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VULNERABILITIES, RISKS AND ENVIRONMENTAL JUSTICE IN A MACRO METROPOLITAN SCALE

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Abstract

The historical process of socio-spatial (dis)organization and the dynamics of the Paulista Macrometropolis (MMP) present a great diversity of situations of urban environmental risks, understood as "dysfunctions" with the potential to generate processes that cause loss and damage to people, surrounding goods and infrastructures. The social construction of risks, linked to the unsustainable management of the urban environment, has, on its most perverse face, the proliferation and perpetuation of vulnerable groups situations of exclusion, victims of socio-spatial segregation that restrict the poorest populations to valley floors, floodplains and the steepest slopes. Therefore, we propose a review of the relationship between the physical environment and infrastructure on urban management and the territorialization of socio-spatial conflicts related to environmental justice, considering the complexity of the MMP and the municipal disparities.

Keywords: Vulnerability, Risks, Environmental Justice, São Paulo Macrometropolis.

Resumo / Resumen

VULNERABILIDADES, RISCOS E JUSTIÇA AMBIENTAL EM ESCALA MACRO METROPOLITANA

O processo histórico de (des)organização socioespacial e as dinâmicas da Macrometrópole Paulista (MMP) apresentam uma diversidade de situações de riscos ambientais urbanos, entendidos como "disfunções" com potencialidade de gerar processos causadores de perdas e danos às pessoas, bens e infraestruturas. A construção social dos riscos, relacionada à gestão insustentável do ambiente urbano, tem, na sua face mais perversa, a proliferação e perpetuação de situações de exclusão de grupos vulneráveis, vítimas da segregação socioespacial que restringe as populações mais pobres aos fundos de vale, às várzeas alagáveis e às encostas mais íngremes. Portanto, propomos uma revisão das relações entre meio físico e infraestrutura no âmbito da gestão urbana e a territorialização dos conflitos socioespaciais ligados à justiça ambiental, considerando a complexidade na MMP e as disparidades municipais.

Palavras-chave: Vulnerabilidade, Riscos, Justiça Ambiental, Macrometrópole Paulista.

VULNERABILIDADES, RIESGOS Y JUSTICIA AMBIENTAL EN LA ESCALA MACRO METROPOLITANA

El proceso histórico de (des)organización socioespacial y las dinámicas de la Macrometrópolis Paulista (MMP) presentan una gran diversidad de situaciones de riesgos ambientales urbanos, entendidos como "disfunciones" con potencial de generar procesos que causan pérdidas y daños a las personas, bienes e infraestructuras. La construcción social de los riesgos, conectada a la gestión insostenible del ambiente urbano, tiene en su perfil más perverso la proliferación y perpetuidad de situaciones de exclusión de grupos vulnerables, víctimas de la segregación socioespacial que limita las poblaciones más pobres a residir en fondos de valles, áreas inundables y pendientes. Por lo tanto, proponemos una revisión de las relaciones entre medio físico e infraestructura en el ámbito de la gestión urbana y la territorialización de los conflictos socio espaciales conectados a la justicia ambiental, en el contexto de complejidad de la MMP y las disparidades municipales.

Palabras-clave: Vulnerabilidad, Riesgos, Justicia Ambiental, Macrometrópolis Paulista.

INTRODUTION

In the Brazilian metropolitan urban context, environmental problems have increased and worsened, and the slow pace of attempts to resolve them has contributed to the prevalence of a vulnerable, unsustainable structural framework (JACOBI, 2013). Conflicts, manifested in various ways, have proliferated, and they guide the practices directing the appropriation of territories and their resources. These practices are plagued by factors that complicate progress towards the sustainable management of cities (RIBEIRO, 2005).

The conflicts transcend scale and range from the local to the regional. This case study of the São Paulo Macrometropolis (MMP) illuminates the inequalities created by the formation of a region composed of five metropolitan areas and two urban agglomerations (TORRES et al., 2019). The territory with the highest gross domestic product (GDP) in the country has a heterogeneous configuration, and, until now, the policies and planning implemented by the government of the State of São Paulo have not contributed to a reduction in inequality; on the contrary, they have led to greater concentrations of it on the current developmental axes (TRAVASSOS et al., 2020; TORRES, RAMOS, and POLLACHI, 2020).

The unsustainable nature of the pattern of metropolitan urbanization is characterized by the prevalence of a process of expansion and occupation of intra-urban spaces that, in most cases, offers a low quality of life to significant portions of the population. Cities are marked by duality, with the parts that shelter the neediest populations neglected, having experienced much greater horizontal and vertical growth than so-called “formal” cities (ARRETCHE, 2015).

Land use and occupational planning marked by socio-spatial segregation and environmental injustice have (re)produced areas with urban socio-environmental risks (SOUZA, 2019). These risks relate to the overlapping phenomena of natural and social contingencies that can destabilize the living conditions of urban societies and exacerbate natural (environmental) and social (cultural, political, economic, and technological) elements and factors (MENDONÇA, 2011). Therefore, problems that could be avoided, neutralized, or reduced tend to result in catastrophes and/or disasters. The construction of houses on slopes and along the edges of waterways creates areas where residents are at risk of experiencing landslides and floods, reflecting a disorderly, exclusivist, and segregationist pattern of land use.

