



Article

Urban Design Solutions for the Environmental Requalification of Informal Neighbourhoods: The George Dimitrov Neighbourhood, Maputo

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Abstract: The current dimension of informal settlements in Maputo requires the definition of action models framed by empirical evidence, taking advantage of pre-existing socio-spatial and environmental conditions to define physical interventions through sustainable urban design strategies, with a view to their physical (and socio-economic) upgrading. Thus, this paper highlights the potential of urban design in the environmentally sustainable upgrading of Maputo's informal neighbourhoods. This article aimed to develop sustainable and resilient urban design proposals and identify strategies capable of guiding the future process of physical territorial transformation towards a more sustainable model. Methodologically, a literature review was undertaken for the purpose of understanding the issues related to the theme and the general characteristics of informal neighbourhoods, as well as for exploring a case study: the George Dimitrov Neighbourhood. It was concluded that the current fabric of informal settlements possesses physical characteristics which facilitate the application of sustainable and responsive urban design strategies for the requalification of these deprived areas. Despite the marked difference between the spatial configurations of informal neighbourhoods and those of formal cities, it is possible to increase the level of resilience and sustainability of informal settlements through surgical and deep solutions, anchored on the particularities of the existing fabric.

Keywords: informal settlements; urban design; intervention strategies; urban sustainability; Maputo



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1. Introduction

Cities, where most of the population currently lives [1], are seen as the destiny of humanity [2]. It is estimated that about 50% of people already reside in cities, with a projected increase to 68% by 2050 [3]. Thus, the urban population in the coming period will increase significantly [4], especially in developing countries [5,6]. In these regions, circa one billion inhabitants already dwell in informal settlements; a number predicted to triple by 2050 [7], especially in sub-Saharan Africa [8]. Informal settlements can thus be considered the primary phenomenon of contemporary urbanisation [9].

Multiple factors determine the emergence and spread of this mode of urban production, particularly (i) the incapacity of the state to respond to housing needs [10]; (ii) rural exodus and the unequal distribution of wealth and resources [11]; (iii) the explosion and increase in urban attractiveness [12]; and (iv) extreme natural events and civil wars [13]. Despite their multiple shortcomings and physical precariousness, informal settlements are a key resource for addressing poverty [14]. Therefore, in order to improve the quality of life of residents of informal settlements as well as curb their uncontrolled growth, several intervention modes have been implemented [15–17]. However, these regions still proliferate rapidly and precariously [18], especially in the Global South [19].

Due to their size and exacerbated growth, as well as their strategic location that allows easier access to employment and urban amenities, currently their demolition and replacement is consensually perceived as unnecessary and impossible [20,21]. In this sense, there is an urgent need to recognise informal settlements as a mode of urban self-production [22] and thereby create more sustainable solutions informed by scientific evidence [21], taking advantage of the existing human, physical and socio-economic fabric in order to create effectively sustainable solutions through urban coproduction [23].

In this process, sustainable urban design strategies emerge, such as: (i) the permeability of the road structure, urban variety and robustness [24]; (ii) the inclusive and accessible network of public spaces and green spaces [25]; and (iii) urban densification, the inclusion of vegetation and sustainable urban services_ [26,27] among others, which play a crucial role in sustaining and improving the liveability at the district and regional levels of informal settlements [28–31]. This study presents an exploration of the role of urban design in the physical (and social) transformation of informal settlements through a prospective approach, driven by empirical evidence and based on theoretical assumptions obtained from the observation and analysis of the local scale of the case study.

Therefore, this article highlights the study of the physical dimension of intervention in informal settlements, an approach that has been little considered or even progressively forgotten in favour of the socio-spatial analysis [19,31–33], of socioeconomic and political issues [34]. While these are admittedly unavoidable, they should not void other contributions of urban planning, which is material/physical by nature and definition [35]. Therefore, based on the principle that the current and apparently disorderly configuration of the urban fabric of Maputo's informal settlements leads to a set of functional and socio-environmental problems that embody its urban unsustainability, we analysed proposals for physical interventions in informal neighbourhoods through the strategies of sustainable urban (and architectural) design with a view to understanding their role in the environmental upgrading of informal neighbourhoods.

The following research questions were thus addressed. First, is it possible to intervene in the physical (and social) urban fabric of informal settlements in Maputo, based on sustainable urban design strategies, in order to improve their environmental quality? Second, which sustainable urban design strategies can be considered applicable to the environmental upgrading of informal settlements, taking advantage of existing spatial and socio-economic conditions?

This article is structured in five chapters, namely (i) introduction; (ii) methodology; (iii) literature review; (iv) case study; (v) verification of the integration level of knowledge derived from the literature review into the proposed solutions; and (vi) final considerations.

2. Methodology

This article is the second scientific communication undertaken by the authors on this theme. It uses a mixed approach, i.e., qualitative and quantitative, following two methodological paths: (i) a literature review, which sought to identify, analyse and understand the informal settlements of Maputo, their socio-spatial dynamics, their socio-environmental, economic and morphological characteristics and their problems; and (ii) a case study, conducted through fieldwork carried out by the authors, aiming to isolate and understand both the morphological (and socio-economic) and environmental characteristics of the George Dimitrov Neighbourhood as well as to analyse the investigative issues derived from the application of sustainable and resilient urban (and architectural) design strategies, in order to understand their role in improving the environmental quality of informal neighbourhoods.

The aforementioned literature review focused on: (i) the conceptual framework of informal settlements and intervention models, exploring the diversity inherent to their definition as well as the positive and negative aspects of previously applied modes of intervention; (ii) urban design in order to briefly explore its definition and relevance within the current debate and in the context of informal settlement upgrading; and (iii) the characteristics of Maputo's informal settlements for the purpose of understanding their

existing spatial and socio-economic qualities as well as their problems. A complementary critical literature review on the concept of informal settlements, their environmental characteristics and problems was previously presented in Salamagy and Alves [23].

The following urban (and architectural) design strategies were applied to the morphological units (the block [36], the street network [37], the public space [38], and the housing [21]) that structure the organization of the George Dimitrov Neighbourhood: (i) the physical and visual permeability of the street fabric; (ii) functional diversity; (iii) the public space network; (iv) sustainable stormwater drainage systems; and (v) natural ventilation and housing densification. This procedure analysed the role of these strategies in the requalification of informal neighbourhoods, taking into account the results of the research analysis presented in Salamagy and Alves [23], namely in terms of what pertains to socio-economic conditions, urban services, housing and daily life, the residents' perception of the environmental conditions of their house, public space and the detected mobility and environmental problems. This work also details the methodological procedures used for the selection of the presented case study; briefly and schematically, it followed the methodological process presented in Figure 1.

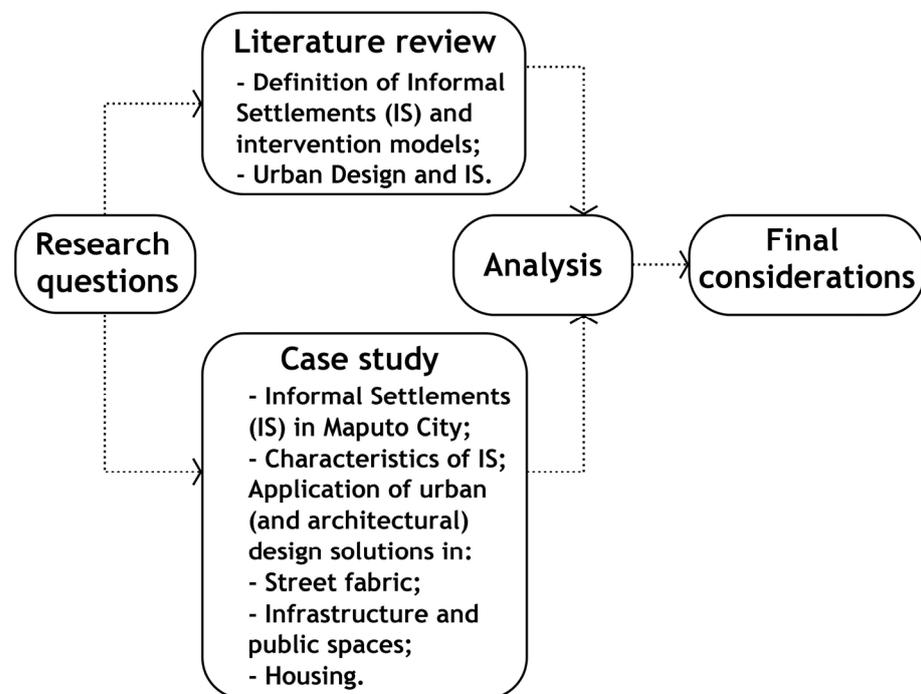


Figure 1. Diagram of the methodological process of the research.

