

The adequacy of urban planning policies in Brazilian cities in response to the effects of climate change

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Abstract. Since the enactment of the City Statute in 2001, urban planning in Brazil has stood out in municipalities as a promising mechanism for regulating land use and city expansion through Master Plans (PDM) and Sectoral Plans (Habitation, Mobility, Environment, Waste Management, etc). However, as the climate crisis deepens, more episodes of environmental disasters and catastrophes occur in the country, causing urban relationships to change drastically and requiring specific guidelines on climate change tailored to each city. This article aims to analyze how Municipal Master Plans have addressed this issue and the type of approach chosen by city governments, as well as to determine whether low-impact planning is predicted in the respective legislations. For this purpose, the plans of twelve Brazilian cities were selected for evaluation, divided into two groups: the six capitals of the most populous states, according to IBGE data (2022), and the six cities with the highest *Municipal Climate Vulnerability Index* (IVCM, 2023) that have a PDM, along with other notable examples. Based on the analysis of both socioeconomic and environmental data, public planning documents (Master Plans) and public budgetary documents (LOA), It was found that most Brazilian cities that suffer the most from the climate crisis lack sufficient preparation to confront, adapt, and mitigate the effects of climate change. At the same time, the few municipalities whose master plans address territorial planning in a systemic, integrated, and ambitious way fall short in allocating the necessary budget for these proposals to become practical actions, addressing the adaptation of cities to climate change with the robustness the topic requires.

Keywords. Urban Public Policies, Socio-environmental Vulnerability, Low-Impact Planning, Climate Change.

1. Introduction

The Brazilian urbanization process, which intensified with the significant rural exodus of the 1960s, brought to the cities the phenomenon of Urban Macrocephaly [1], in which urban areas experienced intense and rapid changes due to the population explosion, causing urban fabrics to grow in a disorganized, unequal and uncontrolled manner [2]. This growth transformed the country's reality and the way in which governments led and planned the development of municipalities. As a result, urban planning frameworks that were once successful became insufficient to meet the population's demands, leading to the development of new city planning strategies from 1970 onwards [2].

At the same time, the effects of industrialization became evident by science due to the expansion of globalization and the discovery of the significant

increasing in greenhouse gas (GHG) emissions into the atmosphere [3], categorizing the Climate Change. Since then, global multilateral organizations have been working to develop ways to mitigate or counter these effects, starting with the 1972 Stockholm Protocol and continuing with the annual COPs (*UN Conventions on Climate Change*). Notably, COP 21 in 2015 produced the ambitious 2030 Agenda for Sustainable Development, a plan of action containing 17 goals and 169 targets across various integrated and indivisible areas, balancing the three dimensions of sustainable development: economic, social, and environmental. The agenda, through Goal 11, also addresses city planning [4].

In Brazil, the City Statute of 2001 [5] provided a legal framework that regulated the use of various instruments for municipalities to anticipate and control urban expansion, primarily through Master Plans and Sectoral Plans, such as popular housing,

mobility, and the environment. With COP 21 and the worsening of the climate crisis, it was determined that the 2030 Agenda should be included among the guiding principles of these planning instruments [6].

In this context, cities play a central role both as contributors to global warming and as the ones most affected by it [7], with 84,6% of Brazil's population living in urban areas [8]. Therefore, the increasing exposure to the occurrence and intensity of environmental disasters in municipalities, along with social vulnerability and urbanization patterns, presents a challenge for urban planning [9]. This article aims to analyze how the municipal administrations of Brazil's major cities, in terms of population and vulnerability, address the issue in their most recent planning instruments, comparing them and seeking to understand the direction Brazilian cities are taking in confronting and mitigating the effects of climate change in their urban areas.

2. Methodology

Brazil's strategy for addressing the climate crisis was institutionalized through the *National Climate Change Plan* of 2009 [10], which encouraged the development and improvement of mitigation actions in Brazil, as well as aimed to create domestic conditions to deal with environmental impacts. The plan is updated every four years and is structured around the following pillars: mitigation opportunities; impacts, vulnerabilities and adaptation; research and development; and education, training, and communication [11].

