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Climate emergency and urban housing precariousness: guidelines for climate adaptation in the São José neighborhood, João Pessoa - PB

Emergência climática e precariedade habitacional urbana: diretrizes para adaptação climática no bairro São José, João Pessoa - PB

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ABSTRACT: In the context of a climate emergency, cities are understood as key elements that mainly promote ecosystems and territorial transformation, thus contributing to the concentration of environmental risks. The Brazilian urbanization process is dominated by self-construction by the poorest, mainly in river floodplains and hillsides. The main impacts of climate change in Brazil are floods, landslides, and mass movements caused by extreme rainfall events. Those most vulnerable to these impacts are the people living in precarious settlements in ecologically fragile areas. Therefore, this article presents a social, physical, and environmental diagnosis of the São José neighborhood in the city of João Pessoa, state of Paraiba, Brazil, where more than half of the dwellings are in areas at risk, intending to identify guidelines and spatial interventions in the territory that guarantee an improvement in the social and environmental conditions of the resident population and local climate adaptation with minimal displacement of families.

Keywords: climate emergency; climate adaptation; green and blue infrastructures; precarious settlements; João Pessoa.

RESUMO: No contexto da emergência climática, as cidades são entendidas como elementos-chave, principalmente por promoverem a transformação de ecossistemas e territórios, contribuindo, consequentemente, para a concentração de riscos ambientais. No processo de urbanização brasileiro, a autoconstrução é predominante

para os mais pobres, e se dá prioritariamente nas várzeas de rios e encostas de morros. No Brasil, os principais impactos das mudanças climáticas são as enchentes, inundações, deslizamentos de terra e movimentos de massa, causados por eventos extremos de chuva. E são justamente as populações dos assentamentos precários, que residem em áreas ambientalmente frágeis, as mais expostas a estes impactos. Assim, este trabalho faz um diagnóstico social, físico e ambiental do bairro São José, João Pessoa – PB, onde mais da metade das residências encontram-se em área de risco, para apontar diretrizes e espacializar intervenções no território que garantam melhoria das condições socioambientais da população residente e adaptação climática local com a mínima realocação de famílias.

Palavras-chave: emergência climática; adaptação climática; infraestruturas verde e azul; assentamentos precários; João Pessoa.

1. Introduction

The intensification of the exploitation of natural resources over the last two centuries, such as deforestation, species extinction, uncontrolled urbanization, and the increasing emission of greenhouse gases (GHGs) into the atmosphere, has brought humanity to a point in history where human actions are interfering with the biophysical and chemical relationships of the planet, defining a new geological epoch that Crutzen (2006) calls the Anthropocene.

In the current context, planetary climate changes have impacts at different spatial scales and resonate differently in their social components (IPCC, 2014). No one is safe, but the poorer populations, countries, and regions on the margins of the financial and technological development of the planet's western, northern bloc are less secure, even though they contribute the least to greenhouse gas emissions and thus to the climate emergency (IPCC, 2021; IPCC, 2022).

In Brazil, the main impacts of this situation are related to extreme weather events, such as heat waves, droughts, and, above all, extreme rainfall, which cause geohydrometeorological disasters. Between 2005 and 2019, about 10,000 incidents of floods, inundations, flash floods, and inundations were recorded throughout the country, causing 2,038 deaths and leaving more than 5 million people homeless or displaced, besides nearly 1,500 incidents of mass movements and landslides, causing 518 deaths and leaving more than 183,000 people displaced or homeless (CEPED, 2020). From 2005 to 2015, the Northeast region had the second-largest concentration of affected people among the five Brazilian regions, with 32% of people affected by mass movements or landslides and 22% by episodes of floods, flash floods, and inundations (Perez *et al.*, 2020a).

The impacts of the climate emergency in northeastern Brazil, where a large part of the territory is located in the Caatinga biome, will be heat waves and droughts (Marengo, 2014; IPCC, 2021), which will increase the aridity of the region and potentially cause mass migration to capital cities, almost all of which are coastal and located on the borders of the Atlantic Forest biome (Ojima, 2013). In these cities, future scenarios indicate an increased frequency and intensity of extreme precipitation events (Perez *et al*., 2020a; IPCC, 2021).

As an anthropogenic product, cities are the ultimate expression of pressure on ecosystems and play a prominent role in the chain of events that

affect climate: changes in land use and land cover, soil sealing, destruction of fauna and flora, pollution of air and water resources, and displacement of agriculture, resulting in dependence on distant agricultural areas, and high energy consumption. Recognizing the unsustainability of these long-term dynamics, climate change poses challenges and requires greater adaptive capacity from our urban centers (IPCC, 2022), implying "a necessary interrelationship between social justice, quality of life, environmental balance, and the need for development" (Jacobi & Sulamain, 2016, p. 135).

In urban areas, risk scenarios are linked to land occupation, with socioeconomic inequalities and the absence of urban policies in land use management being the determining factors for increased risk (Jacobi & Sulamain, 2016; Nogueira *et al.*, 2014). The irregular occupation of urban land is permeated by sociospatial segregation, which is imposed primarily on the poorer segments of society, who suffer from the lack of housing alternatives, whether provided by the market or by the government (Maricato, 2003). These dynamics have led, over the decades, to the occupation of undervalued areas or those with remaining vegetation in cities, such as riverbeds and slopes (Maricato, 2013), which are the areas most vulnerable to disasters related to extreme rainfall.

In the case of João Pessoa, the capital of the state of Paraiba, the most recent demographic census of the Brazilian Institute of Geography and Statistics (IBGE) showed that in 2010, 13% (91,284) of its 723,515 inhabitants lived in households located in "subnormal clusters" (SNC)[1] (IBGE, 2010) and budgetary issues. The Municipal Secretariat of Social Housing of João Pessoa (SEMHAB) estimates the current housing deficit is 50,000 housing units. However, between 2013 and 2019, only 7,553 housing units will be built and delivered to beneficiaries (PMJP, 2020a).

In terms of risk, data from IBGE and the Brazilian Geological Survey (CPRM) show that in João Pessoa, 22 out of 64 geohydrometeorological risk areas are located along the banks of the Jaguaribe and Sanhauá rivers, which are characterized as meandering (CPRM, 2019) and are in SNCs (IBGE, 2010; CPRM, 2019). These areas have historically been characterized by a lack of adequate urban infrastructure and stigmatized by precarization (Jacobi & Sulamain, 2016; Perez *et al.*, 2020a). Between the early 1980s and 2016 alone, as shown by Silva (2018), the number of environmental disasters in João Pessoa reached 564, with 378 floods (67%), 110 inundations (20%), and 76 landslides (13%) recorded during the study period.

