

Article

Adaptability and Interconnectedness in Latin American Innerburbs: An Assessment of the Public/Private Interface in Informal Settlements

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Abstract: An “Innerburb” is an urban structure that emerged between the 1950s and 1980s, settled in rural areas, and is considered the first periphery of the Latin American city. This structure results from socio-spatial and territorial evolutionary processes, constituting the pinnacle of informal evolution. However, despite offering a comprehensive perspective on the informal problem, innerburbs have been scarcely reviewed in the literature. This article explores the Latin American innerburb by adopting as a method a comparative study of the public/private interface in the cases of San Cosme in Lima, Villa Rodolfo Ricciardelli in Buenos Aires and Vila Heliopolis in São Paulo, evaluating their adaptation and interconnection with the city through morphological indicators, using morphological mapping through satellite images as an analytical tool, and using Space Syntax as a topological approach in the analysis of connectivity and visibility indicators. The objective of the research is the detection of morphological patterns that alter the functioning of the public/private interface in innerburbs. The results show that the existence of impermeable facades, the lack of public spaces and the illegal appropriation in the development of informal practices are transgressive adaptability patterns at the micro-scale that affect the interface, drastically limiting the interconnection between the innerburb and the formal fabric, restricting its morphological openness and affecting the development of socioeconomic activities. As a discussion and conclusion, corrective measures for progressive improvement in innerburbs are established, focusing on the adaptability of housing and road space as a means of interconnection between the innerburb and the city.

Keywords: public/private interface; informal interstices; innerburbs; inner peripheries; Latin America



Citation: Muñoz, C.A.M.; Ramos, F.J.M. Adaptability and Interconnectedness in Latin American Innerburbs: An Assessment of the Public/Private Interface in Informal Settlements. *Buildings* **2024**, *14*, 1378. <https://doi.org/10.3390/buildings14051378>

Academic Editors: Shisong Cao, Yang Shi, Shuo Li and Meizi Yang

Received: 25 March 2024

Revised: 26 April 2024

Accepted: 30 April 2024

Published: 11 May 2024



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1. Introduction

Innerburbs were the first suburbs in cities of the global north and south, initially developed between 1950 and 1980 [1–3]. The term, coined by Peter Ward, originally described 1950s North American suburban development for the middle class and its progressive decline due to factors linked to immigration, high poverty levels, land use changes and a weak housing market [3]. Thus, according to Ernest Burgess’ concentric theory, these structures would be in the second ring of the city, between the transition zone and the residential zone [4]. In Latin America, innerburbs were formed by immigration from rural areas, causing large-scale suburbanisation, initially turning rural and agricultural territories into active interstitial areas characterised by a precarious informal economy [5]. The slow development processes of these structures produced their morphological and social isolation, becoming enclosed in the middle of the city by the proliferation of new encroachments [6] and by impassable geographical features, progressively becoming “inner peripheries”. In that sense, self-built housing became the main evolving component of innerburbs, according to the population’s needs [7,8]. The morphology of innerburbs is mostly irregular in a constant state of intensification (intensification: a process of infilling

in which the settlement gains density as spaces or plots are filled, streets/roads are encroached upon and floors are added [9]), with an average height of three levels and lots between 70 and 200 square metres, oriented to a real estate market linked to generational housing tenure, land trafficking mafias and informal renting [3,10]. However, while informal consolidation processes are observed, there is also evidence of physical deterioration of the urban fabric due to overcrowding, economic inequality, lack of access to essential services and socio-spatial segregation, leading to slumification (slumification: process that occurs when a consolidated neighbourhood starts to degrade due to a lack of government or private upgrading actions on the settlement [11]). Although these aspects have been widely studied in the literature, few works investigate the innerburb as a segregated transitional structure in continuous transformation, with autonomous processes of adaptability and interconnection. Issues such as interior and exterior spatial configuration and their socio-spatial relationships are analysed from a morphological perspective by studying the public/private interface. This instrument identifies morphological components in patterns that produce cohesion, morphological fragmentation and socio-spatial dynamics. However, they are scarcely disseminated in the literature as components capable of directing the interactions of the settlement towards its success or failure in the processes of public/private interface with the formal city, filling a gap in the body of knowledge on the Latin American innerburb. Thus, although the body of scientific literature presents essential works on the morphology and forms of operation in informal settlements, its conclusions focus on exploring urban form and the typological categorisation of interfaces without answering the problem of morphological interaction between the formal and informal fabric. In this sense, the research aims to reveal the main morphological patterns that alter the public/private interface, restricting the inner and outer interconnection of the innerburb, taking as case studies the innerburbs of San Cosme in Lima, Villa Rodolfo Ricciardelli in Buenos Aires and Vila Heliópolis in São Paulo, which have morphogenic characteristics and socio-spatial and productive dynamics close to the central areas. As a hypothesis, it is proposed that detecting these patterns in the inner and outer spheres of the innerburbs can enable the application of differentiated morphological corrections in domestic settlements and road infrastructure as systems of interconnection with formal fabrics. The researched patterns are essential to advancing knowledge on interface dynamics in the innerburbs, producing new lines of research that can be extrapolated to other Latin American informal contexts.

1.1. Innerburbs and Urban Informality

The processes of urban informality-causing structures such as innerburbs have resulted from factors such as poverty, encouraging migration to cities as a response to a search for economic opportunities close to urban centres. The difficulty of access to urban land, the scarcity of housing alternatives due to their high cost, and the lack of adequate housing policies forced massive settlement in remote or inaccessible areas [12–14]. These developments are the product of squatting, experiencing rapid processes of land intensification and urban consolidation [9,15]. Thus, urban informality is encouraged as a mode of production by the need to develop economic activities as a form of survival for the population, involuntarily establishing a morphogenic assemblage with formal structures with the capacity to create new informal fabrics according to their needs [16,17]. Thus, urban planning actions in the face of these processes are reduced to morphological “healing” actions with little impact on the regeneration of informal fabrics [18,19].

1.2. Public/Private Interface

The public/private interface is a transitional space where the private domain connects with the public sphere, revealing the existence of socio-spatial dynamics and economic exchanges [20,21]. Its study allows us to measure the interaction between the urban morphology configured by the façade and the transitional space, composed of the street and the activities carried out in its ambit. The study of interfaces has been a central theme in urban design discourse to foster urban diversity and increased social interactions in streets

through a classification of typologies of street-building interfaces in planned cities [21–25]. However, the exploration of interfaces in informal settlements is recent, with studies developing morphological analyses that have led to typological classifications. However, given the complex dynamics of transformation in informal settlements [20,21], establishing a general typology requires a comprehensive global study. Nevertheless, several studies have made significant findings in identifying recurrent morphological interaction components in informal space, such as permeability, interconnectedness, mobility and adaptability. Thus, interconnectedness and adaptability in informal settlements have been reviewed in the exploration of informal configurations based on initial studies of incremental organisation and codes [26–29] and as an instrument for measuring street vitality and spatial permeability [30,31]. Kamalipour has identified interface typologies according to their degrees of connectivity (impermeable, accessible, porous) and their proximity, with levels of enclosure according to interface transition (adjacent and distant) [20]. Jones developed a combination of typologies based on proximity and remoteness (aligned, setback and set-forward) identified in the informal context of Lebak Siliwangi in Indonesia [32]. Van Oostrum has explored the limited relationships between streets and buildings in Beijing, Delhi, Guangzhou and Bangalore, identifying their narrowness as a morphological characteristic of informal space (accessible, cantilever and sawn) responding to an increasing intensity of urban living [30]. Peimani and Kamalipour incorporate the mobility component into the study of interfaces through the behaviour of ambulatory street shops, identifying three temporal conditions of interaction (fixed, semifixed and unfixed) providing micro-scale dynamics capable of activating pedestrian streets through social, economic and spatial dimensions [33].

2. Materials and Methods

2.1. Case Selection

The proposed methodology (Figure 1) is a comparison of case studies by mapping the informal innerburbs of San Cosme in Lima (Figure 2), Villa Rodolfo Ricciardelli in Buenos Aires (Figure 3), and Vila Heliopolis in São Paulo (Figure 4) from a synchronic approach. The selection of the cases responds to characteristics that place these structures as representative Latin American models:

- Because of their age, they are recognisable as urban structures produced in the 1950s and 1960s.
- By its informal morphogenesis, following a characteristic informal evolutionary process (invasion-occupation-intensification-consolidation).
- Because of their condition as inner peripheries close to the central nuclei of Lima, Buenos Aires and São Paulo, respectively.
- For the existence of formalised fabrics within their morphological limits, configuring socio-spatial and economic dynamics is identified as an informal production system.
- The difference in the scale of the cases allows us to understand informal behaviour from a multi-scale perspective. Thus, each case configures three recurrent urban phenomena in Latin America: San Cosme is a reference to urban practices of informal trade; La Villa Rodolfo Ricciardelli presents critical processes of informalisation in state housing; and Vila Heliopolis is a reference to the intention to establish a connection between informal housing and public intervention in social housing.

