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ARTICLE

Why do extreme events still kill in the São Paulo Macro Metropolis Region? Chronicle of a death foretold in the global south

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ABSTRACT

This paper contributes to the study of climate change and environmental justice with a particular focus on a Global South case-study in the São Paulo Macro Metropolis of Brazil. We also aim to contribute to mandatory critical dialogue between (anticipatory) governance and environmental justice. This study focuses on the rainy seasons from 2016 to 2019. We examine the incidence of 61 extreme precipitation events, as well as 47 deaths caused by rain events, considering their location based on vulnerability indicators. The correlations among these data allow us to reveal the socio-environmental patterns within the relationships between social vulnerability and deaths caused by general rainfall and, more specifically, extreme events. Based on this, we demonstrate that current infrastructure or its lack is one of the reasons why death tolls remain due to the absence of anticipatory governance.

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KEYWORDS
Macro metropolis; São Paulo; climate change; environmental justice; anticipatory governance

Introduction

The debate on justice and social inequalities related to climate change has intensified throughout the past decade, mainly due to the growing incidence of extreme climate events, as suggested by evidence for global warming published in the latest IPCC report (IPCC 2018). This debate tends to expand, exposing unequal territorial cartographies of those most impacted by these events (Birkland and Waterman 2008; Shi et al. 2016; Anguelovski et al. 2016; Bell et al. 2018; Pelling and Garschagen 2019).

For small oceanic islands that have begun to disappear, underscoring the process of immigration and climate refugees from areas devastated by hurricanes, floods, and droughts has increasingly exposed the reality of the social and environmental inequalities present in the contemporary production of space.

In Brazil, ~85% of natural disasters are related to rainfall or a lack of it. Flash floods, landslides (usually caused by soil saturation), and prolonged droughts produce events that have resulted in more than 10,000 deaths in the last five decades (Pivetta 2016). With climate change, such events tend to increase in frequency and spatial scope. Climate scenarios for 2100 indicate that in the state of São Paulo, either there may be a 10% increase in torrential rainfall or a decrease in total rainfall (Marengo 2007).

In the state of São Paulo, as in other parts of the world, especially in the Global South, tragedies are already a certainty when discussing extreme events. This study aims to address the following question: 'Why do extreme events still kill in the São Paulo Macro Metropolis (SPMM)?' (Figure 1). Macro Metropolis is a specific terminology coined by the São Paulo State Government, based on previous

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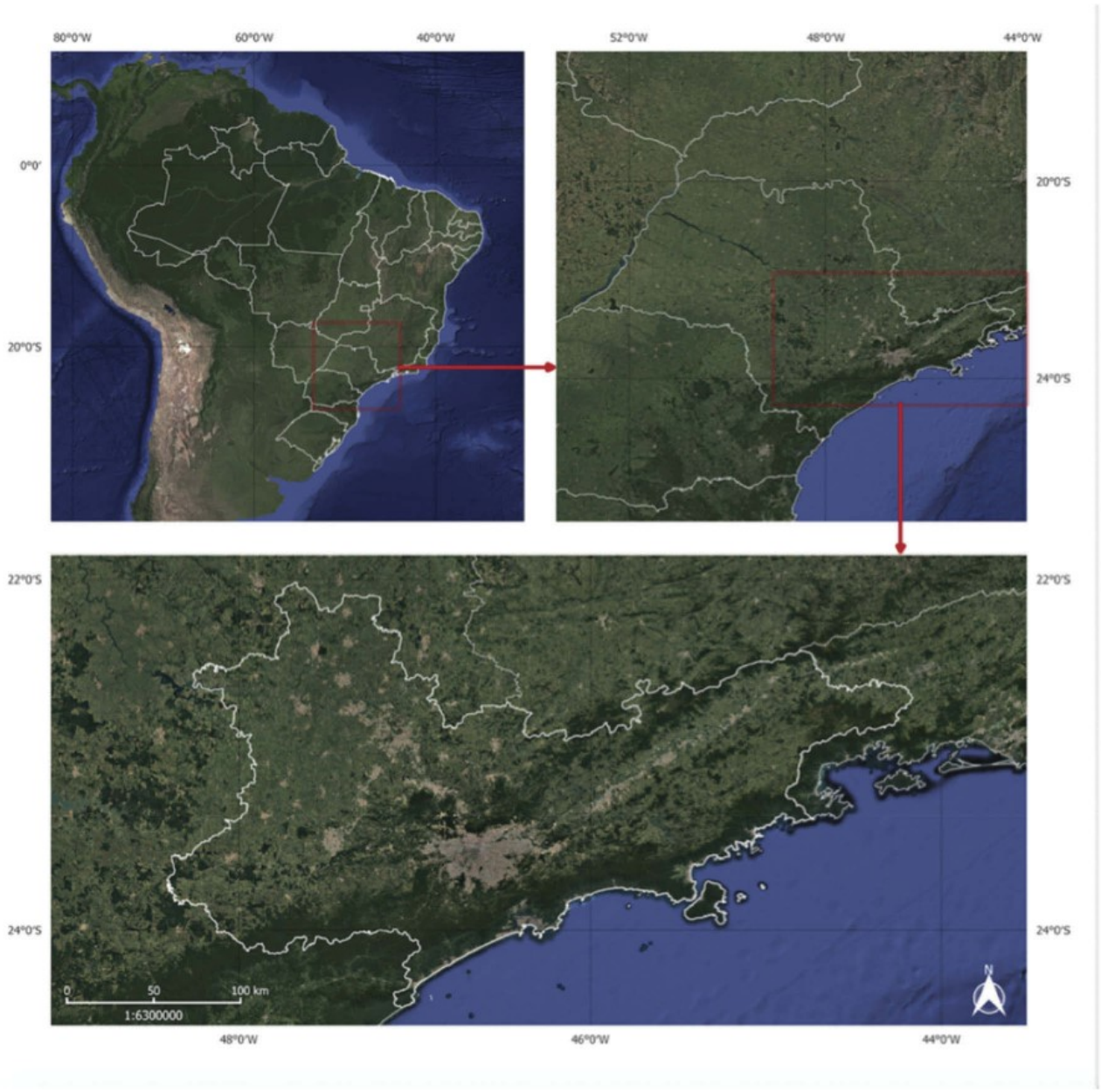

Figure 1. **The location of the São Paulo Macro metropolis (SPMM)** (Source: LaPlan/MacroAmb, 2018).

academic discussions on the expansion of the São Paulo Metropolitan region (Travassos et al. 2020). SPMM is composed of five metropolitan regions (i.e., São Paulo, Campinas, Paraíba Valley and North Coast, Sorocaba, and Santos), two urban agglomerations (i.e., Piracicaba and Jundiaí), as well as the micro-region of Bragança (non-institutionalised). With an estimated 33 million inhabitants and a GDP of nearly 400 million dollars, the SPMM covers 53,000 km^2. Urban areas take up 11,000 km^2 of this area, represented by 174 municipalities that account for nearly 73.9% of the state's total population, 82.5% of the State's Gross Domestic Product (GDP), and 27.3% of the Brazilian GDP (Emplasa 2019).

Although this region holds a significant portion of the country's wealth, the SPMM still exhibits indicators that show the existence of profound environmental and social inequalities (Travassos et al. 2019). These inequalities have a crucial spatial expression, i.e., a reflection of inefficient and unequal public and governance policies, such that rainfall still poses a risk of death for certain parts of the population.