In the context of the climate emergency and the increasing frequency of heavy rainfall extremes that trigger disasters, it is the populations living in precarious settlements, who are more socioeconomically vulnerable, who are most exposed to risk and have less resilience capacity[2] (IPCC, 2019; IPCC, 2022).

In João Pessoa, among the SCNs with the highest number of people exposed to geo-hydrometeorological risk, are the São José neighborhood and the adjacent communities of Chatuba I, II, and

[1] Subnormal cluster (SNC) is a term introduced by IBGE (2010). In this paper, SNC refers to the spatial boundary used for precarious settlements.

[2] "The ability of social, economic, and environmental systems to cope with hazardous events, trends, or perturbations by responding or reorganizing in ways that maintain their essential function, identity, and structure while preserving their capacity to adapt, learn, and transform" (IPCC, 2014, p. 1772, our translation).

III, comprising the largest low-income precarious occupation area in the city, with high socioeconomic vulnerability, established since the 1960s. In this area, 11,016 people live at a very high-risk level, according to CPRM (2019), as 18 flood or inundation occurrences and eight landslides or mass movements affected around 3,000 people between 1983 and 2016 (Silva, 2018).

If the use of nature-based solutions is increasingly necessary to minimize economic, human, and social losses in the coming years, in João Pessoa, urban planning policies in recent years seem to follow an opposite paradigm, inclined towards a market-driven, deregulatory agenda, which has put pressure on ecosystems and compromised long-term climate adaptation capacity[3] (Perez *et al.*, 2020b; Trigueiro *et al.*, 2020). Hence, this article proposes, at the local level and based on an analysis of environmental and social conditions, a set of guidelines that prioritize the climate adaptation of the São José neighborhood, aiming to ensure the maintenance of the community in the area where it has been established for decades, with risk mitigation and adaptation of the space to the new reality of climatic conditions.

2. Urban planning and the climate emergency

Currently, an estimated 55% of the world's population lives in urban areas, and this figure is expected to reach 68% by 2050, with the urbanization of Africa and Asia lagging behind (UN, 2018). Above the global average, Brazil's urbanization rate approached 85% in 2010. Notwithstanding that the reversal of global warming is not foreseen, the promotion of mitigation and adaptation policies is essential for the resilience of populations to its negative impacts (IPCC, 2019). Thus, the construction of positive scenarios necessarily involves methodological changes and the reconfiguration of urban environmental policies, with the city understood as a key element (Figure 1) in this process (ICLEI, 2016).

Margulis & Dubeux (2010) stress that the concepts of climate mitigation and adaptation differ in terms of the scale at which they operate. While the former requires global synergies, such as the reduction of CO_2 emissions proposed in international agreements (e.g., The Paris Agreement), climate adaptation requires the implementation of effective, individualized actions at the local level, which do not replace the importance of supporting mitigation policies. To achieve an appropriate level of adaptation, convergent efforts are needed in the definition of public policies at different levels of government (i.e., federal, state, and local) that promote either structural or nonstructural interventions.

In this equation, as argued by Nogueira *et al.* (2014), municipalities face a worrying reality because they are the most fragile federal entities because of economic and technical-administrative limitations and because they are the recurrent site of

[3] "The process of adjusting to the effects of current and expected climate. In human systems, adaptation seeks to mitigate or avoid damage or to take advantage of beneficial opportunities. In some natural systems, human interventions may facilitate adaptation to expected climate change and its effects" (IPCC, 2014, p. 1758, our translation).

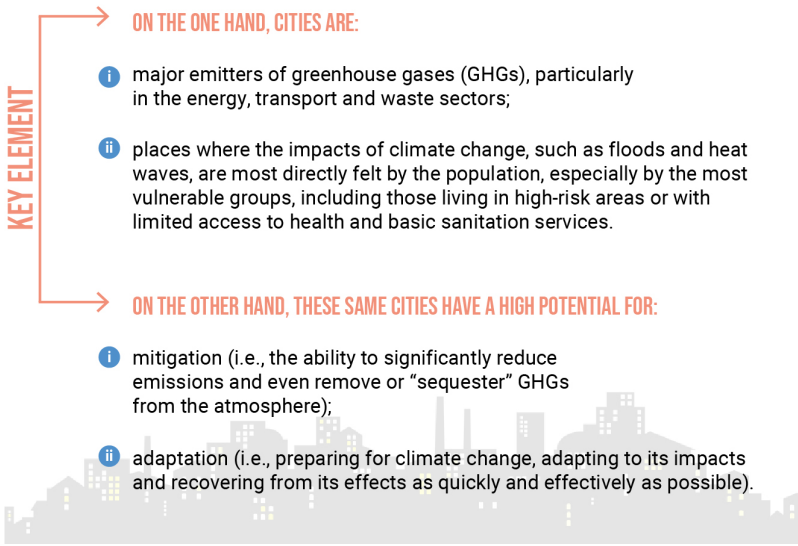

FIGURE 1 – The city as a key element.
SOURCE: Adapted from ICLEI (2016).

environmental disasters in the country. This fragility is reinforced by Maricato (2013), who states that the capacity and autonomy of local power to solve structural problems is relative and does not exempt the need for a "development project for the country that considers the defense of national and popular interests" (Maricato, 2013, p. 66). Because of the unpredictability of climate events, adaptation is a multisectoral process that requires the establishment of adaptive climate governance, where actions are flexible and constantly reassess existing risks, besides political decisions (IPCC, 2019).

Literature (IPCC, 2022; Perez *et al.*, 2020b; Rosenzweig & Solecki, 2018; Broto, 2017) shows that urban development policy is a key element in building more sustainable and climate-resilient urban centers. In Brazil, this policy is guided by the municipal master plan (MMP), which aims to promote democratic debate and equity among different social actors, representing a potential driver of urban transformations. This scenario favors the inclusion of necessary discussions for climate adaptation, such as:

(i) zoning to preserve the environment and landscape and to promote the production of housing of social interest (HSI);

(ii) Control of risk areas;

(iii) building an adaptive process through no-regret[4] measures that go beyond the palliative measures commonly used; and

[4] "These are adaptation actions that promote co-benefits regardless of the potential impacts or risks projected as a result of climate change." (IPCC, 2014, p. 1758, our translation).

(iv) creating or strengthening disaster prevention and mitigation capacities (Figure 2), where disaster risk management (DRM) is "understood as a component of sustainability in urban, economic, and social development" (Nogueira *et al.*, 2014, p. 179).

