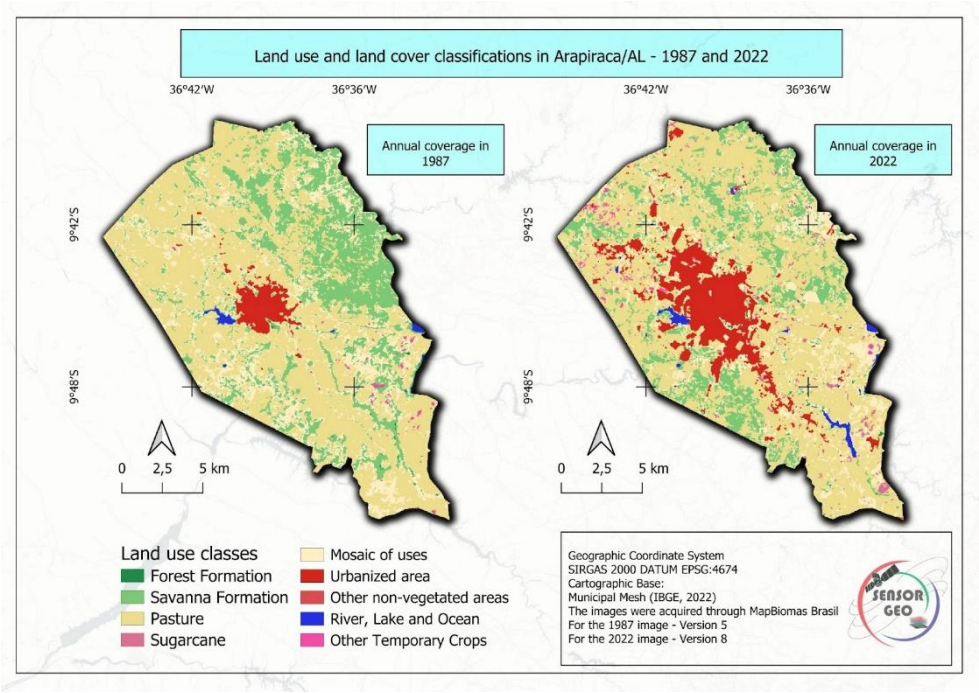

Figure 4. Environmental, geographic, and socioeconomic behavior for the City of Arapiraca. The environmental indicators for 1987 and 2022 (MapBiomas, 2024).

The non-vegetated area class showed the greatest change among the analyzed classes, with an increase of 313.2% between 1987 and 2022. The body of water in the city of Arapiraca and the forest also underwent notable changes, with percentage variations from 0.5% and 10.41% in 1987 to 0.86% and 14.21% in 2022, respectively. The area designated for agri-livestock experienced a reduction of 15.50% (Table 5).

Table 5. Area of classified variables

Classes	1987 area in km^2	2022 area in km^2	Difference (2022-1987) area in km^2
Non- vegetated areas	10.130	41.860	31.730
Body of water	1.860	2.980	1.120
Forest	36.010	49.150	13.140
Agri-livestock	297.660	251.410	-46.250

NDVI x LST

The data on surface temperature variation and NDVI extracted with the average clipped values for the municipality of Arapiraca and converted into a single product denote the seasonal behavior of temperature versus NDVI in an alternating manner, where the maximums of one variable coincide with the minimums of the subsequent variable. Both analyzed elements demonstrate similar patterns. The change in vegetation health throughout the year shows susceptibility to changes in the precipitation regime, considering that the characteristics of the caatinga biome present in the study region directly influence the NDVI values.

The analysis obtained through satellite data supports the investigation conducted by Torres (2017), who affirms the high soil impermeability in the city of Arapiraca due to the use of asphalt and the

limited green urban spaces. According to the author, among the few green areas found in the city, impermeabilization can be identified in their surroundings. The lack of green areas negatively impacts local climatic conditions. Although there is a correlation between the variables, this correlation does not directly determine a causal link between the analyzed factors.