3. Literature Review

3.1. Informal Settlements and Intervention Models

The world is undergoing a rapid and unprecedented process of urbanization [39]. In this process, the population residing in informal settlements is likely to double in the next decade [40], particularly in developing countries. Large numbers of urban dwellers live on the threshold of poverty amidst decaying infrastructure and socio-spatial deprivation [41], with impacts on their health and well-being, an issue recently exacerbated by the COVID-19 pandemic [42].

Informal settlements are globally known by various designations [43], such as *favelas*, *caniço* or *musseques*. relevant names vary according to language and geographic region [44]. From a morphological point of view, they were initially understood as seemingly cluttered areas, built spontaneously and organically, rather than purposefully designed. Their complex configuration suggests an incompressible environment without structure nor any form of planning logic [45]. However, while it is recognized that informal settlements are complex and dynamic social systems [42], there is also a growing understanding of these areas

as a mode of urban production [21], resulting from self-organizing practices [46]. According to Mohamed et. Al. [47], they function well locally due to their strong internal structure but relate poorly to the broader context because, from a socio-economical perspective, they interact inefficiently with the rest of the city.

In several situations, informal settlements are located in the suburbs and peripheries of formal and consolidated urban centres [48,49]. However, only a morphological dichotomy is recognized; most so-called formal cities cannot sustain themselves without informal settlements, as there is a connection and interdependence between the two realities [14,22,50].

Currently, informal settlements are understood as residential areas where: (i) residents lack security of land or housing tenure [51]; (ii) neighbourhoods lack basic services and infrastructure [52]; and (iii) housing is precarious, overcrowded or does not comply with current planning and building regulations [53] and is often located in areas considered environmentally hazardous. However, despite their critical socio-spatial conditions, informal settlements are the only viable solution to transform the lives of the poorest urban dwellers in a meaningful and cost-effective way [12]. Therefore, there is now a greater awareness that removing informal settlements is almost impossible, resulting in a shift from 'eradication' to 'improvement' approaches, which seek to absorb the informal fabric into the formal city [54].

In recent years, several modes of intervention in informal settlements have been implemented, as illustrated by Figure 2 [12,15,17,55]. Namely: (i) Direct public housing—the provision of public housing by the state [55]. (ii) Sites and service schemes—the provision of land with basic infrastructures for households by the state through their own house building initiatives [56]. (iii) Housing production and delivery modes—the production and distribution of better-quality housing for poor inhabitants through various mechanisms that include social housing, self-help housing and/or public rental housing [8]. (iv) Reforming building codes and standards—the reform of building codes and standards to adjust to the economic, social and cultural patterns of the context [57]. (v) Integrated approaches—strategies that integrate the socio-economic and environmental aspects of the various intervention models already applied in informal settlements, as well as the participation of communities and the public and private sectors, in order to achieve an holistic intervention model that integrates all positive aspects [15]. (vi) Upgrading informal settlements—strategies for local improvement of informal settlements [58].

The debate on the intervention models applicable to informal settlements has already been explored by Amado et al. [15]; Cirolia et al. [54]; Keivani and Werna [55]; Wekesa et al. [17]; and Wegelin [58], and thus it will not be repeated here. Nevertheless, the variety of already applied intervention models highlights the multiplicity of perceptions regarding the problem of informal settlements. In these forms of urban policy action, important differences are found in the (lack of) use of existing conditions. The intervention model may opt for the renovation and consequent resettlement of populations or for requalification, improving local conditions; furthermore, the public sector can play a centralized role when it is the main promoter of the interventions, or a decentralized role when the state participates indirectly and the private sector has an active role.

Upgrading informal settlements is a model that takes advantage of existing spatial (and socioeconomic) conditions, i.e., the morphological configuration of the informal settlement after upgrading is genetically influenced by the existing urban condition. However, there is little research on how urban design can take advantage of the physical (and social) fabric of informal settlements to define strategies that improve their functioning. On this, Venerandi et al. [39] praise the irregularities and organic forms of informal settlements, comparing them to vernacular urban centres such as medieval cities; they also highlight several desirable features and configurations, such as a human-scale, well-connected urban fabric that not only promotes commerce and social interactions but also favours pedestrian movement and the overall well-being of city residents [59].



Figure 2. Intervention models in informal settlements (source: prepared by the authors, based on Amado et al. [15]; Cirolia et al. [54]; Keivani and Werna [55]; Wekesa et al. [17]).

This perspective framed the present research. It is aligned with the Millennium Development Goals [60], and more recently the Sustainable Development Goals [61], under their goal aim of improving the lives of at least 100 million slum dwellers. Likewise, it also aligns with the various agendas of international initiatives, such as Cities Without Slums, which recognizes informal settlements as a mode of urban production [21] that is difficult to eradicate through major urban reforms, and thus takes notice of their socio-spatial characteristics to implement redevelopment strategies based on the existing urban condition.

3.2. Urban Design and Informal Settlements

According to Cuthbert [62], urban design emerged with the first conscious urban transformations. However, the more common perception is that it emerged in the post-war period [63] of the 1950s [14] to address large-scale urban challenges [64]. Traditionally, it was understood as an art [65], derived from the interstice between architecture and urban planning [63]; however, this is a controversial view in light of the current debate [14].

Although the tangible dimension of urban design is common, its definition is not consensual in the literature. For Madanipour [66], urban design deals with the organizational modelling of the forms and functions that cities should assume. That is, the shaping of the parts that constitute the city as well as the relationship between them [25,67]. It is not only a combination of creative and critical thinking in order to imagine and invent the urban future [68] but also a conscious and multidisciplinary process of shaping and managing the built environment at all scales [14]. The debate on the definition of urban design is vast [69]. The intention is not to exhaust it here but rather to briefly understand the concept as well as its strategies and scientific relevance regarding the sustainable transformation of informal settlements. Regarding the latter, it is important to highlight that urban design contributes to more efficient urban ventilation [70], increased resilience to extreme weather

events [71] and public health [72] as well as to the promotion of sustainable mobility and urban vitality [73].

In its bioclimatic perspective, urban design foresees, first of all, the choice of the ideal place for the implantation of cities [74] and then the construction of urban and architectural forms adapted to the cultural, material or climatic conditions of the place [75,76]. Nevertheless, the organic, spontaneous and incremental processes responsible for producing the configuration of informal settlements result from intentional but not centrally coordinated micro-actions [14,51]. Therefore, informal settlements are often built in inappropriate locations without respecting the bioclimatic characteristics of the place.

In contrast, urban design implies a spatial order generated by designers in a rational and intentional way [26,73]. However, urbanistic solutions in informal settlements evolve naturally in order to achieve an optimal balance, i.e., the condition of the configuration of informal settlements in which physical and functional characteristics evolve to achieve scenarios more in balance with the natural and social conditions of the place [26]. In truth, most cities are neither fully planned nor spontaneous but result from a balanced relationship between design and spontaneity. In this sense, informal settlements and urban design can be understood as complementary rather than contradictory [69]. Moreover, design is applied not only to new urban developments but also in upgrading the operation of already built urban environments [25].

Thus, urban design is a relevant discipline in improving the quality of life in informal settlements. It is fundamental to understand the complexities of informality in order to define appropriate intervention strategies [14]. In this process, it is also fundamental to incorporate not only aesthetic but also social, cultural, economic and environmental place concerns in order to (re)produce 'meaningful urban spaces' that facilitate adaptation and appropriation by multiple users [77]. Thus, new forms of urban design action must be created in order to enhance existing qualities. At the same time, certain urban design strategies that respect the characteristics of informal settlements are already contributing to the sustainability of current cities [24,26,27,74,78–80] and can be applied in informal neighbourhoods. Below, several examples of these strategies are presented.

Urban density: a parameter that can be strategically used to achieve environmental balance in informal settlements along several perspectives, as a highly compact density is related to reduced energy consumption in transportation and, consequently, lower CO₂ emissions [27]. In addition, a higher density means a lower amount of green surface converted into built space and therefore a lower impact on emissions, since vegetation absorbs CO₂ [80]. However, high density is also positively correlated with the urban heat-island phenomenon [81], thus resulting in increased energy consumption for the purpose of spatial cooling. A balance is necessary in the face of these contradictions, which is why Butera [27] places the optimal density for a sustainable neighbourhood at 150 people/hectare.

Mixed land use: contexts with a mix of functions reduce commuting distances, thus increasing the attractiveness of soft and more sustainable travel modes. This is based on the assumption that the primary aim of car travel is to participate in geographically distant activities within the territory, and thus shortening these distances reduces the need for private cars [79]. In addition, mixed land use is associated with cities where short distances prevail, which promotes greater vitality in public spaces.