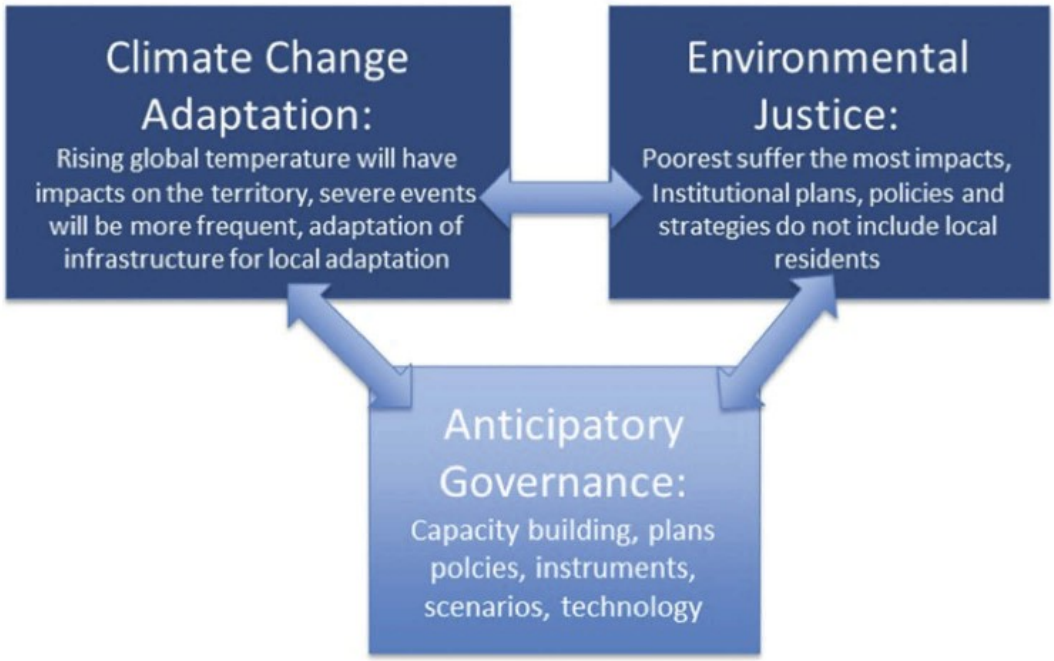

Figure 2. Theoretical Framework.

Officially established, produced, and designed to integrate public policies and joint actions throughout the expanding metropolis territory, different spatial and social realities coexist within the SPMM territory. The three most significant metropolitan areas present a contingent of nearly 3 million people living in precarious housing conditions, many in at-risk areas with poor urban and social infrastructure. Of these inhabitants, 2.1 million live in the Metropolitan Region of São Paulo, 297,000 in the Metropolitan Region of Baixada Santista, and 160,000 in the Metropolitan Region of Campinas (Marques et al. 2013).

From this perspective, this study uses the links among the negative consequences of global warming and marginal groups, as well as how climate change exacerbates existing social inequities. We also, however, perform an imperative analysis on how social inequality interacts (if at all) with policy responses, examining how existing infrastructure or its lack thereof is one of the reasons why there are still deaths related to rainfall. Therefore, we investigate 61 extreme precipitation events and 21 precipitation events, not necessarily extreme but in which deaths occurred, to verify two dimensions: the relationship between extreme events and deaths related to precipitation in SPMM cities and the housing or neighbourhood vulnerability where these deaths have occurred.

With this focus, we seek to contribute to the study of climate change and environmental justice based on a particular Global South case-study and data-driven research. We aim to contribute to the necessary critical dialogue between (anticipatory) governance and environmental justice, i.e., dialogue that is still scarce, except for rare exceptions. For the cases examined in this paper, there is a well-established link between the negative consequences of global warming and marginal groups, thus exacerbating social inequalities. Responses, or rather the lack of answers from the government, an absence of planning, or what we understand of anticipatory governance, all expose how inequality interacts with policy responses.

For cities in the Global South, resistance to advances in climate adaptation measures is profoundly affected by robust regimes and interest groups (Chu et al. 2017), mismatches between the scale of urban issues and extent of local government authority, and lack of inspection (Di Giulio et al. 2019b).

Using rainfall and mortality data, we conduct a series of correlations to attempt to understand the relationship between extreme events and mortality and between mortality and social vulnerability, considering that vulnerability has a specific spatiality in the SPMM, which can be identified by neighbourhood and housing conditions.

Theoretical framework

Assuming that climate inequality shapes climate resilience in a continuous and dialectic process, which reshapes climate inequalities, this study theoretically engages in what Pelling and Garschagen (2019) state as a moral duty for the case of climate adaptation: it must directly meet the needs of the poorest, placing them at the centre of decision-making. In this sense, our study meshes with the dialogues of the contemporary Environmental Justice literature perspective (Mohai et al. 2009; Adger et al. 2013; Schlosberg 2013; Agyeman et al. 2016; Torres et al. 2020a), which includes a new lens of analysis, such as climate justice (Schlosberg and Collins 2014), among other relations in terms of the environmental impacts in territories with marginalised groups.

The first approaches in environmental justice focused primarily on the occurrence of inequalities in environmental exposure as a community, i.e., those who may have more risks than others and how it is related to their social class, which was exposed in Robert D. Bullard's classic 'Dumping in Dixie' (1990). Mohai et al. (2009), however, point out that climate change increases social inequalities in several ways, especially with respect to those who suffers its consequences most severely, indicative of injustice both between nations and within one nation. This inequality overlaps with existing inequalities based on class, gender, ethnicity, and race characteristics. There is also an unequal distribution of the resources that promote easy adaptation. The effects of climate change will then require new practices for adaptation, such that this approach merges environmental justice and governance. In the specific case of spatial adaptation policies, it has to bring environmental justice closer to anticipatory governance, where with planning and the use of science, we can avoid severe impacts on more vulnerable populations.

In our case, there are two central and intertwined issues crucial for the present analysis: 1) the specificity regarding the impacts of climate change and its adaptive capacity in large urban areas of the Global South and 2) the current means of understanding and reacting to this issue requires a disruption to ongoing planning and governance paradigms, breaking with the 'business as usual' status quo towards anticipatory governance or new planning paths (Quay 2010; Momm et al. 2017).

Thus, a new concept of governance emerges, i.e., anticipatory governance, which is used as a scenario planning tool (concerning future predictions arising from climate change) for adaptive management (Quay 2010, 2015; Gober 2014; White et al. 2015; Vervoort and Gupta 2018; Pickering 2019). However, this concept only maintains a small presence in the literature, which renders the concept's use to a limited scope (Boyd et al. 2015) and scale (Vij et al. 2017), such that this a challenge that, as we understand it, can only be overcome with more empirical research.

Anticipatory governance has its roots in scenario planning and adaptive management (Quay 2010). This concept represents a governance structure in which planning and decision-making may be able to overcome the obstacles of traditional physical planning for climate change. Anticipatory governance consists of three necessary steps (Quay 2010, p. 498): anticipating and analysing futures (taking into account a range of possible scenarios); creating flexible adaptation strategies, including monitoring and action; and constant monitoring and response to change (Quay 2010, p. 499). In the context of the Global South, there is still a highly fragile institutional agenda linked to prevention. In general, measures have been post-disaster, but also the recall of backwardness in investments to prevent floods, landslides, and other impacts of precipitation intensification (Torres et al. 2020b).

On the other hand, adaptation is defined as the result of deliberate policy decisions and planning with regard to how to manage climate change and its effects (planned adaptation). The literature focuses on urban climate governance, highlighting that adaptation may be understood as a long-term process, which involves the interactive process of change towards climate risk reduction and sustainable urban measures that potentially deliver multiple economic, social, and environmental benefits (Rosenzweig et al. 2015; Aylett 2015; Castán-Broto 2017).

Particularly in the context of Global South cities, where effective adaptation planning is highly dependent on municipal efforts, the literature recognises that adaptation should not be conceptually separated from development or infrastructure projects that reduce vulnerability, improve the wellbeing of human subjects and ecosystems (Carmin et al. 2012; Agrawal and Lemos 2015; Ryan 2015; Rosenzweig et al. 2015; Chu et al. 2017), and deal with existing passives at the same time as changes in the status quo building form.