The urban planning of João Pessoa has been guided by practices common to most Brazilian cities: piecemeal interventions for the urbanization of slums by prioritizing paving, access to water and sewerage networks, the construction of basic educational facilities, but above all, the removal of houses at risk without a dedicated analysis of their management. Often, the relocation of these families to areas far from the original community is anticipated, without preserving the existing social protection networks among residents, and with a sudden change in the way of life of these populations and in their urban cultural landscapes (Scocuglia, 2019).

The São José neighborhood has undergone interventions in recent decades, with attempts at expropriation and urban actions by public authorities (Lima, 2004), the most recent being the construction of the Novo São José housing complex, inaugurated in 2018. This process began in 2011 with the launch of an urbanization proposal with controversial ideals that denied all the existing urban and social fabric of the community. The community's resistance ensured the development of a new project on the strength of diagnostic phases and discussions with the local population, which resulted in the implementation of a phase of the project and the construction of 336 housing units.

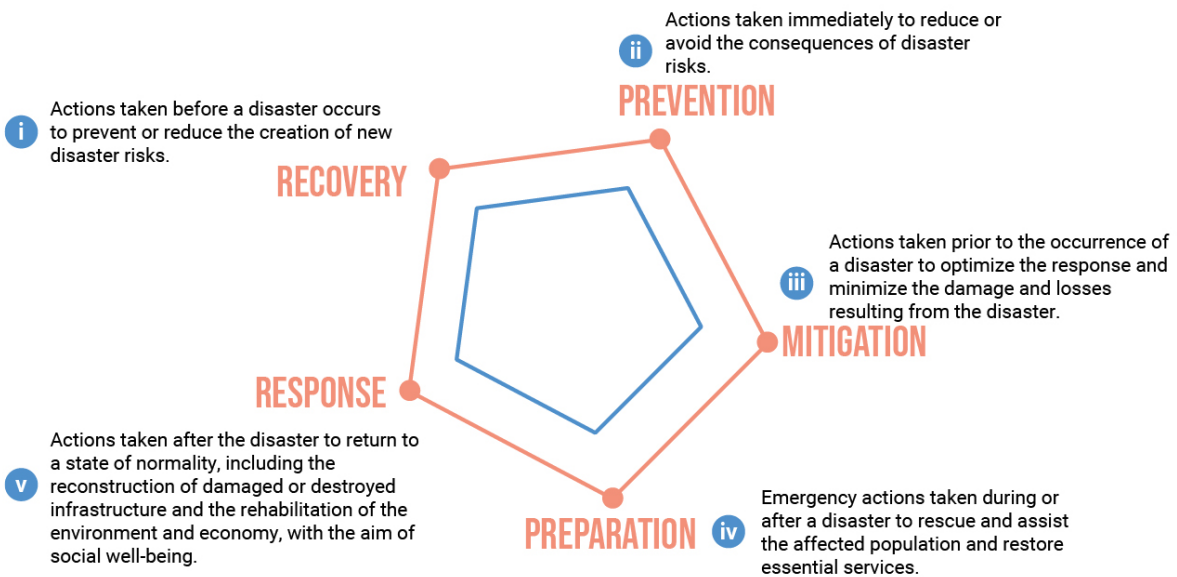

FIGURE 2 – Actions for disaster risk reduction.
SOURCE: Adapted from Brazil (2017).

3. Methodology

The work was developed by analyzing the state of the art on the topic, analyzing data derived from various official sources, creating a corpus of spatial data, and producing thematic maps.

Spatial analyses were performed by using Quantum GIS (QGIS) software, version 3.18. 1, with census data (IBGE, 2010), such as income, household inadequacy rate, number of school-age children, and number of female household heads; boundaries of SNCs (IBGE, 2010); boundaries of risk sectors (CPRM, 2019); data from the Municipal Government of João Pessoa (PMJP) on road system coverage and access to public transport; elaboration of data (outline of built masses, here called features, and vegetation) based on high-resolution satellite image analysis and web tools such as Google Street Map. Within the results and discussion of the work, based on spatial analysis, thematic maps, and literature, the following were developed:

(i) urban environmental diagnosis of the study area; and

(ii) climate adaptation guidelines.

4. Diagnosis of the study area

São José was settled on the banks of the Jaguaribe River in the 1960s, and today has 7,416 inhabitants, with 2,224 dwellings in an area of only 0.375 km^2 (Lima, 2004; IBGE, 2010). It is in the eastern zone of João Pessoa, bordered to the north by the municipality of Cabedelo (Figure 3), to the east by the Manaíra neighborhood, to the west by the Brisamar and João Agripino neighborhoods, and to the south by the Miramar and Tambaú neighborhoods.

Historically, its occupation has developed between two geographical features (the Jaguaribe River and a hillside), currently defined by municipal legislation as a special zone of social interest (SZSI). Despite the informal occupation, the area is consolidating and, according to the last two demographic censuses (2000 and 2010), has shown an increase of

FIGURE 3 – Location of the study area. a: Brazil; b: Paraiba; c: João Pessoa, São José neighborhood and surroundings.
SOURCE: IBGE (2010) (Prepared by the authors).

8% in the number of households. In the last census, 39% of families in the neighborhood were headed by women; 50% of the population was between 22 and 59 years old; 90% of household heads had an average income of up to one minimum wage; and 68% of them were literate. Overall, 50.6% of the housing was inadequate[5] (IBGE, 2010).

Self-construction is one of the practical consequences of the process of spontaneous occupation of the neighborhood. These aspects, besides compromising the environmental comfort conditions of the houses, favored the population density of the area, being the highest among the neighboring districts. The contrast with the surrounding area is striking—while Manaíra, one of the most vertical neighborhoods in the city, has a population density of 10,892 inhabitants/km^2, São José has 19,776 inhabitants/km^2, almost double the population density (IBGE, 2010).

The circulation areas of the neighborhood serve as the main promoters of social interaction, given the lack of recreational areas and squares. In a recent intervention, the municipal government built the neighborhood's first plaza (Figure 4:a), after relocating some families that lived along the banks of the Jaguaribe River; there are also two other plazas in the immediate vicinity (Figure 4:b). The street system and the new square are the main public spaces of the neighborhood, and the green spaces, formed by the vegetation of the hillside and the river, appear as the most prominent landscape elements of the area, with great potential for integration into the urban fabric. The difference in level and the low height of the buildings also allow for a visual connection with the forest throughout the entire extent of the neighborhood (Figure 5:a).

