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The environmental sustainability of Maputo self-produced settlements: The case of George Dimitrov Neighbourhood

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ABSTRACT

Urban environmental sustainability is currently essential to ensure a healthy society, especially in the Self-Produced Neighbourhoods (SPN), since poverty and urbanization embody their environmental problems. However, considering that the temporal construction of the SPN sets up urban tissues linked to cultural and social values of its residents, this research aims to analyse the possibility of requalifying the Maputo SPN taking advantage of the existing one in order to reach its environmental sustainability. For this purpose, a literature review of specialty and George Dimitrov Neighbourhood (GDN) in Maputo were used as a case study to understand and discuss the research question. As a result, it was found that, despite the apparent disorder of the urban tissue of the neighbourhood, GND shows a considerable morphological and social potential that can be taken advantage of in their environmental requalification. Moreover, it has been found that poverty and the scarcity or lack of adequate technical knowledge in the neighbourhood's self-construction is the main environmental problems detected. In this point of view, it was concluded that, it is possible to requalify environmentally Maputo SPN taking advantage of existing conditions. To this end, urban public policies must, in addition to effectively taking up the urgency of SPN environmental issues in their interventions, create sustainable solutions that understand the cultural and socioeconomic logics that guide self-construction and, thus, integrate strategically in this process.

Keywords: Environmental sustainability, requalification, self-produced settlements, self-produced neighbourhoods, Maputo city, George Dimitrov neighbourhood.

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INTRODUCTION

Self-produced settlements are certainly a global challenge to the environmental sustainability of the contemporary city, especially in developing countries (UN-HABITAT, 2015; Smit et al., 2017). In these regions, the explosion of urban population contributes simultaneously to the rapid growth of cities and the widespread proliferation of extreme poverty (Ramin, 2009). Thus, aggravating critical living conditions, particularly in Sub-Saharan Africa, where more than half of the urban population lives in the SPN (UN-HABITAT, 2006: 13). In Maputo, for example, about 70% of the population lives in these neighbourhoods (UN-HABITAT, 2010: 11).

The environmental problems in these areas are manifold, namely: poor sanitation, poor housing, vulnerability to natural disasters and extreme thermal events (Nassar and Elsayed, 2018), insufficient open public and green spaces, reduced life expectancy due to the critical conditions of the urban microclimate and, in addition, the inevitable urban heat island effect make life in the SPN a catastrophe (Angelis et al., 2016). Therefore, the SPN currently represent the physical and spatial manifestation of poverty, inequality and exclusion in the right to a healthy city (Lefebvre, 2011; Jorge and

Melo, 2014). Thus, if the city is a temporal construction, linked to the culture and way of life of its inhabitants (Lage and Lage, 2017), it is therefore necessary to develop practical instruments that, taking advantage of the existing, propose solutions for environmental requalification of SPS (Forjaz, 2005).

Thus, considering the assumptions mentioned above, this research aims to analyse the following question: “is it possible to environmentally requalify the SPN of Maputo, taking advantage of the existing (physical, cultural and socioeconomic) conditions, from a cost-controlled perspective?”, that is, considering the present financial limitations and respect for local culture and habits, what actions can be implemented in the SPN of the Mozambican capital to: improve energy efficiency and thermal comfort of housing; increase and improve the quality of public and open green spaces; close the cycles of energy, water and solid waste, aiming at self-sufficiency based on renewable resources without, therefore, proposing major urban reforms.

Therefore, achieving the simultaneously beneficial objectives of climate change mitigation and adaptation, as well as reducing the carbon and ecological footprint with a view to achieving the environmental sustainability of the SPN (UN-HABITAT, 2018). To this end, the neighbourhood is studied, as it is widely recognized as a fundamental building unit of the city, a starting point for creating truly sustainable cities because their combination with two or more units results in the city setting (Tam et al., 2018).

LITERATURE REVIEW

Concept of self-produced settlements

Called by various names, according to language and geographic regions (Nolan, 2016; Mazarro, 2018), self-produced settlements have traditionally been called slum when referring to lower quality housing and unhealthy conditions (UN-HABITAT, 2003: 9). Slum is currently understood as residential areas where: (1) residents have no security of tenure or housing; (2) neighbourhoods often lack basic services and infrastructure; (3) housing is precarious, overcrowded, does not comply with current planning and construction regulations and is often situated in environmentally unsafe areas (UN-HABITAT, 2003: 11).

According to several authors, this definition is intended for operational identification and measurement of slums, however, it is restricted to physical and legal aspects, excluding social dimensions that are more difficult to evaluate (Jorge and Melo, 2014). Therefore, the slums designations, informal and illegal, reveal a derogatory sense (Melo, 2015). Hence, the result of the distance from the more sensitive and academically rigorous lexicon. For the traditional perception as well as the previous definition of UN-HABITAT demonstrate a negative reading corresponding to an exclusionary view of the city. Given this, Melo (2015), Jorge (2017) and Lage and Lage (2017) addressed to Maputo, they resort to the notion of self-production in order to broaden the analysis dimensions of these spaces, including not only their needs, but also the qualities and aspirations of the inhabitants, as well as what gives them identity.

In this research, the notion of self-production is used associated with the neighbourhood forming the combination of Self-Produced Neighbourhoods (SPN). Designating, thus, a space whose authorship and management belong to the residents; thus substantiating the autonomy and self-sufficiency that, to some extent, characterize these spaces (Melo, 2015). It is not intended here to exhaust the theoretical debate on the definition of SPN, but to briefly make known the complexity of the competing issues for the understanding of this problem, its evolution and current spatial distribution. In the latter, according to UN-Habitat (2003), it is a planetary condition. However, it is more present in the African city, and in relation to its evolution in this context, there is a slight reduction in the chronological interval of 1990-2010 (Figure 1). However, Mozambique and other countries during this period remained with over 70% of the urban population residing in self-produced settlements.

Characteristics and environmental problems

Acording to Carrilho et al. (2014), SPN are characterized, on the one hand, by “stable insecurity”, this is the legal insecurity regarding official territory management instruments, which contrast with the recognition by neighbourhoods and local authorities, which testify to the occupation of land and the construction of their habitats. On the other hand, for “inverted governance”, in this case, the search for the legitimacy of their neighbourhoods or parts of them, through their own initiatives, the inhabitants invest in specialized technicians to elaborate urban plans of their neighbourhoods, mimicking to some extent what is being called "formal".

Therefore, the inhabitants of SPN are usually left to their own devices and are generally handed over almost exclusively to the inhabitants. This results in the production, transformation and configuration of urban space through complex micro survival strategies (Viana, 2010). As a result, for example, Carrilho and Lage (2010) report that in the suburbs and periphery of Maputo it is difficult to find reeds or natural materials houses today, because through the savings and creativity of households, housing has gradually been transformed into buildings based on industrial production materials such as cement, zinc and iron. Therefore, in the search for better living conditions, as well as the architectural and sometimes urbanistic influences of the consolidated urban center, the houses were transformed. For this reason, self-organization is a fundamental characteristic

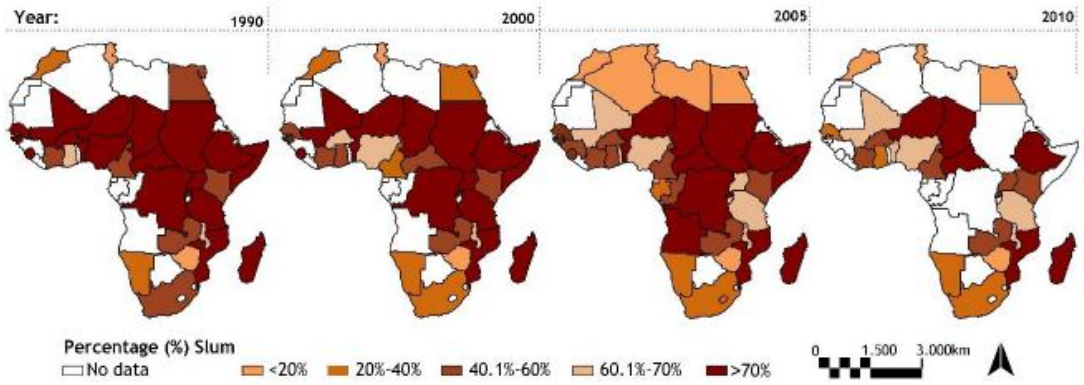

Figure 1. Evolution of slum condition in Africa. Source: Elaborated by the authors from UN-HABITAT (2015).

of these neighbourhoods.