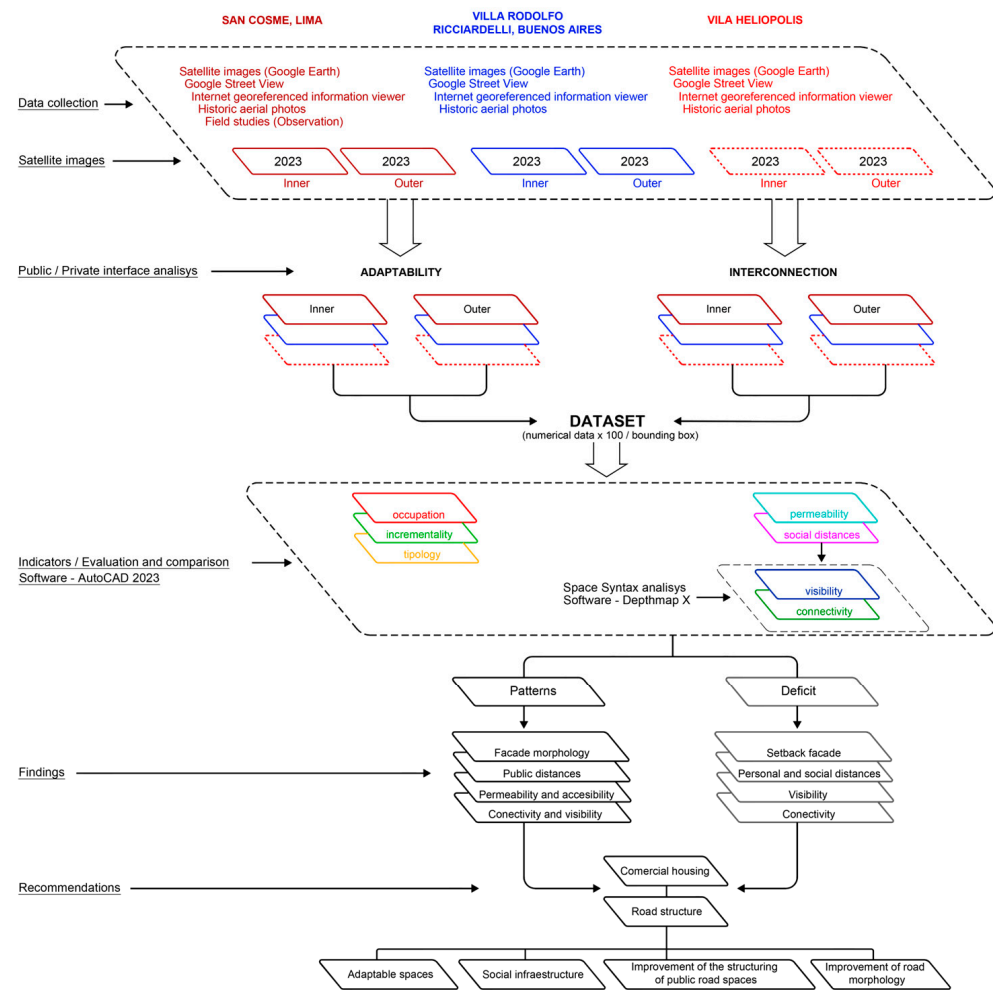


Figure 1. Research design and methodological structure.

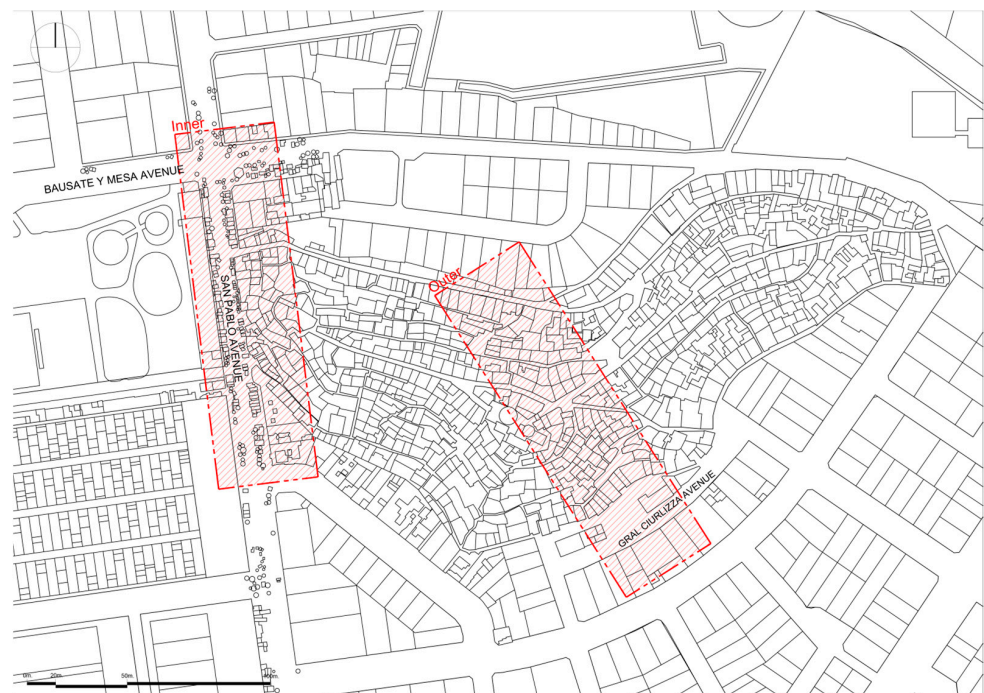


Figure 2. San Cosme and the inner and outer sample areas.

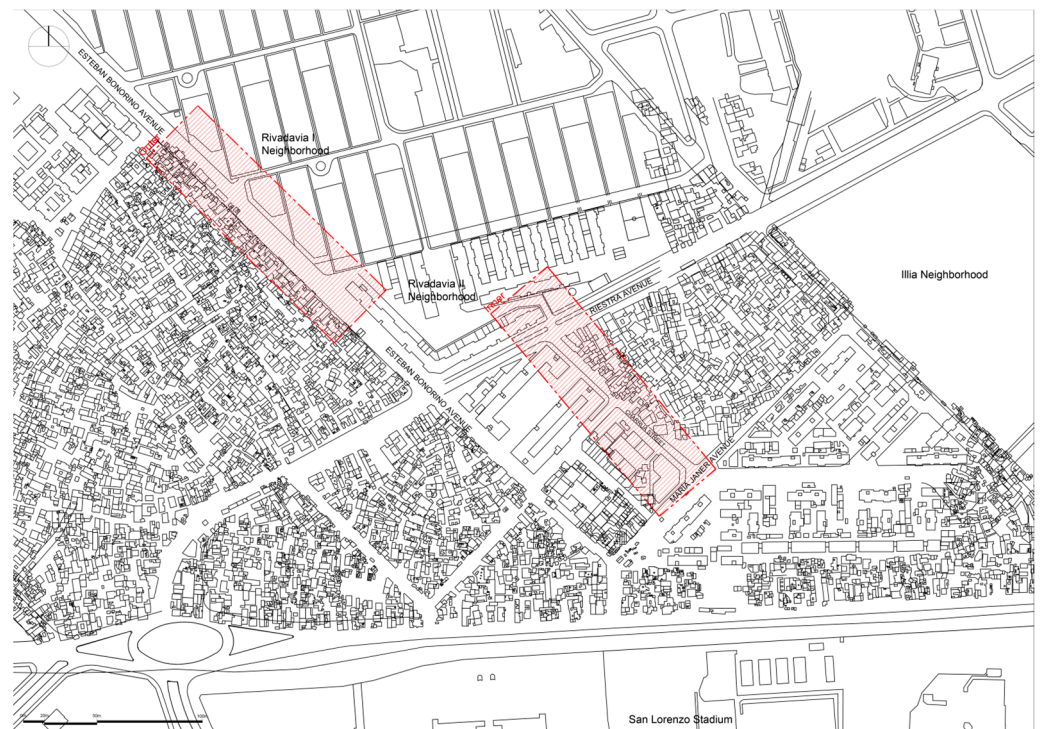


Figure 3. Villa Rodolfo Ricciardelli and the inner and outer display areas.



Figure 4. Vila Heliopolis and the inner and outer display areas.

2.1.1. San Cosme, Lima

San Cosme (SC) (Figure 2) constitutes an urban island within an inner periphery [6] located in the district of La Victoria in Lima, starting in 1946 with the establishment of fruit markets and “La Parada” to its new location, near the slope of San Cosme hill, attracting settlers and traders and initiating the invasions on the slope of the mountain [34]. SC, with a population of more than six thousand inhabitants, represents the formation of the

slum by commercial interests, produced mainly by the markets. This innerburb presents two important commercial dynamics around housing; its existence as a “dormitory town” encourages the adaptation of domestic spaces for the development of commerce and the use of housing for the rental of rooms near the wholesale market, the most critical need in Lima [35].

2.1.2. Villa Padre Rodolfo Ricciardelli, Buenos Aires

The Villa Rodolfo Ricciardelli (VRR) (Figure 3), located in the Autonomous City of Buenos Aires (CABA), began in the mid-1950s, constituting Villa 31, the first innerburbs in the city. VVR originated from the foreign immigration of Peruvians, Paraguayans and Bolivians. Its rapid consolidation initiated the informalisation of the social housing previously located within its boundaries through tenancy as a commercial practice [36,37]. VRR is a high crime rate neighbourhood, with a periphery consolidated from the incremental development of housing as the most common infrastructural element thanks to the commercial activities on its boundaries (mechanic workshops, drug dealing and *remiserías* (*Remisería* is a business in charge of providing taxi services)).

2.1.3. Vila Heliópolis, São Paulo

Vila Heliópolis (VH) (Figure 4) was formed as a villa hacienda until 1971, when the occupation of the villa began with the relocation of 153 families as part of the Vilas de Habitação Provisória programme. VH was subject to the occupation of some sectors by Petrobras and SABESP and new constructions from other favelas [38]. Its location close to the centre of São Paulo and industrial axes led to its rapid urbanisation, making it one of the largest favelas in the city [39]. The settlement was subject to the illegal commercialisation of land in the face of state neglect, consolidating itself as an inner periphery. Since the 1980s, VH has been subject to urban reintegration with the Companhia Metropolitana de Habitação de São Paulo (COHAB) and the Secretaria Municipal de Habitação (SEHAB). VH has since become an intervention laboratory for eradicating favelas and developing new social housing.