Still reflecting the informal occupation of São José, the lack of direct connection to drivable streets can be observed. Edmundo Filho Street, with

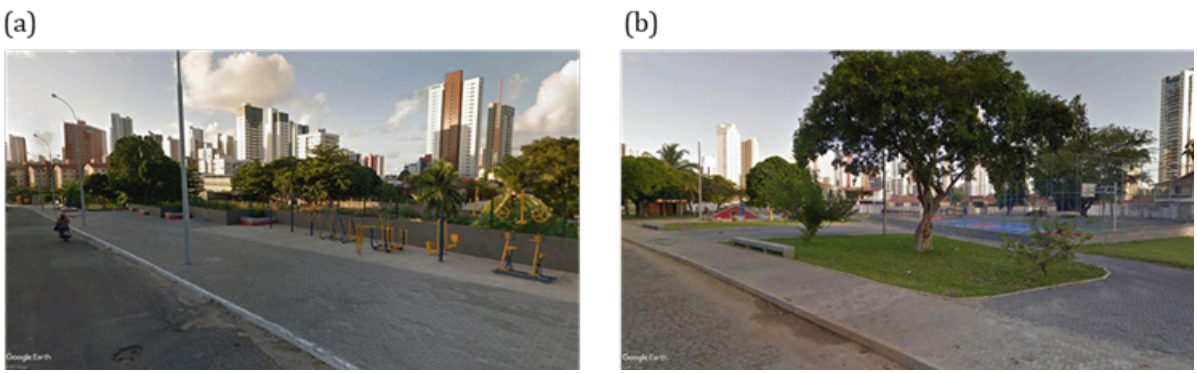

FIGURE 4 – a: São José neighborhood's plaza; b: Brisamar neighborhood's plaza.
SOURCE: Google Earth Pro.

[5] "The IBGE (2010) defines them as dwellings that do not meet the conditions of (i) access to general water and sanitation networks, (ii) direct or indirect garbage collection and (iii) up to two residents per bedroom.

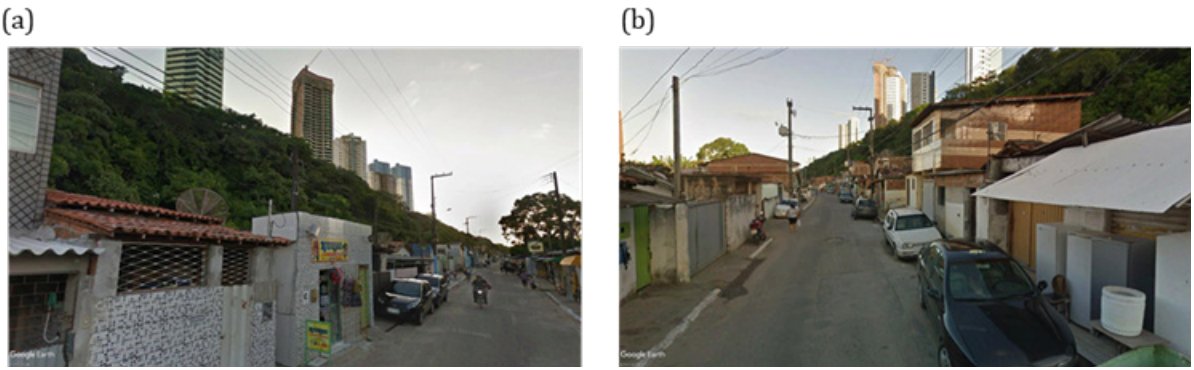

FIGURA 5 – a: Edmundo Filho Street, São José neighborhood; b: Occupation of sidewalks, Edmundo Filho Street.
FONTE: Google Earth Pro.

an average lane width of 6 meters, is the central, organizing element of the neighborhood's road system. On this road, which concentrates the public transportation lines and most of the neighborhood's traffic, there are congestion points, favoring unrestricted occupation of the sidewalks (Figure 5:b).

The circulation areas that branch out have distinct morphological characteristics in terms of (i) width and (ii) geographical limitations: besides the single collector road, there are narrow streets and one-way lanes—with variable lane widths between 2.5 and 4.5 meters; alleys—between 2 and 2.5 meters; and passages between buildings. Because of their dimensions, the alleys and passages favor pedestrian circulation and are more common near the Jaguaribe River, as they provide access to the buildings along its banks. Given the geographical limitations, alternative routes are constructed, some of which are defined by the community itself, such as ramps, narrow corridors, bridges, stairs, stepped paths, and platforms. The location of these elements is strategic since they overcome the geographical obstacles of the area and ensure the community's access to the main points of interest, in particular by opening paths through the vegetation of the hillsides. Although these spaces are conducive to active mobility because they provide opportunities for smoother movement, the lack of quality is striking. According to Gehl (2013), an important condition for free flow and movement is the existence of "relatively free and unobstructed" spaces (Gehl, 2013, p. 121). One of the main compromised elements in this system is the sidewalks, which, when they exist, are uneven, lack trees, and are constantly obstructed, either by irregular parking of vehicles or by structures (ramps and steps) and irregular progression of buildings.

In terms of paving, only the central street of the neighborhood is paved, a characteristic typically associated with streets that are part of the public transportation system. However, the condition of the pavement is questionable (Figure 6:a). Some of the narrow streets and alleys are paved with cobblestones, possibly as an intervention by the public authorities (Figure 6:b). At least three of the four bridge entrances have this type of pavement. In

the absence of government action, residents tend to seek alternatives, often environmentally inappropriate, such as unrestricted waterproofing. Cemented sidewalks, which provide a better quality of access to homes, are associated with improvements made by the community itself.

The public transportation lines are located outside the community boundaries, and some pedestrian bridges over the Jaguaribe River are located near the bus stops, in actions possibly undertaken by the population. Regarding other public facilities for education, health, security, and leisure, only five of them are installed in São José, although there is a relationship between the neighborhood's road system with elementary schools and surrounding squares (Figure 7).

In terms of environmental aspects, according to CPRM (2019), São José is exposed to the risks of landslides and flooding, with an area coverage that affects about 58% of the neighborhood, thus intensifying the socioenvironmental vulnerability of the population. Both risks are classified as "installed," which refers to areas that are occupied and exposed to real risks (Brasil, 2017). Within these two polygons, the presence of 11,016 inhabitants in 2,754 households is indicated (Figure 8). These data show that in this region, approximately 35% of the population exposed to some type of environmental risk is concentrated in João Pessoa (CPRM, 2019). The risk of planar slides is associated with the dense population on the slope and the construction pattern used, with cuts and fills for building adaptation, resulting in different failure points (CPRM, 2019). In parallel, as presented by Vital *et al.* (2016), the action of humid coastal winds compromises the stability of these slope areas[6], increasing the risk of erosion and mass movements. The unrestricted occupation of the floodplain of the Jaguaribe River exposes the area to the risk of flooding. Based on the record of impacts of extreme rainfall events presented by Silva (2018), São José is highly exposed to these tragic scenarios, with a concentration of

FIGURE 6 – a: Asphalt covering; b: Cobblestone paving.
SOURCE: Google Earth Pro.