Regarding environmental problems, although there is not urban scenario considered in a consensually environmentally sustainable way, consciousness about the problems and the need for environmental protection is common (Heywood, 2012; Sartori et al., 2014; Oliveira, 2018), not exactly because of the fragility of the planet itself, but because of human vulnerability resulting mainly from our actions on the environment (Heywood, 2015). It is in this context that the environmental problem of SPN fits, either by environmental impact or by vulnerability.

According to Devi et al. (2017), although the ecological footprint is an overly complex index of environmental impact, SPN have in their early stages of formation a low ecological footprint, resulting mainly from the difficulty of residents in accessing basic urban services (water and energy) and financial resources for its maintenance and use. Additionally, as noted by Grove (2009), SPN are sustainable urban tissues due to their compact morphological condition and variety of functions. However, due to the lack of basic infrastructure such as sanitation, self-produced neighbourhoods severely impact the environment, damaging water and soil quality, thus weakening regions wherever they are (Andrade, 2011). Moreover, they are often built in places of high ecological value, such as the construction of the *Costa de Sol* mangrove in Maputo.

On the other hand, most SPN are vulnerable to natural hazards such as landslides, floods and rising sea levels (Amado et al., 2016). Also, according to Lwasa (2010), the infrastructure deficiencies of the SPN increase their risk to climate change. In addition, the lack of adequate infrastructure may contribute to increase the risk of exposure to environmental pathogens that increases infectious and communicable diseases in poor urban areas (Corburn and Sverdlik, 2017).

Moreover, housing in this context is poorly constructed and therefore more prone to collapse when hit by the bad weather (Khalil et al., 2018). Also, climate change and the inevitable urban heat island effect make living conditions in the SPN a catastrophe (Angelis et al., 2016). Allied to this, the high illiteracy rate, accompanied by extreme poverty and high unemployment rates and, consequently, urban crime, negatively impact individual housing improvement processes in the neighbourhoods, say the same authors.

According to Broto et al. (2015), the environmental vulnerability of self-produced settlements is closely associated with poverty and limited access to resources, soil characteristics (their compaction and limited water infiltration capacity), the coverage of built and paved surfaces, poor drainage and to tree felling. In short, given the reciprocal relationship between the two perspectives of environmental sustainability, that is, climate change, for example, is due in part to the lack of environmental conservation by mankind, resulting in increased environmental vulnerability. Therefore, interventions around the environmental requalification of self-produced neighbourhoods should under no circumstances neglect both their impact and environmental vulnerability.

RESEARCH METHODS

The research was essentially based on literature review and case study to isolate, understand, analyse and discuss the research question. Thus, in the first stage, we sought to understand and build knowledge about the main issues inherent in the environmental requalification of SPN, with a view to its analysis in the selected case study. Therefore, by reviewing the specific literature on the subject, it was possible to construct a critical analysis of the SPN and, consequently, to understand their evolutionary genesis, as well as their environmental problems and challenges.

In the second stage, the case study analysis was developed in George Dimitrov Neighbourhood[1] (GDN) in Maputo. First, the neighbourhood was chosen considering its relevance to the problem under investigation. For this, based on the different classifications of the city's territory (Figure 2), and with

[1] In the three classifications the George Dimitrov neighborhood is always in the largest urban clusters of Maputo.

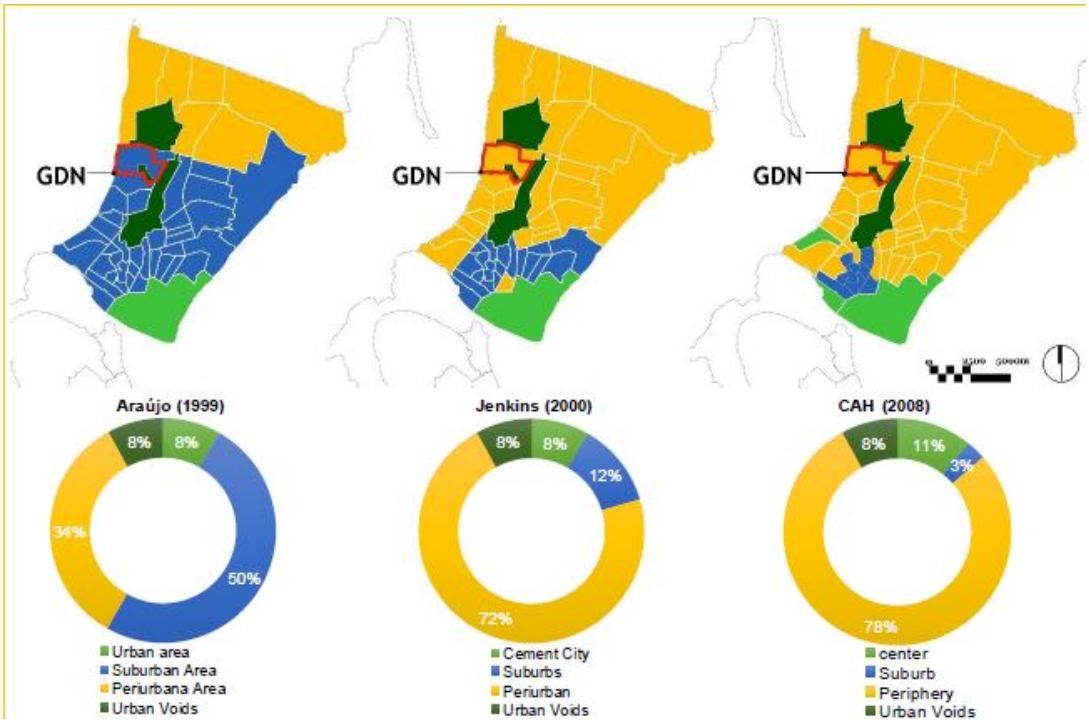

Figure 2. The George Dimitrov neighbourhood in the different classifications of Maputo City. Source: Elaborated by the authors from Henriques (2008).

the indicative map of the self-produced settlements of Maputo, the GDN was defined by its representative character. Allied to this, the fact that this neighbourhood is currently the target of various studies and implementation of different forms of intervention, especially the university extension project called *Kaya-clinic*[2].

Thus, in order to understand the urban genesis in the light of the physical, cultural and socioeconomic structures that make up the GDN, as well as the environmental problems associated with them and perceived by the residents, a fieldwork was conducted based on (i) surveys of the neighbourhood population, (ii) interviews with community leaders and municipal technicians, and (iii) physical housing survey fact sheets. Then, with the results of the fieldwork, treated and presented, the relationship of the main findings in the answer to the research question was discussed, as well as with the reviewed literature.

Research sample

A sample of the present investigation is composed of 62 families from block 33 (B33) of the George Dimitrov neighbourhood, which correspond to 3% of the total universe of families in the GDN pilot area[3]. Of the sample, 26 (42%) female residents and 36 (58%) male were surveyed. In addition, of the 44 (100%) chiefs of the pilot area blocks, only 5 (11.4%) chiefs were interviewed, including B33. In addition, a Maputo Municipal Council technician was interviewed, in this case the architect and physical planner and head of the Department of Urban Planning and Environment.

RESULTS

The following results are derived from GDN fieldwork based on surveys of 62 families and physical surveys of block 33 (Figure 3), as well as interviews with neighbourhood leaders (block chiefs) and to the technicians of the Maputo Municipal Council. The aim is to deepen: (i) the understanding of the urban and socioeconomic structures that make up the neighbourhood (ii) the associated environmental problems and challenges (iii) understand community perceptions of main environmental issues (iv) and to identify the environmental potentialities of the neighbourhood. It is important to note that the B33 has 4.13 hectares of land, where 35% (1.43 hectares) is occupied by buildings.