2.2. Mapping

The mapping design (Figure 1) drives through the conceptual differentiation of two spheres of action in the innerburbs: the inner zone, characterised by its social segregation and morphological compactness, with limited social practices, and the outer zone, the innerburb boundary area where economic practices and interaction with the formal fabric of the city take place. As the primary mapping technique, 270.00 m × 70.00 m boundary squares were established for the inner and outer areas. The squares have been referenced from studies with similar comparative intentions [15,30,40,41]. For the comparative development of the cases, satellite images obtained from Google Earth and Google Street View were used as the main tools to determine typologies in existing informal buildings. San Cosme was the only case where observing the interface relationships in the interior environment with satellite images was impossible. Therefore, it was necessary to carry out a direct observation in this informal settlement in March 2023 through photographs and field studies “in situ” through the measurement of the plots included in the analysed areas, developing facade surveys to observe the height of the dwellings (incrementality), the illegal occupation of spaces (appropriation) and their morphology (interface typologies), given the morphological compactness of the settlement. Three people participated in the field study, accompanied by two residents, for our safety. In the cases of Buenos Aires and São Paulo, the settlements have high-resolution images and the possibility of observing heights from Google Earth in three dimensions, making direct observation in situ unnecessary. However, the complex morphology of the cases made it necessary to use geo-referenced viewers and cadastres of the settlements in Buenos Aires and São Paulo to obtain the exact delimitation of the lots. Although most of the indicators used synchronic information, the appropriation indicator required a compilation of historical photos for

the diachronic observation of squatting using chronological images from Google Earth, the National Aero Photographic Service in Peru, the Ministry of Urban Development and Transport of the city of Buenos Aires and the Prefeitura de São Paulo. Once the information had been constructed in AutoCAD 2023 software, the methodological analysis was complemented with Space Syntax for topological analysis of connectivity and visibility indicators. For this purpose, the “DepthmapX 8.0” program was used, using the parameters “Axial Map—Connectivity” and “Visibility Graphic Analysis”. The pre-processing methodology consisted of a calculation of areas and perimeters, obtaining percentages (numerical data x 100/bounding box) for each indicator and converting the information into linear diagrams to enable the normalisation of results and allow a comparison between cases (Figure 1). The results were filtered using a proposed protocol for detecting predominant interface components, where values above 40.00% in one indicator were considered as interface patterns in the analysed areas. Additionally, values below 5.00% are presented to identify morphological components of low presence at the public/private interface.

2.3. Space Syntax

The development of new analysis platforms such as GIS and the Space Syntax approach has added valuable information to the body of literature on transformation processes in informal settlements, focusing on their connections, integration and morphology. These researchers develop studies based on the use of axial axes and angular segments obtained through GIS [42]; other researchers analyse urban connectivity and integration using visibility maps [43,44]; incremental informal morphogenesis in Nigeria from Space Syntax [45]; the identification of new centralities from the assessment of integration and connectivity in informal settlements from a macro-urban perspective [46]. These studies present Space Syntax as a valuable tool for analysing morphological and social spatial structures. However, its main disadvantage is the impossibility of measuring degrees of permeability, producing problematic results in axial measurements on a micro-scale [47]. This disadvantage is a significant issue in the morphological analysis of informal settlements, being necessary for the construction of detailed maps and the support of other tools for a correct interpretation. In that sense, several researchers have complemented the use of Space Syntax with different approaches in the study of urban forms, such as the Space Matrix and mixed-use index, to diagnose the functioning of the settlement [48,49]. However, most of these works explore cases in European and Asian contexts, with few studies addressing the Latin American context [50,51]. The application of DepthmapX 8.0 software in the analysis of connectivity and visibility has been used in several investigations to improve resilience in informal settlements with restricted essential services in vulnerable areas or to reveal informal regions of high economic production. [52,53]. The use of the parameters “Visibility Graphic Analysis” (VGA) and “Axial Map—Connectivity” of the DepthmapX software applied on the roads and streets of the cases allows identifying and evidencing the existence of isolated sub-zones in areas of informal appropriation, as well as the proliferation of morphological intersections of low social and economic interaction arising from the spontaneous organisation of the initial population in the settlements; the established informal practices; and a segregative governmental housing design.

2.4. Description of the Indicators Used in the Analysis

The study uses the concepts of adaptability and interconnectedness to identify visible socio-spatial dynamics that foster resilience to external factors as an inherent characteristic of informal fabrics. The results of these dynamics are reflected in the public/private interface. Adaptability (Adaptability is an inherent process in the evolution of informal settlements. It is a response to external phenomena (environmental, physical, political, geographical changes, etc.) that produces resilience [54]) and is obtained through incrementality indicators, studying levels of growth, successive appropriation processes and typological identification of facades based on previous studies, which aim to establish variations in connectivity and proximity [21,27,30,55,56]. The second dimension is inter-

connectedness (interconnectedness: the socio-spatial dynamics and practices that assemble the informal settlement with the formal fabric), identified at the outer boundary of the innerburb with systems linking to adjacent areas. Permeability and socio-spatial distances are reviewed from an approach based on the studies of Dovey and Wood, Kamalipour, Hall [21,27,57]. Visibility and connectivity indicators were obtained using Space Syntax to measure and establish a comparison between cases. A more extensive evaluation of interfaces is proposed in the study, resulting in two linear comparison diagrams for inner and outer areas. The study describes the indicators analysed in the research:

- a. **Incrementality.** Incremental processes in housing are an informal morphological characteristic that modifies the spatial relationship between the street and the building through illicit appropriations using horizontal and vertical additions that progressively improve living conditions inside the dwelling but detract from the spatial quality on the outside. The study focuses on mapping the constructive conditions, height, permanence and temporality of the dwellings that establish a relationship with the street, identifying their degrees of consolidation and degradation (Figure 5).
- b. **Appropriation.** In informal urbanism, appropriation is the progressive exclusion of users of public space, which begins temporarily and ends with the permanent occupation of a given territory [58]. The study presents the appropriation and spatial privatisation of public spaces in settlements through urban voids and current infrastructure, as well as the processes of road transgression at the innerburb limits. The aim is to identify a pattern of behaviour in informal occupation that undermines the production of a transitional avenue/street—building interface (Figure 6).
- c. **Façade typologies.** This mapping reveals a pattern of façade design, configured according to their predominance in the interior and exterior realms in the cases studied and their compatibility or incompatibility as means of interface with commercial practices and social interaction in innerburbs (Figure 7).
- d. **Permeability.** Permeability measures road “porosity” in pedestrian streets and avenues. In that sense, the objective is to identify the openings and enclosures produced by the processes of appropriation and incrementality in the different types of façades, as well as social and commercial activities in innerburb environments, extending or reducing the transitional interface spaces (Figure 8).
- e. **Socio-spatial distances.** The analysis aims to measure the morphology of streets as an element of interaction in proxemic relations of personal proximity and distance. This study indicates areas where spaces for social interaction are predominant and scarce (Figure 9).
- f. **Visibility.** This analyses the visual openness of the settlement’s internal and external roads. The analysis used the “Visibility Graphical Analysis” (VGA) parameter of the DepthmapX software, identifying the road morphological openness and the quality of the visual fields configured by the innerburbs. The study makes it possible to determine the degree of inner compactness and the level of morphological spatial openness with the outer formalised fabric (Figure 10).
- g. **Connectivity.** It allows for establishing the degree of road segregation based on the settlement’s topological connections. The DepthmapX 8.0 software was used in the analysis, using axial road lines identified under the parameter “Axial Map—Connectivity”. This analysis considers all the direct connections that a street has with other streets in its closest range. In that sense, a street with many connections has a high degree of connectivity, while a street with few connections has a low degree [59,60]. The measurement is set from grade 1 (low) to grades 6 and 13 (high and very high) (Figure 11).

2.5. Methodological Procedure

The research procedure consisted of processing the collected data in AutoCAD 2023 software, allowing the construction of indoor and outdoor sample tables for the comparison of cases (Figure 1). This numerical processing divided the study into two types of data

obtained: surfaces in square metres (m^2) and linear metres (mL). The incrementality, appropriation, socio-spatial distances and visibility were measured by the percentage between the square metres obtained in each indicator and the total square metres (m^2) of the bounding box in each case study. On the other hand, the permeability, façade typologies and connectivity indicators were obtained by calculating the percentage of linear metres drawn for each indicator and the number of linear metres (mL) existing in the streets of the sample in each case. The results were represented in linear diagrams (Figures 5–11) to standardise the results and offer a better understanding of the case comparison process. Finally, the results were filtered using a proposed interface component detection protocol (Figure 12). Values above 40.00% in an indicator were considered public/private interface patterns in the analysed zones, while values below 5.00% were considered morphological components in deficit in the interface processes. This protocol type was used in similar research [27,61].

2.6. Limitations

The lack of previous evolutionary information on the settlements studied constitutes the main limitation in the study, making it challenging to obtain historical information on the transformation processes and the progressive increase of informal practices in the three cases, with the collection and subsequent cataloguing of evolutionary data in informal settlements being a pending work agenda. On the other hand, the scarce literature on socio-spatial functioning in Latin American innerburbs constitutes a critical gap, as does the lack of detailed information through geo-referenced viewers in Lima, making in situ documentation necessary. These limitations and gaps in information constitute a line of research pending development and dissemination.

3. Results

3.1. Adaptability

3.1.1. Incrementality

Inner

Inner pedestrian walkways in SC have irregular facades with a standard height of three to five levels and overhangs at their upper levels that reduce street lighting and ventilation due to a lack of municipal regulation. In comparison, the incremental façade in VRR has a greater height facing the main avenue and, to a lesser extent, the street. The social housing system maintains a profile that regulates building size. In contrast, in VH, the height of social housing is predominant, with illegal growth being observed on the first level (Figure 5a).

Outer

The proximity of the metropolitan markets to SC promotes using the first level as warehouses, adaptable shops and a higher building height. In VRR, the facades are modified for the development of commercial activities (workshops, taxi shops, room rentals and shops). These activities increase the informality of adjacent state-owned housing, adding new flats for rent. In VH, incremental housing is in the upper levels, as the first ones are occupied with commerce, establishing contact with the formalised limit of Estrada das Lagrimas Avenue, with an entirely commercial profile (Figure 5b).

3.1.2. Appropriation

Inner

Two processes divide the informal appropriation in SC: the occupations of 1950 that precariously structured the inner roads and their later delimitation. In VRR, the occupation of social housing developed in urban voids and commercial squatting. In VH, the occupation is similar, with the appropriation of openings for private use and the eradication of uninhabitable informal dwellings to construct social housing (Figure 6a).

Outer

The process of squatting in SC is an extension of the innerburb towards markets as a form of street trade development. In this sense, the transition of interfaces is diffuse, hindering the fluidity of pedestrian and vehicular movement. In VRR, Bonorino Avenue is the nexus of informalisation between the innerburb and the adjacent social housing. In VH, the Sacomã neighbourhood is a morphological border with commercial activities and metropolitan equipment, limiting its extension. However, the informal zonal commerce establishes the socio-spatial connection with Sacomã (Figure 6b).