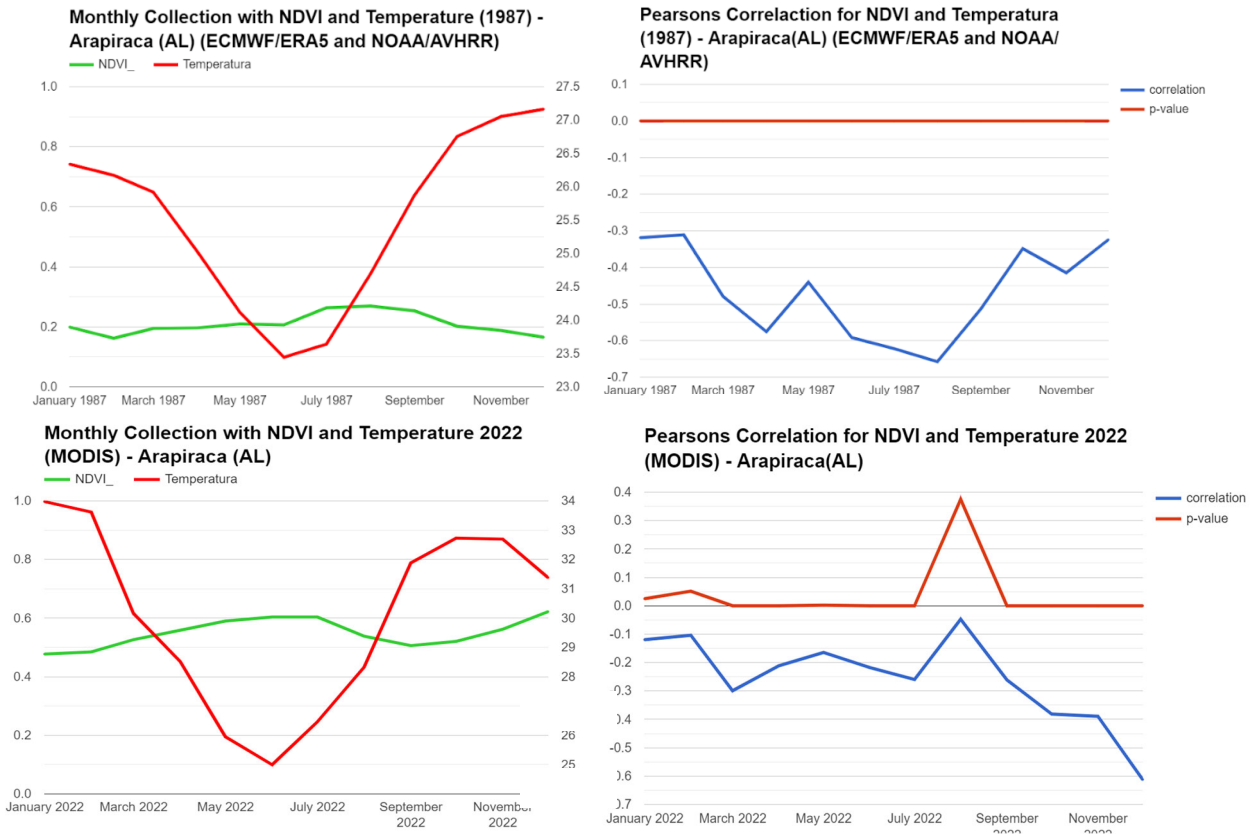

Figure 5. Time series and Pearson's correlation of temperature vs NDVI.

Relationships between Urban Temperature and Local Sustainable Actions

Based on the results obtained from the map (Fig. 5), there has been an increase in surface temperature throughout the city's territory. The reduction of native vegetation, in favor of agricultural interests, has impacted the thermal comfort of the population (Correia Filho et al., 2021).

In addition to the urban expansions already mentioned, with housing access programs such as PMCMV, gated residential communities undermine the sustainability dimensions established within municipal laws (Neves, 2022). The author also points out that some gated residential communities today are being built within environmental preservation areas.