Building adaptive capacity in these cities requires not only improvements to generic elements that are associated with resilient, sustainable, and livable outcomes but also includes creating and consolidating specific components necessary to overcome climate stressors, including climatic information, preventative and response plans, and infrastructure investments. When combined, both generic and particular elements improve a city's ability to cope with climate change; reduce the harmful effects of flooding, landslides, and heatwaves; promote sustainable development; and improve a community's quality of life (Eakin et al. 2014).

While a successful climate adaptation process is strictly dependent on understanding the problem, planning actions, and managing the implementation of the selected options, fostering anticipatory planned adaptation through the existing management context is a precondition for adaptation in the case of Global South cities (Simões et al. 2017).

Particularly in the context of Brazilian cities, Di Giulio et al. (2019a) endorse that administrative practices, political will, level of commitment, a mismatch between the scale of urban issues and the extent of local government authority, pressures from private sectors, and inspection have the highest levels of impact on adaptation. More specifically, concerning the local dynamics of urban planning, the authors argue that the combination of pressures from private sectors and insufficient inspection negatively affect the ability of cities to consolidate adaptation interventions.

The territorial approach of the São Paulo Macro Metropolis to analyse the impacts of severe climatic events is original. This approach complements current perspectives that tend to focus either on the national or city level. There is still limited research that focuses on the regional territory for planning and governance, as well as under the lens of environmental justice analysis. An apparent reason is the availability of regional climate change scenarios and models for both analysing past impacts and future scenarios. The absence of scenarios and technological innovations, however, should not allow the region, the richest in the country, to continue to fail to plan for climate change impacts in its territory. Based on the total absence of an anticipatory planning component in its principal instrument of planning and governance: the São Paulo Macro Metropolis Action Plan.

In the wealthiest region of the country, extreme inequalities occur, including in municipalities with high GDP rates, income, or low vulnerability index. In this sense, the attempt to articulate the territorial approach, with anticipatory governance and environmental justice, contributes to the reflection on how climate change impacts these territories. Also, we can ask as to how they are prepared (or not) for future impacts? Finally, how do inequalities manifest themselves in the effects due to severe climatic events in the population, which primarily affect the poorest and most vulnerable, whether due to landslides, slopes, or floods.

Territorial approaches for environmental justice, especially for climate justice, must incorporate territorial and anticipatory aspects of planning and governance. This is what we propose here with the theoretical triad (Figure 2) that attempts to force the imperative dialogue in terms of adaptation to climate change, environmental justice, and anticipatory governance. If cities or countries in the context of the Global North search for strategies and solutions for a transition to low carbon development and resilient urban infrastructure, the same cannot be said for the most vulnerable residents of Earth.

For the Global South, governance approaches related to the impacts of climate change should include local analyses of environmental justice. However, this is not the case in the current literature, i.e., the involvement of the two theories, but even less specifically with respect to the theory of anticipatory governance, with fewer exceptions (Ajibade 2019; Paprocki 2018). Therefore, we also seek to contribute to the debate on the importance of including aspects of environmental justice within the scope of anticipatory governance, especially in cases such as the São Paulo Macro Metropolis, similar to other territories in the Global South.

Material and methods

The methodology consists of the collection of two datasets. The first dataset is related to the extreme event selection while second concerns the number of deaths that occurred during precipitation events. Based on these datasets, we analysed the correlations among the characteristics of the mortality location of deaths, as described below. We discuss the results within the framework of contemporary Environmental Justice literature in a dialogue on the anticipatory governance concept and adaptation to climate change.

Selection of extreme events

The selection of extreme precipitation events during the rainy periods of 2016–2017, 2017–2018, and

2018–2019 was based on several sources but were mainly derived from Civil Defence warnings and online newspaper reports. To select the cases, we initially considered the text messages sent by the Civil Defence to warn of heavy rain events. From these messages, we searched for news on the internet that validated the severity of the case, such as deaths and/or wind gusts and floods. After confirmation, satellite images, synoptic charts, and meteorological radar images provided by REDEMET (https://www.redemet.aer.mil.br/) were used to analyse the event type.

Based on our weather forecast experience, each severe weather event, after analysis, was associated with one of the possible atmospheric mechanisms that generally occur over the region. The mechanisms/systems identified were: 1) pre-frontal condition; 2) South Atlantic Convergence Zone (SACZ); 3) Moisture Convergence Zone (ZCOU); 4) Squall Line; 5) local daytime heating; 6) mesoscale heat and moisture convergence; 7) local moisture convergence only; 8) frontal systems; and 9) daytime heating and moisture supply.

In general, the Civil Defence in Sao Paulo tends to deliver warnings even when the event does not have a high potential to become severe, i.e., erring on the side of caution. Therefore, to eliminate any cases that could characterise a false alarm, we confirmed the seriousness of a specific event based on other sources, as previously mentioned. Therefore, we are confident that we were able to confirm the severity of the weather events that occurred during the selected rainy periods.

Severe weather forecasting is still a significant challenge due to its nature and volatile development. Although models can provide relatively good forecasts for periods of 12–48 h, extreme weather events cannot be predicted within such a significantly long period. Due to spin-up limitations, models, in general, do not provide suitable forecasts within short periods, referred to as nowcasting (0–6 hours), such that it is necessary to use other tools for this specific type of forecasting. One of the most powerful tools for nowcasting is the weather radar, despite the possible use of satellite images in certain cases. Based on this type of data, websites in Brazil[1] and cell phone apps[2] have been developed to provide the necessary information on severe weather occurrences for meteorologists, governmental agencies, and ordinary citizens.

The main limitations of these tools rest in their reliance on data availability, especially radar, which depends on the maintenance of equipment and the goodwill of those responsible for freely distributing this data. As the number of weather radars in Brazil remains low, any failure in available equipment may cause a scarcity of valuable information on severe weather occurrences. Therefore, we must invest in these essential instruments and maintain a well-prepared team of technicians to sustain continuous operation.

Selection of case studies in the SPMM

The death cases were selected using printed media, more specifically from news reported by the 'O Estado de São Paulo' newspaper, as there are no detailed data available for research on these deaths from the Civil Defence agencies. The State Coordination of Civil Defence in São Paulo annually publishes a brief report on the Summer Rains Operation, which collects information on the numbers of people killed, injured, missing, and homeless due to rain events and their effects. However, only the latest report is available for consultation. The lack of official information is a limitation of this study and other as the number of deaths may be higher than reported. However, this is currently the only way to obtain necessary details for this type of research.

The newspaper search used pairs of descriptors ranging from broader to more specific definitions. The selection was made successively until no new news appeared in the search. The pairs were as follows: death and rain, death and flood, death and landslide, death and drowning. This study covers the entire period between October 2016 and March 2019, without any specific a priori designations for the rainy periods, despite results restricted to those periods without selecting from them. In other words, there were no records of deaths resulting from rainfall outside of the rainy season. We stress that not all events that resulted in deaths were due to the extreme events mentioned in the previous section. Certain deaths occurred due to smaller amounts of precipitation.

This study was guided by a mortality framework with (1) the type of death, considering flood, rapid flood, landslide (or other), (2) the location of death and, (3) when present in the media, the type of management problem observed and what action was deemed necessary. Deaths were considered as drowning, caused by flooding, landslides, the collapse of built structures, falling trees, and lightning-related shock or fire. For location, the urbanisation and

building conditions in which each of the deaths occurred were observed, such that the location was classified as vulnerable or non-vulnerable. This classification relied on two existing spatial vulnerability indicators, the São Paulo Social Vulnerability Index (IPVS)[3] and precarious settlement. The classification considered death in vulnerable areas, the ones that occurred where there was a concentration of these characteristics. The conditions of the deaths were also analysed based on media coverage. For example, when death by drowning occurred in a non-vulnerable neighbourhood as classified by IPVS, but in a nonofficial mapped slum, the news information provide support for its reclassification.