Vegetation: green areas not only absorb CO₂ but also contribute to the mitigation of the urban heat-island effect, as even a small green area (60 m × 40 m) can reduce its temperature in comparison to its surroundings by up to 3.0 °C [27,82,83]. In addition, urban agriculture allows energy savings, as producing food locally reduces the need for transportation and refrigeration.

Shape and solar orientation of the streets: in southern hemisphere regions (as is the case of Mozambique), the overheating of spaces is very high [78]. Therefore, the cooling of public spaces should be guaranteed—the more uncomfortable the open spaces are, the more uncomfortable the internal spaces of the houses will be, and more energy will be needed

to obtain thermal comfort. In this sense, the ratio between the height and width (H/W) of the street, as well as its orientation and textures, are decisive in the thermal comfort of pedestrians. That is, in a street where the H/W ratio is high, the ground surface and the lower parts of walls remain in shadow for much of the day. Furthermore, light-coloured materials improve natural lighting conditions and have a high albedo, thus reducing heat accumulation on urban surfaces, especially those in contact with people [74].

Physical and visual permeability: the variety of choices of paths that a given environment offers to access urban functions is a quality called permeability. It can be visual, when it refers to the ease of observing the choices that the urban fabric offers, but it can also be physical when pathways and accesses are well connected [25,26]. It is a fundamental environmental quality for the sustainable functioning of cities [25].

Sustainable stormwater drainage systems: an alternative to traditional stormwater management systems [84–86], which mimics the natural hydrological processes of drainage (infiltration, evapotranspiration, filtration, retention, reuse) lost to urbanisation and the impermeable surfaces associated with the installation of piped drains [87,88]. These systems contribute to the creation of habitats for nature, opportunities for water reuse and improvements in water quality [89]. While traditional systems use built infrastructure (usually underground) to capture and transport water out of the urban area [86], sustainable stormwater drainage systems use a range of devices—ditches, green roofs, permeable pavements, ponds, constructed wetlands, basins and infiltration ditches—to reduce the flow and overall level of pollution in runoff [86,90].

It was not the intention of this work to present all the existing urban design strategies. The challenge of this research lay in the fact that the aforementioned forms of intervention are usually applied in the design of new urban developments, but not in existing urban contexts, built through spontaneous processes that do not follow a previously designed urban project. It is necessary, on the one hand, to understand the diversity and importance of the sustainability of informal settlements in the implementation of certain already consolidated urban design strategies; on the other hand, it is necessary to analyse their applicability in informal settlements, taking into consideration their pre-existing characteristics. In this process, it is also important to identify, within the complexity of informal settlements, the specific modes of intervention informed by the specificities of a place. Therefore, in the following subsection, a brief literature review on the characteristics of the informal settlements of Maputo is presented.

4. Case Study

4.1. Informal Settlements in Maputo

The Mozambican capital is a city of colonial genesis, with two morphologically distinct urban realities [48,49,91]. On the one hand, there is an urban centre built with quality materials, which is resistant and structured according to rational urban design; this is where the colonial population used to live, and today the Mozambican population with greater resources and education levels resides here. On the other hand, we have the suburbs and periphery, built with precarious and fragile materials and organised in an organic way, apparently ‘disorderly’, where populations with fewer resources and lower levels of schooling are located [49,50].

Thus, regarding the emergence and growth of informal settlements in Maputo, two distinct periods can be identified [91]. The first relates to the settlement of the colonial population and the subsequent emergence and development of the city until the country’s independence. In this period, the city was planned and built according to various urban plans [92]. At that time, the residents of the informal neighbourhoods received little consideration; they lived in peripheral settlements, near the main roads and without infrastructure, of a semi-rural character [93]. This was how the informal settlements in Maputo emerged: firstly Xipamanine, in 1919, and then Lagoas (now Maxaquene), around 1938 [94].

The second period stretches from the post-independence period to the present day, which is characterised by the implementation of several measures by FRELIMO (Frente de Libertação de Moçambique (FRELIMO) is the partisan movement which launched the armed struggle for the colonial liberation of the country (25 September 1964), and, through the Lusaka agreements (7 September 1974), officially achieved the right to independence.) [95], aimed at reducing the socio-spatial inequalities that made it impossible for natives to exert their right to the city under the colonial regime [48]. In view of such measures, Maputo became an attractive hub for the population. In addition, other factors amplified the uncontrolled growth of informal settlements in Maputo, such as: (i) the abandonment of the Portuguese colonial community, resulting in a shortage of qualified experts available to manage the city and, as a consequence, the physical and environmental deterioration of the city [49]; (ii) the civil war that led the country to a financial crisis and made urban centres ‘cities of refuge’, i.e., safe places to host the rural population buffeted by the scourge of war; (iii) cyclical natural calamities [13]; (iv) the increase in urban employment arising from the restructuring of the state apparatus and the nationalisation of several enterprises; and (v) low salaries that did not allow for tax contributions to urban maintenance [94].

In this context, informal settlements proliferated throughout the ‘urban periphery’. The immediate surroundings and periphery of the urbanised centre densified in a process of rapid spontaneous expansion without a proportional increase in infrastructure and services [96]. Not even the urban centre inherited from the colonial period had the capacity to respond to the needs of this new urban growth, since its infrastructures and services were designed and dimensioned for a limited settler population and were unable to accommodate new inhabitants [48]. Furthermore, the state provider did not expand the existing infrastructures, much less build new urban centres, thus accentuating the urban asymmetry after independence [97]. Currently, around 70% of Maputo’s population resides in informal neighbourhoods [98], and thus the urban fabric of the Mozambican capital is predominantly composed of informal settlements (Figure 3).



Figure 3. Location of informal settlements in Maputo City (source: [99], edited by the authors).

Characterisation of Informal Settlements

Informal neighbourhoods are characterised by urban self-production and stable legality. Self-production arises from the initiatives of the inhabitants themselves in the provision of housing, construction, neighbourhood management and obtaining land outside the official systems established by the state administration. Stable legality refers to the insecurity of informal settlements in the face of legal territory management instruments, an insecurity which contrasts with their recognition by surrounding areas and by the local authorities witnessing the land occupation and habitat construction [100]. Therefore, informal settlements represent the (re)configuration of the urban environment through complex survival micro-strategies in order to solve the urgency of housing [101]. These strategies depend not only on the financial means of the residents but also on their habits, culture, needs and governance structures.

For example, in the suburbs and periphery of Maputo, it is currently difficult to find houses made of reeds or natural materials; through the families' efforts at saving and creativity, the houses were gradually transformed from constructions based on indigenous materials, such as reeds (Scientifically, this is called phragmites, a genus of wetland plants. It is a tall, fine and highly productive grass. Due to its worldwide prevalence, it is often cheap and readily available as a raw material. The stems are traditionally harvested in winter for crafting and building materials (including walls and roofs); they also provide thermal insulation [102]. Thatch (dry vegetation which, due to its rustic image and thermal insulation properties, is predominantly used in the construction of roofs and walls in regions with tropical and temperate climates) and thorn hedges, into constructions based on industrially produced materials, namely cement, steel and zinc [24,103]. Proof of this are the results of the 2017 General Census of Population and Housing, which showed that of the total 245,005 dwellings registered in Maputo City, from the point of view of their construction characteristics, about 93% (227,601) had cement block walls, 83% had zinc sheet roofing (203,283) and 73% (179,628) had cement flooring (Figure 4).

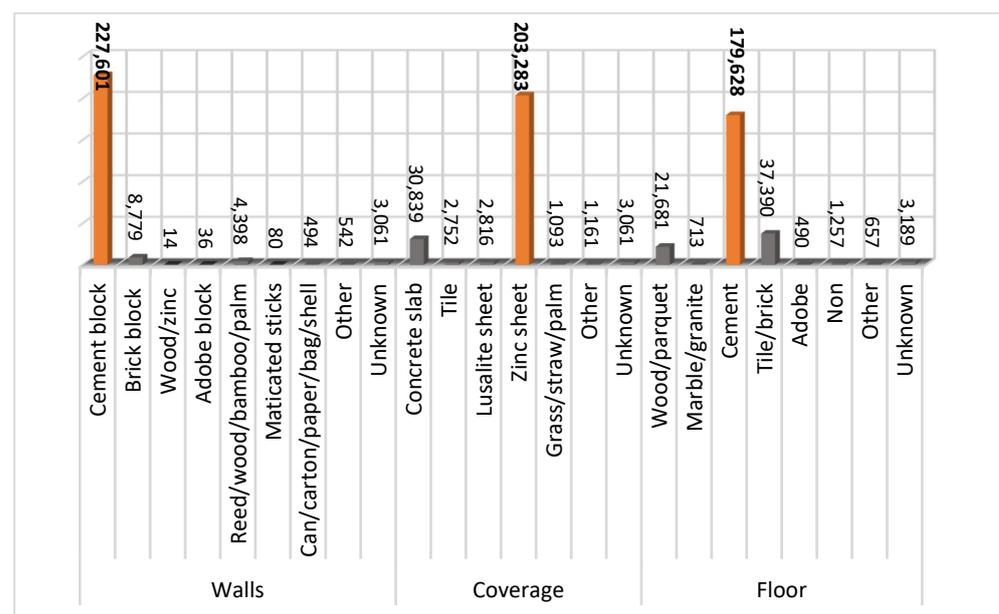


Figure 4. Housing construction materials in Maputo City (source: [104]).