The municipality of Arapiraca has an inadequate structure for local climatic conditions, significantly contributing to the thermal discomfort of its inhabitants. There is a notable need for new land use standards through effective planning that aims to address different guidelines than those currently being implemented (Torres, 2017).

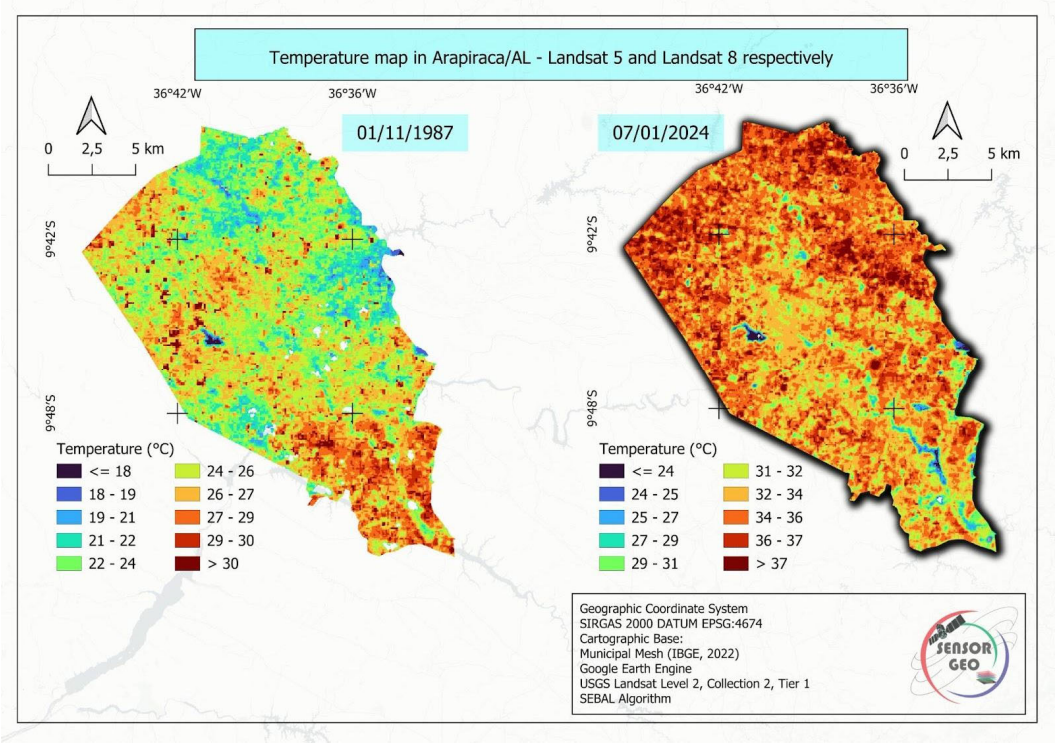

Figure 5. Temperature classification for Landsat 5 and 8 images.

Due to the unavailability of images with low cloud cover in the study region in 2022, the 1987 image was analyzed compared to an image from 2024, both available in the Landsat data line. The behavior of surface temperature in the images calculated with SEBAL demonstrated the variations in surface temperature at each time point along with their respective spatial distributions. To evaluate the accuracy of the calculations performed in the Google Earth Engine environment, in situ data available from the weather station of the National Institute of Meteorology (INMET) network were extracted, located in the study area (Station code: A353, lat: -9.8044, lon: -36.6191). Table 6 shows the variability of surface temperature on the approximate day and time of the Landsat 8 scene acquisition.

Table 6. Comparison between estimated and measured data

	Empirical data		**Estimated data**
Date/Hour	Air Temperature (Dry Bulb)	Temperature	Scene Time
2024/01/07 - 11:00	27.6°C		
2024/01/07 - 12:00	29.7°C	31.42	12:36:08
2024/01/07 - 13:00	32°C		

Analyzing the surface temperatures at 12:00 PM and 1:00 PM (empirical data) results in an average of 30.85 °C. To approximate the time of scene acquisition (12:36:08), the percentage error between the average value of the approximated empirical data and the estimated data is 1.84%. This demonstrates the effectiveness and accuracy of the calculations based on the SEBAL model and the surface data.