[6] In the mapping by Vital *et al.* (2016), 22% of the slopes in João Pessoa showed a high vulnerability to the action of humid coastal winds due to their orientation to the southeast, east, and northeast, as is the case of the slopes in the study area.

FIGURE 7 – Points of interest, São José neighborhood and surroundings.
FONTE: PMJP (2020b); Google Street View (Prepared by the authors).

about 83% of the affected people (injured, buried, and displaced), 32% of the deaths, and 50% of the material goods destroyed in the city between 1983 and 2016.

The ecological structure of the neighborhood is composed of:

(i) vegetation and watercourse; and
(ii) topography of the area.

The predominant feature of the "patch" is the remaining Atlantic Forest on the slope, bordering the João Agripino and Brisamar neighborhoods to the west, while the Jaguaribe River is the structuring element to the east, where the suppression of the riparian forest and the occupation of the Permanent Conservation Area (APP) of the Jaguaribe River by buildings in the Manaíra and São José neighborhoods can be observed. The anthropogenic environmental impacts on the river are presented

FIGURE 8 – Ecosystem structure and risk areas, São José neighborhood and surroundings.
SOURCE: PMJP (2020b); CPRM (2019) (Prepared by the authors).

by Queiroz (2009), who compiled data from the Superintendence of Environmental Management (SUDEMA) between 2000 and 2007. According to the author, the presence of fecal coliforms is an important indicator of bacteriological pollution, and the high levels found in Jaguaribe River are related to the lack of access to urban infrastructure, which may exacerbate, for example, the inappropriate discharge of domestic sewage and solid waste directly into water bodies or their surroundings. Out of the points studied, the one located in the São José neighborhood had the highest rates of water contamination (Queiroz, 2009).

In terms of topography, part of the neighborhood has a slope ranging from 5% to 15%, which becomes steeper towards the slope and can reach approximately 45% in some areas (Figure 9). It is observed that the geomorphology of the area:

(i) favors the flow of sewage and rainwater towards the riverbed, contributing to its pollution and siltation; and

(ii) creates scenarios of landslides due to the suppression of vegetation and the unrestricted occupation of the slope, prohibited by federal legislation (Brasil, 1979).

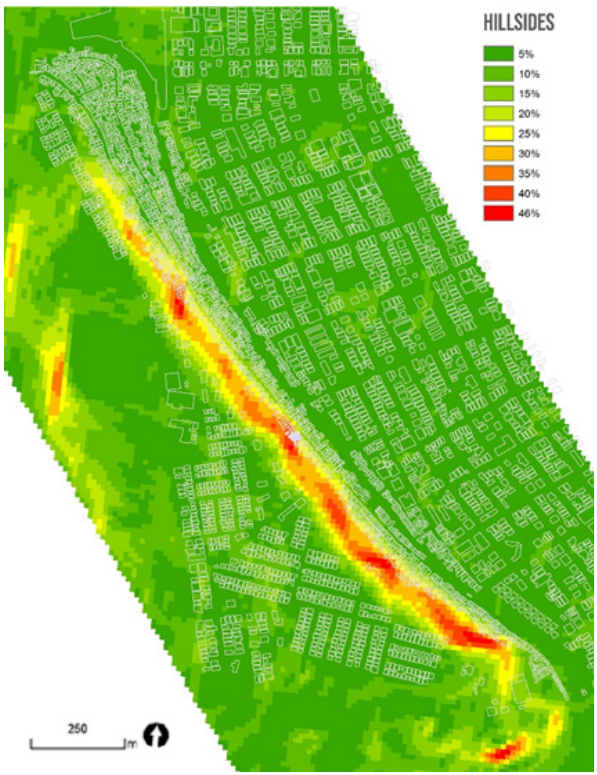

FIGURE 9 – Hillside of São José neighborhood and its surroundings.
SOURCE: Global Mapper (Prepared by the authors).

Finally, the buildings in the São José neighborhood and on the right bank of the Jaguaribe River (Figure 10), in Manaíra, were categorized as (EDU, 2013):

(i) *mixed*, where there is a direct connection to the central collector street;

(ii) *organic*, if access to the building is through narrow streets, alleys, lanes, or ramps; and

(iii) *residual*[7], if the building exerts any kind of pressure on the ecological structure of the region, or if all or part of it is located within the Permanent Preservation Area (PPA) of the Jaguaribe River, on plots with a slope of more than 30%.

The "residual" occupations are the first to be affected by natural disasters because of extreme weather events and represent 47% of the 1,865 features in the area, which also includes the Manaíra Shopping Mall, an occupation approved by the public authorities. The "organic" type (31%) is more common in the northern part of the municipality and in the central-southern area. On the other hand, the "mixed" category, with about 22% occurrence, is associated with a direct connection to the central street of the neighborhood and belongs to the first set of occupations (Lima, 2004), being present on both sides of the collector road.

Being a consolidated site with a high population density, the São José neighborhood does not have available urban spaces for large-scale interventions. Therefore, specific relocations are considered essential for the area's climate adaptation process. Some features have been reclassified into areas (i)

[7] In this case, the concept of residual is associated with the most recent period of occupation, as presented by Lima (2004), when housing was installed in the residual or remaining areas of the neighborhood.