The rural influence over the current urban fabric of informal neighbourhoods is evident. In other words, the narrow and winding roads that connect large plots of land in rural Mozambique (Figure 5A), where the backyard plays a key role in the socialisation of dispersed families, have been transposed to informal settlements (Figure 5B). In the meantime, the high density of buildings horizontally occupying the ground in informal settlements has transformed the existing paths; while in the rural context paths are visually and physically

permeable, they now turn into veritable labyrinths connecting small plots of various sizes and geometries, with the public–private interface made of opaque surfaces of great height that mostly comprise house fences. The backyard of these houses is the central place of daily life, as that is where the real living and conversation room is located [105]—not only due to the rural influence but also for the thermal comfort that the shade of trees offers these environments [23].

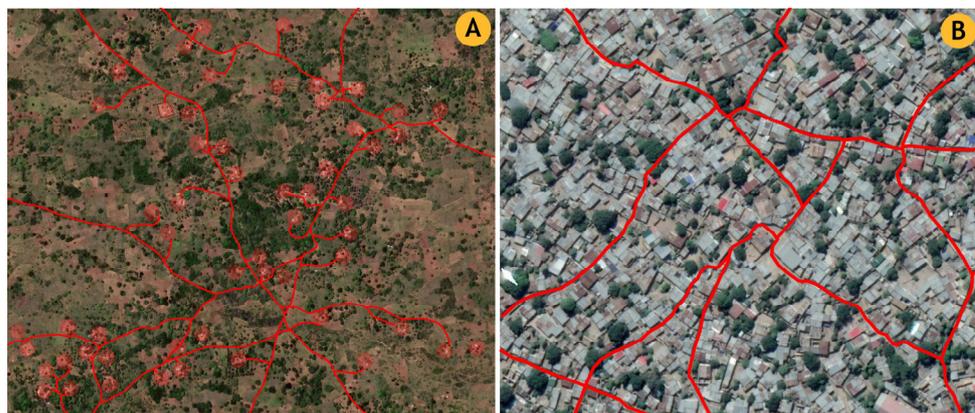


Figure 5. Transition from rural setting to informal settlement (source: created by the authors using Google Earth (2018) aerial photography). Legend: (A)—routes, plots and buildings within the rural fabric; (B)—routes, plots and buildings within the informal fabric.

Housing, in turn, is more than just accommodation. It is, at the same time, a space for survival financial support, with roughly 60% of families undertake some kind of economic activity on their plot according to Carrilho [100]. This situation is more common in the poorest households and usually consists of selling basic household goods and vegetables placed on an outdoor table that is taken back into the house during the night. Kiosks, often built as an integral part of the house fence, are found in wealthier households [24,105], as illustrated by Figure 6.



Figure 6. Informal trade integrated into the fences of dwellings (source: created by the authors based on Salamagy and Alves [23]). Legend: (A)—house backyard; (B)—kiosks as an integral part of fences; (C)—a wide street, prime space for circulation, socialising, meeting and local commerce; (D)—the street as a public space for entertainment.

Regarding public space in these neighbourhoods, a simple drinking water fountain has the minimum conditions necessary to promote the dynamics of a square, even if this space does not have the formal appearance of a square [106]. In other words, the minimal infrastructure and the most elementary urban public resource becomes a place of reference in everyday life, capable of allowing various uses and appropriations. An example of this is the wide street, a space that, in addition to allowing the circulation of people, also becomes a place for socializing, meeting and promoting urban prosperity through informal trade.

Therefore, we face a diversity of strategies that influence the configuration of the urban fabric in informal neighbourhoods, even in its apparent ‘disorder’. It is an environment that, when not responding to the residents’ needs, is systematically transformed according

to the dynamics of their daily lives. For Viana [101], it is this variety of micro-survival strategies that results in an urban structure morphologically characterized as a plural and polymorphic urban mosaic (Figure 7). That is, the intersection between various forms of survival and architectural inspirations, and in some cases also urban inspirations from the consolidated urban centre of Maputo, births an environment in which every square centimetre of space is used. From these simple iterations of ‘city making’, an organic, complex and dense urban system emerges, reflected by the improvised dwellings that generally have a different physical appearance from those of the so-called ‘formal’ city [107].

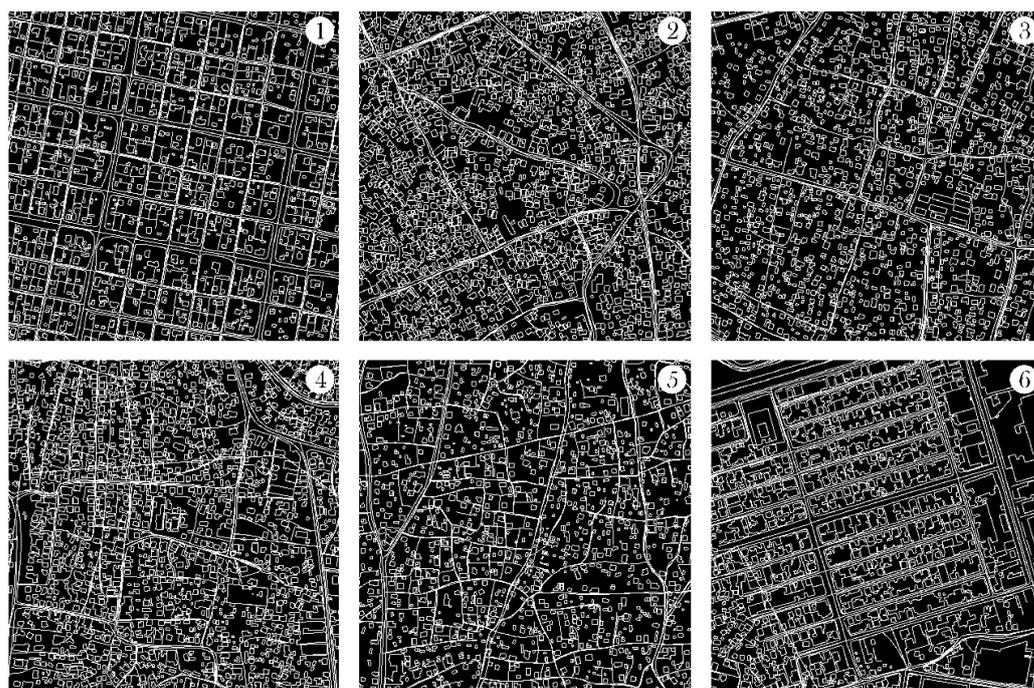


Figure 7. Plurality and polymorphism of the urban fabric of Maputo’s informal settlements. (source: created by the authors using the CAD basemap of the municipality of Maputo). Legend: 1—Laulane; 2—Chamanculo; 3—Inhagoia; 4—Mafalala; 5—Helene B; 6—Airport A.

4.2. Design Proposals for the Requalification of Block 33

This subsection presents the application and description of the urban (and architectural) design solutions to the morphological units that structure the organization of Block 33 of the George Dimitrov Neighbourhood. The application of these solutions takes into consideration the observations, analysis, diagnosis and findings reported by Salamagy and Alves [23] as well as the literature review presented in this paper. Thus, a spatial contextualization of the case study is first conducted in the context of the city as well as within the scale of the neighbourhood; then, the solutions applied in (i) the road fabric, (ii) the system of public spaces and, finally, (iii) the housing are explored.

Spatial Context of the George Dimitrov Neighbourhood

The George Dimitrov Neighbourhood is located in the Kamubukwana Municipal District (The Kamubukwana Municipal District comprises seven municipal districts. Two of them, Katembe and Inhaca, are separated from the urban center by Maputo Bay. The small island of Xefina is administratively considered part of Municipal District 4 [108].), in the suburban area of Maputo City [109]. It is 480 hectares in area and has 40,972 inhabitants [110]. Its boundaries include: to the north, the former Paiol de Malhazine and Bairro do Zimpeto; to the south, the Bagamoyo Neighbourhood; to the east, the Malhazine Neighbourhood and Maputo International Airport; to the west, the floodplain of the Infulene river and the Matola Municipal Council (Figure 8).