A population’s degree of socioeconomic vulnerability is usually associated with differential exposure to risks and indicates the greater or lesser exposure of people, places, infrastructure, and/or ecosystems to some specific type of risk factor, leading to an uneven distribution of risks that are both social and spatial (CANIL, LAMPIS, and SANTOS, 2020). This leads to a discussion of the theme of environmental justice (ACSELRAD, 2002) as an approach that raises questions about the need to advance public policies focused on making cities not only better-prepared for various types of disasters but on reorienting the way that cities are being (re)produced, a factor essential to increasing their resilience. This is especially true in the context of climate change and the ensuing severe-weather events that tend to disproportionately affect the most vulnerable populations (LAMPIS et al., 2020). This issue demands that the population of an area become more aware of the risks to which it is exposed and that awareness of them be integrated into planning and decision-making processes.

Thus, the management of socio-environmental risks increasingly requires expanded public involvement through initiatives that enable an increase in the population’s level of environmental awareness and action and involve an intellectual exercise comprising social learning based on dialogue and interaction coupled with a constant process of recreation and reinterpretation of information, concepts, and meanings. This process originates with learning through training and education courses that improve the practices of civil society and the public authorities from the perspective of cooperation between the actors involved (SULAIMAN and JACOBI, 2018).

To facilitate an analysis of these issues, this paper is divided into three interconnected parts based on various viewpoints of the social construction of risk and environmental justice. It includes a territorial profile of the MMP, revealing a territory with intrinsic contradictions regarding the process of the financing of space, inequality, and social vulnerability. The first part concerns the conceptual debate proposed by the contemporary discussion on risks and vulnerabilities. The second part is meant to connect the dynamics presented in the first section to the territory under analysis. In this sense, we

attempt to characterize the macrometropolitan region based on the Macrometropolis Action Plan (PAM), its main planning and governance instrument and the place where one can identify the state's vision for the territory.

As an illustrative element in exposing and analyzing the social vulnerabilities of the MMP, we present the distortions proposed in the PAM to address social issues and regional inequalities as well as the key, defining theme of the extreme inequity that exists in terms of access to water and sanitation in the region. The article does not take the question of water and sanitation as its central theme but rather uses it to reinforce its argument about the social production of vulnerabilities, risks, and disasters and its conceptual intertwining with the notion of "environmental justice."

The third, and last, part presents a characterization of susceptibility to landslides and vulnerability in the territory of the MMP considering the geotechnical maps of susceptibility, urban capacity, and risk. What is observed in general and confirmed by the research on the MMP is that local governments that promote sustainable and inclusive actions, based on premises that support innovation over repeated ideas, become examples of how cities can face strategic issues with local sustainability and resolve social inequalities. The challenges for these actors in articulating processes that generate decisions within a complex context are multiple and are strongly associated with the need to provide visibility and transparency and to bring actors closer to addressing the questions posed by contemporary risks in society.

SOCIAL CONSTRUCTION OF RISK

The increase in inequality and socio-spatial segregation has been marked by the expansion of urban areas subject to the occurrence of natural events (landslides, floods, storms, etc.) and has consequently led to environmental degradation, forming new territories of vulnerability and risk (CANIL et al., 2019). Natural phenomena have always been considered the "villains" of risk and disaster situations, but, from the mid-1980s onward, a theoretical-methodological approach that sought to place the focus on risks and disasters (natural and technological) from the point of view of not only the physical triggering factors, but also the elements at risk, i.e., the population or society exposed to these processes, has been implemented (ALMEIDA, 2011).

This perspective gained influence with the international conferences on the theme hosted by Japan. At the 1st World Conference (1994), the Yokohama Strategy and Plan of Action for a Safer World was presented, calling into question the predominantly technical, scientific approach and proposing to address the vulnerabilities and risk factors of the population concerned. The 2nd World Conference (2005) resulted in the following outcomes of the Hyogo Framework for Action 2005-2015: increasing the resilience of nations and communities and making evident the need to support the capacity of populations to adapt to disasters and increase the resilience of governments and local communities. The 3rd World Conference (2015) culminated in the development of the Sendai Framework for Disaster Risk Reduction 2015-2030 and put the perspective of governance and political participation by society on the agenda (SULAIMAN, 2018).

An increase in the occurrence of disasters, the outbreak of the environmental crisis, and a gradual improvement in living conditions contributed to the deconstruction of the belief that technical-scientific development would automatically enable the construction of a safe society, completely immune to such risks (SANTOS, 2015). Thus, risks are considered intrinsically connected to the predatory actions that a contemporary society performs within its territory.

According to Santos (2015), risks are part of a process of social construction, since they are produced by the actions of a society, and it is there that they can be observed. Risks are felt by individuals, and, when they manifest themselves, can cause damage to people, property, structures, and the organization of a territory. The perception, knowledge, and consideration of risk can vary depending on a population's culture, the level of economic development of an area, and even the social group involved. In an official document from the Ministry of Cities (BRASIL, 2007, p.26), a "risk area" is understood to be:

> an area liable to be affected by natural and/or induced phenomena or processes that cause an adverse effect.

> People living in these areas are subject to damage to their physical integrity, and to material and property losses. Normally, in the context of Brazilian cities, these areas correspond to low-income housing units (precarious settlements).