Finally, the management framework classified solutions, or narratives, of what should be done into six categories: grey hard infrastructure (reservoirs, river channelisation, and other measures related to significant interventions on the macro drainage system); grey soft infrastructure (primarily related to traditional interventions on micro drainage systems, eventually increasing the superficial flow); green infrastructure (responses that use natural elements to mimic watershed functions); maintenance (drainage system cleaning); planning (mainly land use and management practices); and remediation credit, used by households to recover from flood or landslide damages. We emphasise that this final category infrequently appears in media coverage.

Results

During the rainy periods analysed, 61 extreme events were selected, two of which were characterised by more than 100 mm/h of precipitation and two events between 50 and 100 mm/h of precipitation. Their distributions are regular throughout the study period, with 21 events in each of the rainy periods from 2016–2017 and 2017–2018 and 19 from 2018–2019. Most extreme events in this region are associated with frontal systems (15 cases) and isolated thunderstorms (11 cases).

During these periods, there were 47 deaths in the SPMM, 32 of which occurred from 2018–2019, highlighting the severity of the processes in those months. Considering all the deaths, there were 20 by drowning, 12 by landslide, five as a result of lightning, five as a result of falling branches or trees, four as a result of collapsed construction structures, and one due to electric shock. For location, the same number of deaths (23) were observed in vulnerable and non-vulnerable areas while one death occurred in a natural forest area. An absolute predominance of deaths (38) is observed in municipalities within the Metropolitan Region of São Paulo (MRSP). Among these deaths, 13 occurred in the capital of São Paulo and 18 in municipalities that belong to an area known as the Great ABC Region, which is a wealthy set of municipalities where the automobile industry was born in Brazil, located in the southern part of the MRSP.

Out of the 62 news items selected, which discuss possible causes, only 15 provide the opinion of institutional actors in terms of the causes of death and small indication of solutions. They emphasise the lack of hard grey infrastructure components and the need to build them, especially reservoirs, as well as a lack of essential maintenance services. As a remediation measure, the State Government announced, in a specific event, the release of individual credit for repairs. Other categories were not mentioned in the media coverage.

More relevant analyses include the correlations between the two major causes of death and their locations, which is a diametrically opposite relationship: of the 20 drowning deaths, 15 were in non-vulnerable areas. In contrast, all landslide deaths occurred in vulnerable areas. Of the 47 deaths, 25 occurred during extreme events, where 11 of them were due to drowning and six were due to landslides. 10 March 2019 stands out as a particularly extreme event characterised by 100 mm/h of precipitation, during which 13 people died, i.e., 12 in the Great ABC region within one of its main watersheds (the Tamanduateí River). At the headwaters, five people died due to landslides while closer to its mouth, there were 7 drowning deaths, as shown in Figure 3. This event will be discussed in more detail because it reveals the challenges that governance faces in the context of the existence of a large vulnerability passivity and a likely increase in extreme events.

(Source: LaPlan/MacroAmb, 2020).

Most flood mitigation interventions are characterised by large-scale hard grey infrastructures that are inappropriate for managing uncertainties that arise from climate variability or climate change (Depietri and McPhearson 2017). In this context, the reproduction of these interventions has the consequence of propagating the risk. This is the case, although with new characteristics, especially considering changes in water velocity, which is the leading cause of death, and the extent of

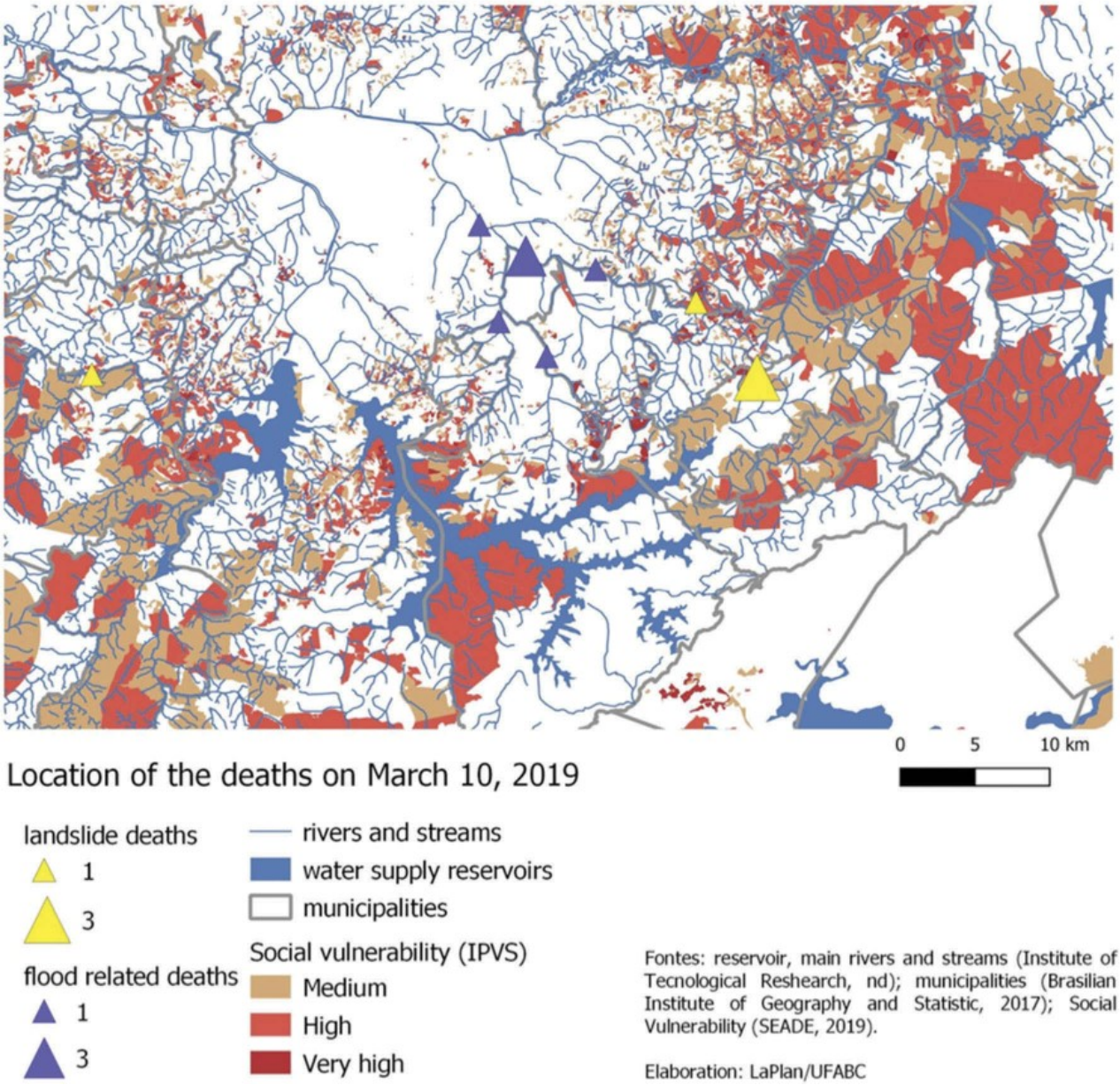

Figure 3. Location of deaths for the 10 March 2019, event.

flooding in cases of infrastructure failure (Travassos and Schult 2013).

The city of São Paulo, the most populous among all Brazilian cities, with 13 deaths, is the most impacted city. This shows that the wealthiest city is also the most unequal and presents the most risks to the population despite a wealthy/high GDP. Other cities with the highest number of deaths are all located in the Metropolitan Region of São Paulo.

Mauá, with 414,485 inhabitants and a per capita income of 500 USD, where 17.5% of households do not exceed half a minimum wage per capita, is the municipality with the second highest number of deaths (5). According to the IVPS, 16.2% of the population in this municipality lives in a highly vulnerable territory, where the income is no more than half a minimum wage per capita and people reside in subnormal agglomerates, i.e., an average of fourfold higher than that registered in the state of São Paulo (4% of the population currently live in this situation).