3.1.3. Façade Typologies

Inner

In SC, the “cantilevered” façade predominates (54.57%). This typology drastically reduces the visual perception of the street, reducing illumination and increasing the feeling of narrowness. In the case of VRR, “set-forward/direct” predominates in squatter buildings. This façade, in combination with the “aligned/direct” typology (34.89%), produces interfaces with little road interaction. In VH, the aligned/direct facades have a higher percentage (51.77%). This typology comes from the beginnings of social housing, characterised by low visual interaction with the surrounding public spaces (Figure 7a).

Outer

In SC, the “aligned/direct” typology predominates (71.52%). Set-forward/direct and cantilevered typologies prevail in the interior. In VRR, the “set-forward/direct” typology (43.68%) is recurrent, especially in squatting. The “aligned/direct” typology (34.89%) predominates in buildings in front of main roads. In VH, the “setback” typology (26.19%) is found in formalised areas, while the “aligned/direct” type corresponds to the innerburb boundary. However, the intercalation between these typologies encourages more significant social interaction (Figure 7b).

3.2. Interconnection

3.2.1. Permeability

Inner

In SC, the openings (doors and windows) allow minimal accessibility (53.16%) without connecting elements or are impermeable (46.84%). The scarcity of permeable facades is a characteristic associated with the functioning of the innerburb and its territorial segregation. In VRR, impermeable facades (77.31%) are a product of monolithic social housing design, encouraging private squatting and reducing social interaction. In VH, there is a contrast between the porosity of shops in front of arterial roads (11.46%) and the impenetrable facades of social housing, appropriating common spaces to privatise them (garages), eliminating visibility and accessibility on the facades (Figure 8a).

Outer

The facades in SC are adapted as product stores and shops of relative accessibility (45.84%) due to their proximity to the wholesale market in front of San Pablo Avenue. However, SC’s occupation form produces impermeable access (48.43%). In VRR, the innerburb accesses towards Bonorino Avenue are composed of impermeable façades (50.04%), while in the avenue, accessible and permeable façades predominate with shops that invade the road profile. In VH, the exterior façade is accessible and porous, favouring socio-spatial contact with the Estrada das Lagrimas Avenue (Figure 8b).

3.2.2. Socio-Spatial Distances

Inner

In SC, the interconnection is pedestrian, with wide pedestrian-scale access streets that function as social spaces. SC lacks interior public spaces. Thus, street trading is located at road intersections to increase their visibility. In VRR, the general distances near and far on

the main roads are maintained despite the reduction of the road profile on Charrúa Street due to squatting. In VH, public lengths on Da Silva and Almirante Delamare avenues vary near and far. However, the design of public spaces adjoining social housing is restricted to social and personal distances, isolating the street-building interaction (Figure 9a).

Outer

Street trading in SC and VRR modifies the social distances produced by urban morphology. The itinerant trade zones in SC create sub-zones with social and personal spaces for moving goods by privatising them. The case of VRR is similar, with the creation of privatised sub-zones (car parks) of a permanent character on the innerburb frontages. In VRR, the innerburb accesses are narrow, with distances between 0.70 and 1.20 mts. In comparison, the innerburb boundary of VH is marked by the Estrada das Lágrimas Avenue with public socio-spatial spaces (13.50 mts.) without ambulatory shops, homogenising the road profile (Figure 9b).

3.2.3. Visibility

Inner

In SC, the low road visibility of the corridors constitutes the highest percentage (31.77%), along with the lack of inner road intersections. The area with the most increased visibility (26.65%) is a public space with no interior access. In VRR, the junction of Riestra and Charrúa avenues has intermediate visibility (3.76%) but is limited by social housing buildings. In VH, Almirante Delamare Avenue and its public space present higher visibility at their intersections. However, illegal parking squats drastically reduce road visibility (Figure 10a).

Outer

In SC, San Pablo Avenue allows an intermediate visibility (19.79%) towards the Lima wholesale market. However, street commerce reduces its visibility (14.21%). In VRR, the intersection of the pedestrian streets of the Rivadavia I neighbourhood visually ends in public spaces towards Bonorino Avenue. Similar to SC, squatting on the outer façade reduces visibility. Compared to SC and VRR, Estrada das Lágrimas Avenue in VH presents the highest visibility rate without visual obstacles (73.30%) (Figure 10b).

3.2.4. Connectivity

Inner

The existence of irregular roads causes the low connectivity of SC without intersections and the identification of dead-end streets. Thus, grades 1 (24.92%), 2 (51.12%) and 3 (16.31%) are the central values detected. In VRR, 10.87% of the roads lack connectivity (grade 0), while Charrúa Street has grade 3 connectivity due to its scarce road intersections. The roads with the highest connectivity in VH are pedestrian inside the public space, surrounded by social housing buildings reaching grade 5 (3.49%), while in the road intersections, grade 3 predominates (14.05%) (Figure 11a).

Outer

In this sense, it is proposed to fill this gap by studying interfaces as a tool capable of identifying with urban morphology the socio-spatial behaviour as a system of interaction between the formal and informal urban fabric, improving physical interventions in these settlements. This section discusses patterns and deficits in the form of interfaces, which establish a greater or lesser adaptability and spatial interconnection between the innerburb and the formal city (Figure 11b).

Figure 5. Comparison of incrementality processes of the study areas. The linear diagrams represent a comparison between the indicators.

APPROPRIATION

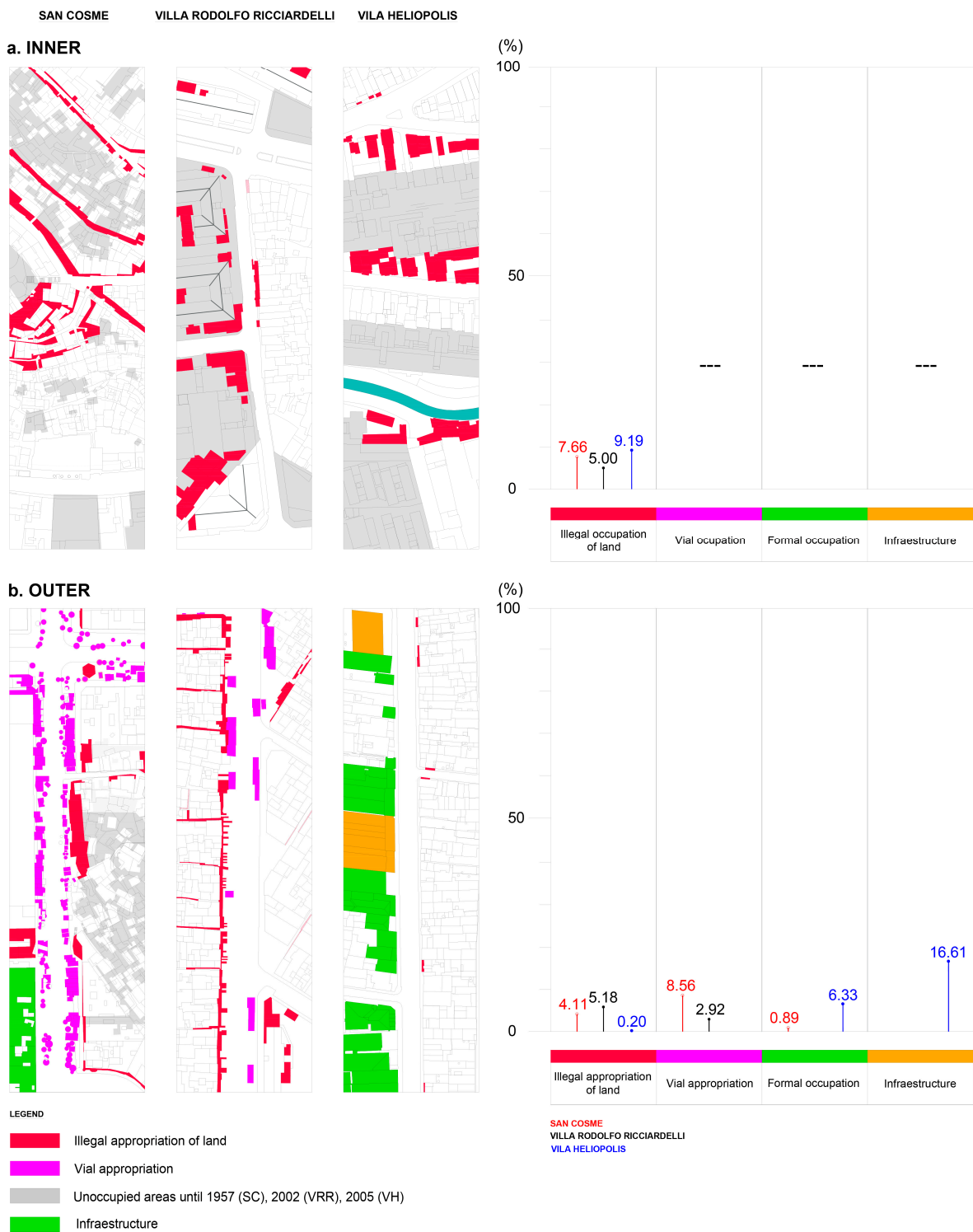
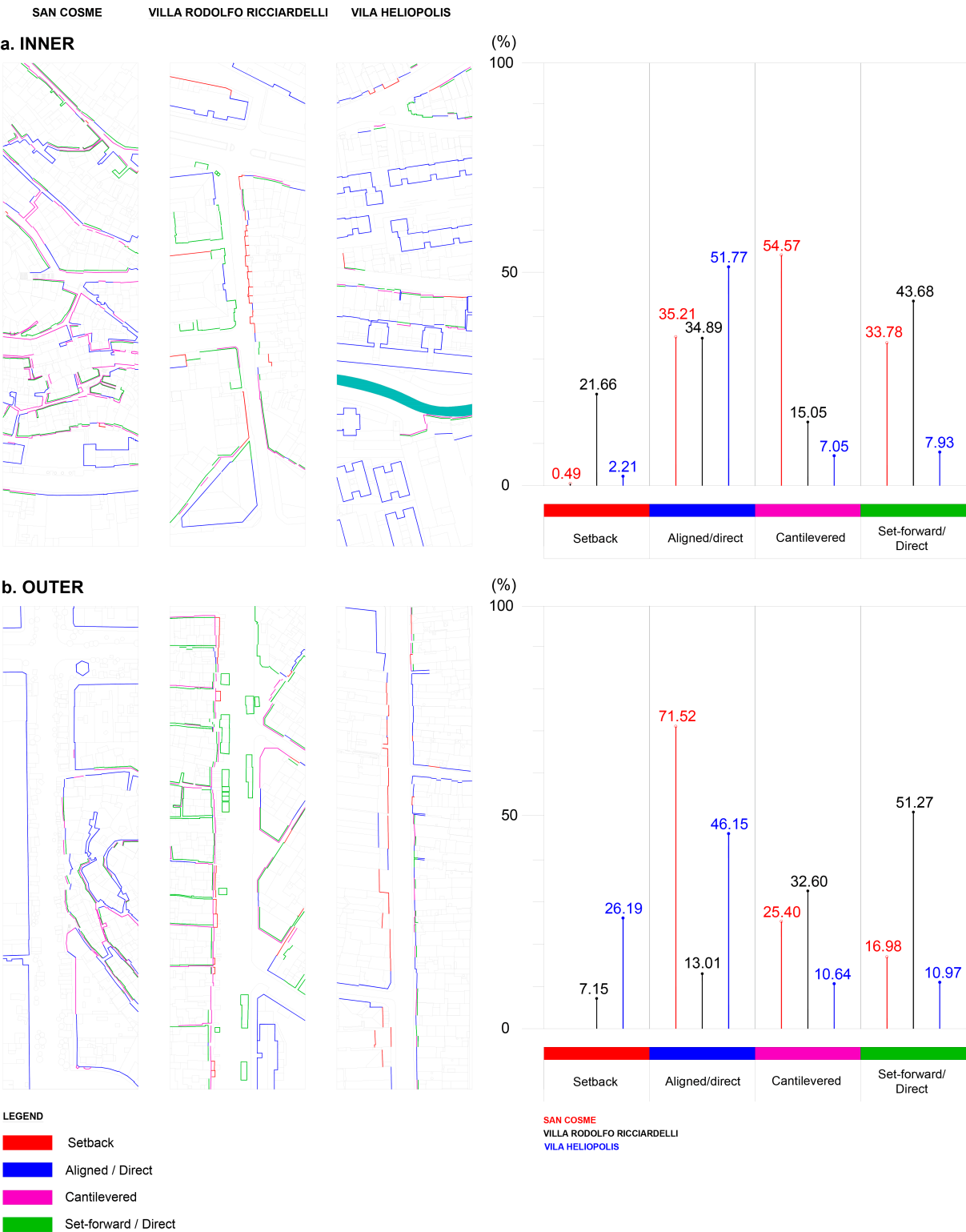


