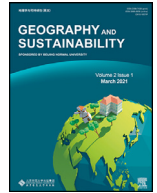


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Extreme rain event highlights the lack of governance to face climate change in the Southeastern coast of Brazil

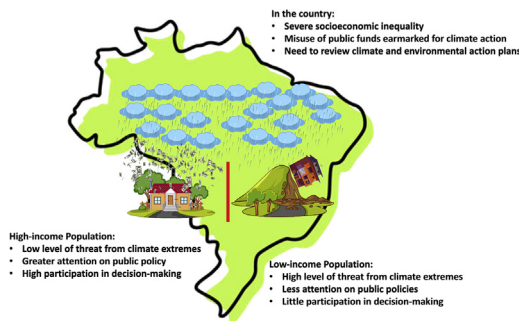
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HIGHLIGHTS

- During February 2023, the southeast region of Brazil registered an extreme rain event.
- Extreme weather event threatened the poorest population in Brazil.
- Funds earmarked for disasters induced by natural hazards have been underused.
- Brazil needs to rethink the financial governance to face the challenges of climate change.

GRAPHICAL ABSTRACT



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ABSTRACT

New rainfall records were registered in the southeastern region of Brazil during February 2023. The amount of rain in the north coast region of the State of São Paulo was more than 650 mm in less than two days. Landslides and tragedies with a socioeconomically vulnerable population marked this climatic extreme. The country has a regulatory system that suggests the elaboration and implementation of municipal public policies aimed at territorial organization, environmental conservation, and the prevention of disasters induced by natural hazards. In addition, both federal and state funds earmarked for such hazard's prevention have been underutilized over the last decade. In addition to this current devastating climate episode, other events were registered in this decade, reinforcing that financial governance is a key challenge to face the climate crisis in Brazil. The predicted future extreme events in different regions of Brazil will require a different governance system to minimize social inequality, seek sustainable alternatives for urban environments and manage to adapt cities for the challenges posed by climate change.

1. Introduction

In recent decades, several extreme weather events have devastated cities in the global north and south, with severe heat waves and storms that impact both urban landscapes and people's lives. According to the World Meteorological Organization (WMO), the month of July 2023 was the hottest ever recorded, with an average air temperature of 0.72 °C above the mean observed between 1991 and 2020, and 0.33 °C warmer than July 2019, the second hottest month in the organization's records so far (Copernicus, 2022). Likewise, storms have affected topographically critical regions with greater chance of landslides. An inventory

carried out after a month of an extreme rainfall event in central Italy recorded 1,687 landslides in an area of 550 km² (Santangelo et al., 2023).

Such extreme rain episodes have caused tragedies in several cities around the world. In July 2021, the western region of Europe suffered severe floods that resulted in the death of 200 victims, in addition to extensive damage to the infrastructure network. Events of this magnitude would be expected at every 400 years, but anthropogenic contributions to climate change have already increased their intensity and frequency, according to recent climate models (Tradowsky et al., 2023). Similarly, a study over 40 years in the middle Yangtze River region, China (1980–2020), revealed that the frequency, intensity, and duration of all com-

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posite events increased significantly at the beginning of this century (Tao et al., 2023).

In Southeast Brazil, the summer months (from December to February) are typically marked by high amounts of rain. However, February 2023 was marked by tragedies and disasters induced by natural hazards in São Paulo. The north coastal region of the State registered a rainfall record exceeding 650 mm in less than 48 h. The historical average value for the month of February in the region was nearly 250 mm (INPE, 2021). Coastal cities of São Paulo have high importance for tourism and thus for economic activities. São Paulo is the richest state in Brazil and presents the highest GDP in Latin America.

In the last decade, Brazil registered rainfall records in three of the four state capitals that compose the southeast region. Such extreme events caused landslides and led to the death of thousands of people who lived in economic and housing vulnerable situation, in addition to the loss of their supplies (Marengo et al., 2023). Although the situation is critical, little has been done regarding public actions and transformation of this situation.

Several contemporary problems have been aggravated during the last years. Recently, a new international policy has prioritized the climate policy in Brazil and put it on the discussion table. In less than a year in office, the new president of Brazil has already spoken to heads of different Asian, European, and North American States, and highlighted the need for developed countries to actively participate in the climate commitment that afflicts countries with poorer economies.