São Bernardo do Campo, also in the ABC region of São Paulo, recorded four deaths. Part of this

municipality, especially in the central–west region, is characterised by a high level of vulnerability, which is higher than the average rate in the State of São Paulo. Of the four deaths recorded in the city, all were due to landslides.

Four deaths occurred in Ribeirão Pires, which is also in the ABC region, with 112,951 inhabitants, whose average income is 560 USD, where 13.4% of the population do not exceed half the minimum wage. Most of the population lives in the portion of the territory with a low degree of vulnerability. Only 2.3% of the total population lives in subnormal agglomerations in which 30% of the individual incomes are no more than half a minimum wage per capita.

São Caetano and Arujá, both in the Metropolitan Region of São Paulo, had three deaths each. São Caetano, in the ABC Region, with 148,664 residents, is a municipality with a low vulnerability rate, a per capita income of 1 USD,074, and no media or high vulnerability in the territory. Arujá has 74,408 inhabitants of which 20% of the residents do not exceed half a minimum wage while 26.3% of the residents live in portions of the territory considered highly vulnerable (urban sectors) and 1.7% at high vulnerability (rural areas).

Discussion

For Brazil, as in other cases in the Global South, the need for urban spatial policies that concern the unequal and unfair production of space is historical, especially when considering the socio-environmental vulnerability and economic inequality that stricken the population (Momm et al. 2017). The stability of the institutional arrangements that perpetuate this model is linked to 'discursive hegemonies' that shape the plans and public policies within this spatio-temporal context, always concentrating wealth and innovation in certain parts of the cities. However, external pressures, such as climate change, challenge stable planning cultures as a result in the process of institutional reflection. In this sense, climate change, with its impacts and uncertainties, may represent an opportunity to modify the forms of spatial development (Momm et al. 2017, p. 17).

Thus, it is strategic that there are specific policies and plans to adapt to (or with) climate change as an instrument that recognises synergies and guides integration with other land planning instruments throughout the territory (Barton 2013). Nevertheless, in Brazil, policies, programs, and actions that may contribute to climate change adaptation are often disconnected from the climate change theme and deeply sectoral, leading to partial fulfilment of infrastructure deployment demands and the frequent consolidation of certain liabilities and the risk associated with them. The agencies responsible for social housing, green areas, and stormwater management policy plans prioritise their actions according to their own agendas. This results in the absence of a joint spatial effort and the establishment of priorities based on different dimensions of vulnerability, as well as social and environmental susceptibility (Travassos and Schult 2013).

A peculiarity of adaptation is transversality involving various sectors and levels of governance. In this sense, strategic adaptation plans must be integrated with other existing instruments, such as development strategies designed with 'climate lenses' but that are also a tool for integration. One method of circumventing sectoral fragmentation imposed on environmental policies, as in the case of climate change adaptation, is through spatial approaches. Once they are spatially defined, knowledge of their determinants is mainly contained in institutions associated with spatial planning at local and regional levels.

The appropriation of climate change issues in planning and decision-making processes requires the internalisation of uncertainties, specifically uncertainties related to the effects that climate change has on regional or local spatial scales. Uncertainties related to the impacts of climate change in conjunction with changes due to city form and their microclimates are prominent. These are also due to changes in the production of regional space. Both relationships can produce even more extreme situations, such as more prolonged droughts or more intense and localised precipitation, as has been observed in the SPMM.

In the current Brazilian situation, there are no projections of long-term planning focused on climate adaptation. However, previous studies state that, within the country, important climate changes variations will occur in the 21st century, causing adverse social and economic impacts, especially in urban centres (Di Giulio et al. 2016) and their adjacent regions, as in the SPMM.

The National Climate Change Adaptation Plan (MMA 2016), approved in 2016, notes that it is essential to boost the adaptation processes in Brazilian municipalities. In particular:

(1) Promote precarious settlement upgrades, which includes slums and other irregular

settlements, and improving the living conditions of the population via integrated urban infrastructure actions, housing construction and improvement, and land regularisation;
(2) Environmental restoration;
(3) Public policies that increase the resilience of social groups of greater vulnerability to climate change while considering adaptation to climate change in terms of improvements to urban planning models.

While there may be an overall perception that mitigation responses can be associated with potential economic gain (e.g., 'the green economy'), adaptation is mostly perceived as a cost to the cities (Denton et al. 2014), especially for cities that will most likely be the receivers of this investment. There is a distinction between policy adoption and policy implementation. The first tends to be relatively uncontroversial politically, whereas the second requires concrete government actions and, for this reason, is likely to trigger latent oppositional interests and deploy organisational and economic resources (Ryan 2015).

As shown by empirical research in the SPMM, there are two predominant patterns of deaths due to precipitation, landslides and drowning from flash floods or inundation (flood-related). The fact that the former is related to vulnerable areas while the latter to non-vulnerable areas is highly relevant to answer the question posed in this paper's title. Rain, especially in its extreme form, still kills in the SPMM because of two issues. On the one hand, there is an absence of infrastructure in landslide risk areas but a presence of inadequate infrastructure near rivers, streams channel, and wetlands. On the other hand, there is a presence of buildings in areas susceptible to flooding and landslides. In terms of governance, deaths also occur due to a lack of a solid civil defence structure.

Di Giulio et al. (2019b) highlight that most cities in the State of São Paulo do not rely on a specific prevention plan when responding to climate risks and emergencies. Besides the difficulties associated with coupling urban management and policy to mitigation and adaptive strategies, the authors highlight other critical challenges that hinder the adaptation process in São Paulo cities, e.g., information systematisation and sharing, gaps in the knowledge of local impacts related to climate events, difficulties in establishing responsibility when dealing with these events, and low adhesion by the municipalities to networks and organisations directly working on climate change issues.

In non-vulnerable areas, the majority of deaths (15 out of 20) were flood-related that occurred in channelled rivers and floodplains occupied by avenues in highly impervious basins, which leads to rapid runoff. In these cases, in addition to inadequate infrastructure, the reasons for mortality include a lack of knowledge of the dangers associated with entering or remaining in flooded areas, as well as the absence of a rescue structure that can respond at a sufficient speed to prevent these deaths, which can be inferred from case analyses.

In vulnerable areas, deaths occur mainly due to housing precariousness and their locations in areas susceptible to land movement. All landslide deaths occurred under these conditions. Deaths due to lightning also occurred in these areas, three caused by a fire in a precarious house and fatalities related to electric shocks in trees serving as a permanent shelter for homeless victims.

We also note that the correlation between the extreme events and resulting deaths is not particularly high, i.e., only slightly more than half of the deaths occurred during these events. However, the rainfall event on 10 March 2019, indicates that, when an extreme event occurs in a localised manner, there are significant negative consequences with respect to current conjunctures. As an illustration of the dimensions of the problem, it is useful to describe, in more detail, the precipitation event and deaths that occurred that Sunday. Throughout the previous day, the region experienced unusually high temperatures, reaching 33.5°C, which significantly decreased the following day due to the entry of a frontal system. The combination of the humidity transported by this front and the heat that had accumulated the day before produced heavy clouds, such that precipitation began in the late afternoon, approximately 6 pm, and lasted until approximately 9 am the following morning. In the Tamanduateí basin, where the highest number of deaths occurred, over 100 mm of rainfall accumulated in approximately 3 h. By the end of the period, the region had received, according to CEMADEN (National Centre for Natural Disaster Monitoring and Alerts) data, between 168.1 (Mauá Station/Parque das Américas) and 182.3 mm (Santo André Station/Vila Ramalho) of rain, which is more than half of the average for the entire month (Pegorim 2019).

In Ribeirão Pires, four people died in a landslide. Two other deaths occurred in São Rafael Park, a district in the city of São Paulo, and Embu das Artes, another metropolitan municipality. Three flood-related deaths occurred in São Caetano do Sul, two in Santo André, and one death each in São Bernardo do Campo and São Paulo. All of these deaths were related to the water speed during the flooding of the main Tamanduateí River channel or its affluents. Six municipalities and the State government were faced with the impacts of this rainfall. At the same time, regional arrangements have been forgotten due to their weak role in drainage and urban infrastructure issues.