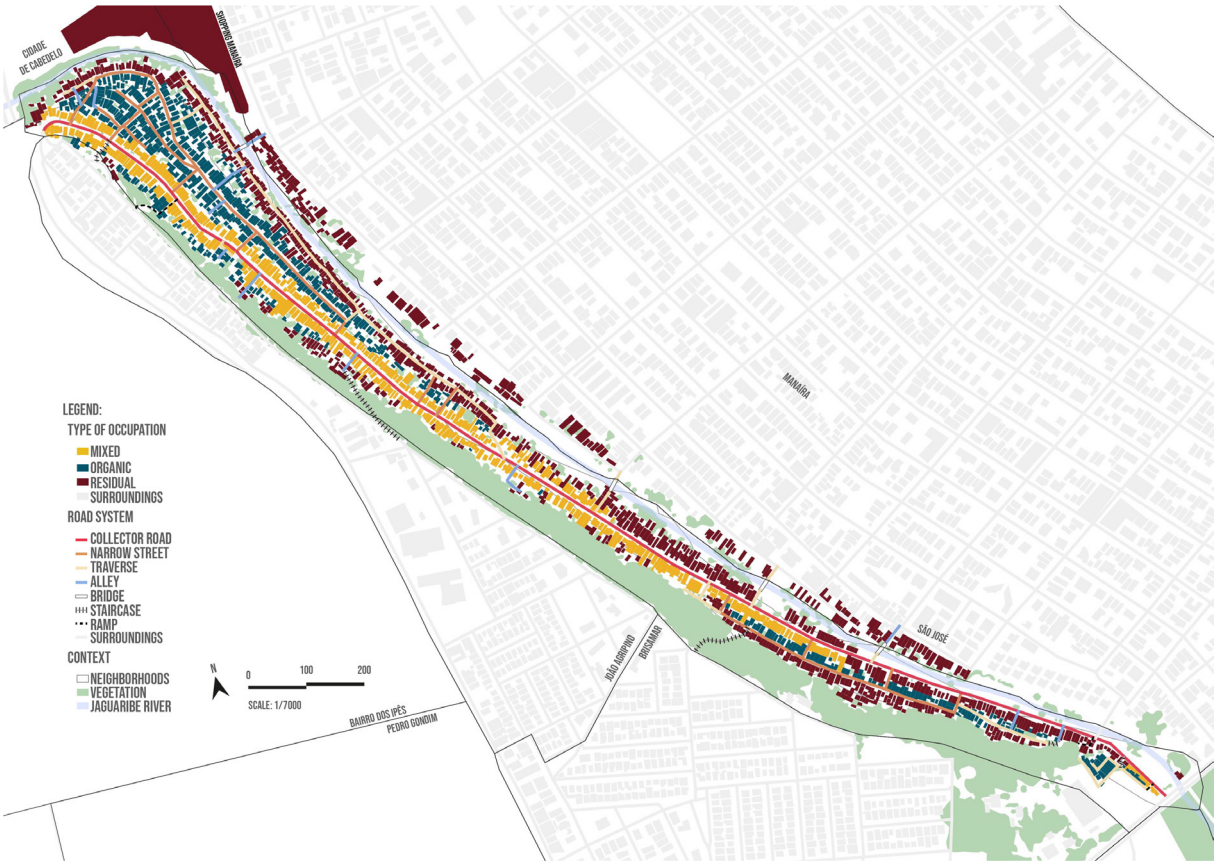

FIGURE 10 – Built environment and road system, São José neighborhood and surroundings.
SOURCE: PMJP (2020b) (Prepared by the authors).

of imminent risk and (ii) with potential for incorporation, considering the following criteria:

Areas of immediate risk: these are mainly of the residual type since they are in the front line of exposure to the environmental risks present in the neighborhood. Thus, the following buildings are at immediate risk:

(a) located within a 10-meter strip from the Jaguaribe Riverbed (Figure 11:a), as they are on the riverbank and directly contribute to its siltation;

(b) located less than 5 meters from the top of the slope (Figure 11:b), in accordance with the recommendations of the Civil Defense;

(c) built in the vicinity of points with a slope greater than 30%, where irregular incisions are observed in the houses along the slope (Figure 11:c). In total, about 231 residual type features were reclas-

sified, mainly concentrated in the floodplain region (65%). Despite the application of these parameters, observations in Google Earth Pro were necessary to validate this information.

Areas with incorporation potential: These are well located areas in the neighborhood, close to existing urban facilities and with good access to the road system. A total of 36 features have been reclassified within this category, from which it is possible to foresee the implementation of elements that promote new dynamics within the community.

In this perspective, once the families residing in the areas of imminent risk are relocated, the vacated structures are demolished to allow the implementation of measures that prevent the resettlement of the area, as observed by Nogueira *et al.* (2014). However, the new elements must have an attractive and inviting interface, not only serving as a physical barrier. The vacant space created also favors the implementation of green and blue infrastructures (Figure 12), which, besides the cobenefits already discussed, provide multisensory experiences, closer proximity to the environment, and strengthen the relationship between the community and the ecological structure of the region.

5. Guidelines for climate adaptation

According to CABE (2004), urban development requires the adoption of a clear strategy that values local physical, social and economic aspects. As a method, the establishment of guidelines supports the definition of this strategy, as it allows the articulation of different levels of strategic thinking as well as the collective construction of its principles. For the São José neighborhood, the proposal of a set of guidelines, discussed below, guides the process of its climate adaptation. All these aspects aim to prioritize:

(i) reclaiming space within the community, to reduce existing risks and prevent the creation of new ones;

(ii) prevent the community from being suddenly affected;

(iii) identify solutions to mitigate the effects of flooding from the Jaguaribe River;

(iv) prepare areas to receive the water that inundates the floodplain and causes landslides; and

(v) respond to extreme rainfall events without the need to relocate families.

FIGURE 11 – a: ocupação às margens do rio; b: ocupação da crista da encosta; c: recorte irregular na encosta.
SOURCE: Google Earth Pro (Emphasis added).

FIGURE 12 – Intervention proposal, São José neighborhood and surroundings.
SOURCE: Prepared by the authors.

5.1. Sustainability

5.1.1. Coexistence with population in consolidated areas

Despite the programmatic requirement to preserve the 30-meter riparian forest strip, as established by law, the proposed design strategy avoids removal as the first design approach, given that the community is already consolidated and protected by the Municipal Statute and Reurb (Law No. 13.465/2017). Therefore, measures of no regret are adopted, accompanied by careful planning for the relocation of families at imminent risk, since this represents a threat to the lives of these populations. This effort favors the accommodation of infrastructures (green, blue, and gray) that allow the improvement of the adaptive capacity of the neighborhood in the short and medium term. These measures can be restructured in the long term based on the impact of climate change and population dynamics. In addition to contributing to the mitigation of existing risks, these infrastructures can increase the availability of public open spaces while preventing the reoccupation or future modification of these areas.

5.1.2. Preservation of the ecological structure

The prevention of soil erosion is one of the cobenefits of the existing vegetation in the area, as it prevents the siltation of the rivers and ensures the stability of the slopes. In this regard, in addition to preserving the remnants of the Atlantic Forest, actions are needed to promote the reforestation of areas cleared during the urban occupation process, such as in parts of the Jaguaribe River floodplain and on the slopes. The vegetation restoration should prioritize native flora species, and their size (small, medium, and large) should be evaluated on the basis of the steepness of the terrain. Furthermore, this process can create medium and long-term opportunities through sustainable forest management, contributing to income generation, environmental

conservation, and fostering a link between the community and the reserve.