2. Socioeconomic inequality and environmental injustice

Some cities in the global South that experienced rapid urban and demographic growth in the last decades have high socioeconomic inequality. On the one hand, there is a small social group that benefits from the rapid and unrestrained economic development at the expense of the other large social group, which is normally socio-spatially excluded and occupies irregular areas for the construction of houses and slums. Such areas are normally vulnerable to flooding, landslides and/or under high epidemiological risks, i.e., public health problems associated to landfills (Domingo et al., 2017; Wanderley et al., 2017).

The coast of the State of São Paulo (Brazil) embraces cities with high touristic potential, and the north coast is usually the preferred destination of the elite from the State capital due to lower demographic rates, safe and beautiful beaches. In the last 20 years there has been an explosion of mansions and high standard houses built near the sea, expanding the urban fabric hitherto occupied by traditional communities of fishermen and artisans. Such urban occupation and the lack of popular housing complexes generated social exclusion, leading the poorest population to inhabit hills and areas of geological risk. In addition, the region attracted new low-income workers looking for indirect job opportunities in the summer season, which basically drives the local economy.

Since 1980s, Brazilian urban areas have tripled in size, with a significant increase in irregular areas, which totaled 106 thousand hectares in all national territory. Proportional to such urban growth, occupation in risk areas increased three times in the same period (MapBiomas, 2022). However, public funds and urban infrastructure mechanisms have been spent mainly in the noblest parts of these cities. This has increased their touristic vocation, especially with summer concerts and festivals on the beaches and serving the richer population that sporadically visits the coastal region. This scenario has neglected basic care in aspects such as housing, sanitation, and health. Such disregard in poor regions opens the way for a parallel market of invaded lands that expands the urban areas towards environmentally inappropriate and crowded places. There is an association between demography and public investment which has been historically unfair and favors the economic elite of the State of São Paulo. Local communities predominantly composed by fisherman suffer from the lack of adequate urban planning and investment in infrastructure (Fig. 1).

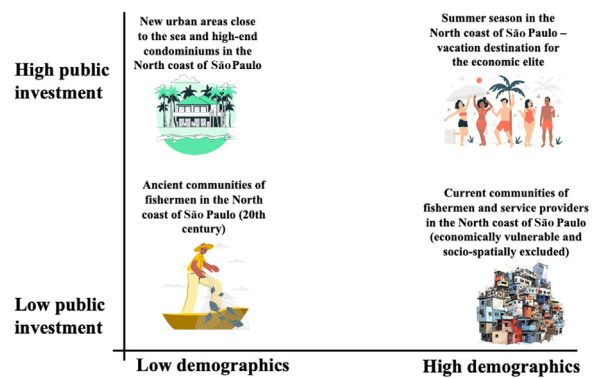


Fig. 1. Illustrated diagram showing the contrasts between demography and public investment in the north coast of São Paulo, Brazil.

3. Negligence in the implementation of environmental public policies

This Brazilian region is immersed in the Atlantic Forest biome, which geomorphology is dominated by steep hills in the coast. The phyto-physiognomies are marked by low soil stability and constant landslides, undoubtedly characterized by low agricultural and urban aptitude and important ecosystem processes (Souza-Neto et al., 2017). In addition, the coastal region of the State of São Paulo is home to high biodiversity and comprises the largest preserved corridor of the Atlantic Forest, linking forest patches that extend from the State of Rio de Janeiro to the State of Parana through Serra do Mar State Park, a biodiversity hotspot (Myers et al., 2000; Lima et al., 2020).

Given the importance of the biome for maintaining biodiversity, climate regulation and carbon stocks, since 2006 the Federal Law of the Atlantic Forest (Law No. 11.428/06) has come into effect with the purpose of protecting the remaining 12% of its original formation (Lima et al., 2020). This federal law recommends that cities must prepare the Municipal Plan for the Atlantic Forest (MPAF), since the control of deforestation and land use change occurs on a local scale. This plan has been as a fundamental principle for the municipal cartography for land tenure regularization, selection of priority areas for conservation and territorial planning. All municipalities immersed into the Atlantic Forest must elaborate this legal instrument, however, out of the 3,429 municipalities included in the biome, only less than 10% have developed this policy yet.