In 2023, an inter-ministerial *Committee on Climate Change* (CIM) was established by the Ministry of Civil House and Ministry of Environment of the Federal Government of Brazil to monitor the implementation of actions and public policies related to the Plan, as well as to coordinate and define action lines concerning objectives, guidelines, and instruments for states and municipalities. Thus, the creation of a working group was decreed to develop the *Climate Plan 2024-2035*, together with the Ministry of Cities, based on the pre-defined sections of the National Strategies for Mitigation and Adaptation of urban areas [12].

In August 2024, the Ministry of Cities announced a public call for citizen participation in the development of the *Climate Plan 2024-2035*, emphasizing priority regions and locations for strengthening mitigation and adaptation actions. According to data from the Ministry of the Environment, there are currently 1,942 Brazilian cities at high risk of environmental disasters due to climate change, out of a total of 5,570, representing about 8.9 million people, or 4.5% of the country's population [13].

Thus, the internal approaches of Municipal Master Plans to urban area planning in response to climate change will be analyzed, alongside a socioeconomic diagnosis. Additionally, another area of evaluation

will be the institutional and budgetary capacity of the municipalities, based on the publicly available documents that outline the financial allocation of municipal taxes among the agencies responsible for the topic, namely, the versions of the last biennium (2023 and 2024) of the Annual Budget Law (LOA) of each municipality, as made publicly available.

For this purpose, twelve municipalities were selected, divided into two groups of interest, as detailed below.

2.1 First Group of Research

Although this list of cities is not yet publicly available, one of the indicators used by the Federal Agency was the *IVCM - Municipal Climate Vulnerability Index* [14], a measure used in the development of this research. Figure 1 shows the vulnerability of Brazilian municipalities. Based on the analysis of IVCM data, cities with the highest vulnerability were selected, considering the average across the following urban risk factors: floods, flash floods, and waterlogging; landslides; extreme temperatures; air quality; and incidence of diseases related to climate change.

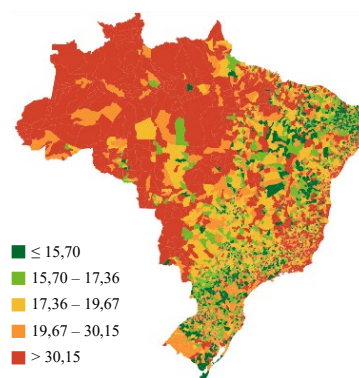


Fig. 1 – Municipalities in Brazil per IVCM: landslides.

From the results, only the six municipalities with more than 20,000 inhabitants that have an active Master Plan (PDM) were filtered, arriving at the final list of cities to be analyzed, as shown in Table 1.

Table 1 – Municipalities with the highest IVCM and a Master Plan (PDM).

City	State	Inhabitants	PDM
Macapá	AP	442.933	2004
S. Félix do Xingu	PA	132.138	2023
S. P. de Olivença	AM	40.073	2010
Atalaia do Norte	AM	20.398	2008
Paragominas	PA	105.550	2023
Petrópolis	RJ	278.881	2014

It is important to highlight that, among the 30 most vulnerable cities according to the ranking for urban environmental disasters, only ten have more than 20,000 inhabitants, and of these, eight have an active PDM. The municipalities selected for this article are listed in descending order of IVCM.

2.2 Second Group of Research

Simultaneously, another model for classifying cities to categorize their climate actions should also be implemented in order to expand the scope of the analysis. Here, the grouping methodology was based on the selection of urban areas where population concentration has been growing exponentially, meaning where more inhabitants are suffering the consequences of environmental impacts.

States in Brazil play a central role in formulating guidelines, planning, and budget transfers to municipalities, being the federative entity responsible for coordinating plans and urban planning instruments in localities where the physical city has surpassed the limits of the legal city, forming the Metropolitan Regions and the Urban Agglomerations [15].