Therefore, urban socio-environmental vulnerability is directly associated with risk and is linked to a series of social, political, economic, cultural, and technological contingencies that explain various conditions of the exposure and vulnerability of social groups to risks. In other words, urban socio-environmental vulnerability shows the heterogeneity of impacts arising from the risks that affect a given population in which both urban risk and vulnerability form a highly complex area for urban understanding and management (MENDONÇA, 2011).

It is precisely the degree of vulnerability of the affected social groups that determines their capacity for reconstruction after the occurrence of a disaster, which, in a way, reflects the socioeconomic conditions of the population and its socio-spatial relationships (SANTOS, 2015). Therefore, a society's level of risk exposure and responsiveness are directly connected to the socioeconomic conditions of the affected social groups.

The current hegemonic view of contemporary risks, whether coming from the media, "common sense," or academia (BOURDIEU, 2001; BECK, 1992), in a context of climatic variability and its interface with environmental inequalities (ACSELRAD, 2002), must be problematized and given visibility in terms of environmental justice. Thus, Acselrad (2009) explained that it is the poorest populations that are the most prone to environmental risks and that the

> disproportionate imposition of environmental risks on populations less endowed with financial, political and information resources, can be described as environmental injustice. As a counterpoint, the notion of Environmental Justice was coined (ACSELRAD, 2009, p.17).

In this context, the concept of systemic risk--the risk to which all social groups are prone--is differentiated from the risks of socio-natural disasters, whose impact specifically falls mostly on vulnerable socioeconomic/sociodemographic groups. This process occurs due to a decision-making process that shifts the risk from the most privileged groups/regions to the most vulnerable ones and can, over time, shift the environmental impact to future generations (SULAIMAN and ALEDO, 2016). Thus, through the decisions of the elites, whether in planning or urban investment, an uneven distribution of risk is perceived in different territories.

As stated by Acselrad (2002), in addition to questioning the unequal distribution of the effects of environmental risks, another collective action against socio-environmental injustices occurs at the level of discourse. There is a discourse on the legitimacy of the unequal distribution of environmental resources that is being contested by the social movements fighting against environmental injustice, "evidencing the social logic that associates the dynamics of capitalist accumulation with the discriminatory distribution of environmental risks" (ACSELRAD, 2002, p.52).

When the concept of environmental injustice is associated with the issue of climate change in urban areas, it occurs in the context of scenarios involving severe climatic situations in which people in precarious settlements are subjected to the negative impacts of dangerous events, such as floods and landslides. It is within this context that it is necessary to democratize not only technoscientific knowledge, but also decision-making processes, and integrate them into the sphere of urban planning (JACOBI and SULAIMAN, 2016).

In the context of the notion of a territory as an area of power disputes and, therefore, conflicts, vulnerability must be seen as a historical construction or process. In this sense, the vulnerability of a territory is defined not only by technical data on infrastructure (or the absence of it), by the means of calculating risks, or by an unfortunate circumstance to which a location is susceptible, but by the set of factors, within a historical context, that have established the specific conditions determining whether a locality exhibits social injustice and possesses natural resources of interest in the appropriation and reproduction of capital, and, at the same time, can serve it with a minimum infrastructure for the operation of this engineering.

In addition to examining the vulnerability of groups of individuals living in municipalities, it is

also necessary to reflect on the institutional fragility of smaller municipalities, which often do not have the means to implement risk-management policies on their own. Therefore, Nogueira, Oliveira, and Canil (2014) have argued for the consortium model of risk management, which was successful in the case of the São Paulo Greater ABC's (an industrial region in Greater São Paulo, Brazil) intermunicipal cooperation because it allows for smaller municipalities to communicate with more-qualified, better-equipped municipalities in the region, optimizing the acquisition of material, technical, human, and logistical resources at a regional level (without the need for this structure at the local level) and enabling the analysis of physical processes at the regional level. The Metropolitan Region of São Paulo (RMSP) has other partnerships, but it is still in the process of forming and consolidating them to approach a structure similar to that of the ABC, namely, the Intermunicipal Consortium of Municipalities in the Juqueri Basin (CIMBAJU); Development Consortium of Alto Tietê Municipalities (CONDEMAT); and Intermunicipal Consortium of the Western Metropolitan Region of São Paulo (CIOESTE).

ENVIRONMENTAL INJUSTICE IN THE CONTEXT OF THE MMP

The São Paulo Macrometropolis is one of the largest urban agglomerations in the southern hemisphere. It includes the Metropolitan Region of São Paulo (RMSP) and those of Baixada Santista (RBS), Campinas (RMC), Sorocaba, and Vale do Paraíba and Litoral Norte (RMVPLN) and the urban agglomerations of Jundiaí (AUJ) and Piracicaba (AUP) as well as the Bragantina Regional Unit (URB), which has not yet been institutionalized (Figure 1).

Figure 1 - São Paulo Macrometropolis and its regions. Source: Adapted from IBGE, 2015 and IGC, 2016.