5.1.3. Encouragement of urban agriculture

According to the IPCC (2019), dietary change is a climate adaptation measure because diets rich in animal protein consume a number of natural resources (e.g., grazing land, water, and other inputs) and consequently contribute to the release of GHGs into the atmosphere. In the case of the São José neighborhood, the relocation of families exposed to the risk of landslides creates terraced areas created by the cuttings where these houses were built, which can be used to promote urban agriculture. According to FIDEM (2004), structural interventions involving re-grading allow for slope stabilization, which requires the redirection of rainwater drainage through channel systems (foot, descent, and edge channels).

Combined with these techniques, which are essential for slope stabilization, these "agricultural pockets" (Figure 13) aim to reconnect urban populations with food production, allowing for

(i) the consumption of organic vegetables;
(ii) food safety;
(iii) reducing food waste; and
(iv) generating employment and income.

The efficient processing and distribution of this production requires supporting structures such as storage facilities, composting systems and distribution centers. All these actions can be organized through cooperatives formed by residents, in a fundamental initiative to promote coordination between public institutions and agents that provide resources and technical assistance (e.g., universities, research centers, NGOs, and the government itself).

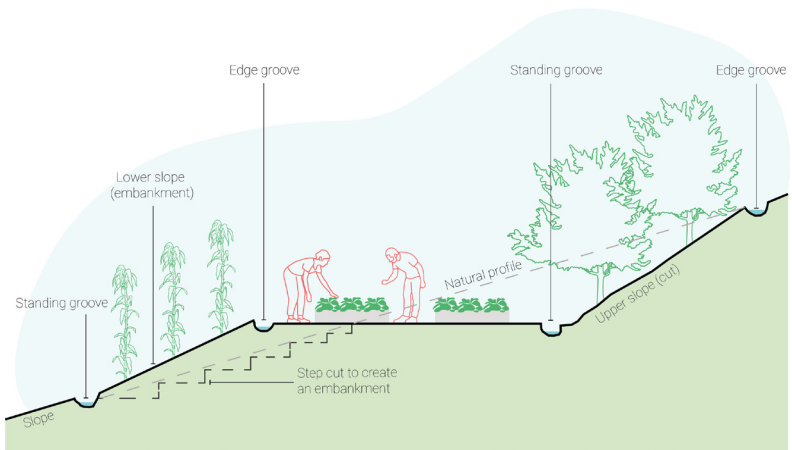

FIGURE 13 – Proposal for an "arable pocket" on the hillside.
SOURCE: FIDEM (2004) (Prepared by the authors).

5.2. Resilience

5.2.1. Relocation of families at imminent risk

In the short and medium term, buildings located close to the river and in areas with steep slopes (greater than 30%) would be more exposed to the intensification of weather events, such as increased and unpredictable rainfall. Therefore, the removal of buildings that are:

(i) within 10 meters of the riverbed

(ii) less than 5 meters from the crest of the slope; and

(iii) in areas where incisions are observed that threaten the stability of the slope, with relocation of these families around the community.

5.2.2. Creation of green and blue infrastructure

The open spaces created by the removal of some buildings allow for the implementation of green and blue infrastructures in the neighborhood. One example is urban wetlands (Figure 14), which are floodable areas that absorb excess rainwater, thereby reducing pressure on the drainage system and the population's exposure to sudden increases in water levels. When used in public open spaces, nature-based solutions offer cobenefits such as:

(i) mitigation of flood and inundation scenarios in areas close to the river and of planar landslides on the slope;

(ii) combating "heat islands";

(iii) reduction of air and water pollution;

(iv) expansion of vegetative cover and improvement of local bioclimatic conditions; and, finally,

(v) greater biodiversity in the region.

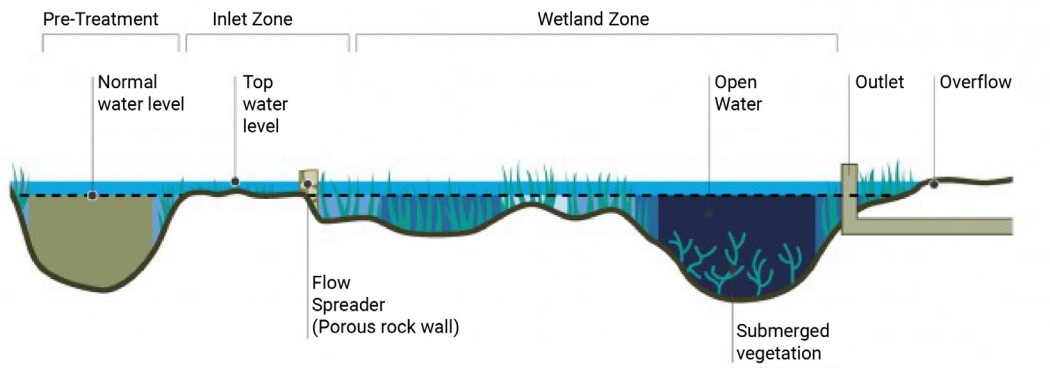

FIGURE 14 – Operating principle of an urban wetland.
SOURCE: Adapted from Urban Green-blue grids (2021).

5.2.3. Nonstructural risk interventions

The construction of the adaptation process for the São José neighborhood also includes the implementation of nonstructural interventions that promote the resilience of the population before, during or after meteorological events, thus reducing local social, economic and environmental losses. In this regard, preventive actions and measures are necessary, such as:

(i) territorial planning considering different timeframes (short, medium, and long term);

(ii) monitoring of the geomorphological conditions of the area;

(iii) alert systems and evacuation plans; and, finally, threading all these discussions together,

(iv) environmental education, through the establishment of a Community Civil Defense Center (NUDEC - *Núcleo Comunitário de Defesa Civil*), where, for example, community participation in risk planning and environmental preservation is encouraged.

These policies can be readjusted over time as new local environmental and demographic dynamics are observed.

5.3. Cooperation

5.3.1. Structuring of the community association

The availability of large, multifunctional space enables to diversify the activities promoted by the "Unified Association of Residents of São José Neighborhood," encouraging the strengthening of community ties through the promotion of meetings and democratic discussions, and through links with other civil society actors. In addition, active community groups enable the development of independent projects, such as locally developed alternative systems for sustainable natural resource management, creative economy, and training courses, creating new income-generating opportunities and job prospects for the community. For the symbolic and integrative effect, priority should be given to its placement in the central space of the community.