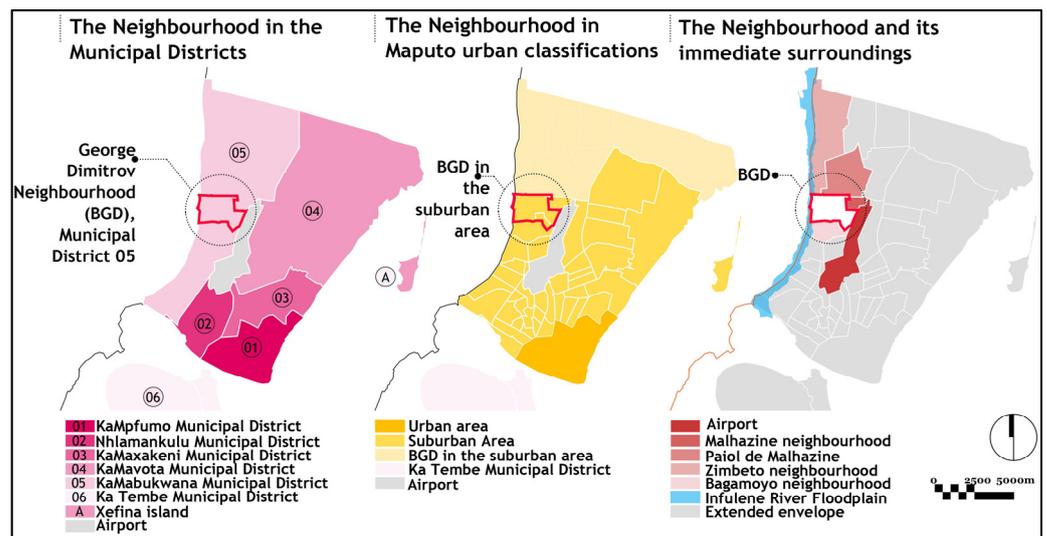


Figure 8. The George Dimitrov Neighbourhood in the context of Maputo.

This research focused on the George Dimitrov Neighbourhood, designated by the Municipal Council of Maputo City as the George Dimitrov Neighbourhood pilot area (Figure 9). With a surface area of 100 hectares, or approximately 20% of the total area of the neighbourhood, it includes 44 official administrative urban blocks.

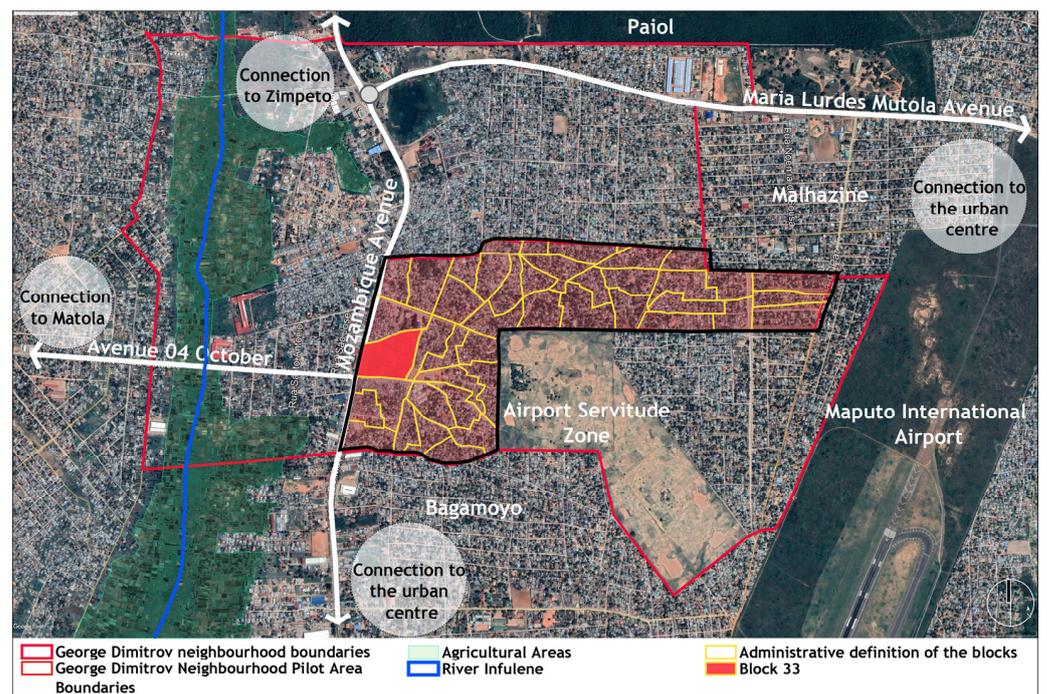


Figure 9. The context surrounding the George Dimitrov Neighbourhood (source: own authorship using Google Earth (2019) aerial photography).

From the point of view of accessibility, the George Dimitrov Neighbourhood is located in a privileged zone, since the existing road structure provides connections both with its immediate surroundings and with more distant parts of the city. In the latter, we highlighted *4 de Outubro Avenue*, which connects the neighbourhood to the Matola Municipal Council, as well as *Moçambique Avenue*, which is a segment of the city’s inner ring road. In this case, it connects the George Dimitrov Neighbourhood to the consolidated urban centre and the new centrality of Zimpeto Neighbourhood, where the National Stadium (the largest sports infrastructure in the country) is located.

Given the large size of the pilot area, a detailed physical and socioeconomic survey was conducted in Block 33 [23]. Due to the existing information about its situation, Block 33 was also used for the analysis of physical interventions through design strategies. In general, the pilot area of the George Dimitrov Neighbourhood presents a regular mesh pattern of low density in the east and an organic mesh of higher density along its greater extent; Block 33 is inserted in the latter.

4.3. Prospective Analysis of Sustainable Physical Transformations

4.3.1. Interventions in the Urban Fabric

The road fabric of Block 33 (Figure 10A) is organic and disconnected. Its system of irregular lots, with variable dimensions and geometry, is fenced with cement block walls or, in a few situations, with thorn hedges. Lots are occupied by scattered ground-floor dwellings, whose layout often defines a central outdoor patio under the shade of a tree. In this informal urban fabric, the structure of the existing public spaces was first analysed; it was found that, notwithstanding the discontinuity of the streets, there is a set of small public squares that make up a cul-de-sac system, mostly with pedestrian access (Figure 10B).

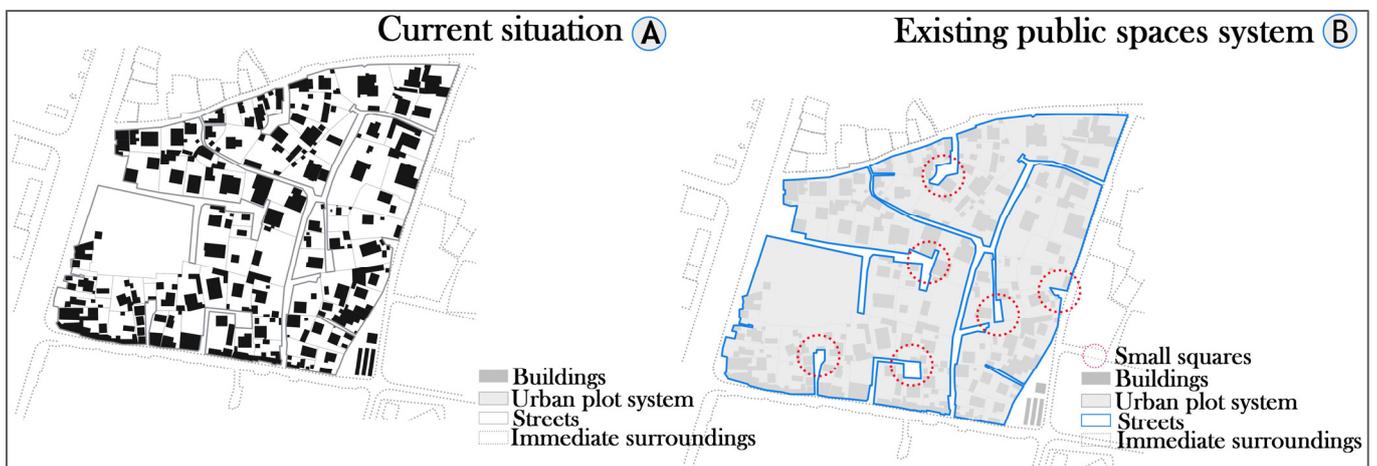


Figure 10. Current situation of Block 33.