[2] Kaya Clínica is Kaya Clínica is a project that involves several faculties of Eduardo Mondlane University and aims to help families improve their living conditions from different perspectives

[3] Within the official boundaries of the George Dimitrov neighbourhood, there is a designated GDN pilot area, where the Maputo City Council and the Kaya Clinic are intervening.

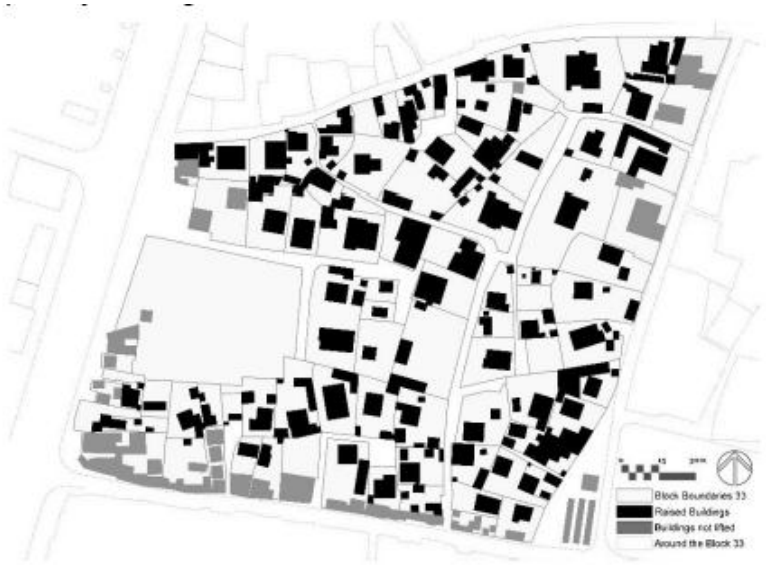

Figure 3. Block 33 of George Dimitrov neighbourhood. Source: Elaborated by the authors.

Socioeconomic condition

The results show that only 6% of the population lives in the neighbourhood temporarily, that is, they are visiting or sightseeing in the city (Figure 4A). Of the permanent residents, only 5% are tenants, the rest are owners (Figure 4B). However, land tenure security is still a problematic situation, because 68% of the population states that they do not have documents proving ownership of the land (Figure 4C). In addition, commercial activity is indeed an important form of income generation, as 34% of household's trade (practice their commercial activity) in their lot (Figure 4D).

On the other hand, of permanent residents in the neighbourhood, 93% have lived for over 10 years and 17% of families have lived in the neighbourhood since the period before independence. Therefore, as shown in Figure 5A, generally most families have lived in GDN for a long time, so the sense of belonging of families in the community will certainly be very large. The variation in household income (Figure 5B) shows that 90% of households have a monthly income of less than or equal to 220 € (exchange rate - 70 meticais = 1 €). The highest remuneration recorded is 1500 €. However, it is earned by only one family (2%). The lowest monthly income is 10€ and the most frequent (15%) is 220 €.

Regarding the variation and distribution of household types in B33, 62% of households have more than 5 members. In addition, it is found that the family with 7 members is the most frequent type. It is important to highlight the existence of 9% of families with more than 10 members (Figure 6). That is, on the one hand, as presented before 90% of households have a monthly income of € 220, on the other hand, at a minimum, most families have more than 5 members, so overall, most people live on less than 1.4 per day. Therefore, absolute poverty is still a dominant phenomenon, even in the Maputo Municipal Council.

Urban services

Overall, although 21% of the population has no access to urban solid waste collection and treatment services, most (>79%) of the population has access to basic urban services (Figure 7A). In the water supply sector, the private sector (Gawat) plays an important role as over half (53%) of the population receives this precious resource through the private sector (Figure 7B). It should be noted that GAWAT is a decentralized, privately owned system that captures groundwater through boreholes and stores it in large raised tanks and then distributes it to families through a network of buried pipes in the streets. On the other hand, the Public *Fundo de Investimento e Património da Água* (FIPAG) is a centralized system that captures water from the Umbeluzi River and then treats it at a Water Treatment Plant and distributes it to the dwellings.

In sewage treatment, septic tanks are the most prevalent system, used in this case by 76% of households, followed by 21% of improved latrine and, finally, 3% of unimproved latrine (Figure 7C). Garbage is mostly (77%) collected by the Municipality for disposal in the Hulene Dumpster (Figure 7D). In addition, 10% of households collect waste in person. Electricity is only provided by the public company *Eletricidade de Moçambique*, 98% of households have electricity installed in their homes. However, in relation to the

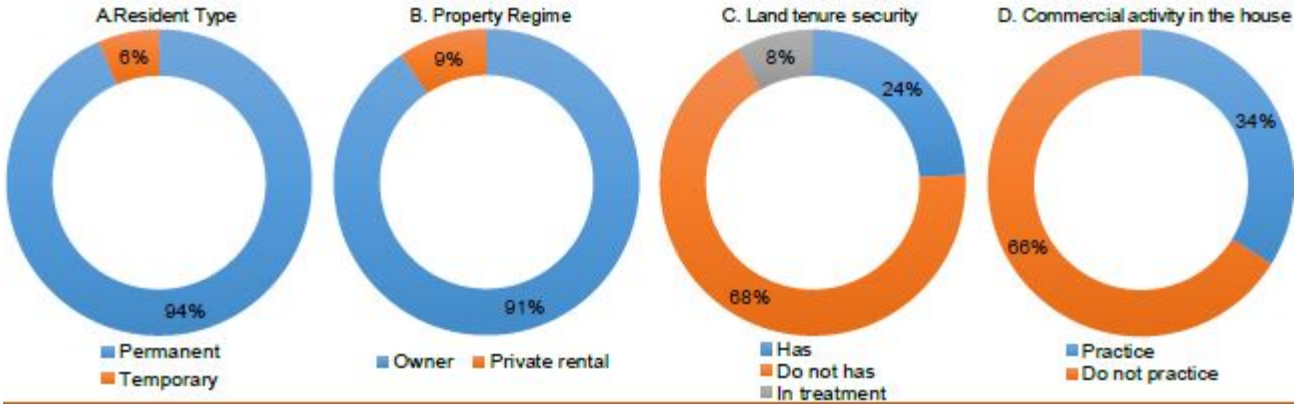

Figure 4. The house and its socioeconomic characteristics. Source: Elaborated by the authors.

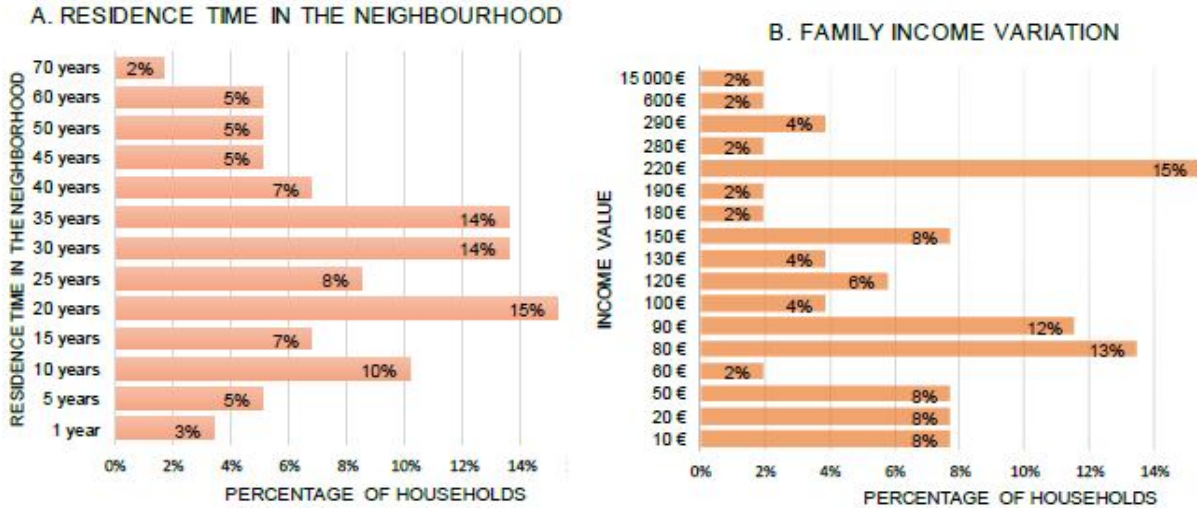

Figure 5. Residence time and variation and distribution of household income B33. Source: Elaborated by the authors.