According to data from the Paulista Metropolitan Planning Company SA (EMPLASA), which recently became defunct (under Law No. 17.056/2019), the MMP occupies an area of 3.4 thousand km2 (21.5% of the State of São Paulo), with a concentration of high-tech industries, diversified trade sectors,

complex services, and productive agribusinesses. It includes important ports (such as the Port of Santos, which saw 29% of the country's export and import movement in 2019) and airports (such as Guarulhos International Airport, which saw 42 million passengers in 2019), large road systems, and prominent knowledge and innovation centers.[1] It includes 174 municipalities (50% of the state's urban areas) and generated 81.9% of the state's GDP in 2016. It accounted for 74.7% of the state's population in 2018 and 2.68 million people in subnormal settlements (2010 Census). In addition, it represented 20% of the protected natural heritage areas of the state. The socioeconomic importance of the region has grown exponentially, as have the social disparities evident in it and the uneven distribution of risks and environmental injustices that we will address in this paper.

Since the formation of the MMP (TAVARES, 2018), the official narrative of the government of São Paulo has reinforced the idea that the creation of this city-region (LENCIONI, 2015; FREY, 2019; TORRES, RAMOS, and POLLACHI, 2020), because of its unique characteristics from the point of view of its borders and size, can resolve regional distortions, especially outside the hubs of São Paulo, Campinas, São José dos Campos, and Santos.

This preoccupation was recorded in the planning instrument published in 2014 by EMPLASA: the São Paulo Macrometropolis Action Plan (PAM) (2013-2040), which has served as a guide for planning and governance in the region. However, the plan itself (EMPLASA, 2014), structured around prioritized axes and a business portfolio, appears to contain contradictions that become evident if we critically analyze the planned projects. The projects reinforce the development of the existing axes-poles, not the polycentric development of the other regions, agglomerations, and micro-regions.

Table 1 contains the details of the projects prioritized by the MMP, separating them by the axes proposed by the state government. The maintenance of inequalities in investments and priorities by region, as well as the fact that the RMSP has established itself as a radiating axis for attracting and circulating capital within the territory, is evident.

Development Vector	Number of projects	Area of influence	Estimated investment in millions of reais - BRL (R $)			
			2025	2035	2040	Total
RMSP	13 projects	RMSP	68,930.0	97,340.0	3,800.0	170,070.0
Bandeirantes	10 projects	Covers the connection between São Paulo/Jundiaí/Campinas/Rio Claro/Piracicaba.	14,001.3	10,016.7	-	24,018.0
Vale do Paraíba	13 projects	Covers the connection between São Paulo/São José dos Campos/Taubaté.	7,419.3	9,416.7	250.0	17,086.0
Caminho do Mar	11 projects	Covers the connections between the logistics centers, roads, and transposition modes of the Serra do Mar for cargo and passengers directed towards the Port of Santos.	3,188.0	13,016.7	-	16,204.7
Sorocaba	9 projects	Covers the region to the west of the MMP along the Castelo Branco and Raposo Tavares axis.	8,115.3	7,556.7	-	15,672.0
Perimeter of the MMP	10 projects	Covers a territorial strip formed from the Port of São Sebastião/São José dos Campos/Jacareí/Campinas and Sorocaba.	7,228.0	3,727.0	-	10,955.0
Total	**66 projects**	-	**108,881.9**	**141,073.8**	**4,050.0**	**254,005.7**

Table 1 - Quantity of projects and estimated investment (in millions of reais) by territorial vector of the São Paulo Macrometropolis. Source: PAM Project Portfolio, EMPLASA, 2014. Adapted from Torres, Ramos, and Pollachi, 2020.

The proposed regional development, which is directly linked to transport and logistics projects, is

presented in the PAM without problematizing its objectives, impacts, or alternatives or even reflecting on how these projects would, in fact, resolve the regional distortions and enormous contrasts in the MMP (TRAVASSOS, MOMM, and TORRES, 2019). If, on the one hand, the region produced approximately 82% of the state's GDP (EMPLASA, 2016) on 21.5% (53.4 thousand km2) of its area, on the other hand, the remaining 78.5% of the territory would only produce 18% of the GDP, representing an extremely low per capita contribution and showing the fragmentation, heterogeneity, and inequality characteristic of the MMP (TRAVASSOS et al., 2020).

Another contrast, which appears perverse from the point of view of public health and quality of life, is reflected in the unequal distribution of urban socio-environmental risks and can be seen in the public water supply and sewage treatment indexes of the territory. The service access index for the public water supply, when considering the entire territory of the MMP, is considered good, with 90% service coverage in all metropolitan regions. For sewage collection, the overall rate is 86%; however, for the treatment of the collected sewage, the rates are quite low, reaching only 31% (EMPLASA, 2014, p.201). When examining the specific water supply and sewage-collection/treatment indexes, observing the service rates by municipality and the metropolitan region, there are wide gaps in the sanitation infrastructure in the cities that comprise the macrometropolitan territory, especially in relation to these services.