In the fragmented occupation of the lot by the housing complex, multiple private ‘voids’ were identified. These constitute opportunities not only to connect the disconnected streets and activate physical permeability but also to connect the existing small public spaces in the form of squares and thus structure them according to a logic of an urban public space network (Figure 11A). Furthermore, the proposed intervention of chamfering street corners, inspired by Ildefonso Cerdá’s Barcelona expansion proposal [111], and the widening of the cross-section of the streets (Figure 11B) avoids, at all costs, the demolition of buildings and, consequently, the complex processes of population resettlement, while at the same time increasing the visual permeability of the organic system of the streets. These interventions also create the spatial conditions necessary to introduce vegetation and street furniture into public spaces, which is necessary to guarantee environmental comfort in the pedestrian circulation of the residents as well as to maximize the dynamic appropriation of public spaces that already occurs in informal settlements, even in the face of multiple spatial deficiencies.

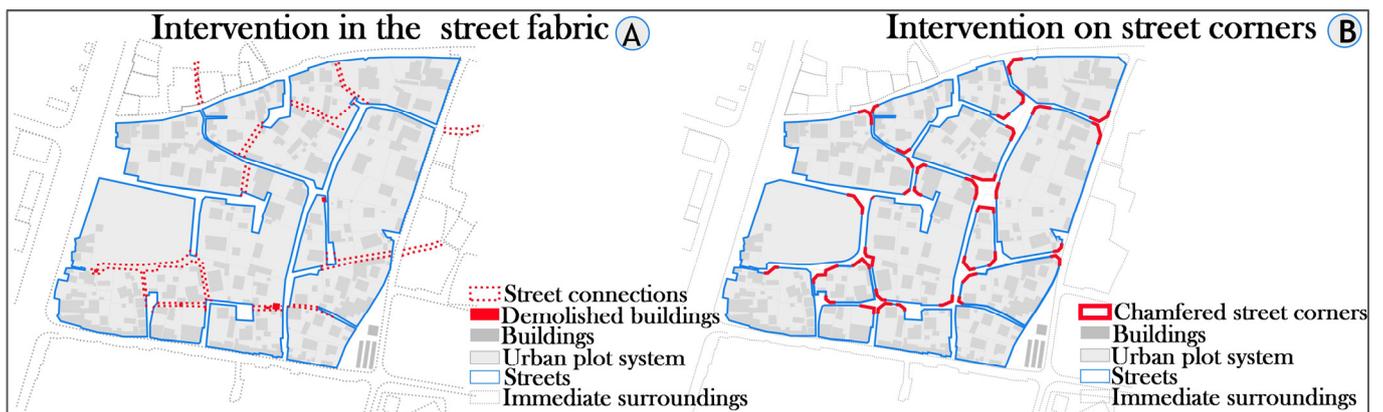


Figure 11. Activating the physical and visual permeability of the organic street system.

Local informal commerce, an economic activity currently very present in the housing of informal settlements and naturally also in the George Dimitrov Neighbourhood [23,100], is an opportunity that can be used to increase the mix of functions and vitality of public and green spaces. To this end, multiple commercial activities (Figure 12A) that support family livelihood can be implanted on the chamfered corners, always safeguarding the good visual relationship of the commerce with the street as a whole. A deep understanding of the neighbourhood fabric also allows us to identify opportunities to increase the number of micro public and green open spaces (Figure 12B) without major urban reforms. Depending on the morphological situation of the lots—in this case characterized by having small private voids—the public administration can acquire these small private spaces in order to convert them into public green environments to reinforce community socialization as well as to improve the overall thermal quality of the neighbourhood.

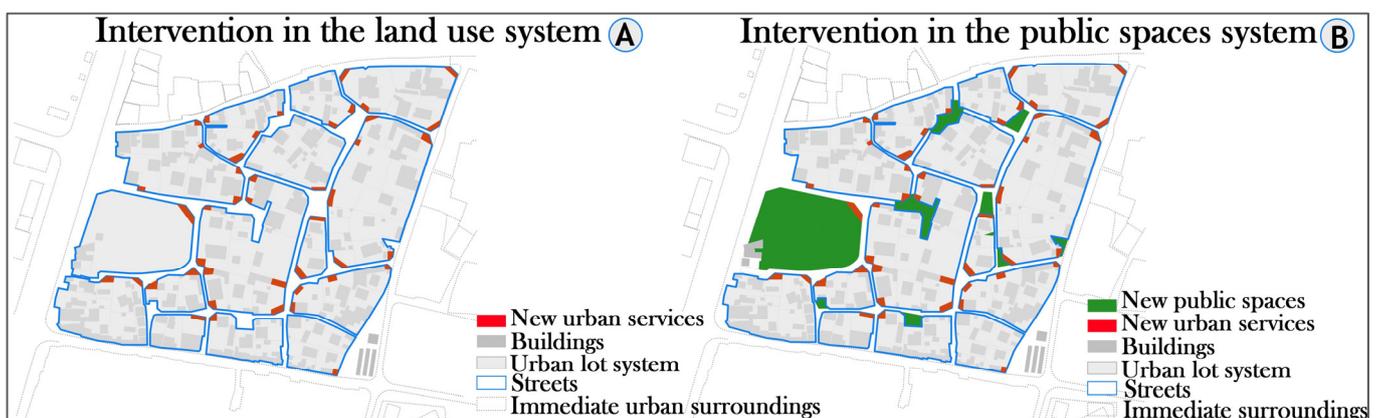


Figure 12. Activating functional diversity and the network of public micro spaces.

It is therefore evident that these interventions depend on the opportunities that the morphological characteristics of the block offer. Without wanting to force a transformation of the block towards a formal and more orthogonal planning model, it was necessary to opt for a logic which takes advantage of the existing conditions. The result was a street fabric that, although organic, is well connected and visually permeable, as the streets were widened, and the intersections and junctions now have chamfered corners. In addition, various functions were installed on the corners, and micro public spaces were created. In this way, an urban fabric with short distances between various family income-supporting functions can be promoted, with various environmental and social benefits [27,83].

4.3.2. Interventions in Infrastructures and Public Spaces

With the street system better physically connected, thus creating a more functional street network, and with most street corners consisting of small public spaces and various functions, opportunities then arise to insert more environmentally sustainable connections into the street system. These new features aim to improve climatic comfort, contribute to the selective collection of municipal solid waste, increase the attractiveness of pedestrian and bicycle travel, improve storm water drainage and at the same time maximize the presence of street vegetation.

Through a sustainable stormwater drainage system that mimics nature by encouraging water to soak into the ground, storing it and allowing it to slowly flow into the groundwater, flooding in streets and dwellings—a strongly existing problem in informal settlements [23]—can be reduced. Rainwater can then be taken advantage of to maintain green spaces and increase the green fences made of thorn hedges that already exist in Maputo’s informal settlements. In practice, this means creating ditches and filling them with stones and vegetation to encourage water to flow under the surface or using a permeable sidewalk to allow water to infiltrate. These drainage ditches would be one-sided on narrow streets and bilateral on wide streets (Figure 13).

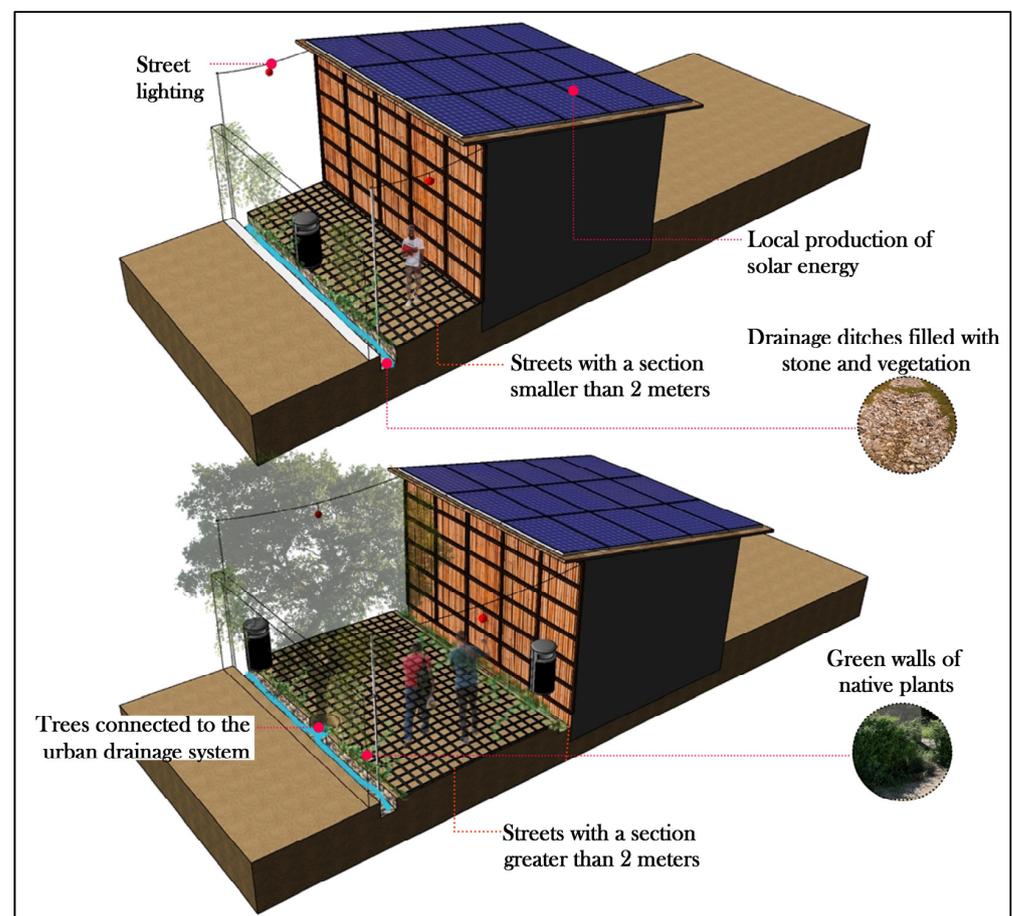


Figure 13. Infrastructural interventions.