Figure 6. Comparison of appropriation processes of the study areas. The linear diagrams represent a comparison between the indicators.

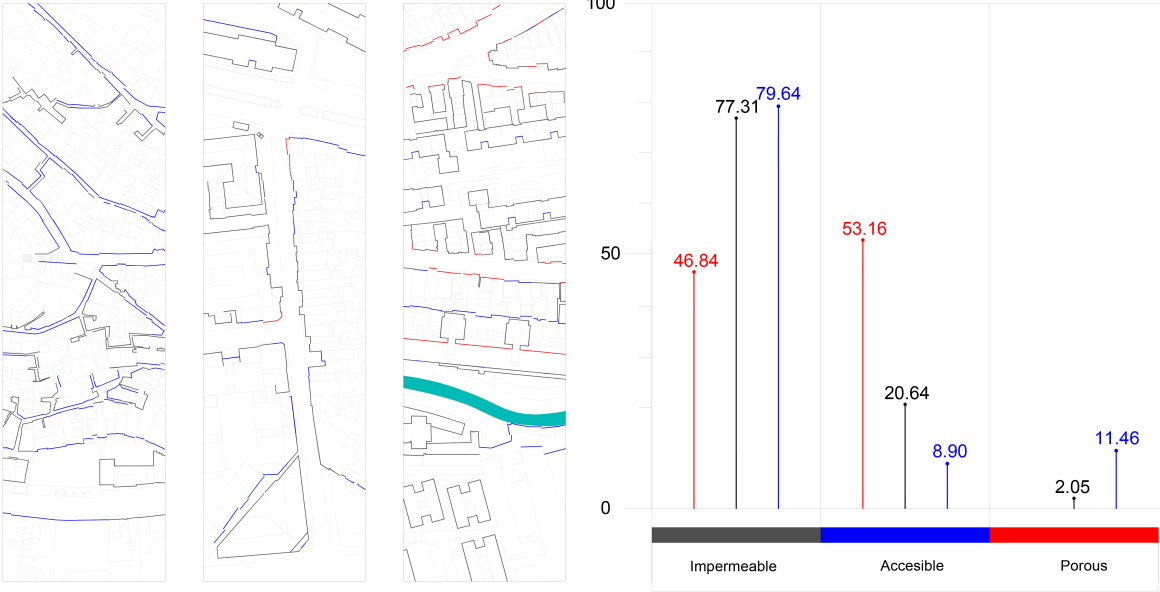
FACADE TYPOLOGIES



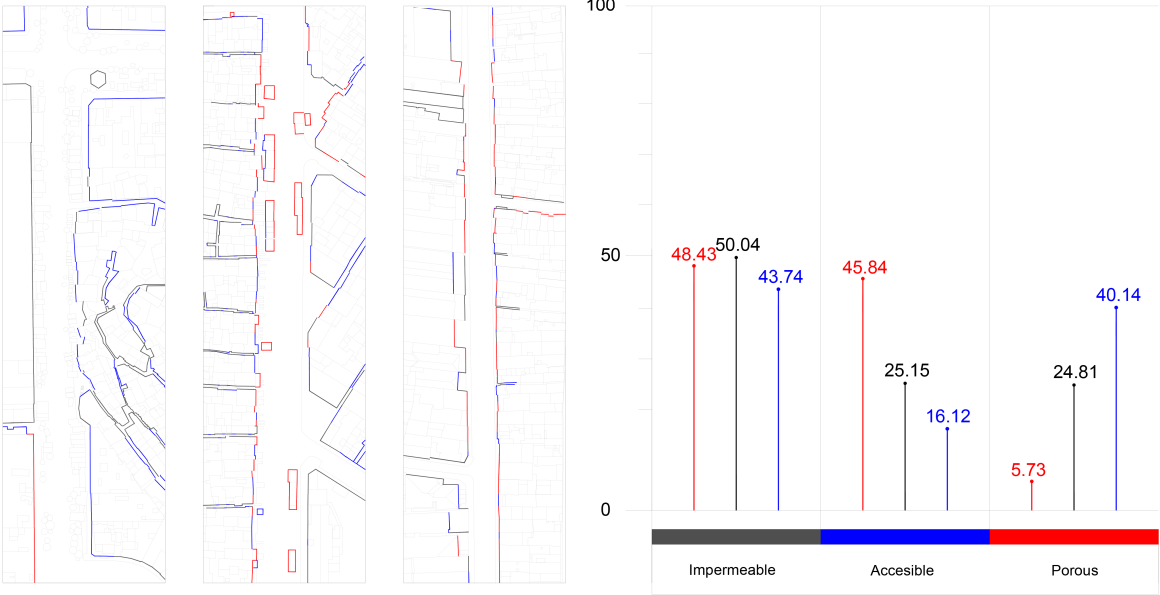
PERMEABILITY

SAN COSME VILLA RODOLFO RICCIARDELLI VILA HELIOPOLIS

a. INNER



b. OUTER



LEGEND

- Impermeable
- Accessible
- Porous

SAN COSME
VILLA RODOLFO RICCIARDELLI
VILA HELIOPOLIS

Figure 8. Comparison of permeability of the study areas. The linear diagrams represent a comparison between the indicators.