WATER-SUPPLY AND SEWAGE COLLECTION/TREATMENT INDEXES OF THE MR AND UA IN THE SÂO PAULO MACROMETROPOLIS (2018)

Metropolitan Region or Urban Agglomeration	Urban Water Service Index below 90%	Sewage Collection Index below 50%	Total Absence of Sewage Treatment	Municipalities Without Information
UA of Jundiaí, including 7 municipalities	Campo Limpo Paulista (79.4%); Jarinu (85.2%); Cabreúva (87.2%)	Jarinu (30.6%)	-	-
UA of Piracicaba, including 23 municipalities	-	-	Araras; Cordeirópolis; Rafard; Rio das Pedras	Analândia
MR of Baixada Santista, including 9 municipalities	Bertioga (74.4%); Guarujá (82.4%); Cubatão (85.4%)	-	-	-
MR of Campinas, including 20 municipalities	-	-	Cosmópolis	-
MR of São Paulo, including 39 municipalities	São Lourenço da Serra (52.8%); Juquitiba (57.6%); Mairiporã (62.6%); Biritiba Mirim (64.5%); Pirapora do Bom Jesus (82.4%); Santa Isabel (83.1%); Guararema (83.9%); Rio Grande da Serra (84.9%); Embu-Guaçu (86%)	Vargem Grande Paulista (25.5%); Itapecerica da Serra (27.4%); Santana de Parnaíba (32.5%); Mairiporã (33.2%); Juquitiba (34.1%); Francisco Morato (35%); Cotia (37.4%); Embu-Guaçu (37.8%); Pirapora do Bom Jesus (49.2%); Arujá (49.4%)	Caieiras; Cajamar; Francisco Morato; Franco da Rocha	-
MR of Sorocaba, including 27 municipalities	Araçariguama (60.3%); São Roque (74.4%); Aluminum (84.8%); Boituva (89.4%)	Araçoiaba da Serra (33.2%); Ibiúna (36.1%)	Mairinque; Sarapui	-
MR of Vale do Paraíba and Litoral Norte, including 39 municipalities	Campos do Jordão (65.2%); Ilhabela (69.2%); Igaratá (70.5%); Santa Branca (72.7%); São Sebastião (74.5%); Ubatuba (75.9%); Redenção da Serra (81%); Caraguatatuba (83.8%)	Areias (18.3%); Ubatuba (39.5%); Cunha (40.5%); Igaratá (44.6%)	Aparecida; Areias; Cruzeiro; Paraibuna; Piquete; Potim; São José do Barreiro	-

Table 2 - Municipalities with low water-supply access and sewage collection/treatment rates in the metropolitan areas of São Paulo, Baixada Santista, Campinas, Sorocaba, and Vale do Paraíba and Litoral Norte as well as the urban agglomerations (UA) of Jundiaí and Piracicaba. Source: Ministry of Regional Development, National Sanitation Information System – SNIS, 2020. Compiled by the authors.

Providing an illustration of the inequalities in the coverage of basic sanitation services in the MMP, Table 2 shows the lowest rates of water-supply access and sewage collection/treatment among the municipalities of the São Paulo metropolitan region, Baixada Santista, Campinas, Sorocaba, and Vale do Paraíba and Litoral Norte as well as the urban agglomerations of Jundiaí and Piracicaba.

Regarding public water-supply access, even though the overall MMP rate is around 90%, there are cities with a much lower coverage rate. For sewage collection, although there are locations with an index of 100%, in some municipalities, the rate is quite low, as in the case of São Lourenço da Serra, with 51% coverage; Juquitiba, with 59.4%; Itanhaém, with 30%; Itapecerica da Serra, with 18%; and Vargem Grande Paulista, with 24%. Regarding sewage treatment, the overall MMP sewage-treatment index is considered poor. For example, the RMSP treats 53.1% of its sewage, and the RMBS only treats 16.4% (EMPLASA, 2014, p.201). There are also some MMP cities that do not have any type of sewage treatment, such as Caieiras, Franco da Rocha, Praia Grande, and Santos.

The continuous release of wastewater directly onto slopes or through leaks from cesspools, besides causing health risks and other negative environmental impacts, is an important indicator of, and contributor to, the prevalence of landslides in areas with precarious settlements. Such situations are evidenced in the various mappings of risks and municipal risk-reduction plans prepared for municipalities in the RMSP, such as Franco da Rocha.

Figure 2 - (Left) Release of wastewater and rainwater on a hillside – Vila Josefina, Franco da Rocha. Source: LabGRis, 2018. (Right) Poor wastewater collection infrastructure – Vila Josefina, Franco da Rocha. Source: LabGRis, 2018.

SUSCEPTIBILITY TO LANDSLIDES AND VULNERABILITY IN THE MMP TERRITORY

Law No. 12.608/2012 of the National Civil Protection and Defense Policy includes a set of instruments and mechanisms for planning and territorial organization, requiring municipalities to adopt a series of measures to protect their inhabitants and infrastructure, with support from geotechnical charts with various scales and objectives.

In general, the term “geotechnical cartography” can be conceptualized as the cartographic representation of the characteristics of the physical environment (soil, relief patterns, and rock) in an integrated manner. It also includes the associated geological-geomorphological and hydrological processes, such as erosion, landslides, floods, and collapses, among others, and the various behaviors of the land in relation to the types of interventions and land-use and occupation patterns. Thus, to comply with Law No. 12.608/2012, three types of geotechnical maps are considered in assessing risks (BITTAR, 2014; SOUZA and SOBREIRA, 2014; CANIL et al., 2018):

A “susceptibility map” that shows the degree of susceptibility of the terrain (high, medium, or low) to geodynamic processes (mass gravitational movements, such as landslides and related processes) and hydrodynamics (inundations and floods) on a scale of 1:25,000;

An “urbanization capacity map” that explains the potential uses and limitations of land given the occurrence of geodynamic and hydrodynamic processes and indicates guidelines for safely constructing settlements on a scale of 1:10,000; and

A “risk map” that represents the sectorization of the degree of risk (very high, high, medium, or low) considering the occurrence of geodynamic processes on a scale greater than 1:2,000 (detail scale).