The streets can be illuminated by solar energy, with energy production installed on the roof of the houses or placed on the public lighting itself. The equipment for the selective collection of urban garbage, with its dimensions adjusted to the existing space in the streets, would have to be located on the side of the street drains in order to maximize the use of the street service area. The new, small open public spaces created through the interventions in the road fabric (Figure 14) could be requalified based on a process guided by the needs of the place, recognising the local community as the expert in creating and managing its own public spaces. In this way, the small squares and other micro public

spaces predominant in informal settlements will be intervened with in order to provide them with functions, furniture, image, comfort and security that allow various forms of appropriation and socialization.

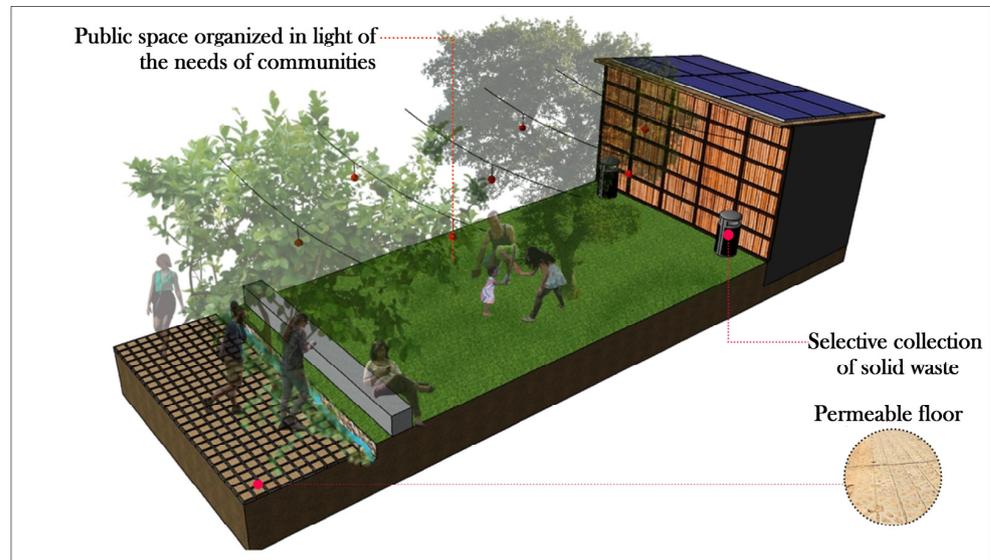


Figure 14. Improvements in infrastructure and public micro spaces.

4.3.3. Interventions in Housing

In the informal urban context of Maputo, a predominant housing typology called the ‘*Casa Ventoinha*’ (Fan House) was identified [23,105]. This type of dwelling comprises a balcony, a living room with areas between 9 and 12 m² and a variable number of bedrooms, the most-common type including three bedrooms. In an analysis of this standard dwelling, Carrilho et al. [105] state that the compartmentalization of the house is carried out in four phases (Figure 15: a Fan House, the standard housing typology found in Maputo’s informal settlements) in a process of spatial agglutination, according to the growth needs determined by the economic conditions of the family; in other words, construction is carried out incrementally according to the savings achieved in construction materials.

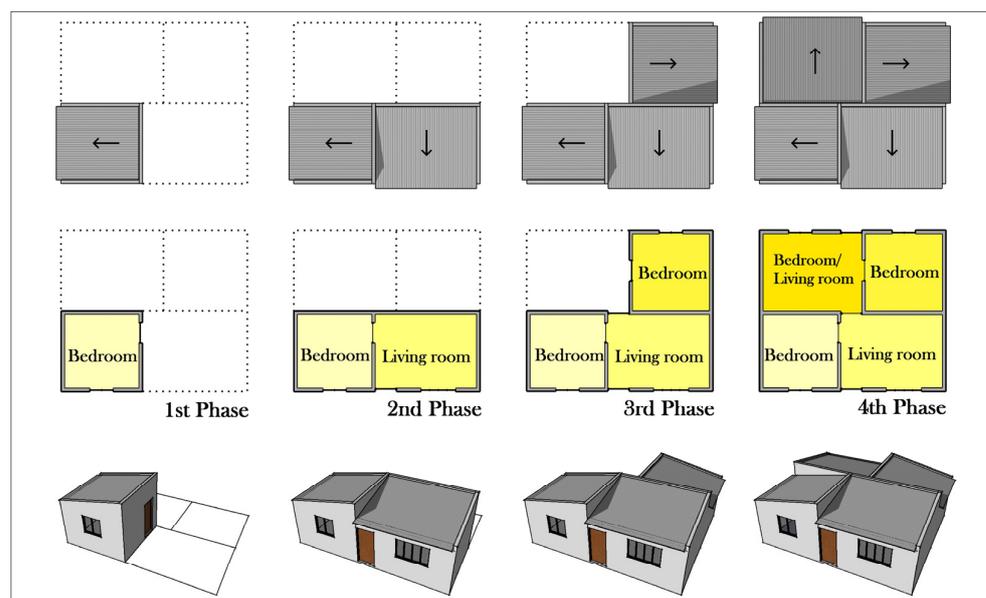


Figure 15. Fan House, the standard housing typology found in Maputo’s informal settlements (source: prepared by the authors based on Carrilho et al. [105] (p. 78).

The Fan House of the informal neighbourhoods of Maputo has different identified construction phases (Figure 16). It can grow vertically in order to counteract its current horizontal and compact expansion that contributes towards an excessive increase in soil waterproofing as well as the urban heat-island effect. Furthermore, since the outdoor space is a central place in the house where families spend most of their day [23], a covered space can be created near the main building that allows for natural cross ventilation in order to improve the conditions of these spaces and ensure their comfortable and continuous use regardless of weather conditions. Connecting the outdoor kitchen to the main house through a covered outdoor space is another way of densifying the house and increasing the available permeable soil without, however, interfering with the lifestyle of the population.

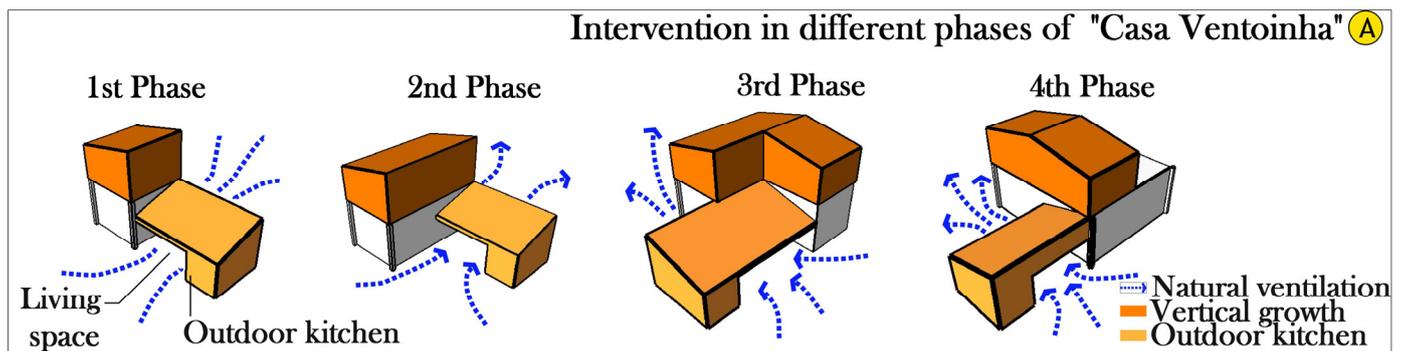


Figure 16. Interventions in the model house.