SOCIOSPATIAL DISTANCES

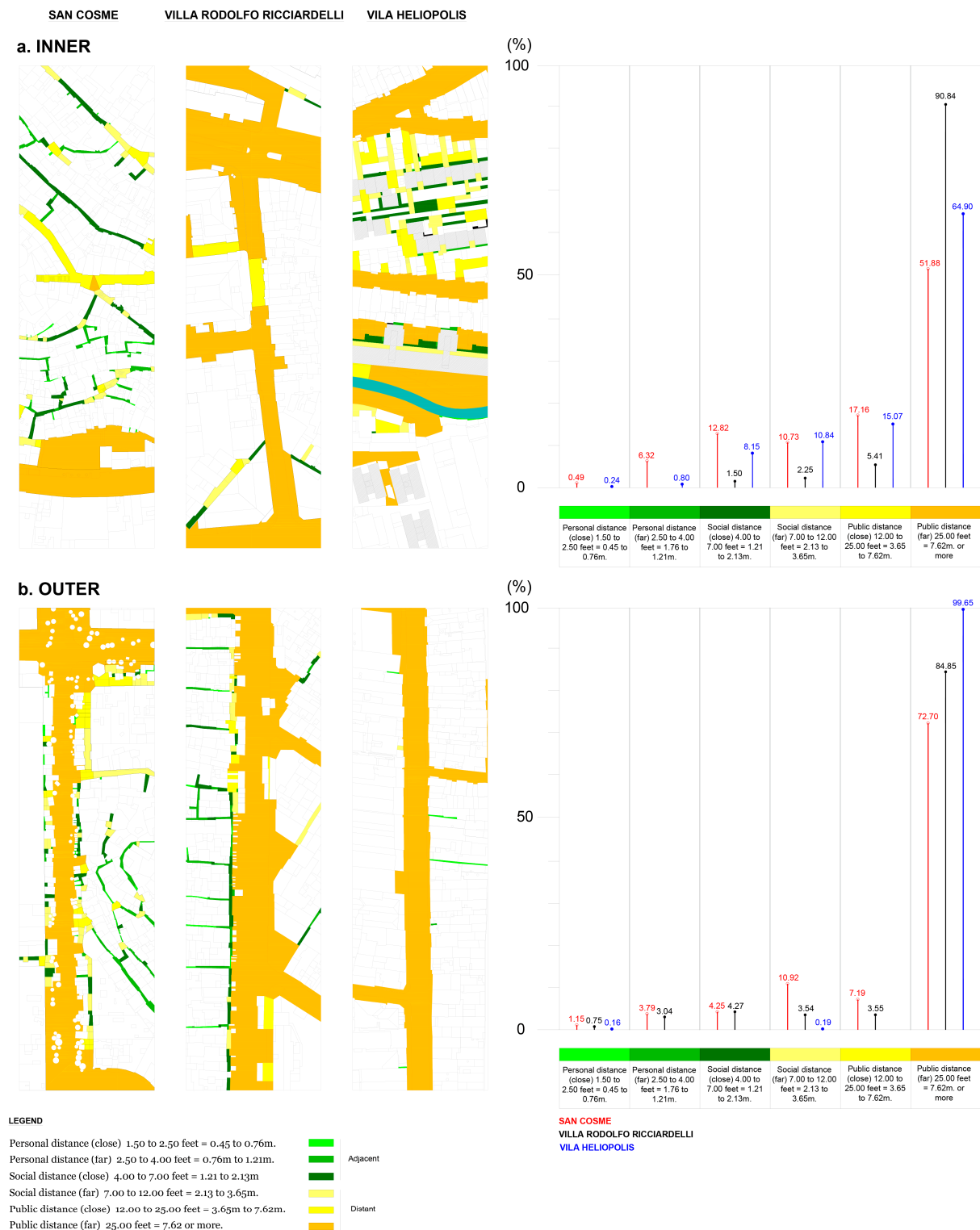
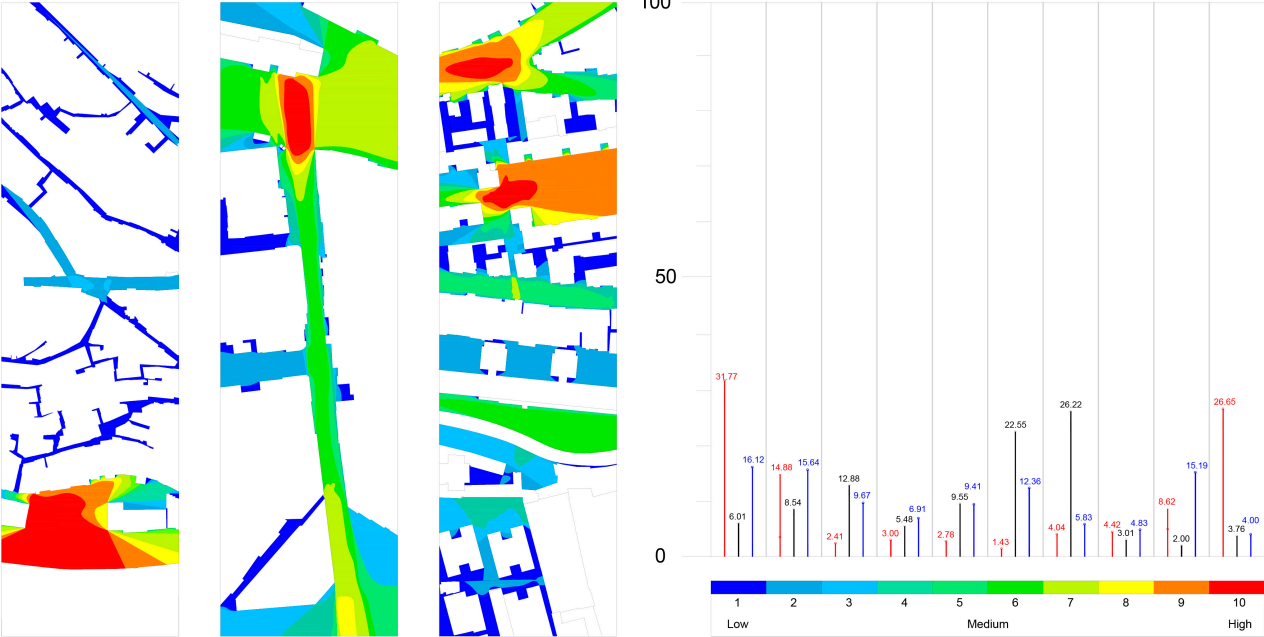


Figure 9. Comparison of the socio-spatial distances of the study areas. The linear diagrams represent a comparison between the indicators.

VISIBILITY

SAN COSME VILLA RODOLFO RICCIARDELLI VILA HELIOPOLIS

a. INNER



b. OUTER

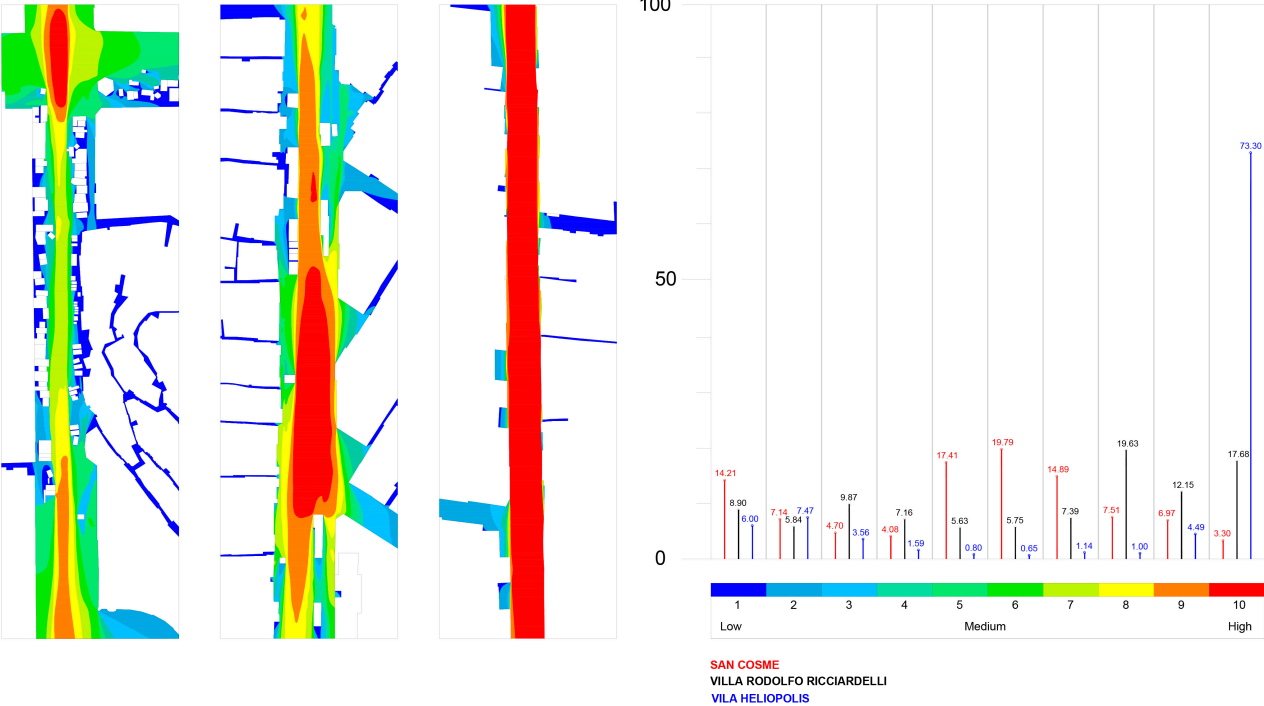


Figure 10. Comparison of visibility of the study areas obtained with DepthmapX 8.0. The linear diagrams represent a comparison between the areas with the highest and lowest visibility.