5.3.2. Support for local initiatives

To create a network of socioeconomic sustainability in the neighborhood, it is important to first recognize and encourage community actors who develop actions in this direction, such as the existing recycling center. Giving prominence to such initiatives and integrating them, for example, into urban waste management processes will help to reduce the negative effects, caused by improper waste disposal, on the environment and the health of the population.

5.4. Habitability

5.4.1. Construction of social housing

With the resettlement of some families, it is necessary to build Housing of Social Interest (HIS), preferably within the community, respecting the social fabric and existing support networks.

Although the SZSI that includes São José extends beyond its perimeter, immediate occupation of the remaining area could contribute to the emergence of new pressure points on the riparian ecosystem. Therefore, immediate occupation should be avoided in the short term. On the other hand, strategic points should be designated for this purpose - within the district or its immediate surroundings, where urban voids are noticeable. However, this type of intervention requires a redesign of the current housing typology -characterized by floor plans of 35 to 60 m²—since they do not correspond to, and even compromise, the unique dynamics of each family. Housing can offer degrees of adaptation or expansion of its basic module, as seen in contemporary housing projects. The additional costs of this new typology can be mitigated through the implementation of self-managed collective work systems (i.e., the "Erundina collectives," named after the former mayor of São Paulo) for the construction of housing units that:

(i) allow for the reduction of material waste and construction time
(ii) leverage the existing labor force; and
(iii) reinvest in the local economy.

5.4.2. Housing improvement

Since the project aims to preserve the urban social fabric of the area, strategies to improve the living conditions of the population are indicated. Technical Assistance for Housing of Social Interest (TAHSI), which is guaranteed to low-income families by Law No. 11.888/2008 (Brasil, 2008), should be offered as one service offered to the residents of the community who already live with self-construction. The preservation of the urban fabric should not be confused with the maintenance of inadequate housing, which relegates the population to precarious marginal living conditions. These aspects also show the concern for qualitative interventions—not only quantitative ones—in the Social Interest Housing (SIH) policy.

5.4.3. Definition of public facilities

The lack of public facilities in the neighborhood and its surroundings hinders the dynamics of the neighborhoods, mainly because it is necessary to commute to access certain services, such as high schools. Thus, the potential of the nearby vacant areas (e.g., the municipal lands in the Brisamar neighborhood) can be exploited for the creation of new facilities, prioritizing the following axes:

(i) educational, such as day-care centers and full-time schools, which aim to meet the demand for places;
(ii) recreational, such as squares and parks, which provide moments of socialization and contact with the environment;
(iii) cultural and sports, such as libraries, theaters, and multipurpose sports centers, which use their activities as tools for social cohesion and physical and mental development; and finally
(iv) community-oriented, through structures that aim to meet the new social and logistical demands proposed for the neighborhood, such as community centers, public markets, and areas designated for holding open-air markets. Considering the

unavailability of urban voids for the construction of urban facilities within the community, existing plots can be optimized through qualitative interventions.

5.4.4. Expansion of urban infrastructure

Access to basic infrastructure for water, sanitation, and waste collection is essential to mitigate existing vulnerabilities. The extension of these public services can take place in parallel with the rehabilitation of the neighborhood's road system. Regarding solid waste management, strategic collection points can be established for buildings located on impassable roads, and recycling cooperatives operating in the area could be encouraged.

5.5. Mobility

5.5.1. Improvement of the existing road system

The requalification of the district's street layout focuses on redesigning the street profile to support active displacement: accessibility of the sidewalks, greening of the streets, and covered and safe passages over the river and the hillside are the main strategies. More specifically, the intervention would require:

(i) the recovery of spaces intended for sidewalks;

(ii) the use of materials within a sustainable logic, such as permeable pavements;

(iii) the incorporation of green and blue infrastructures, such as bioswales, which promote the microdrainage of rainwater;

(iv) the consolidation or restructuring of existing elements that overcome geographical accidents, such as ramps, stairs, and bridges; and

(v) the extension of the coverage of basic urban water and sanitation services, since they are underground infrastructures.

5.5.2. Definition of new accesses

The exploration of new points of articulation with the neighboring districts allows for integration with existing and planned urban facilities as well as improving residents' access to public transportation lines. Therefore, the definition of new access to the neighborhood is essential, based on alternative structures that promote active mobility, especially for children and older people. Thus, there is speculation about the construction of:

(i) elevators at specific points in the neighborhood, which should have good connections to public spaces (squares and streets) and have an independent structure to avoid significant stress on the slope; and

(ii) covered bridges over the Jaguaribe River, avoiding the use of grates on the ground—which can cause accidents—and exploring options other than concrete (e.g. wood and steel).

6. Conclusions

The need to prioritize adaptation measures in urban planning in the face of extreme climate

events is becoming increasingly urgent. Although the effects are felt throughout the city, it is in areas of greater social vulnerability that the severity of the impacts requires greater efforts to develop adaptation measures. This is because the distribution of urban environmental problems follows the logic of the unequal reproduction of urban space.

Therefore, the present article, through the methodological approach adopted, contributes to the debate with the construction of a proposal for the climate adaptation process of the São José neighborhood—the largest precarious settlement of João Pessoa—with emphasis on serving communities vulnerable to the adverse effects of climate change, such as increased frequency and intensity of geohydrometeorological events.

The idea that the recovery of the ecological structure is a long-term programmatic demand that should be observed in the region is well established. This aspect derives from the real need to create buffer infrastructures (green and blue) compatible with the alteration of hydrometeorological dynamics caused by climate change. However, as observed here, about 47% of the features in the study area are classified as "residual," which does not make them "suitable for removal." On the contrary, it warns that traditional and rigorous interventionist attitudes would cause significant ruptures in the social fabric, with immeasurable negative consequences. An ethical debate is necessary, as we question the sustainability and coherence of actions to remove populations from consolidated urban areas, which contribute to the perpetuation of the hygienist discourse, supported by a hegemonic view of urban planning.

Therefore, criteria have been defined to identify priority areas for redevelopment, to carefully plan the neighborhood's adaptation to climate change. This involves the incorporation of no-regret measures that favor the availability of housing, public urban amenities, and, above all, an ecologically balanced environment. The proposed set of guidelines represents a truly sustainable potential, allowing for social development, but not at the expense of the rich local biological and cultural diversity, which has been gradually "hijacked" by the dubious interests of large corporations and political groups in other areas of the city.

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