Therefore, the capitals of the most populous states were selected for analysis, as shown in Table 2, while the "inhabitants" column shows the corresponding population of the respective municipalities.

Table 2 – Capitals of the most populous states.

City	State	Inhabitants	PDM
São Paulo	SP	11.451.245	2014
Belo Horizonte	MG	2.416.339	2019
Rio de Janeiro	RJ	6.729.894	2023
Salvador	BA	2.568.928	2016
Curitiba	PR	1.829.225	2015
Porto Alegre	RS	1.332.570	2010

3. Cities' Regional Context

To understand how the territorial planning of the selected municipalities operates, we begin with a brief environmental and socioeconomic analysis of their regions. The cities in the first group share the characteristic of belonging to the Northern region of the country, which, with the exception of Petrópolis, has a complete vegetation cover of the Amazon biome. The dense forest combined with the large number of rivers in the region, makes these cities almost entirely isolated from each other by land [16], with mobility often occurring through waterways. In this context, urban planning focuses on addressing the direct consequences of forest fires and deforestation on the urban population.

According to the 2022 Census by the *Brazilian Institute of Geography and Statistics* (IBGE), the states of Amapá (AP), Amazonas (AM), and Pará (PA) have *Human Development Index* (HDI) scores of 0.694, 0.677, and 0.646, placing them in the region with the lowest access to healthcare, education, and income, and below the Brazilian average of 0.760. In terms of the municipalities, it is important to highlight that the city ranked first in urban climate vulnerability is a capital, Macapá, with an HDI of 0.733, which is

considered high for the region and its state. Meanwhile, the socioeconomic analysis of other cities in the first group is concerning, with indices ranging from 0.450 (Atalaia do Norte) to just 0.645 (Paragominas). Once again, the only exception is Petrópolis, due to its imperial history and proximity to wealthy regions such as Rio de Janeiro and São Paulo, which provide it with a high HDI of 0.745 [17].

The municipalities in the second group, along with Petrópolis, are all located in the Atlantic Forest biome, the most devastated one in the country, which now retains only 12% of its original vegetation cover [18]. This is a direct result of the uncontrolled population and urban growth along the northeastern, southern, and especially southeastern Brazilian coast, which is home to some of the most populous cities in the country.

Socioeconomically, these municipalities are characterized by their regions having high HDI scores. With the exception of Salvador, all other capitals have indices ranging from 0.800 (Rio de Janeiro) to 0.824 (Curitiba), with most cities in their respective states following this trend. In the case of the Bahian capital, its score of 0.759 is considered high compared to the state average, which hovers around 0.660, the sixth worst in the country [17].

3.1 Urban Planning Analysis

As previously clarified, the Master Plan is the main urban planning instrument for Brazilian municipalities, and it is mandatory for cities with more than 20,000 inhabitants in consolidated urban areas. The City Statute mandates a 10-year review cycle to ensure updated diagnoses and guidelines [5], with federal funding contingent on the topic.

Upon investigating how urban planning incorporates climate adaptation and mitigation for Group 1 cities in this study, various discrepancies emerge. Macapá [19], Atalaia do Norte [20], and São Paulo de Olivença [21], with outdated plans from 2004, 2008, and 2010, respectively, have generic, limited and superficial guidelines in their PDMs, treating the environmental-urban relations in indirect and transversal ways.

In this context, the Master Plans of São Félix do Xingu [22] and Paragominas [23], both enacted in 2023, contain innovative, integrated, detailed, and proactive guidelines on the subject. They align federal and international regulations with the concept of climate resilience, promoting low-impact planning and sustainable practices, such as agroforestry, urban green corridors, climate contingency plans, and resilient infrastructure.

These municipalities play a crucial role in the national strategy for mitigating and adapting to climate change, as they contain vast areas of native forests vulnerable to wildfires and deforestation, which directly affect the local microclimate as well as states in southern, southeastern, and central-western Brazil. A notable example is the dense smoke corridor caused by fires in Amazonian

municipalities, which extended across ten states, resulting in the worst air quality in the world in capitals like São Paulo and Belo Horizonte in August and September 2024 [24].