Therefore, we can infer that an increase in the incidence of extreme events will produce negative impacts in the urban areas of the SPMM, especially if actions are not taken for urban and housing structuring, infrastructure implementation, and the restructuring and institution of Civil Defence programs within legal norms and planning activities.

One example is that Brazil approved a National Policy on Civil Protection and Defence (Federal Law n. 12.608/2012) after a series of disasters caused by extreme events in São Paulo, Santa Catarina, and Rio de Janeiro between 2008 and 2011. This law aimed to incorporate disaster risk management (DRM) into urban planning and public management agendas. The law succeeded in creating certain organisational institutions, especially at the federal level. However, it failed to build the necessary decentralised structures until recently (Nogueira et al. 2014). The law has had a significant impact on rapid alarm systems and rescues. Although the State of São Paulo had built a civil defence structure, even before the national legislation, the amount of resources allocated to this activity is small, which has had a significant impact on rapid alarm systems and rescues in the municipalities and local levels. More than this, the law is predominantly directed towards the maintenance of specific organisations, such that has been scarce funding for investment, i.e., only 17% of the total civil defence resources between 2016 and 2018 (São Paulo (Estado) 2019).

DRM was also not integrated into urban planning tools and laws or adequately considered with high priority in public interventions. Based on an analysis of secondary data derived from questionnaires on climate change and adaptation filled out by municipal agents acting in São Paulo cities, Di Giulio et al. (2019b) point out that most respondents recognise that the Master Plans in force in their municipalities do not include prevention actions or responses to extreme events or climate change.

Due to the significant number of precarious houses built in susceptible areas only in the municipality of São Paulo, Travassos et al. (2017) mapped 274,000 households in precarious settlements along stream banks in 2010, highlighting the fact that investment in social housing and slum upgrade programs is insufficient. In 2018, considering its 645 municipalities, the State of São Paulo delivered over 16,000 homes, with nearly 50,000 under construction (CDHU 2018). Although the numbers of precarious houses in susceptible areas do not have a consolidated methodology, the significant distance between its overall values (more than 2.5 million alone in the SPMM) and the results of public policies lead to the perception that it will not be possible to reduce the risk of death in the short term.

The highly diverse, often adversarial, stakeholders, institutions, interests, values, relations, and issues involved in environmental governance of the Macro Metropolis are suggestive of the strong interdependencies and, thus, the limitations of unilateral governmental action and the need to strengthen the links among local governments, the private sector, and social organisations. From a governance perspective, the fundamental challenge exists in the articulation and intermediation of the interests, strategies, and actions of the different public and private actors based on public and inclusive deliberation forums. More than this, operating with an anticipatory governance planning strategy, instead of typical remedial actions that generally characterise the risk policy of the state and municipalities, is crucial.

Local governments can lead and deliver adaptation actions (Araos et al. 2016; Castán-Broto 2017). We must assume, however, that effective and anticipatory adaptation planning in urban areas is closely dependent on municipal efforts linked to higher governmental levels, especially, in this case, the metropolitan and macro metropolitan levels.

For the SPMM, in 2014, the government of São Paulo launched the Action Plan for the Macro Metropolis 2013–2040 (AP-SPMM). This is the first policy and planning instrument that focuses on the macro metropolitan territory as a specific planning unit (Emplasa 2014). The predominant view is of integration in favour of development and economic growth. This plan recognises the importance of ecosystem services, as is their relevance to

well-being and quality of life. This plan also recognises the need to integrate territory and traditional sectoral policies and establish multilevel and polycentric dialogues. The action plan aims at 'formulating integrated public policies for the SPMM territory and involving other levels of government, the private sector and society in the proposal and implementation of metropolitan actions and projects (Emplasa 2014, p. 8),' especially concerning climate change and water safety.

The AP-SPMM, however, does not focus on climate variability and the need for new infrastructure projects that take into account such scenarios with higher adaptive capacity and resilience. For example, drainage systems and its components are not considered, even for the establishment of development guidelines.

Although the AP-SPMM states that the State Climate Change Policy (PEMC) is taken as a reference for its development, defining strategies for mitigating and adapting to these changes (Emplasa 2014, p. 21), all of these targets are based solely on CO_2 emissions and the mitigation and adaptation strategies do not explicitly appear in the text and are vague.

Therefore, this plan delimits specific and highly generalist actions depending on minority and local projects, which are poorly listed, localised, and do not cover the entire SPMM region. We also highlight that the AP-SPMM, despite its narrative of integration between government levels and sectors, does not present specific actions that may lead to this integration in both administrative and spatial dimensions. Furthermore, the State Government has recently dismantled regional planning and governance institutions. Sectorial agents must implement the actions proposed in the Plan.

For the region impacted by the event on 10 March 2017, the municipalities within this region, through their municipal consortium (i.e., the Greater ABC Consortium), developed a Greater ABC Climate Change Action Plan. However, this plan focused on mitigation issues and postponed the adaptation to a posterior plan. The action plan established that, by 2018, two instruments should be developed: a Regional Risk Reduction Plan and an Integrated Risk Warning and Monitoring System. However, both instruments remain non-existent. At the municipal level, Master Plans or Social Housing Plans rarely deal with climate change issues. However, these tools focus on the areas of social vulnerability and susceptibility and seek to prioritise such areas for action. Again, the investment capacity with respect to the required amount of action is meaningless.

The lack of institutional capacity and resources to promote preventive actions in at risk areas and respond rapidly to emergencies represents a failure at the three levels of government: federal, state, and municipal. As a result, they are unable to anticipate events and prevent tragedies, especially the loss of life.

The challenge to identify and change the status quo in the planning system is enormous, considering that, especially in the current Brazilian political scenario, there is a call to 'get off the ground' policies and projects that operate in the grey area of uncertainty and possibility. The timing of the political-electoral agenda with long-term actions is also an obstacle. An initial understanding to overcome these challenges is to recognise that this is no longer a future problem, but rather is a now problem. The focus of governance and planning actions must contain distinct time scales in continuous social learning processes, with action, monitoring, and action review, among other steps. (Jacobi and Sulaiman 2016).

São Paulo has and is missing opportunities to make climate adaptation an issue linked to other existing public policies and resources. Instead, the debate on climate change in the region occurs 'behind the scenes' or is obscured with terms, such as 'green economy' (Di Giulio et al. 2018). Moreover, existing policies cannot be properly implemented because the engagement of various actors and stakeholders occurs only during their elaboration, which is not reflected in subsequent actions (Di Giulio et al. 2018).

Conclusions

In this paper, we sought to better understand the connections among extreme weather events, deaths, and social vulnerability in the SPMM, a Brazilian territory characterised by environmental and social inequalities spatially distributed across 174 municipalities. Assuming that climate inequality shapes climate resilience in a continuous and dialectic process, we propose a theoretical framework that connects anticipatory governance, climate adaptation, and environmental justice perspectives to bring to the forefront two critical and intertwined issues in the context of Brazilian cities: 1) the close relationship between extreme events and the amplification of existing social vulnerabilities; 2) the fact that on the ground adaptation process is primarily local and context-specific, as well as the fact that concrete responses require a disruption to the current planning and governance paradigms.

Covering the rainy periods from 2016 to 2019, with examination of 61 extreme precipitation events and 47 deaths related to precipitation events, extremes or not, our analysis provides several important insights to better understand the socio-environmental patterns regarding the relationship between social vulnerability and deaths caused by extreme events. In the cases analysed, we observe that rain, especially in large amounts over a short period, still kills in the SPMM due to an absence of infrastructure and the presence of inadequate infrastructure. Fatalities also occur due to the presence of buildings in areas susceptible to flooding and landslides. In all these situations, existing government structures have not been sufficient to prevent deaths.