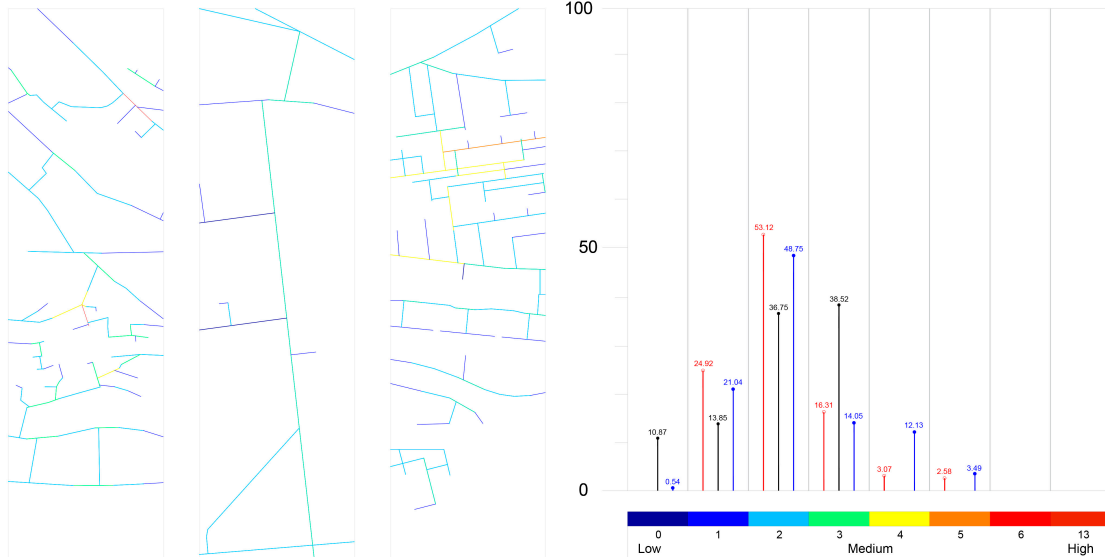
CONECTIVITY

SAN COSME

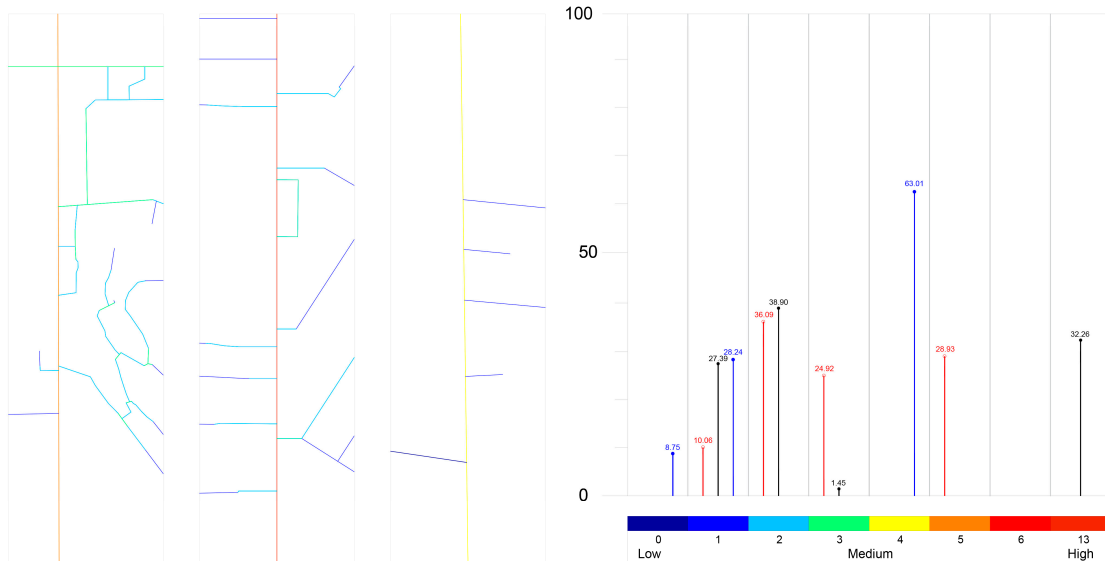
VILLA RODOLFO RICCIARDELLI

VILA HELIOPOLIS

a. INNER



b. OUTER



LEGEND

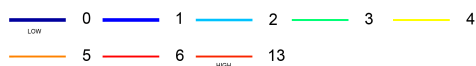


Figure 11. Comparison of the connectivity of the study areas obtained with DepthmapX 8.0. The linear diagrams represent a comparison between the paths with the highest and lowest topological connection.

3.3. Results of the Analysis

The results reveal a series of factors that provoke and intensify the socio-spatial fragmentation of innerburbs, limiting their public/private interface. Rapid informal urbanisation driven by governmental and private entities enclosed these suburban structures that managed to exist due to their specific socio-spatial dynamics, such as informal trade, the informal housing market due to migration and the need for housing. However, this enclosure led to slow slumification. Thus, aspects such as the temporary renting of slum

spaces and illegal trade related to migration processes from the interior in developing countries caused residential segregation and the “ghettoisation” of the innerburb, encouraging the emergence of practices such as illegal spatial appropriation, producing a progressive modification of housing in these structures and further residential segregation. These modifications are observable in the study of the façades on interior and exterior roads, with constant morphological transformations in the fronts that limit the innerburb with the adjacent formal fabric, evidencing the appropriation of interstitial spaces that limit the formal fabric with the innerburb, drastically diminishing the possibilities of social interaction between both structures. Spatial permeability is non-existent in the interior, established by the proliferation of blind façades and the lack of social and commercial activities due to the excessive road narrowness and consequent proximity to other neighbouring housing fronts. Connectivity and visibility in innerburbs are conditioned by perimeter arterial roads as the only possibility of interaction and urban interconnection with formalised fabrics. In this sense, a similar problem is observed among the case studies, identifying patterns and deficits in the morphological development of the innerburbs analysed (Figure 12).

3.4. Identified Patterns

- a. Typology of façades: they vary according to their location concerning the innerburb, with cantilevered interior façades predominating. On the outside, aligned façades are predominant. This phenomenon is caused by continuously modifying frontages and transforming the facades to obtain greater commercial visibility or more saleable areas. However, the most apparent transformations occur at the boundaries. This pattern raises the economic value of the building due to its proximity to the street, taking advantage of its location to carry out informal commercial activities and implementing the first level as flexible spaces adaptable to the economic needs of their owners.
 - Aligned/direct: They lack courtyards or entrance halls. They are located on narrow pedestrian thoroughfares. This façade is predominant on the innerburb boundary.
 - Set-forward/direct: They are configured inside and outside the innerburb in narrow corridors. Their configuration is similar to an aligned façade. However, the first level is used for retail.
 - Cantilevered: This is the most widespread typology at an advanced consolidation stage. Its configuration includes several levels. The first floor is generally a cellar; the following floors are used for housing and room rentals. These facades predominate in the interior.
- b. Public distance: The interior and exterior boundaries structure their spatial organisation with arterial perimeter roads as the only form of socio-spatial interconnection, linking informal occupations to economic production. These occupations diminish public distance on the avenues and eliminate interface transitions, becoming unused sub-spaces and privatised dead-end thoroughfares. These appropriations occur spatially at the boundaries of the innerburb.
- c. Permeability and accessibility: The access roads at the innerburb limits contain a high percentage of impermeable facades from informal buildings and social housing, eliminating the interface and acting as a negative pattern limiting its integration with the city by generating barriers.
- d. Connectivity and visibility: Grade 2 roads have a predominance of 50.00% (SC/VH), showing a low connectivity and development pattern in the innerburb typologies studied. On the outside, only VH presents grade 4 connectivity on the Estrada das Lágrimas road and grade 10 visibility. However, the areas with the highest visibility occur near social housing buildings and public spaces, which do not promote interconnection with other informal locations.

3.5. Deficits in Adaptability and Interconnection Interface Components

Values below 5.00% (Figure 12) reveal a lack of dynamism in components that promote the public/private interface, such as setback façades that favour street-to-building spatial transitions and social distances that encourage social interaction. These results also expose morphological problems, such as the functioning of connectivity (grades 4 and 5 below 5.00%), causing spatial segregation. The lack of visibility in all three cases is notorious, a fact related to the connectivity deficit. However, it is necessary to interpret the information presented. The values of incrementality and occupation present reduced percentages because the innerburbs are consolidated structures, making it impossible to observe the processes of occupation and incrementality in previous periods with synchronic analysis. The following components favour the interface, but they are scarce:

- Setback:** Its configuration promotes a transitional space between the street and the building, being used as an extension of the dwelling to develop shops and used for private use. It has the lowest percentage of predominance in the study.
- Social and personal distances:** The compactness of the innerburbs causes a lack of neighbourhood-scale public spaces and road profiles with social interaction (social distance). Although pedestrian routes in the inner city are numerous, their narrowness and irregularity increase the feeling of insecurity (personal space).
- Visibility:** Access in innerburbs lacks visibility due to the scarcity of public spaces and elements of urban articulation, promoting interior self-segregation. There is a greater visual field in areas of state intervention due to the implementation of public spaces that connect streets and avenues, which are not used as formal-informal assembly zones. On the other hand, the illegal appropriation of public areas in the arteries and unregulated incrementality considerably reduce the horizontal and vertical field of vision, eliminating contact with the innerburb fronts as a form of transition of interfaces with the city.
- Connectivity:** The study reveals low levels of grade 3, 4 and 5 connectivity, which is sufficient to reinforce the interfaces inside and outside the innerburbs. The main problem identified is the lack of intersections and irregular dead-end roads. On the outside, the primary connections consist of longitudinal roads with a few perpendicular to the main avenues.

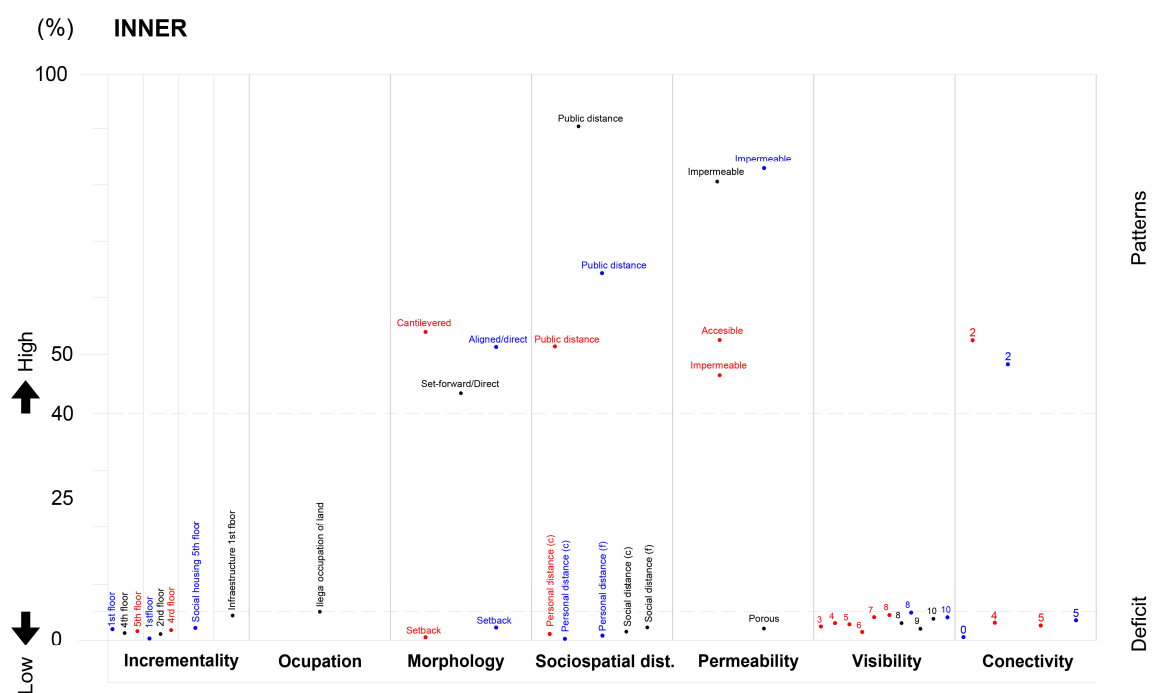


Figure 12. Cont.