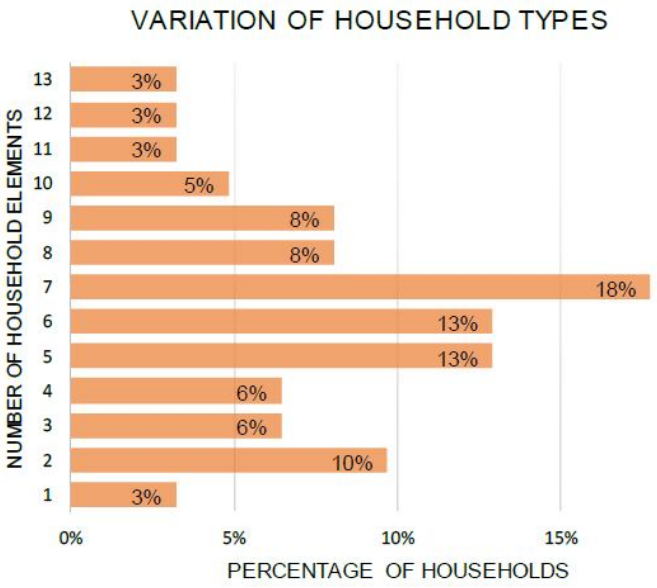

Figure 6. Variation and distribution of household types. Source: Elaborated by the authors.

illumination of public space, it is restricted only to the streets that allow the circulation of cars. Thus, the narrow, pedestrian streets that make up most of the neighborhood's road layout have no lighting.

Concerning population satisfaction, there is a worrying scenario, since in all services; the percentage of satisfied people is less than 50%. In addition, the highly satisfied population is always less than 11% (Figure 8). In contrast, dissatisfaction represents a significant perception of the sample, especially the urban waste collection and treatment service, where 71% of the population is dissatisfied (Figure 8G). Among the various reasons for this, the population indicates the Maputo Municipal Council inability to collect garbage at the doorsteps of the house because, although it is defined that the service is provided at least twice a week, it is not in the meantime that happens. These results in diseases caused by household waste accumulated in the batch.

On the other hand, according to the population, the main causes of dissatisfaction with water and energy supply are mainly related to the systematic cuts in the

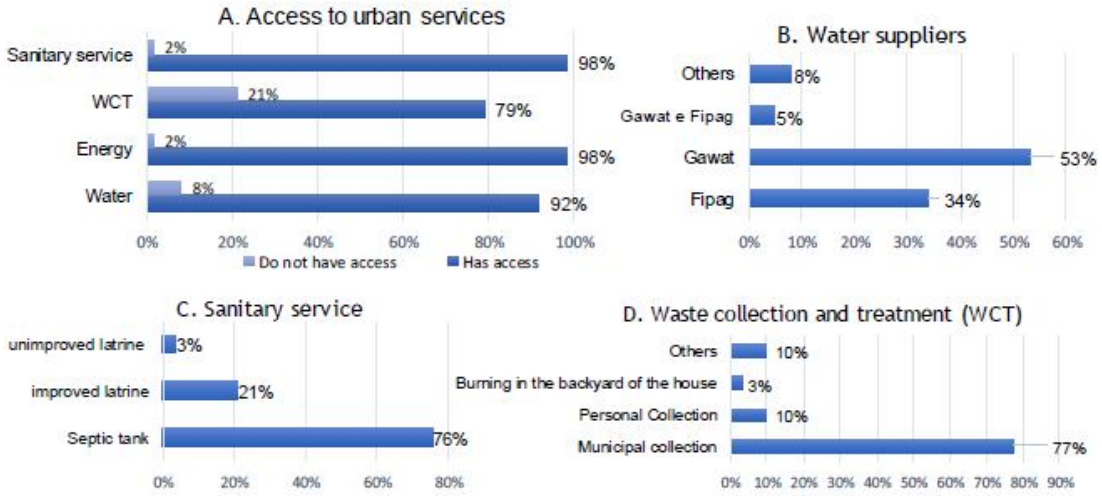

Figure 7. Access and forms of provision of urban services. Source: Elaborated by the authors.

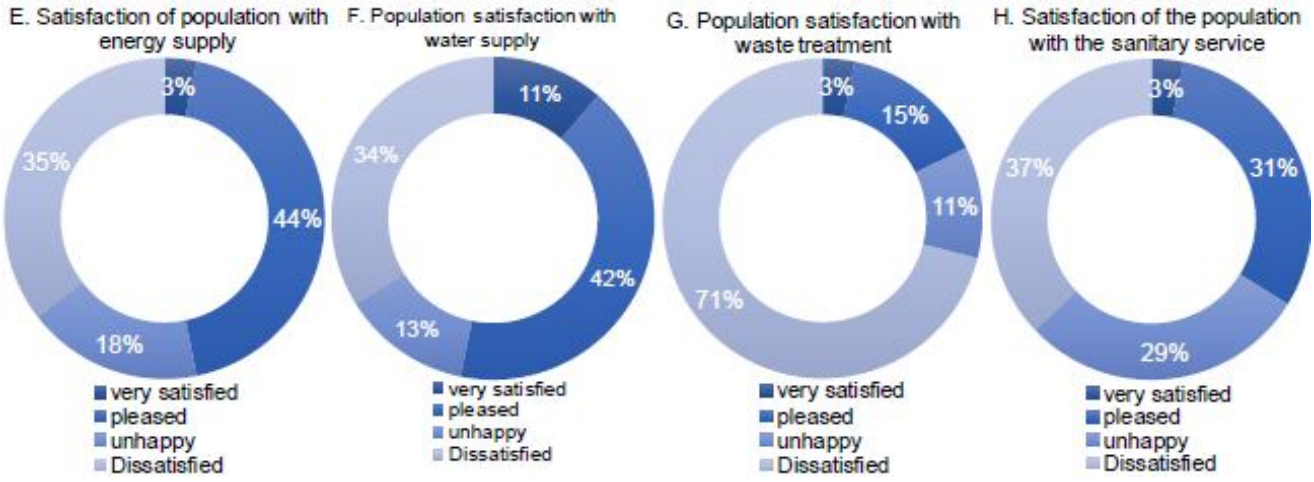

Figure 8. Population satisfaction levels with urban services. Source: Elaborated by the authors.

provision of these services and to the high cost associated with their consumption. In the latter, it was noted that, on average, the population pays monthly for water and energy, respectively, 6 € and 12 €, in a monthly variation where the highest value for water is 17.1 € and the most predominant (20%) is 4.3 € (Figure 9), while for energy the highest is 42.9 € and the most frequent (18%) is 7.1 € (Figure 10).

Housing condition

Of the three building forms recorded in the Maputo SPN shown in Figure 11, the cement block wall house, slab roof and burnt cement floor represent the most predominant building typology of the sample: 98% of the houses are built in cement block (Figure 12A), 73% of the houses have burnt cement floor (Figure 12B), 76% have the zinc sheet roof (Figure 12C) and in most cases, the roof is the ceiling of the buildings. Finally, in the exterior finishing forms of the house walls, it was noted that 50% are plastered and painted.

The outer space of the house

In fact, the backyard of the house is the true living room, because, besides being the privileged place to spend most of the day (Figure 13A), it is also the living core, the meeting and social space between the children from the neighbouring families (Figure 13B). The thermal comfort given sometimes by the shade of the trees, as well as families' rural habits substantiate their choice. Effectively the outer space of houses plays an important role in the socialization of families.