Among the municipalities analyzed in Group 1, their planning converges on guidelines related to Permanent Preservation Areas (APPs) and Ecological-Economic Zoning (ZEE), both urban tools established by the National Environmental Policy (PNMA) of 2002, updated in 2012 and 2023. The exception is the city of Macapá, which, despite having its Master Plan approved two years after the PNMA's enactment, does not include any reference to these strategies, mainly due to the topic of climate change and sustainable environmental management not being a central theme in Brazilian discussions at the time, reflecting the context of the year 2004.

The ZEEs are a variation of urban zoning aimed at supporting the formulation of public policies in alignment with strategic sustainable development guidelines, by creating organized information bases for territorial management. Meanwhile, APPs are designed to preserve forest, vegetation, and water resources, which may or may not be threatened by urban expansion [25].

The second research group comprises mostly of Master Plans updated within the last ten years, except for Porto Alegre. The PDM of São Paulo [26], from 2014, offers an integrated, systemic, and ambitious approach by addressing climate change in almost all its thematic sections and subsections. It focuses on urban resilience by developing sustainable mobility strategies, land use densification, environmental monitoring, and energy decentralization. Promulgated in the same year as Agenda 2030, the Plan incorporated sustainable development goals, establishing interdisciplinary measures for climate mitigation and adaptation.

The São Paulo Plan became a reference for other Brazilian capitals, which updated their legislation accordingly, as seen in Salvador's Master Plan [27]. Concerns about rising temperatures, sea levels, and deforestation led to innovations in addressing climate change, with a focus on concepts such as: sustainable technologies, coastal resilience, urban redevelopment in degraded areas, preservation and expansion of permeable urban zones, and the incorporation of Ecological-Economic Zoning (ZEE).

Thus, the urban plans of Belo Horizonte [28] and Curitiba [29], whose main guidelines are similar to each other, are considerably less ambitious and more conservative in relation to the proposed goals and projects for climate adaptation. The Curitiba Master Plan, moreover, lacks originality in its proposals, especially when compared to the city's notable history in urban planning and environmental themes.

Still in the Southeast region, the most populous in the country, the PDMs of Rio de Janeiro [30] and Petrópolis [31], despite being placed in different

groups in this article and differing significantly in area and population, share evident similarities regarding their limited and superficial approach to environmental issues. The 2022 landslides in Petrópolis, which left 178 dead, and the extreme temperature records and sea level rise in Rio's capital in 2023 [32] demonstrate how these plans failed to develop strategies to address these challenges.

The same issue occurs with the Master Plan for Urban and Environmental Development of Porto Alegre [33], which addresses environmental themes in a broad and generic manner, with outdated strategies for the capital and its concerning history of flooding. The lack of adequate planning and execution is one of the many possible causes for the cities' lack of adaptation, culminating in 2024 with heavy rains and floods that affected about 2.4 million people throughout the state of Rio Grande do Sul [34].

3.2 Budgetary and Institutional Analysis

One of the major issues with urban planning relates to the executability of the proposals and guidelines set forth in the plans [35]. Therefore, it is common for the Action and Investment Plan (PAI) to be one of the final products of Urban Master Plans (PDMs), which must forecast the budget for the coming years and allocate it across municipal public administration departments. However, it is up to the authorities, through the approval of the Annual Budget Law (LOA), to allocate the resources, which may vary based on the political interests of mayors and council members. We thus analyzed the environmental and urban institutional structure and its allocations over the past three years, comparing the progress in implementing the municipalities' plans.

It should be noted that adaptation and mitigation actions carried out within the scope of Infrastructure and Works were not considered in the analysis, due to urbanism being intrinsically related to the legalization and approval of constructions as specified by the Master Plan. The numbers presented here are the result of the proportional relationship between the budget allocated to each department and the total amount available for the municipality in the given year, according to data from the respective Annual Budget Laws.