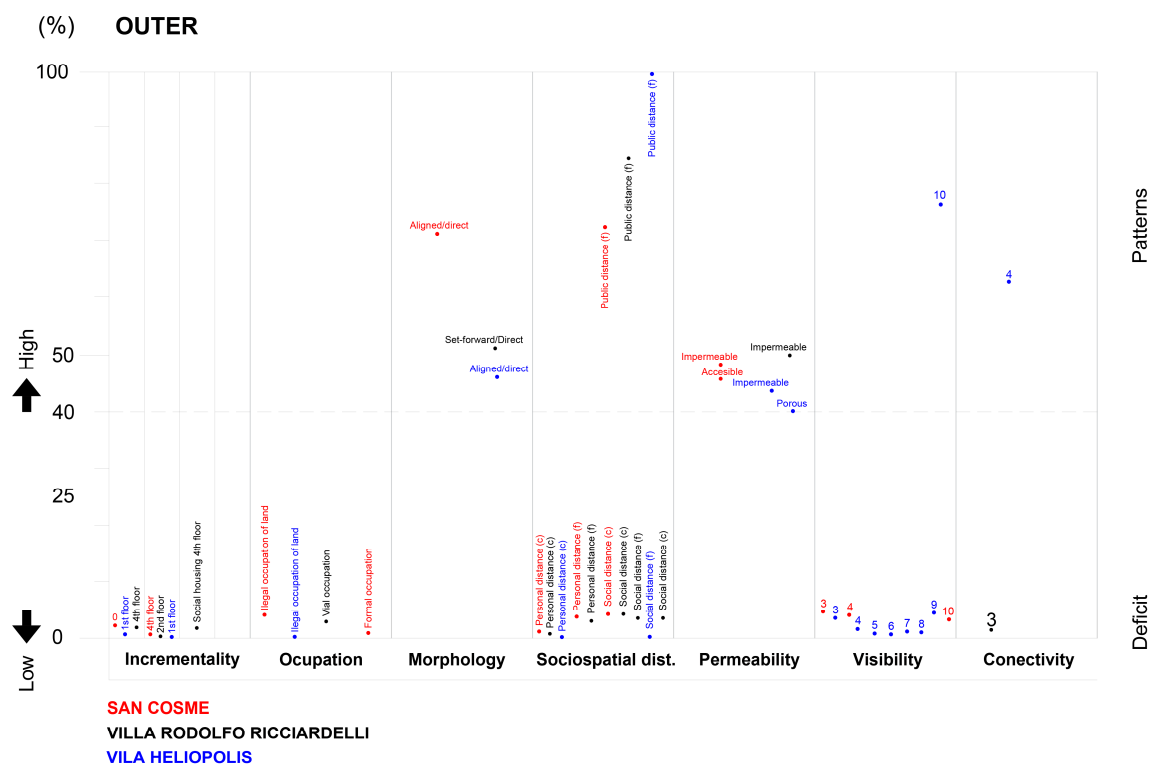


Figure 12. Detection of the predominant and deficit interface components in the cases studied.

4. Discussion

The research addresses the study of the dimensions of adaptability and interconnectedness by analysing indicators that provide new information to the body of literature on the morphological, socio-spatial and transformational functioning of the public/private interface in Latin American informal innerburbs, enhancing the understanding of these urban structures in contexts of the global south. The comparison among the cases reveals contradictory dynamics between adaptability and interconnectedness. Thus, the processes of adaptability identified inside and outside the innerburbs function in isolation, manifesting themselves visibly in the façade typologies through processes of incrementality lacking transitional spaces capable of enhancing the interface. Although the scalar morphological difference in the cases analysed is evident, one of the main findings in the research identifies micro-scale transformations as the primary triggers in the low interconnectivity between the formal and informal fabric, producing morphological alterations through forms of transgression such as the appropriation and privatisation of public domain spaces that promote informalised socio-economic activities, prompting degraded areas of domestic character. Thus, findings such as the illegal appropriation of avenues and streets with a comprehensive road profile for informal economic activities as the primary form of interconnection and social interaction between the innerburb and the city and the spatial subdivision of public space caused by informal appropriation are underlying mechanisms of appropriation processes as one of the most common forms of informal development, observable from the initial processes of invasion and squatting. Another finding is the emergence of hermetic facades during the incremental transformation of dwellings through processes of addition and renovation inside and outside the innerburb, fostered by weak public policies of regularisation and code. The incorporation of Space Syntax in the study as a system for measuring visibility and connectivity has revealed the existence of a precarious network of interior connections whose morphology fosters segregation and the loss of opportunities for socio-economic development. Thus, on the roads that connect with the exterior, informal, productive activities proliferate, appropriating the road profile and considerably reducing pedestrian visibility, being notorious for the spatial ghettoisation

between the interior and exterior zones caused by a chaotic and disorganised configuration produced during the process of illegal occupation of the innerburb. As argued in the Introduction Section, several works have examined the interface in informal settlements. However, they have focused on typological identification as a starting point for more complex future studies. The findings presented in the study on interconnectivity and visibility in innerburbs are comparable to research that has analysed the public/private interface in informal settlements from a morphological perspective [30], identifying typologies characteristic of informal development in slums in China similar to the typologies specified in the study; other work has explored the study of interfaces from the lens of adaptability [58,62] differentiating from research on the use of an incremental approach to adaptability in urban interaction and extension networks in Asian urban slums and research on the creeping occupation of public spaces, the illegal appropriation of spaces adjacent to government-sponsored housing in Nairobi and the temporary occupation of street trading in easily visible areas in different contexts in the global south [17,63]. The incorporation of Space Syntax in the study as a system for measuring visibility and connectivity has revealed a precarious network of connections that foster social isolation and the loss of opportunities for social and economic development caused by a chaotic and disorganised configuration produced by the illegal inception of these settlements. In this sense, this work is a valuable tool in the diagnosis and identification of socio-spatial phenomena of interaction between the formal and informal urban fabric from a morphological perspective, establishing recommendations for physical action to promote a progressive improvement in consolidated settlements with similar characteristics to the innerburbs analysed.

Recommendations

The recommendations are aimed at regenerating informal forms of economic production, spatial quality and road reorganisation, improving the levels of adaptability and interconnection to integrate the innerburb with the city to avoid its segregation. These solutions can be extended to the problem of isolation in other informal settlements in the global south.

Adaptability: The study exposes a more significant commercial proliferation in the outer limits as a basic system of formal-informal interconnection. In that sense, the incorporation of flexible spaces for the development of high-economic-value commercial activities in informal self-construction (air projection for future processes of vertical incrementality) and social interest infrastructure (housing and commerce) may be able to promote spatial porosity by increasing the transitional street-housing space for the improvement of the public/private interface and thereby improve the fluidity of economic exchange at the edges. Applying these two typologies at the edges aims to control the processes of progressive informal appropriation and the development of socio-economic activities for population integration with the economic dynamics of the formal city. This type of solution has been recently implemented in informal contexts [64,65]. However, it has been scarcely reviewed in governmental interventions, so its adoption can be beneficial as a system of urban assemblage between formal and informal fabrics at a local and intermediate scale, promoting its adaptability.

Interconnection: The study shows that given the scarcity of public spaces such as parks and squares, local and arterial roads become the main elements of interconnection between the innerburb and the city, having a decisive impact on the development of the settlement. Establishing a perimeter road renewal between the innerburb and the city is fundamental for promoting urban interfaces. The identified roads function simultaneously as roads and public spaces. Therefore, delimiting commercial zones (permanent and itinerant commerce) and pedestrian traffic on these roads can improve their spatial organisation, eliminating the possibility of fragmentation and privatisation of road space through illegal appropriations. On the other hand, a road transformation is also necessary to improve visibility and the provision of visual auctions that allow for better orientation and public convergence towards arterial roads. Applying similar solutions in programmes like Favela Bairro in

Brazil has been beneficial [66,67]. Finally, including economic dynamics at innerburb intersections and incorporating regulations for street trading activities on public roads are necessary to avoid affecting interface conditions at their boundaries.

5. Conclusions

This paper extends the study of the public/private interface in informal settlements, adding indicators linked to socio-spatial dynamics that allow us to measure the dimensions of adaptability and interconnectedness of the Latin American innerburbs vis à vis formal fabrics. The research provides important lessons that can be considered in future public policies for territorial planning and physical intervention in consolidated and newly formed settlements. Innerburbs are dichotomous interstitial structures characterised by the generation of commercial practices and socio-spatial dynamics at their boundaries as a system of informal economic production. This factor triggers transformations such as the continuous modification of facades, the privatisation of public space, the ambulatory appropriation of streets and vertical incrementality. Meanwhile, spatial segregation and ghettoisation within the innerburb are the result of the initial lack of organisation, a product of the cumulative process of informal housing during squatting as a form of protection against eviction, producing impermeable structures. Similarities such as low connectivity, scarce permeability and the lack of community facilities contribute to their degradation and isolation, relating the case studies to a problem representative of the Latin American context. In this sense, the research is a tool for detecting morphological and socio-spatial phenomena at interfaces between recently formed and consolidated settlements, which can be replicated in similar contexts for diagnosis and improvement. However, adding other indicators can complement the detection of new informal phenomena as possible lines of future research pending development. The cases of Lima, Buenos Aires and Sao Paulo reveal three typologies of spatial dynamics according to the degree of governmental interference, with the construction of social housing buildings being the most extensive form of intervention in the innerburbs analysed. However, the impact of these interventions has been discreet, serving only as containers for population absorption and as impermeable urban barriers without contributing to the improvement of interfaces. The recommendations presented are aimed at enhancing economic practices from a socio-spatial perspective and at improving metropolitan assembly with formal fabrics, optimising the adaptability and interconnection characteristics of the innerburb to reduce its segregation, offering initial responses to a recurrent problem in informal settlements in the global south, which can be applied independently through comprehensive or local planning.

Author Contributions: Conceptualization, C.A.M.M. and F.J.M.R.; methodology, C.A.M.M. and F.J.M.R.; software, C.A.M.M.; validation, C.A.M.M. and F.J.M.R.; formal analysis, C.A.M.M.; investigation, C.A.M.M.; resources, C.A.M.M.; data curation, C.A.M.M. and F.J.M.R.; writing—original draft preparation, C.A.M.M. and F.J.M.R.; writing—review and editing, C.A.M.M. and F.J.M.R.; visualization, C.A.M.M.; supervision, C.A.M.M. and F.J.M.R.; project administration, C.A.M.M.; funding acquisition, C.A.M.M. and F.J.M.R. All authors have read and agreed to the published version of the manuscript.

Funding: Funding for open access charge: Universidad Politécnica de Madrid.

Data Availability Statement: The authors declare that the data obtained, sampling and construction of the information presented in the research are the intellectual property of the authors. However, they can be consulted at any time through your contact and consent.

Acknowledgments: We thank all the people involved in the research during the process of collecting field information and for providing us with access to historical and statistical data in Peru, Brazil and Argentina.

Conflicts of Interest: The authors declare no conflicts of interest.

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