However, these environments often do not have

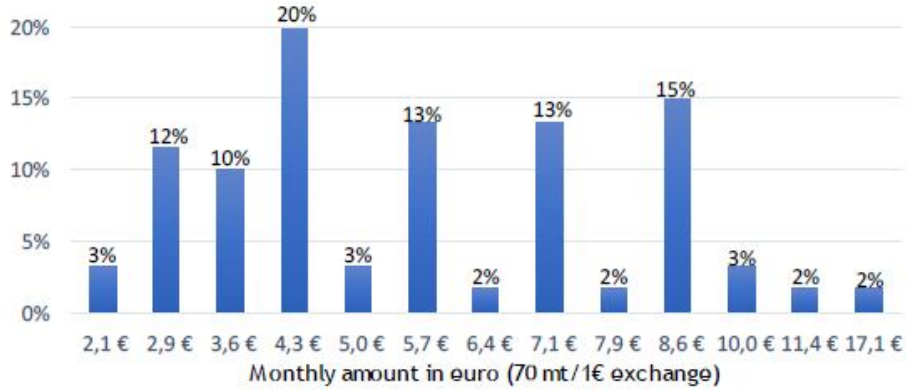

Figure 9. Monthly cost variation of water consumption. Source: Elaborated by the authors.

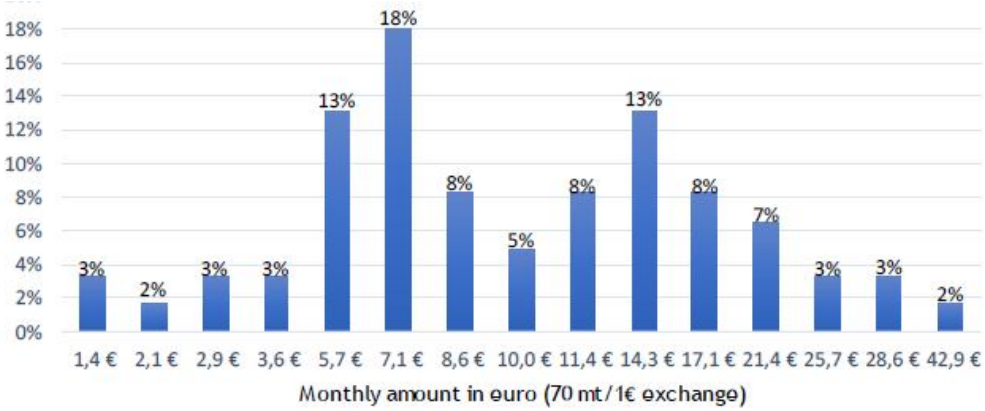

Figure 10. Monthly cost variation in energy consumption. Source: Elaborated by the authors.

Figure 11. The three constructive forms in Maputo's SPN: the reed house (left); the zinc plate house (middle); the cement block house (right). Source: Eskemose and Mottelson (2016: 13).

physical conditions that allow their continuous and comfortable use. 44% of the outer spaces of the houses do not have night lighting (Figure 14C), 39% have no shadow devices (Figure 14B) and 71% have their backyard completely unpaved (Figure 14A).

The house and its territory insertion

Carrilho et al. (2001: 78) identified a recurring house in the self-produced building fabric of Maputo, called "*Casa Ventoínha*" (translation For 'Fan House'), consisting of four compartments, built in 4 phases as families increase and accumulate financial and material resources. It has been found that this type is also an extremely recurring house model in George Dimitrov neighbourhood. However, its insertion in the territory according to the different phases presents multiple types of layouts, mainly due to the organic character of the neighbourhood fabric, resulting in lots with peculiar configurations, where it is often necessary to construct the type "Casa Ventoínha", to fix a or more facades within the

Figure 12. Housing construction materials. Source: Elaborated by the authors.

Figure 13. The house backyard in/ the backyard of the houses in GDN: A - People seek shade from the trees to spend most of their day/ An example of where people spend their time during the day (tree shade); B - The outer space plays an important role in children's life as its where they enjoy themselves. Source: Elaborated by the authors.

boundaries of the lots. In addition, it appears that the growth of the house after phase 4 occurs essentially through constructions in the plot perimeter, with only one floor (Figure 15).

Moreover, from the analysis of the housing configurations, it was found that most of the houses in the plots of B33 quarter have already reached phase 4 of *Casa Ventoinha* (Figure 16). That is, the following constructions will increase the horizontal density of neighbourhood land occupation and, consequently, reduce the amount of permeable soil.

Dwellers' perception of environmental housing conditions

Residents' perceptions about the environmental conditions of their homes show dissatisfaction, since the cases of high satisfaction are always below 11%. However, 40% of the population are satisfied with the outdoor thermal comfort (Figure 17A), 42% are satisfied with the cost and quality of water (Figure 17B) and 56% are satisfied with the natural light inside the house (Figure 17C).

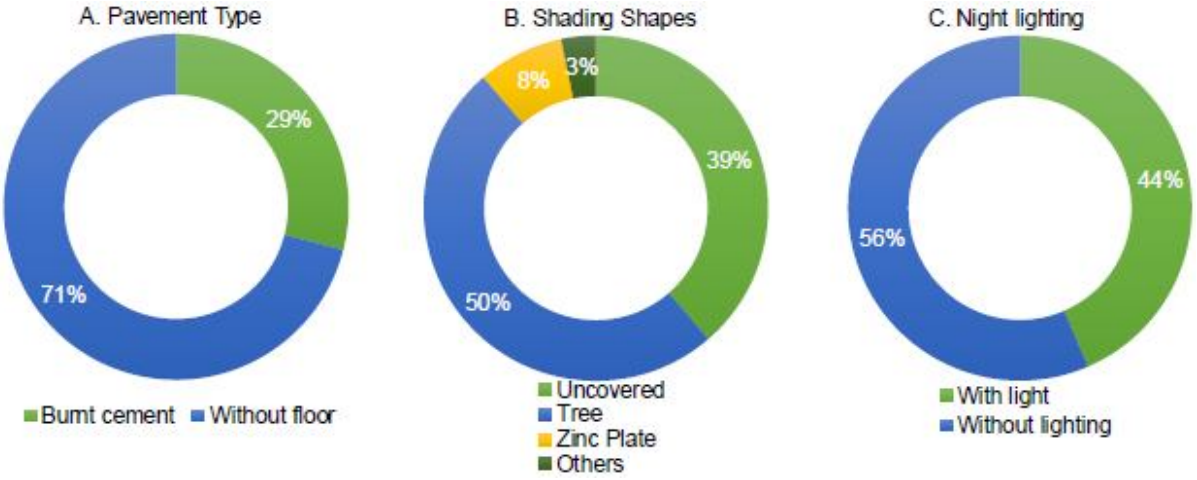

Figure 14. Physical conditions of the outer space of the houses. Source: Elaborated by the authors.

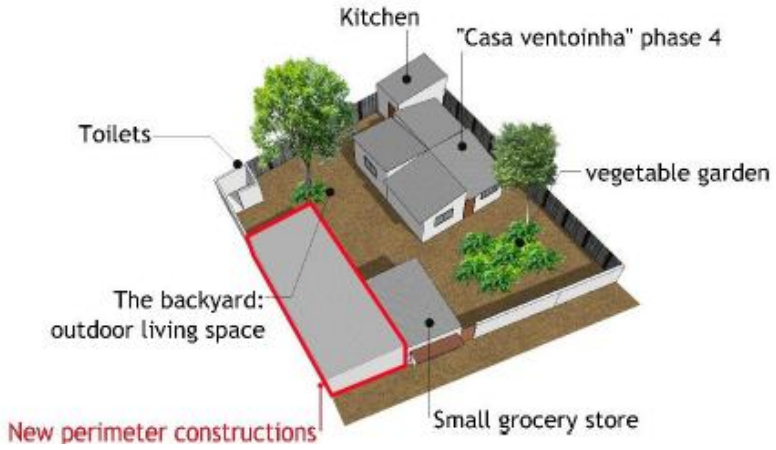

Figure 15. Insertion of the standard house “Casa Ventoínha” in the plots and its growth after phase 4. Source: Elaborated by the authors.

Nevertheless, about natural lighting in the house, families spend most of their day in the outdoor space of the house, so the perception of the quality of lighting inside the house (where they spend less time) will certainly be influenced by this fact. In addition, indoor visits as well as daytime photographic records (Figure 18) shows that indoor spaces need artificial light for visual comfort even during the day.