Paradoxically, contrary to the international agreements signed by Brazil in terms of zero deforestation, mitigation and adaptation policies to climate change during previous administration were proposed as provisional measures (No. 1150/2022) to change article 14 of the Atlantic Forest Law. This change would allow deforestation of primary and secondary vegetation in an advanced stage of regeneration. This does not require a technical opinion from a state environmental agency for deforestation, imposing a greater risk of change in land use to expand the gray infrastructure of cities, enabling future uses and disorderly occupations, since inspection is one of the greatest urban challenges in Brazil.

One of the main contributors to this scenario is the lack of an adequate governance system in a local scale, with popular and different actors' participation in decisions on urban planning and forest protection, added to the lack of specialized human resources in the municipal secretariats. This shows a fragile political structure shaping human-wildlife interaction on urban frontiers (Fletcher and Toncheva, 2021). At a municipal scale, where problems really happen, environmental and civil defense secretariats operate with a minimum number of employees and usually without sufficient technology to face risk situations.

In addition, there is a lack of policies for adapting cities to climate change and managing risks at municipal level, even in the richest region of the country. The deficiency in municipal public policies focus-

ing on climate issues and the serious challenges of territorial planning in Brazilian cities reinforce socio-environmental vulnerability and increase socioeconomic contrasts, highlighting the need for a governance system that meets the desires and needs of the poorest population to face future extreme climate scenarios.

However, although the focus of the present discussion is the extreme event of February 2023, it is important to stress that the relationship between these events and socio-environmental problems that affect the poorest population in Brazil is not a novel issue. During the years of 2014 and 2015 a strong water shortage was recorded in the southeastern region of the country. The Metropolitan Region of São Paulo (MRSP) experienced one of the worst droughts ever recorded in two consecutive years. The lack of urban planning and adequate basic infrastructure to supply water to all population was aggravated by the extreme drought, culminating in a critical scenario of environmental injustice. While some districts with high-income population of the MRSP did not face this water crisis, the poorest population suffered for months a severe daily rationing in water supply (Torres et al., 2020). Even after the end of the crisis, the lack of governance still makes the low-income population vulnerable. They still experience water shortages during the periodic dry seasons, reinforcing inequality and power asymmetries, since the state government and the local water distribution company, which have a mutually beneficial relationship, are basically the only decision-makers involved in this issue (Empinotti et al., 2019; Torres et al., 2020). Another iconic situation was recorded in May 2022, in the coastal city of Recife, northeast Brazil. Approximately 1/3 of the expected rainfall for the entire year fell in just two days. This accumulation caused a tragedy with deaths and severe losses, mainly affecting the poorest population.

Considering that public decisions and policymaking have low popular support, specifically regarding the territorial planning process, Brazilian cities urgently need to strengthen the transformative governance system to face climate change and disasters risk, with high capacity to manage problems and challenges inherent to socioecological systems at various scales (Yang et al., 2021). Critical climate change scenarios marked by extreme episodes reinforce the need to reassess the climate change policy management system, especially in coastal cities, where touristic (economic) and urban issues are very important.

To improve the environmental governance system, strong actions must strengthen the dialogue between public authorities and civil society, among which the guarantee and access of public and popular participation in climate education stands out. These premises were ratified in the Escazú Agreement (Costa Rica), which discussed socio-environmental themes and reinforced the commitment of Brazil's public and formal provision of free information on climate issues (Stec and Jendroška, 2019). Furthermore, the development of adaptation and compensation policies can be a strategy to support environmental governance, since it is necessary to compensate losses and damages (material and immaterial) of individuals and communities affected by extreme climate events (Xiang et al., 2014; Sánchez-García and Francos, 2022), including impacts on culture, housing, and health, especially in territories with more sensitive economies.

4. Misuse of public funds for preventing disasters induced by natural hazards and adapting cities to climate change

It should be noted that even internationally committed to adapt Brazilian cities to climate extremes and to promote mitigation actions at local level, public managers in the State of São Paulo failed to use 38% of the budget allocated to the prevention of disasters induced by natural hazards in the last 12 years. Considering that in Brazil the main responsible entity for financing risk reduction is the federal government, at the country level, the budget invested in this sector has decreased in the last decade. In 2021, the budget invested was 66% less than in 2013. However, there is a light at the end of the tunnel. Recently, the Provisional Measure 1180/23 opened an extraordinary credit of R\$ 280 million to allow emergency assistance to expenses with protection and civil de-

fense actions for states that suffered from the intense rains in the entire territory of Brazil.