In phase 2 of the Fan House, natural ventilation can be activated by opening and sizing the windows on opposite walls to allow cross-circulation of air. In addition, cement block walls can be coated with local materials, such as reed, as thermal insulation. On the roof, the use of thatch overlapping the existing corrugated sheet of metal material will make it possible to take advantage of the waterproofing and durability benefits conferred by the sheet and the insulating capacity of thatch [78]. Interior painting in light colours will make it possible to increase its albedo and, simultaneously, improve natural lighting. From a structural point of view, this vertical growth can occur through structural supports built on the outside of the house (Figure 17) in order to take advantage of existing buildings.

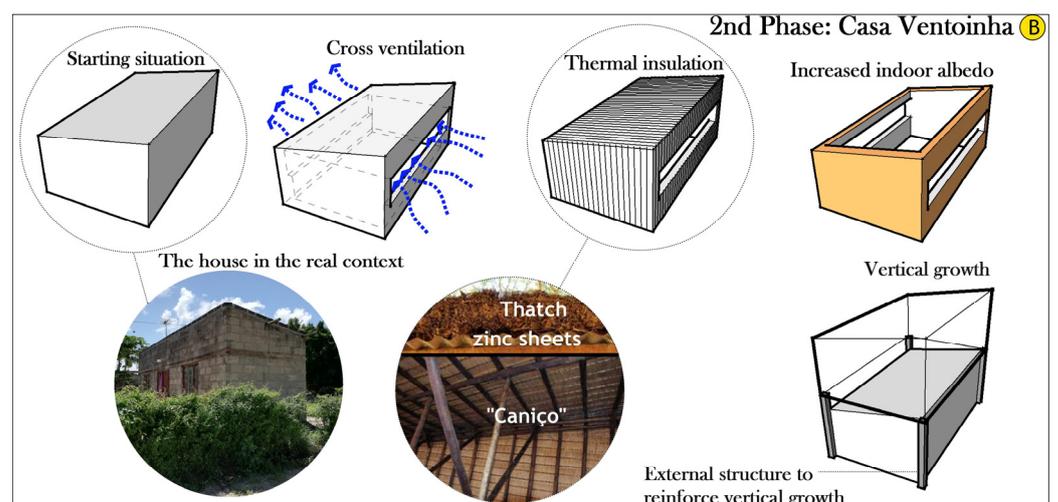


Figure 17. Environmental improvements in the house. (source: prepared by the authors including an image from Guedes [78]).

4.4. Verifying the Level of Integration of the Knowledge from the Literature Review into the Solutions

To analyse the role of more sustainable urban (and architectural) design in the process of the physical (and socio-economic) upgrading of the informal settlements in Maputo, the following research questions were posed. First, is it possible to intervene in the physical (and social) urban fabric of informal settlements in Maputo based on sustainable urban design strategies in order to improve their environmental quality? Second, which sustainable urban design strategies can be considered applicable to the environmental upgrading of informal settlements, taking advantage of the existing spatial and socio-economic conditions?

Surprisingly, the urban fabric of the George Dimitrov Neighbourhood has physical and functional qualities that, based on urban design solutions, allow us to model physical transformations for more sustainable urban scenarios from the environmental (and socio-economic) point of view in a prospective approach. An example of this is the apparently disordered configuration of the street system, which nevertheless creates a set of small squares easily connected to each other through the opening of new streets, without any major demolition of the urban fabric; this is made possible by the fragmented way the residential built mass occupies the territory, creating small voids within private lots. The result is a better-connected road network as well as an urban network of small public spaces.

The local commerce that currently occurs in a dispersed and informal way in the neighbourhood, in addition to the increasing functional diversity, allows for the improvement of visual permeability in the public spaces—although the system of lots sealed by opaque surfaces in cement block walls, or sometimes native vegetation, creates insecurity in the streets, and the increase in local commerce integrated into the private lots of families allows for the creation of ‘street eyes’ [112] that improve vitality and security in public road spaces. For this, new functions must be installed on street corners. Once again, these are operations that do not require a major urban renewal but rather take advantage of the existing conditions to improve the quality of life of residents.

In light of the application of urban design solutions in Block 33, it is understood as possible to improve the environmental quality of Maputo’s informal neighbourhoods through physical interventions determined by sustainable urban design. In this process, urban permeability, mixed land use, public space networks, urban densification, urban design and bioclimatic architecture are strategies that, taking advantage of the existing conditions, can be applied to physically improve the environmental sustainability of informal neighbourhoods.

However, the transformations produced by these strategies did not aim to obtain an urban configuration similar to the so-called formal and regular city but rather an urban fabric with a diversity of urban functions and forms, comprising an organic road structure with several short street segments connecting multiple collective micro spaces. It is therefore an urban composition that, despite the apparent disorder, promotes short distances between various functions and creates circulation spaces with dimensions that, in certain situations, make car use impossible while promoting the use of smoother modes of urban mobility, resulting in environmental and community health benefits.

The interventions applied to the drainage system and the planting of trees in the streets can transform them into small urban green corridors with the presence of vegetation, drainage with sustainable use of rainwater, permeable pavements, the selective collection of urban waste and, in some cases, routes exclusive to pedestrian and cycling mobility. These solutions are therefore the result of an in-depth analysis of the problematic situation in the neighbourhood. Again, they do not seek to impose orthogonality, parallelism, symmetry, linearity or any other aesthetic values of so-called formal cities; it is understood that the unsustainability of the informal settlement lies not in these aspects but rather in the non-functionality of the systems that make up its urban fabric as well as in the set of its infrastructural shortcomings.

In what pertains to housing, it becomes evident that the understanding of its morphological fabric and daily use effectively detects both existing environmental problems

and potentialities. Thus, surgical interventions were applied, driven mainly by the need to solve real problems and maximise the existing qualities. As proof of this, it is possible to identify a standard housing model—the Fan House—which is replicated throughout the urban fabric of the informal city of Maputo as well as understand its dynamics of implementation in the informal neighbourhood plot system [23]. This morphological (and social) analysis led to the application of solutions specific to the situation such as the improvement of thermal comfort through natural cross-ventilation and the use of context-appropriate materials such as thatch and reed as thermal insulators, and the improvement of the quality of indoor natural lighting by painting interior surfaces with lighter colours.

Furthermore, the creation of covered outdoor living spaces is a way to improve the use of private outdoor space, which, according to Carrilho et al. [105], is the most privileged place of the house. It is therefore a way of maximising social and environmental quality through minimal architectural interventions. However, the problem of excessive horizontal land occupation requires interventions for the vertical densification of the dwelling, involving large architectural operations with significant financial costs, although these interventions will result in multiple environmental and functional gains for the housing fabric.

Ultimately, it is clearly possible to improve the environmental quality of informal neighbourhoods through sustainable urban design. For this, understanding the problematic specificities and the characteristics of the context is fundamental in order to identify the qualities of the urban (and social) fabric and apply a set of surgical and specific solutions to the needs of the place. Evidently, although the research achieved its purpose, some no-less-important aspects somewhat limited the research process, namely the scarcity of similar studies centred on the environmental problems of the slums of Maputo in an approach of the prospective transformation of informal settlements based on urban design.

Thus, a significant part of the research was mostly dependent on the undertaken surveys, interviews and observations carried out in the fieldwork. Moreover, given the large size and complexity of the George Dimitrov Neighbourhood, as well as the existing time constraints, it was not possible to obtain a larger sample nor to analyse in detail the other physical and social settings of the neighbourhood that would allow for a more comprehensive reflection. In this sense, considering the morphological variety of informal settlements, further research is needed that focuses not only on this approach but also tests the feasibility and impact of the proposed solutions.

5. Final Considerations

Despite the irregularity and apparent disorder of the urban fabric configuration of Maputo's informal settlements, this paper determined that it is possible to devise interventions based on the understanding of the morphological, social and environmental characteristics of informal settlements. By making use of sustainable urban design solutions to shape more sustainable urban futures, several opportunities to improve the efficiency of the urban fabric of the George Dimitrov Neighbourhood block were found. Evidently, these solutions are contextual and therefore cannot be generalised in other spatial contexts. Housing intervention, in particular, has the potential to significantly transform and improve the environmental (and social) sustainability of informal neighbourhoods, since the house is the essential and most predominant morphological unit in the composition of these neighbourhoods and the place where most of the daily and socio-economic events happen.

This research represents an initial step in investigating the role that urban design, informed by scientific evidence, can contribute to the sustainable transformation of informal settlements. We recognise the importance of informal settlements, as a mode of urban production, in responding to the needs for housing in the contemporary cities of the Global South. Without 'romanticizing' these areas, we also understand the multiple spatial and functional problems they possess; assuming that their eradication is currently impossible, we intend to research sustainable ways to physically (and socio-economically) transform these neighbourhoods with urban design as their foundation. In this research, the observa-

tion, analysis and understanding of informal settlements in their various dimensions may inform specific modes, processes and actors that can contribute to their environmentally resilient and sustainable urban (re)production.

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