On the other hand, among the highest percentage of dissatisfaction of families, regarding the environmental conditions of the houses, 69% of families are dissatisfied with the weather security offered by the house (Figure 19A); 63% with acoustic comfort (Figure 19B); 60% with household waste treatment (Figure 19C); 58% with natural ventilation inside the house (Figure 19D); 56% with the constructive quality of the house (Figure 19E); and 53% with the state of conservation of the house (Figure 19F).

Finally, also with a perception of significant dissatisfaction, but not superior to the characteristics presented above, one can highlight the indoor thermal comfort (Figure 20A), the house dimension (Figure 20B) and the energy consumption (Figure 20C).

Public space

The public space is also one of the priority requalification areas in the neighbourhood, as mostly streets do not have any type of urban furniture (Figure 21C), not even adequate dimensions that could allow and promote socialization among residents (Figure 21A). In addition, the type of fencing of the plots hides the activities in the yard and thus does not allow the visual permeability of the courtyard from its surroundings (Figure 21B). Furthermore, the physical permeability of the roads structure is very low, due to the urban discontinuity of the urban fabric.

Figure 16. Representation of the "Casa Ventoínha" in phase 4, in the neighbourhood. Source: Elaborated by the authors.

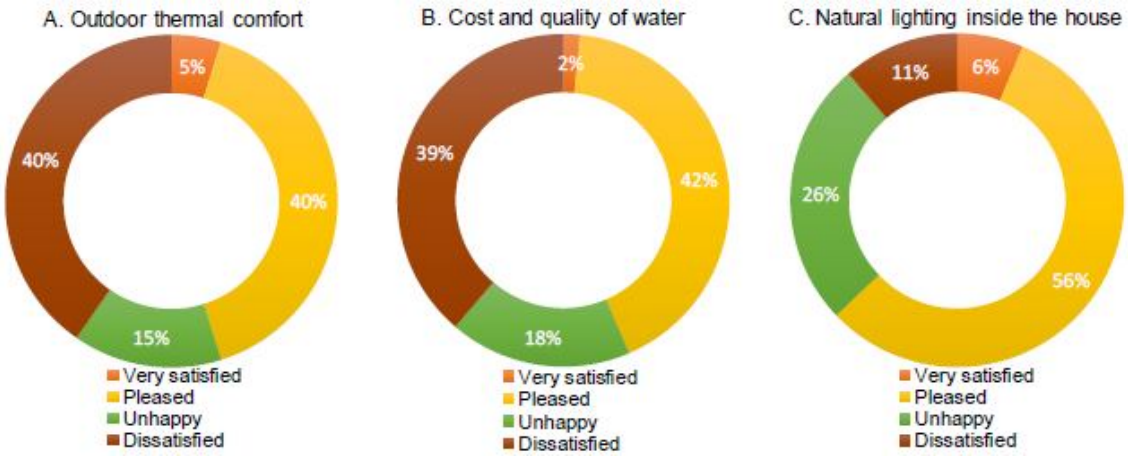

Figure 17. Residents' perception of the environmental conditions of the house: A - thermal exterior comfort; B- cost and water quality. Source: Elaborated by the authors.

Figure 18. Interior lighting backdrops in George Dimitrov neighbourhood homes. Source: Elaborated by the authors.

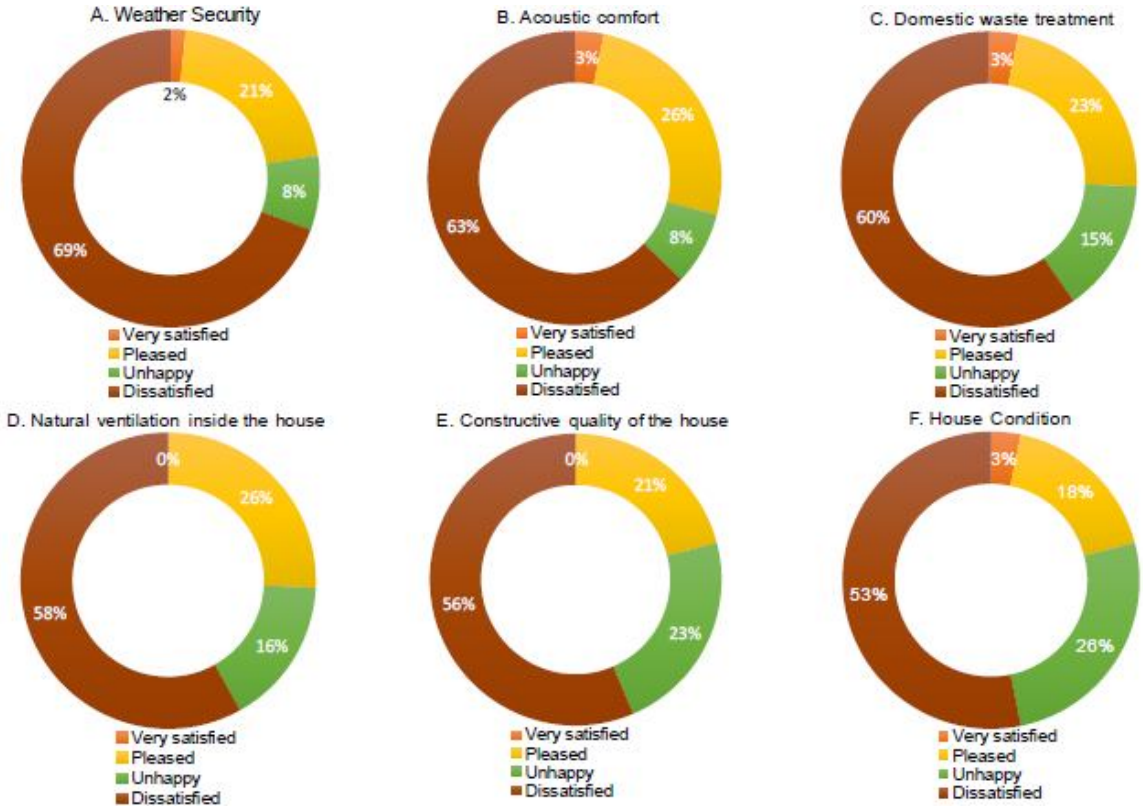

Figure 19. Residents' perception of the environmental conditions of the house. Source: Elaborated by the authors.

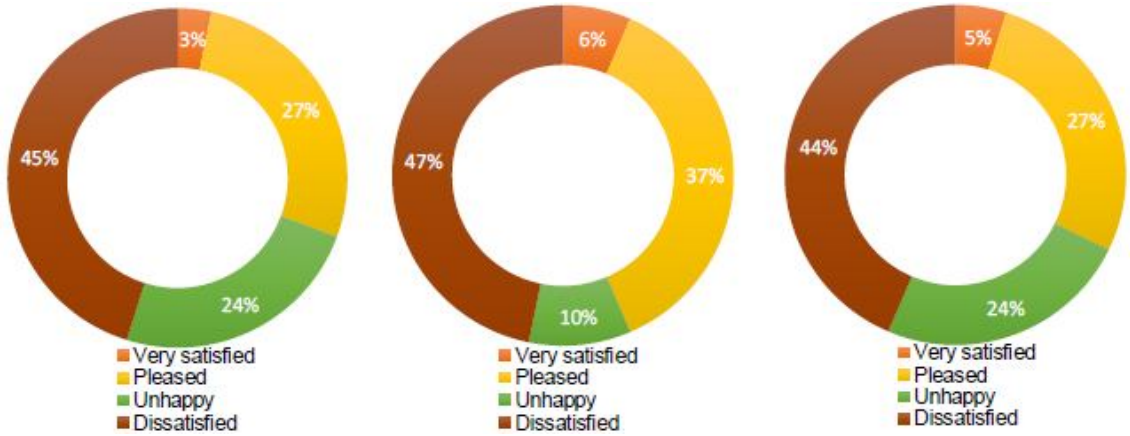

Figure 20. Residents' perception of the environmental conditions of the house. Source: Elaborated by the authors.

However, on the other hand, the irregular composition of the neighbourhood fabric creates a set of small open spaces shared among several families (Figure 22). Moreover, it should be noted that the streets with minimum conditions for the socialization of residents, are those that origins a variety of forms of appropriation revealing a dynamic public space with a high urban vitality.