Our results confirm certain peculiar characteristics that shape large Brazilian cities, as well as the Global South. On the one hand, existing infrastructure located in the middle- and upper-income classes is not adequate with respect to the uncertainties that may arise from climate change. On the other hand, in the peripheries, infrastructure is incomplete or nonexistent, representing a liability that must be prioritised if the adaptation and anticipatory governance strategy will be dealt with the lens of Environmental Justice. Thus, anticipatory governance in Brazilian cities must recover these liabilities while developing innovations appropriate to its urban and environmental contexts.

Our analysis highlights that, in the SPMM region, none of the current environmental plans and policies address the steps necessary for desirable adaptive governance, including anticipation and analyses of possible scenarios, creation of flexible adaptation strategies, and promoting constant monitoring and responses to change. Moreover, while there is an understanding that adaptation may be integrated into already existing public policies and actions, such as urban planning (including, for example, Master Plans and Social Housing Plans), our analysis sheds light on the existence of large gaps between what is planned and what is, in fact, implemented. With the prospect of increasingly extreme precipitation events, a lack of resources and institutional capabilities leads to a worsening of risk conditions and entails even more severe consequences for the poorest residents.

While we recognise that our analysis suggests that vulnerability has a specific spatiality in the study region, we also acknowledge certain limitations. First, in terms of methodological aspects, we understand that the absence of official or precise data for precipitation events and fatalities yields a less robust correlation than it could be with these data. This issue is linked to the monitoring structure itself. The number of radars in Brazil remains low and there is no general framework to register the history of events and their consequences. The second limitation concerns our theoretical framework, which aligns critical elements to advance our comprehension of the complex interactions among urbanisation, inequalities, climate governance, and vulnerability. However, we must refine these interactions to obtain analytical density. The next step of this research is to, therefore, apply and test this framework to identify these correlations and introduce innovation into public policy, considering that the current means of understanding and reacting to this issue requires a disruption to the current planning and governance paradigms, breaking with the 'business as usual' status quo.

Notes

1. http://nowcasting.cptec.inpe.br/, http://master.iag.usp.br/.
2. SOS-CHUVA, available at https://itunes.apple.com/br/app/sos-chuva/id1161149496?mt=8 and https://play.google.com/store/apps/details?id=br.inpe.cptec.soschuva.campinas&hl=pt_BR.
3. IPVS description and methodology could be seen at https://www.seade.gov.br/ipvs/.

Highlights

- Deaths by landslide occur due to housing precariousness at the peripheries.
- Deaths by drowning occur due to the inadequate infrastructure at consolidated areas.
- Deaths occur due to the lack of civil defence structure.
- Current plans and policy are not addressing adaptation and climate change extreme events in São Paulo Macro Metropolis.
- There is a need to adopt anticipatory governance to deal with extreme events.

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References

Adger N, Barnett J, Brown K, Marshall N, O'Brien K. 2013. Cultural dimensions of climate change impacts and adaptation. Nat Clim Chang. 3(2):112. doi:10.1038/nclimate1666.

Agrawal A, Lemos M. 2015. Adaptive development. Nat Clim Chang. 5(3):185–187. doi:10.1038/nclimate2501.

Agyeman J, Schlosberg D, Craven L, Matthews C. 2016. Trends and directions in environmental justice: from inequity to everyday life, community, and just sustainabilities. Annu Rev Environ Resour. 41(1):321–340. doi:10.1146/annurev-environ-110615-090052.

Ajibade I. 2019. Planned retreat in Global South megacities: disentangling policy, practice, and environmental justice. Clim Change. 157(2):299–317. doi:10.1007/s10584-019-02535-1.

Anguelovski I, Shi L, Chu E, Gallagher D, Goh K, Lamb Z, Reeve K, Teicher H. 2016. Equity impacts of urban land use planning for climate adaptation: critical perspectives from the global north and south. J Plann Edu Res. 36(3):333–348. doi:10.1177/0739456X16645166.

Araos M, Berrang-Ford L, Ford J, Austin S, Biesbroek R, Lesnikowski A. 2016. Climate change adaptation planning in large cities: a systematic global assessment. Environ Sci Policy. 66:375–382. doi:10.1016/j.envsci.2016.06.009

Aylett A. 2015. Institutionalizing the urban governance of climate change adaptation: results of an international survey. Urban Clim. 14:4–16. doi:10.1016/j.uclim.2015.06.005

Barton R. 2013. Climate change adaptive capacity in Santiago de Chile: creating a governance regime for sustainability planning. Int J Urban Reg Res. 37(6):1916–1933. doi:10.1111/1468-2427.12033.

Bell JE, Brown CL, Conlon K, Herring S, Kunkel KE, Lawrimore J, Luber G, Schreck C, Smith A, Uejio C. 2018. Changes in extreme events and the potential impacts on human health. J Air Waste Manage Assoc. 68(4):265–287. doi:10.1080/10962247.2017.1401017.

Birkland T, Waterman S. 2008. Is Federalism the Reason for Policy Failure in Hurricane Katrina? Publius. 38(4):692–714. doi:10.1093/publius/pjn020.

Boyd E, Nykvist B, Borgström S, Stacewicz IA. 2015. Anticipatory governance for social-ecological resilience. Ambio. 44(1):149–161. doi:10.1007/s13280-014-0604-x.

Carmin J, Anguelovski I, Roberts D. 2012. Urban climate adaptation in the global south: planning in an emerging policy domain. J Plann Edu Res. 32(1):18–32. doi:10.1177/0739456X11430951.

Castán-Broto V. 2017. Urban governance and the politics of climate change. World Dev. 93:1–15. doi:10.1016/j.worlddev.2016.12.031

CDHU. 2018. Relatório de Sustentabilidade. São Paulo.

Chu E, Anguelovski I, Roberts D. 2017. Climate adaptation as strategic urbanism: assessing opportunities and uncertainties for equity and inclusive development in cities. Cities. 60:378–387. doi:10.1016/j.cities.2016.10.016

Denton F, Wilbanks TJ, Abeysinghe AC, Burton I, Gao Q, Lemos MC, Masui T, O'Brien KL, Warner K. 2014. Climate-resilient pathways: adaptation, mitigation, and sustainable development. In: Field, CB, Barros VR, Dokken DJ, Mach KJ, Mastrandrea MD, Bilir TE, Chatterjee M, Ebi KL, Estrada YO, Genova RC, Girma B, Kissel ES, Levy AN, MacCracken S, Mastrandrea PR, White LL, editors. Climate change 2014: impacts, adaptation, and vulnerability. Part A: global and sectoral aspects. contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change. Cambridge (United Kingdom and New York, NY, USA): Cambridge University Press; p. 1101–1131.

Depietri Y, McPhearson T. 2017. Integrating the grey, green, and blue in cities: nature-based solutions for climate change adaptation and risk reduction. Kabisch N, Korn H, Stadler J, Bonn A editors. Nature-based solutions to climate change adaptation in urban areas. Theory and practice of urban sustainability transitions (pp. 91–109). Springer.

Di Giulio G, Martins A, Lemos M. 2016. Adaptação climática: fronteiras do conhecimento para pensar o contexto brasileiro. Estudos Avançados. 30(88):25–41. doi:10.1590/s0103-40142016.30880004.

Di Giulio G, Martins A, Vasconcellos MDP, Ribeiro WC, Lemos, MC. 2018. Mainstreaming climate adaptation in the megacity of Sao Paulo, Brazil. Cities. 72(B):237–244. doi:10.1016/j.cities.2017.09.001.

Di Giulio GM, Torres RR, Lapola DM, Bedran-Martins AM, da Penha Vasconcellos M, Braga DR, Fuck MP, Juk Y, Nogueira V, Penna AC, et al. 2019b. Bridging the gap between will and action on climate change adaptation in large cities in Brazil. Reg Environ Change. 19(8):2491–2502. doi:10.1007/s10113-019-01580-x.