Regarding the aforementioned crisis of water scarcity, an analysis of investments in water resources between 2010 and 2015 pointed out that, even with studies predicting climate anomalies for the past decade, there was a regrettable failure of medium and long-term planning by the state government and entities linked to the management of water resources. It is expected that in the current administration of Brazil, financial governance will be focused on conflicts that really affect the poorest, i.e., the supporting actors of this story.

As scholars argue, tackling climate change requires a clear and targeted financial governance system for the problems that threaten the poorest, suitable to the aptitudes of each region, with clear transformational objectives, and science-based decisions, especially in countries of the global South. This is an urgent need to break with a history of inequity, uneven development and to promote resilience and socio-environmental justice (Sarkodie and Strezov, 2019; Di Gregorio et al., 2019; Broto, 2017).

The condition of informal jobs added to the financial seasonality faced by the poorest population of the north coast of São Paulo highlights a critical and sensitive situation that weakens the local economy. This leads countless people to seek unhealthy and risky housing environments, making this representative part of the society more vulnerable. Investment in popular housing, with the creation of special funds and economic assistance to the poorest population could be strategies prioritized in local and regional public management, thus minimizing socioeconomic contrasts and risk of tragedies.

5. Final remarks

Climate change has imposed a series of challenges for cities across the planet. However, territories in the global South face, in addition to the climate crisis, a historical legacy of socioeconomic inequalities. Both challenges culminate in the need for a different governance system, with participation of people from every socio-economic status, in addition to their representatives (e.g., non-governmental organizations) in the public decisions and policy elaboration.

Human tragedies, material and immaterial losses could have been avoided in the climatic extreme occurred in southeastern Brazil (February 2023), whether territorial planning and the implementation of public policies were effective. Funds to be applied in disasters induced by natural hazards and adaptations to climate change have been underutilized in the last decade, which denotes the inefficiency of public management to face extreme events.

A governance system that goes beyond the interests of the State and combines multiple actors into common objectives is needed to confront the climate crisis aiming at socioeconomic equity. This requires (i) including actors from different economic status in the public discussion of the territory, (ii) promoting mass climate education, (iii) promoting integrated and lasting urban planning in different sectors, and (iv) directing more efforts to reduce social differences.

Prioritizing the eradication of poverty through social assistance and equitable distribution of public investments, especially in urban infrastructure, can be a mechanism for economically managing public resources towards socio-environmental transformation.

Moreover, it is necessary to review the regulatory system for environmental planning in cities. Finally, there is an urgent need to promote adequate financial governance to manage the risk of catastrophes induced by natural disasters and to adapt cities to climate scenarios.

6. Next steps

It is noteworthy that, in a systemic way, both the lack of territorial planning and the greater occurrence of extreme weather events can be strong future threats and trigger avoidable tragedies. In this sense, it is suggested that land use policies are implemented and consolidated, not

remaining a solely recommendation. Mechanisms for releasing taxes and federal financing can be linked to these municipal plans, so that their elaboration and implementation can be linked to territorial planning at the city scale. This strategy already happens in some countries and in Brazil it has worked very well for the Municipal Solid Waste Policy, which is a prerequisite for requesting funds from the federal budget.

Also significant is the desirable synergism between the land use policies. It is suggested that future municipal plans for water resources, adaptation to climate change and the MPAF present complementary points in their respective Action Plans. These municipal policies must be developed with greater participation of civil society, non-governmental organisations, academia and the private sector, attending multiple interests.

A next step to be taken would also be the involvement of different sectors and institutional spaces in the urban planning. A likely way for this to happen would be through the improvement in sustainable development plans and lasting climate actions, i.e., longer than five years. This time interval would allow climate actions to be addressed in the territory in a transversal way and in different public departments, thus involving the field of public health, mobility, green jobs and even ecosystem services (Shi et al., 2016; Levin et al., 2022; Li et al., 2022).

Declaration of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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