Mobility

Nowadays families of B33 quarter move mainly by car, on foot and by public transport, specifically by bus and the so called "Chapa"[4] (Figure 23).

[4] *Chapa* in Maputo is the name given to semi-collective transport with a capacity of about 18 passengers.

Figure 21. Public space in GDN: A - street too narrow; B - wide street with surrounding native plants and zinc plates; C - wider street without any type of street furniture Source: Elaborated by the authors.

Figure 22. The street net connections with public wider spaces. Source: Elaborated by the authors.

Figure 23. Public transport used in Maputo. Source: Elaborated by the authors.

Commuting from home to work demonstrates a current modal structure (Figure 24) where 66% of the population use public transport system, 18% walk and 16% use private car. However, the potential modal structure is different from the current one, since it is more multimodal, that is, adds the bicycle (13%) and the motorcycle (15%). The car is the transport with the greatest potential for use, in which case 48% of households choose it.

Main environmental problems

In addition to the perception of the population about environmental problems in the house, at the

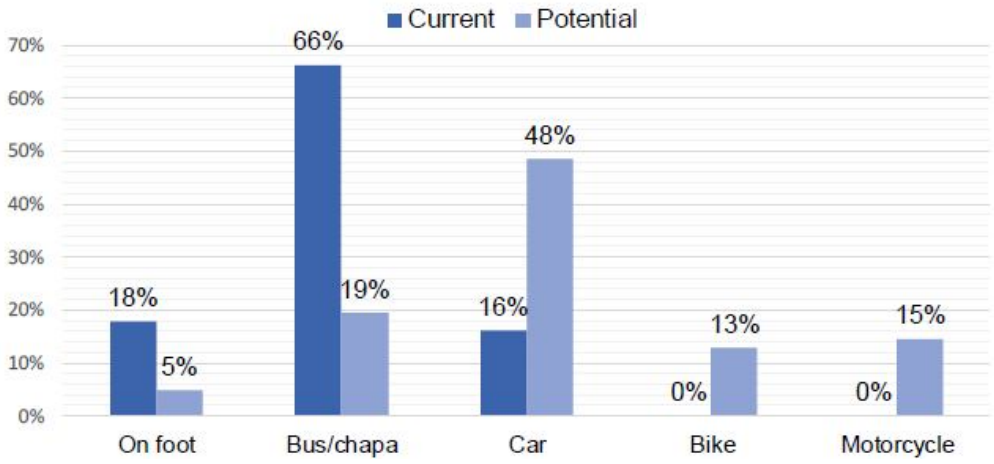

Figure 24. Comparison between the current and the potential mobility model. Source: Elaborated by the authors.

neighbourhood level, it was also possible to collect some environmental (and social) concerns. First, it should be noted that, coincidentally, some activities in the study area were carried out during rainy days. Thus, it was possible to realize that in a few rainy hours block 33 becomes in fact impassable. The houses are completely besieged, the water enters inside and makes them practically uninhabitable (Figure 25).

Thus, as shown in Figure 26, the environmental problems in the neighbourhood are globally pointed out by the majority of the population as existing, highlighting the lack of rainwater drainage infrastructure, identified by 98% of households, as well as the perception of 97 % of households for thermal discomfort on the streets and other public spaces and 95% of families for lack of public spaces and fresh, comfortable and equipped wooded greens. On the other hand, the lack of urban equipment close to home is a problem perceived by 50% of families as existing. However, it should be noted that this understanding stems, according to families, from the lack of a medical post within the pilot area.

DISCUSSION

Given the results of the case study presented above, it is intended, in this section, to discuss its implications in the answer to the research question, as well as to establish the relationship of the main findings with the reviewed literature. First, it should be noted that this research aims to answer the following question: is it possible to environmentally requalify the SPN of Maputo, taking advantage of the existing (physical, cultural and socioeconomic) conditions, from a cost-controlled perspective? Thus, the following points aim to discuss the results according to the different dimensions presented above (socio-economic issue, urban services, housing, public space and finally mobility).

The socioeconomic issue

In fact, it became clear that it was in the post-independence period that the problem of Maputo SPN was aggravated, as only 17% of the surveyed population has lived in GDN for over 44 years[5] (Figure 5A). That is, despite its genesis being linked to the colonization of the country, independence was not a unique condition for its reduction. In other words, as an urban phenomenon, Maputo's self-produced neighbourhoods, more than a consequence of a historical period, represent today a continuous process of searching for the ideal city by a population still rurally rooted and negatively influenced mainly by poverty (Figure 5B).

Thus, from a socioeconomic point of view, as an environmental problem, SPN are certainly not a phenomenon for eradicating, but rather for understanding and improving. For the permanent character of its residents (Figure 4A), as well as the property regime (Figure 4B) and long residence time in the neighbourhood (Figure 5A), substantiate, on the one hand, the sense of belonging to the community, on the other, the existence of cultural values linked to the configurations of such urban tissues. In addition, the current dimension of Maputo's self-produced urban sprawl makes socially, economically and environmentally unfeasible any model of action that does not take advantage of existing conditions.

On the other hand, the illegality of their properties (Figure 4C) is not the main impasse for the improvement of the habitat of the families, for example, in the interventions in the houses that culminated in the complete transformation of the building material (Figure 12). However, poverty and household growth (Figure 6) socially aggravate the environment problem of GDN. But

[5] Independent age of Mozambique

Figure 25. Flood scenarios in block houses 33. Source: Elaborated by the authors.

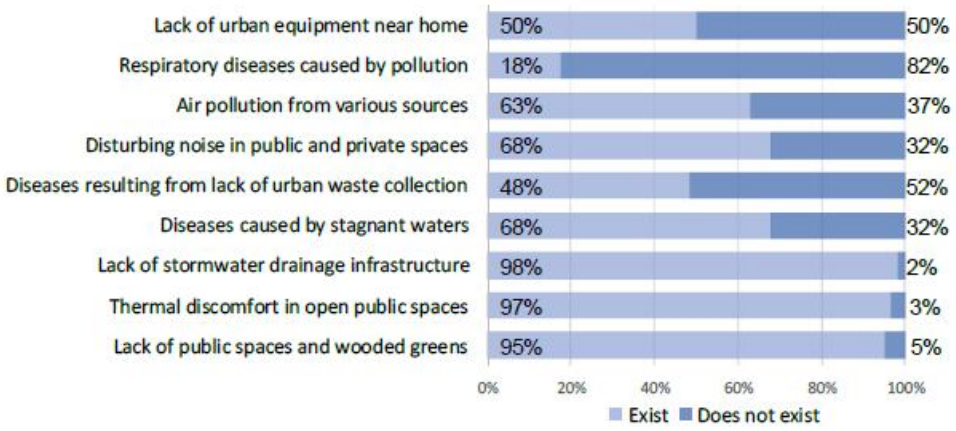

Figure 26. Identification of the main problems of the neighbourhood. Source: Elaborated by the authors.

there are several strategies to counteract, especially the forces of poverty, with emphasis on local trade (Figure 4D).

Urban services

The major environmental problems lie on the urban services. For while most of the population has access to basic services (Figure 7A), their low reliability increases the neighbourhood's environmental vulnerability, diseases resulting from accumulated waste in homes and public spaces (Figure 26), as well as systematic cuts in energy and water supply.

On the other hand, the forms of provision of these services, based on a linear, centralized and conventional metabolism, severely impact the environment. That is, in the undifferentiated collection of waste, fossil fuel is required to transfer the waste to the central dump, thus contributing to increase CO_2 emissions, and waste materials are not used or recycled. In the water supply, both the Fipag and Gawat systems use a lot of energy to capture and distribute water, with deterioration of public health in the water provided by Gawat. Sewage systems are mostly based on direct discharge to the ground, thus contaminating groundwater the main source of Gawat (Corburn and Sverdlik, 2017). In the power supply, the centralized system that exploits hydroelectric power has large distribution losses and is unable to guarantee continuous supply.

About water and energy consumption (Figures 9 and 10), SPN are found to have a low metabolism due to the financial inability of households and cuts in their supply. Therefore, it is as stated by (Devi et al., 2017). That is, in their early stages of formation, SPN have in certain parameters a low ecological footprint but increase with their development. However, in the case of GDN, this low consumption does not translate into a low environmental impact, as the ways of providing these services are environmentally unsustainable. It is therefore urgent to resort to sustainable ways of providing urban services while closing their cycle of use.