Di Giulio GM, Torres RR, Vasconcellos MDP, Braga Diego RGC, Mancini RM, Lemos MC. 2019a. Extreme Events, Climate Change and Adaptation in the State of São Paulo. Ambiente & Sociedade. 22:e02771. doi:10.1590/1809-4422asoc0277r1vu19l4ao

Eakin H, Lemos MC, Nelson DR. 2014. Differentiating capacities as a means to sustainable climate change adaptation. Global Environ Change. 27:1–8. doi:10.1016/j.gloenvcha.2014.04.013

Emplasa. 2014. Plano de Ação da Macrometrópole Paulista 2013–2040. Emplasa, 1 ed. São Paulo.

Emplasa. 2019. https://www.emplasa.sp.gov.br/MMP

Gober P. 2014. Decision making under uncertainty: A new paradigm for water resources planning and management. Mod Water Resour Eng. 15:411–436. doi:10.1007/978-1-62703-595-8_8

IPCC. 2018: Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Masson-Delmotte V, Zhai P, HO P, Roberts D, Skea J, PR S, Pirani A, Moufouma-Okia W, Péan C, Pidcock R, et al. (eds.). In press.

Jacobi PR, Sulaiman S. 2016. Governança ambiental urbana em face das mudanças climáticas. Rev USP. 109(109):133–142. doi:10.11606/.2316-9036.v0i109p133-142.

Marengo J 2007. Mudanças climáticas globais e seus efeitos sobre a biodiversidade: caracterização do clima atual e definição das alterações climáticas para o território brasileiro ao longo do século XXI. Brasília: MMA.

Marques E, Bittar M, Cazolato D, Fusaro E, Waldvogel D. 2013. Diagnosis of slums in the cities of Macro Metropolis paulista second report. Studies Center of Metropolis - CEM/CEBRAP Administrative Development Foundation - FUNDAP. São Paulo

Ministério do Meio Ambiente (MMA). Plano Nacional de Adaptação à Mudança do Clima. Brasília: MMA, 2016. Disponível em//www.mma.gov.br/clima/adaptacao/plano-nacional-de-adaptacao

Mohai P, Pellow D, Roberts JT. 2009. Environmental Justice. Annu Rev Environ Resour. 34(1):405–430. doi:10.1146/annurev-environ-082508-094348.

Momm S, Travassos L, Grisa G, Falcao K 2017. Análises comparativas em planejamento e governança em um cenário de mudanças climáticas. In: XVII ENANPUR, São Paulo. Anais.

Nogueira F, Oliveira V, Canil K. 2014. Políticas públicas regionais para gestão de riscos: o processo de implementação no ABC, SP. Ambiente Soc. 17(4):177–194. doi:10.1590/1809-4422ASOC1100V1742014.

Paprocki K. 2018. All that is solid melts into the bay: anticipatory ruination and climate change adaptation. Antipode. 51 (1):295–315. doi:10.1111/anti.12421.

Pegorim J 2019. Números do dilúvio sobre a Grande SP - 10/11 de março de 2019. Climatempo. Disponível em: Cited Aug, 2019. https://www.climatempo.com.br/noticia/2019/03/11/numeros-do-diluvio-sobre-a-grande-sp-10-11-de-marco-de-2019-3024.

Pelling M, Garschagen M. 2019. Put equity first in climate adaptation. Nature. 569(7756):327–329. doi:10.1038/d41586-019-01497-9.

Pickering J. 2019. Ecological reflexivity: characterising an elusive virtue for governance in the anthropocene. Env Polit. 28 (7):1145–1166. doi:10.1080/09644016.2018.1487148.

Piveta M 2016. Um Brasil mais vulnerável no Século XXI. Revista Fapesp, ed. 249, nov. Cited Nov. 2016. http://revistapesquisa.fapesp.br.

Quay R. 2010. Anticipatory governance – a tool for climate change adaptation. J A Plann Assoc. 67(4):496–511. doi:10.1080/01944363.2010.508428.

Quay R. 2015. Planning for demand uncertainty in integrated water resource management. J Am Water Works Assoc. 107 (2):32–41. doi:10.5942/jawwa.2015.107.0030.

Rosenzweig C, Solecki W, Romero-Lankao P, Mehrotra S, Dhakal S, Ali Ibrahim S 2015. ARC3.2 summary for city leaders. Urban Climate Change Research Network. Columbia University. New York.

Ryan D. 2015. From commitment to action: a literature review on climate policy implementation at city level. Clim Change. 131 (4):519–529. doi:10.1007/s10584-015-1402-6.

São Paulo (Estado). Portal da Transparência Estadual. Cited: Apr. 2019. http://www.transparencia.sp.gov.br/

Schlosberg D. 2013. Theorising environmental justice: the expanding sphere of a discourse. Env Polit. 22(1):37–55. doi:10.1080/09644016.2013.755387.

Schlosberg D, Collins LB. 2014. From environmental to climate justice: climate change and the discourse of environmental justice. Wiley Interdiscip Rev Clim Change. 5(3):359–374. doi:10.1002/wcc.275.

Shi L, Chu E, Anguelovski I, Aylett A, Debats J, Goh K, Schenk T, Seto KC, Dodman D, Roberts D, et al. 2016. Roadmap towards justice in urban climate adaptation research. Nat Clim Chang. 6(2):131–137. doi:10.1038/nclimate2841

Simões E, de Sousa Junior WC, Freitas DM, Mills M, Iwama AY, Gonçalves I, Olivato D, Fidelman P. 2017. Barriers and opportunities for adapting to climate change on the North Coast of Sao Paulo, Brazil. Reg Environ Change. 17(6):1739–1750. doi:10.1007/s10113-017-1133-5.

Torres PHC, Jacobi PR, Leonel AL. 2020b. Nem leigos nem peritos: o semeador e as mudanças climáticas no Brasil. Revi Política Soc. 44:34–52.

Torres PHC, Leonel AL, Jacobi PR, Araújo G. 2020a. Is the brazilian national climate change adaptation plan addressing inequality? Climate and environmental justice in a global south perspective. Environ Justice. 13(2):42–46. doi:10.1089/env.2019.0043.

Travassos L, Momm S, Torres P. 2019. Notes on urbanization, Adaptation and Vulnerabilities in the SPMM. In: Torres P, Jacobi P, Gonçalves L, Barbi F, editors. Governance and environmental planning: adaptation and public policy in the state macro-metropolis (pp. 120–126). Rio de Janeiro: Letra Capital.

Travassos L, Penteado C, Fortunato I. 2017. Urbanização desigual: rios, midia e modernização ecológica/Unequal urbanization: rivers, media and ecological modernization/Urbanizacion desigual: rios, medios y modernizacion ecologica. Espacio Abierto. Cuaderno Venezolano De Sociología. 26(2):61–81.

Travassos L, Zioni S, Torres PHC, Fernandes B, Araújo GM. 2020. Heterogeneidade e fragmentação espacial na Macrometrópole Paulista: a produção de fronteiras e buracos. Ambiente Soc. (in press).

Travassos LRFC, Schult SIM. 2013. Recuperação socioambiental de fundos de vale urbanos na cidade de São Paulo, entre transformações e permanências. Cadernos Metrópole (PUCSP). 15:265–288.

Vervoort J, Gupta A. 2018. Anticipating climate futures in a 1.5°C era: the link between foresight and governance. Curr Opin Environ Sustainability. 31:104–111. doi:10.1016/j.cosust.2018.01.004

Vij S, Moors E, Ahmad B, Uzzaman A, Bhadwal S, Biesbroek R, Gioli G, Groot A, Mallick D, Regmi B, et al. 2017. Climate adaptation approaches and key policy characteristics: cases from South Asia. Environmental Science & Policy. 78:58–65. doi:10.1016/j.envsci.2017.09.007.

White DD, Withycombe Keeler L, Wiek A, Larson KL. 2015. Envisioning the future of water governance: A survey of central Arizona water decision makers. Environ Pract. 17 (1):25–35. doi:10.1017/S1466046614000489.