Indications of Urban Heat Island

During the analysis of the surface temperature classification for the urban area of the municipality of Arapiraca, it was possible to highlight two points within the urban space that have temperature variations above the average for the urban area and are not areas of exposed soil. The coordinates of

the highlighted points are provided in Table 7, projected in decimal format in the WGS84 system; however, the coordinates on the map (Figure 6) are projected in degrees, using the SIRGAS 2000 system.

Table 7. Locations with temperature variations

	Pont 1	Ponto 2
Latitude	-36.65864572554982	-36.648946857751966
Longitude	-9.767666340431381	-9.7504102536360140

The neighborhoods Primavera and Brasília indicated some points with surface temperature variations that may constitute urban heat islands on a micro-scale in these areas, considering that the composition of materials used for land cover is predominantly concrete, ceramic roofing, and asphalt. Additionally, there is a noticeable absence of vegetation in these areas, as the physical properties of the constituent materials directly contribute to the heating of these spaces. The albedo is relatively low in non-vegetated areas, resulting in less reflection and greater absorption of solar radiation. However, it is important to highlight that, even considering the accuracy of the algorithm used to estimate surface temperature and classify anomalous variations from the average surface temperature, a thorough investigation is necessary, using measured data from these neighborhoods to validate the findings obtained via the sensor system.