Due to the size of the MMP, we will present a reading of the integration of various maps showing susceptibility to the landslide processes that have affected the municipalities. These were mapped based on cooperative work between the Geological Service of Brazil (CPRM) and the Institute of Technological Research of the State of São Paulo (IPT), and the work was carried out from 2013 to 2018 (MOURA, CANIL, and SULAIMAN, 2019). In this work, susceptibility maps were prepared individually for each municipality; however, spatial data were available on the CPRM website[3], which enabled the integration of information.

Furthermore, susceptibility maps present, through the integration of various physical environmental conditions, a municipality’s degree of susceptibility to landslides and their related processes and to inundations and floods. Of the 157 susceptibility maps from the State of São Paulo, 125 correspond to municipalities in the MMP. When assessing risks, susceptibility maps indicate a fundamental issue, threat/danger, which can be translated as the probability of a given phenomenon occurring in an area.

Figure 4 shows the integration of the susceptibility maps indicating areas of low, medium, and high susceptibility; from it, it is possible to observe that areas of high susceptibility to landslides and their related processes are present in a strip that extends from the north of the municipalities in the RMSP (Serra da Cantareira) to the limits of Serra da Mantiqueira, which includes municipalities in part of the Vale do Paraíba region.

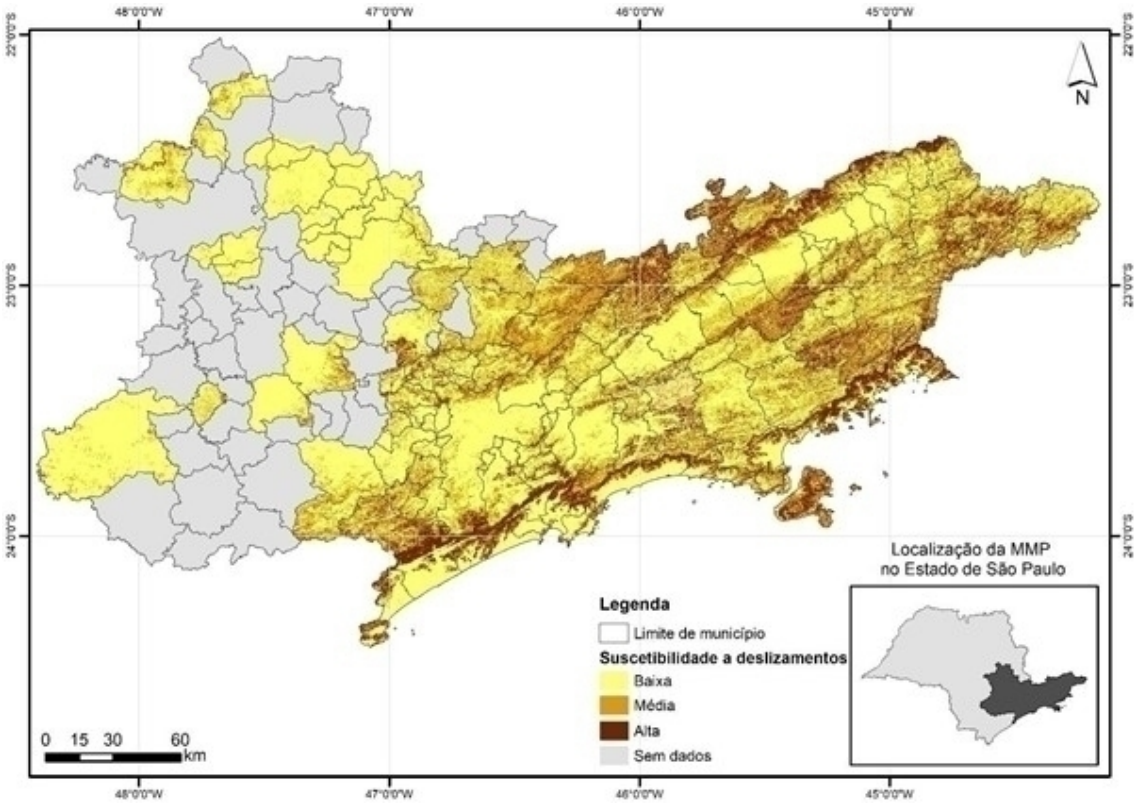

Figure 3 - Map of susceptibility to geodynamic processes (landslides and related processes) for the MMP. Source: Adapted from the CPRM and IPT, 2014 and 2015.

To the south, a significant part of the stretch that limits the plateau region and the coast (south and north) by the Serra do Mar, including the municipalities of the Baixada Santista (Santos, São Vicente,

Cubatão, and Guarujá) and the Litoral Norte (São Sebastião, Ilhabela, Caraguatatuba, and Ubatuba), falls into the high-susceptibility class, with an elevated potential for experiencing risk-generating situations.