Of the twelve cities researched, ten have both municipal Environment and Urbanism secretariats, though their names vary. Atalaia do Norte and Petrópolis, from group one, do not have specific urban planning departments, which is reflected in their urban development. From 2022 to 2024, according to data from their respective Annual Budget Laws (LOAs), seven of the twelve municipalities significantly reduced their investments in urban adaptation and improvement, as shown in Table 3. These cities are Macapá, São Paulo de Olivença, Paragominas, São Paulo, Belo Horizonte, Curitiba, and Porto Alegre.

Table 3 – Annual budget for each of the Municipal Secretary of Urbanism or similar (in %).

City	2022	2023	2024
Macapá	14,77	9,98	6,69
S. Félix do Xingu	5,93	10,41	10,90
S. P. de Olivença	3,90	4,19	2,38
Atalaia do Norte	-	-	-
Paragominas	6,06	5,19	5,44
Petrópolis	-	-	-
São Paulo	0,79	0,72	0,74
Belo Horizonte	0,88	0,97	0,96
Rio de Janeiro	0,10	0,13	0,22
Salvador	1,09	1,26	1,11
Curitiba	0,42	0,41	0,42
Porto Alegre	1,11	0,95	1,01

Regarding direct actions to confront the climate crisis, the core objective of the Municipal Environment Secretariats, only the cities of São Paulo de Olivença, São Paulo, Rio de Janeiro, and Porto Alegre reduced their environmental budget allocations, as shown in Table 4, potentially exacerbating the impact of climate change on their territories. A notable example is Petrópolis, which increased its environmental budget by 1,200% from 2022 to 2023. This spike followed the February 2022 environmental disaster, where heavy rains caused landslides [32], drastically reshaping the city's landscape, characterized by steep slopes and hills prone to such catastrophes. Both budgetary data of urbanism and environment themes were reduced by the governments of São Paulo de Olivença, São Paulo and Porto Alegre.

Table 4 – Annual budget for each of the Municipal Secretary of Environment or similar (in %).

City	2022	2023	2024
Macapá	0,33	0,43	0,56
S. Félix do Xingu	3,19	2,48	3,45
S. P. de Olivença	0,11	0,11	0,07
Atalaia do Norte	1,25	1,78	1,62
Paragominas	0,67	1,70	0,69
Petrópolis	0,01	0,12	0,10
São Paulo	0,53	0,51	0,45
Belo Horizonte	0,18	0,18	0,26
Rio de Janeiro	0,79	0,32	0,36
Salvador	0,64	0,91	0,81
Curitiba	5,17	5,05	5,36
Porto Alegre	0,69	0,53	0,47

4. Conclusion

The presented study is based on the contemporary urban thematic approach, focusing on adaptations to confront the effects of climate change. In addition to hosting the majority of the global population, cities are the most vulnerable to disasters and humanitarian crises resulting from the environmental crisis.

In conclusion, it was understood that in Brazil, the main legal instruments of urban planning for both the most vulnerable and the most populous cities bring a predominantly mild, superficial, and transversal focus on the issue. Meanwhile, the budgetary plans of these municipalities show little to no importance in allocating resources for city preparedness, despite various Federal Government guidelines, along with states, aimed at regulating adaptation and mitigation actions, such as the National Plan on Climate Change (PNMC).

Some municipalities in the survey presented strategic, integrated, and ambitious proposals in their Master Plans. However, when the budget allocated to these actions was examined, it became evident that the implementation is deliberately flawed by public officials. Nevertheless, a successful example is São Félix do Xingu, where both the Master Plan (PDM) and the latest Annual Budget Laws (LOAs) work together to improve the urban and environmental conditions of the municipality.

Finally, it is notable that the understanding by all citizens of how our cities are conceived and managed in their planning is of utmost importance. These assessments bring the possibility of change, which is both necessary and immediate to address the concerns of our historical and environmental time.

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