Thus, both the reliability problems that result in population dissatisfaction (Figure 8), as well as the impact and vulnerability that their use causes to the environment will be eliminated. For this, it is necessary to

produce energy locally; install integrated water management systems (provision, treatment, reuse); (collection, classification, treatment and reuse) and strengthen local food production (urban agriculture). The latter occurred during the fieldwork that is already practiced in the neighborhood and has potential for growth.

Thus, sloped roof-top surfaces of houses will allow rainwater to be collected for purposes other than human consumption while minimizing the problem of flooding due to lack of drainage infrastructure (Figure 26). Selective collection and reuse of waste will reduce siltation of drainage systems caused mainly by the disposal of solid urban waste and, consequently, will reduce both the diseases caused by stagnant waters, as well as air pollution resulting from uncontrolled waste burning.

In addition, it was also found that households are available to install both the rainwater and renewable solar energy collection systems. However, even considering the current decrease in the cost of solar panels and batteries, the main constraint of families is the cost of solar panels and batteries acquisition (Butera, 2018). Therefore, there is a set of positive synergies that allow the cycle of SPN services to close, without resorting to urban renewal processes.

The housing

Indeed, Carrilho and Lage (2010) reaffirmed, that is, by the residents' own initiatives, the houses were transformed in order to assume the materials and constructive forms like the urban centre ones, which are the main reference of inspiration. In this way, native natural materials were replaced by industrially produced materials, namely cement, iron and zinc (Figure 12). On the other hand, one can see here once again the sense of self-construction. In fact, the built-up fabric of the GDN effectively represents the human desire in the construction of its own habitat, so environmental requalification should strategically taking advantage of this condition to “naturally” integrate the forces that today shape these environments, as well as address the scarcity of financial resources.

Moreover, it was evidenced by the constructive characteristics and configurations of the dwellings that the lack of qualified technical knowledge on the part of the families or the home builder results in several problems that substantiate the perception of dissatisfaction regarding the main environmental characteristics of the house (Figures 12 to 15). For Example, the transition from houses built of local materials with bioclimatic characteristics adapted to the conditions of the place to constructions based on modern materials.

In fact, according to Khalil et al. (2018) houses are not equipped to cope with climate stresses or even have viable strategies to adapt to new temperature conditions because they do not have thermal insulation or even adequate coverings. In addition, their configurations do not create environments that provide visual and thermal comfort, nor even weather security.

On the other hand, the lifestyle of GDN residents, rooted in outer space, in this case the main stage of their daily lives, where most of their social relations occur, embodies a society of low consumption, contrary to that of the consolidated urban center whose Everyday life takes place indoors, where its use often means high consumption of resources. However, the lack of physical conditions of the exterior space of the house to provide greater resilience to climate change puts this environmental quality of the population at risk.

However, it is possible with environmental requalification strategies to take advantage of existing conditions, increase the resilience of these spaces and houses. This is, for example, through bioclimatic strategies to ensure thermal comfort and to define ways of vertical growth of the house, with a view to accommodating household growth and at the same time addressing the high-density horizontal occupation that occurs today (Figure 16). That is, important lessons lie on residents' perceptions of the house's environmental conditions (Figures 17, 19 and 20), as well as in the findings mentioned above, which can help contractors and families to create sustainable home upgrade solutions in the process of building and improving their habitats.

Public space

It was evidenced that the lack of open, fresh, comfortable and properly equipped public spaces and green spaces is one of the main community problems (Figure 26), which, in fact, results from the rural influence on the composition of the neighbourhood fabric, as well as the high horizontal density of buildings. Because of this, the backyard becomes a fundamental resource for families socialization. On the other hand, although the existing small plots between lots are practically abandoned, they have great potential to become dynamic public spaces.

It is important to point out that the sense of self-construction that occurs in the houses is not verified here, since mostly spaces did not get any human intervention to guarantee the minimum qualities for socialization. They are therefore leftover fragments that result from the composition of the closed and organic batch system. That is, considering the importance of public space in the affirmation of collective life and, thus, of the sense of city, then the self-produced neighbourhoods present a crisis of collective life, despite finding opportunities in the backyard and wider public spaces. Even so, given the small size and scope of these spaces, socialization only occurs between people with close location or family ties.

These social and physical conditions, on the other

hand, negatively impacts the environmental sustainability of these neighbourhoods, since the importance of these spaces in improving the urban microclimate and comfort is not recognized. Therefore, it is urgent to make the community aware of the environmental and social value of these spaces and, at the same time, to improve them. In this process, the currently abandoned small plots should be an opportunity to create in a network logic of new open public and green spaces, according to residents' needs.

Urban mobility

If, on one hand, the organic fabric characterized by narrow streets does not have adequate dimensions for better socialization, on the other hand, it embodies an environmentally sustainable modal structure. The car is currently the least (16%) mode used (Figure 24) because of the narrow street structure. Other factors explain this condition: the low financial income of the families (Figure 5B), which, for the most part, do not allow the purchase and use of the car; the size of the household (Figure 6); the commercial activities on the plot (Figure 4D), which make up a mixed land use, where the various opportunities are very close, thus favouring the attractiveness of walking instead of using the car.

However, it was found that the potential modal (Figure 24), in other words, the alternative choice of travel mode without any of the limitations mentioned above, is relatively unsustainable, as the car becomes the main choice (48%).Therefore, if families are to intervene in houses to improve them, naturally, as an extremely attractive mode of transport in contemporary society, the car will soon be dominant in the mobility structure of self-produced neighbourhoods.

It is therefore necessary to implement mobility policies that affect the urban form of the SPN, for example by creating natural devices for better comfort on public spaces, increasing the cross section to allow comfortable pedestrian circulation, installing street furniture, activating physical permeability by connecting urban streets networks, reinforcing the proximity between functions as well as the access to them through sustainable modes. That is, physical interventions are priority, but do not necessarily imply demolitions and consequent resettlement of the population, since the use of the automobile will not dictate such actions. Moreover, although seemingly disordered, it is possible to find in these neighbourhoods several opportunities for upgrading in order to ensure a comfortable use of environmentally sustainable modes.

CONCLUSIONS

It was assumed that, even though the SPN represent, in fact, a global environmental problem of the present city, their production over time results from human needs and cultural and social values, rooted in them. Therefore, the possibility of environmentally requalifying SPN was investigated, taking advantage of the existing physical, cultural and socioeconomic conditions. For this, we resorted to literature review and case study to isolate the research question.

Although apparently disordered, the SPN have in themselves physical and social qualities that substantiate environmental values that can be harnessed in the process of environmental requalification. Moreover, most of the observed environmental problems arising from morphological structures, although requiring physical interventions, are nonetheless reversible, without having to resort to major urban reforms. In addition, it was found that it is mainly in poverty and lack of adequate technical knowledge that self-built habitat by households' results in many of the major environmental problems identified.

Due to the discussion of results, it is concluded that it is possible to environmentally requalify the SPN of Maputo, taking advantage of the various existing conditions. To this end, the environmental condition should be gradually improved, based on action models that are integrated into the processes of urban self-construction. In the present approach to the environmental requalification of the SPN, visual or landscape topics were not a central urban purpose of this research, but rather to guarantee new functional and spatial logic, not only at neighbourhood level, but also at plot level, in order to contribute to the effective environmental sustainability of the SPN.

Moreover, urban public policies can not only be concerned with the availableness of public infrastructure (urban services, housing, etc.), but also have to ensure its environmentally sustainability. In this sense, considering the complexity of self-produced neighbourhoods, as well as the associated environmental challenges, it is essential to promote the multidisciplinary involvement of specialists in the environmental requalification process. Finally, this research hopes to contribute to a deeper understanding of the environmental issues of SPN, which will result in new intervention models, capable of recognizing and differentiating the structural aspects of their environmental sustainability, from merely aesthetic and conjunctural. Thus, produce changes that effectively improve the quality of life of the population of self-produced neighbourhoods.

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