In addition to this aspect of the susceptibility analysis, there are other factors that can lead to the discovery of high-risk areas in terms of vulnerability on another dimension and scale of analysis. Thus, it is understood that the "vulnerability" component of the social, economic, and environmental conditions of land use and occupation defines risk as a factor of social construction. Vulnerability influences the socioeconomic losses related to the consequences of a disaster; this is the factor associated with the selective severity of the negative impact of such processes on the population and the amount of infrastructure exposed to the risk. Thus, it is necessary to go beyond the discussion of the areas exposed to threats (susceptibility) when guiding regional risk-management policies, assessing the weaknesses and fragility (vulnerability) of the people and communities that are exposed to physical environmental processes that can intensify such vulnerabilities.

The São Paulo Social Vulnerability Index (IPVS) assesses a territory's spatial vulnerability based on socioeconomic and demographic data from the 2010 Census. Given its scope, this instrument can be used to obtain a regional reading in the sense that it can spatially depict the areas of greatest social vulnerability in the MMP and offer a means of providing support to decision-makers in implementing integrated public policies; considering risk, housing, and social development; and prioritizing the areas of risk that, perversely, tend to accumulate in precarious settlements (MOURA, CANIL, and SULAIMAN, 2019).

Through a combination of variables, both socioeconomic and demographic, the IPVS classifies social vulnerability into seven groups (Table 3). It even considers the type of location (urban/rural) and the form of territorial occupation (precarious/ normal/non-precarious settlements). The socioeconomic condition of an area is translated into high, medium, and low categories, and family composition, understood as a demographic factor, is divided into elderly, adult, and/or young categories (SOUZA, OLIVEIRA, and MINERVINO, 2013).

DETAILS OF THE SÃO PAULO SOCIAL VULNERABILITY INDEX		
Vulnerability Classification	**Vulnerability Dimensions and Variables**	
Groups	Socioeconomic	Demographic
1 - Extremely low vulnerability; 2 - Very low vulnerability; 3 - Low vulnerability; 4 - Medium vulnerability; 5 - High vulnerability (urban); 6 - Very high vulnerability (subnormal clusters); 7 - High vulnerability (rural).	- Per capita household income; - Average income of the female head of household; -% of households with per capita household income up to 1/2 of the minimum wage; -% of households with per capita household income up to 1/4 of the minimum wage; -% of literate heads of household.	- % of heads of household aged between 10 and 29 years; - % of heads of household who are women and aged between 10 and 29 years; - Average age of heads of household; - % of children between 0 and 5 years of age.

Table 3 - Components of the São Paulo Social Vulnerability Index. Source: Adapted from the SEADE (2013). Compiled by the authors.

The number of classes of social vulnerability is determined by the census data, according to widely varied dimensions (from a single condominium to an area of a few kilometers), which on the macrometropolitan scale, presents a challenge for representation and interpretation. Thus, it was decided to aggregate specific groups based on a reinterpretation of the data and considering the original composition of the IPVS proposed by Souza, Oliveira, and Minervino (2013), who were also the authors of the IPVS. Thus, the Social Vulnerability Map for the MMP (Figure 5) was composed of the following classes:

Low (Groups 1, 2, and 3): Medium to very-high socioeconomic status; young, adult, and/or elderly families;

Medium (Group 4): Low socioeconomic status; adult and elderly families;

High (Groups 5, 6 and 7): Low socioeconomic status; young families in urban areas and precarious settlements and young, adult, and elderly families in rural areas.