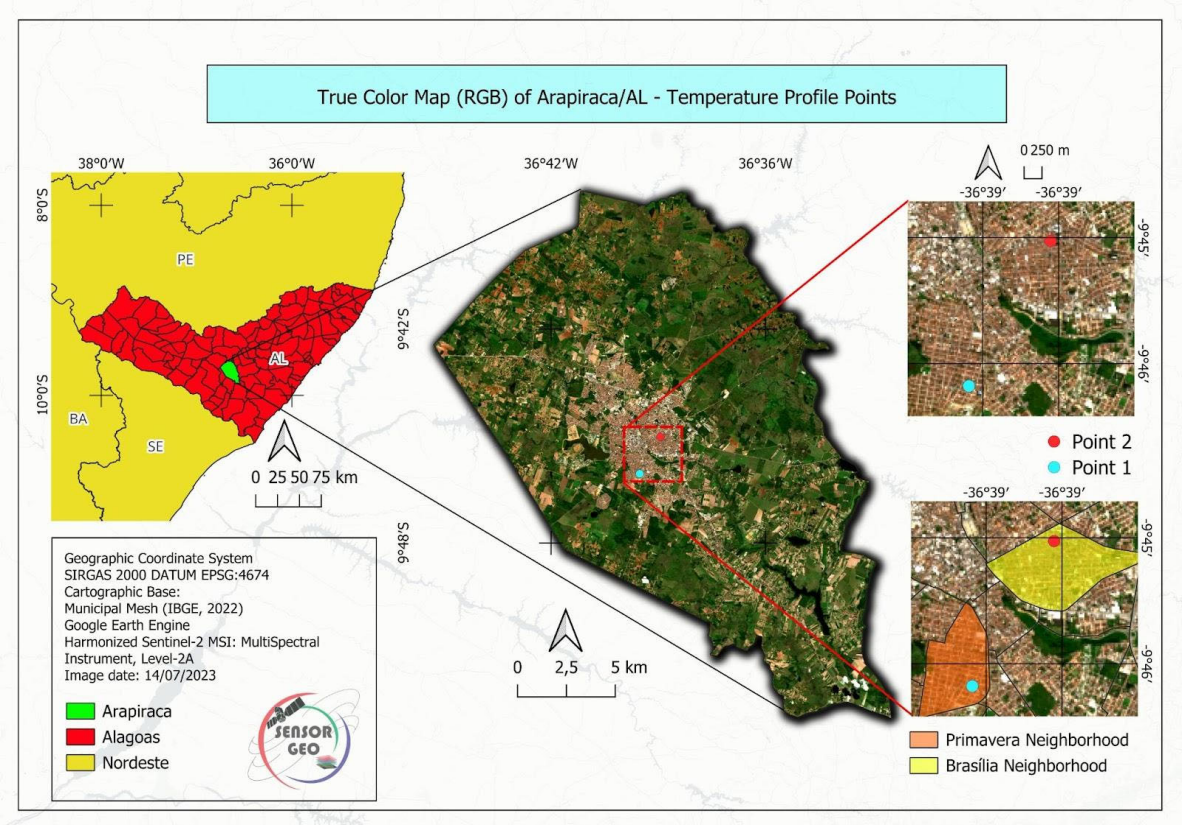

Figure 6. Points in the urban area

The heat retention at these points was compared with the surrounding areas and plotted horizontally in Figure 7. The surface temperature variations between point 1 and the neighboring regions show a

variation of ±2°C relative to the average surface temperature in the latitudinal profile. Ignoring the larger-scale intensity effects of this surface temperature variation, and limiting the profile to the urban grid, it is possible to observe a balanced temperature profile between points 1 and 2 in the line profile. Even with the temperature contrast with the adjacent water body, the microclimate at these specific points demonstrates characteristics that require further detailed analysis, especially concerning the thermal dynamics involving construction materials and urban vegetation in these neighborhoods.

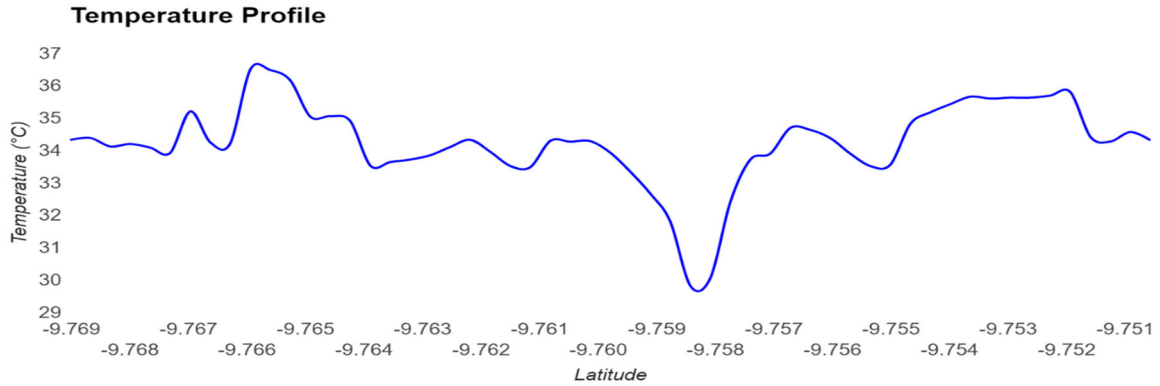

Figure 7. Temperature profile between points.

CONCLUSIONS

The analyses show a substantial change between the periods studied, with a significant reduction in the area allocated to agriculture and a considerable increase in urban area between 1987 and 2022. Relating the city to the state, it is noted that Arapiraca exerts more influence on its neighboring cities, as the residents of these municipalities commute daily in search of public and private services of medium and high complexity. However, the analysis of the city's urban expansion indicates a lack of planning, as the territorial and demographic growth in the city has not been accompanied by strategies to mitigate the evident climate changes, such as the incorporation of urban greenery. The intense transformation in land use and cover, reflected in disordered urban growth, contributes to the emergence of particularities in the urban environment, with conditions that directly affect the thermal comfort of its inhabitants. The analysis of the factors examined highlights the need for effective urban planning that includes sustainability guidelines, with political measures that promote balanced urban space expansion.

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