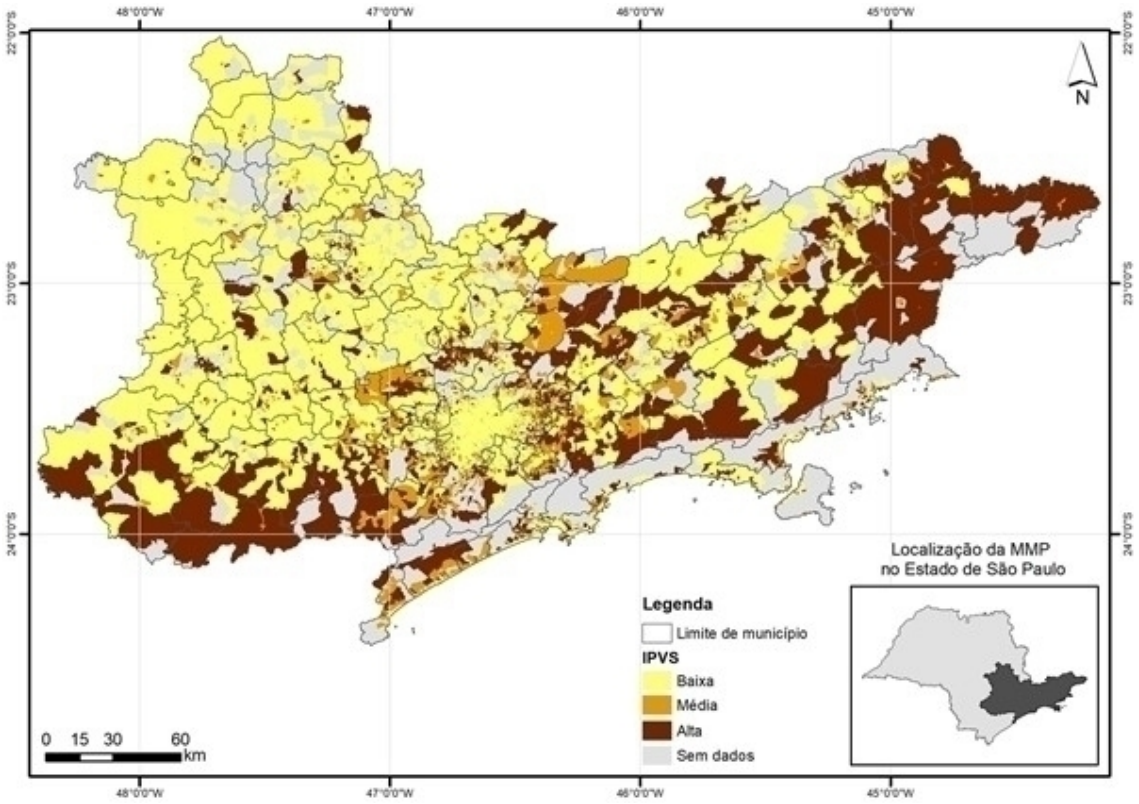

Figure 4 - Social Vulnerability Map for the MMP. Source: Adapted from the IPVS, 2010. (MOURA, CANIL, and SULAIMAN, 2019).

The highest vulnerability indexes are concentrated in the municipalities to the south of the region of Sorocaba in the municipalities of the region of Vale do Paraíba (bordering the Planalto Atlântico), Vale Histórico, and the municipalities bordering the State of Rio de Janeiro. Areas with a medium vulnerability index predominate in the peripheral municipalities of the RMSP, indicating a context of urban segregation, where the most socially vulnerable populations are distant from the center.

It should be noted that the two aforementioned instruments, susceptibility maps and the IPVS, when applied to the MMP, (home to 174 municipalities and 33 million people) and when correlated and considered in addition to other aspects, can guide the prioritization of risk-management actions related to socio-environmental issues. These tools display the need for political articulation and governance between municipalities and metropolitan regions to address this issue. In this way, they can be used to address the situations that lead to the formation of high-risk areas through interventions to improve living conditions and security, especially in peripheral territories.

The application of these mappings must, above all, be integrated into the context of efforts to address other infrastructure deficiencies, such as issues with the water supply and sewage treatment, as we have previously mentioned, as these factors are also involved in the socio-environmental risks in the territory. Most of these scenarios show that such issues are largely inseparable, and their effective treatment depends on implementing integrated interventions and addressing technical, urban, legislative, and community-related questions.

CONCLUSION

By integrating the reading of maps of the areas susceptible to geodynamic processes (landslides and related issues) with those of social vulnerability and analyzing various aspects of sanitation (rates of

water-supply access and sewage collection/treatment), we observed that the areas where precarious infrastructure related to water and sewage predominates correspond to those of the greatest environmental vulnerability. The susceptibility component indicates the probability of a phenomenon occurring within a specific territory, and, although the area is predominantly classified as medium-risk, the external factors that lead to precariousness, inequality, and socio-spatial segregation can create areas with high-risk tendencies.

In the context of the MMP, vulnerability is extremely evident when addressing the peripheral territories, which, from the perspective of the physical environment, are more fragile and susceptible to processes like landslides and floods. From an environmental perspective, we are responsible for the maintenance of ecosystem services, guided by environmental-protection laws, which leads to a conflict between the need for environmental protection and the population's right to housing and use of the city's amenities.

Understanding risk as a social construction linked to a process of environmental injustice and socio-spatial segregation is a fundamental premise for local and regional diagnosis of such issues, especially in view of the territorial complexity of the MMP. Understanding the concept of risk from this perspective also aids in the articulation of issues related to the design of territorial planning, urban development, health policies, the environment, climate change, water-resource management, geology, infrastructure, education, science, and technology, all with the purpose of promoting sustainable development, as provided for in Art. 3 of Law No. 12.608/2012.

Thus, many municipalities must be considered in relation to various socio-environmental risks, and, in order to mitigate them, actions must be taken at the local level (dealing with unsafe housing conditions and precarious settlements in areas at risk of landslides and floods) and at the regional level (in consideration of the role of planning as fundamental to solving the mapped problems). This is the key to building a public-policy agenda for effective governance and risk-management. The dissolution of the EMPLASA, as well as the approval of the new regulatory framework for sanitation (Law No. 14.026 of July 15, 2020), leaves the direction and the complex problems pointed out in this paper in an even more uncertain position. Thus, it will become even more imperative to encourage participatory processes and active citizenship, aiming at constructing territories that are more resilient to the effects of climate change that affect the area's most vulnerable populations most severely.

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NOTE

1- For more data on ports, see "Waterway Statistics," available at: http://web.antaq.gov.br/ANUARIO/ and accessed on August 31, 2020. For more data on the Guarulhos airport, see , which was accessed on August 31, 2020.

2- According to the PAM, a water-supply index above 90% is considered "good"; between 50% and 90% "regular"; and under 50% "poor." For sewage collection, over 90% is considered "good"; between 50% and 90%, "bad"; and under 50%, "very bad" (EMPLASA, 2014). Compiled by the authors.

3- http://www.cprm.gov.br/publique/Gestao-Territorial/Prevencao-de-Desastres/Produtos-por-Estado---Cartas-de-Suscetibilidade-a-Movimentos-Gravitacionais-de-Massa-e-Inundacoes-5384.html

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