



Socio-environmental Vulnerability: Municipality of Três Rios/RJ

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ABSTRACT

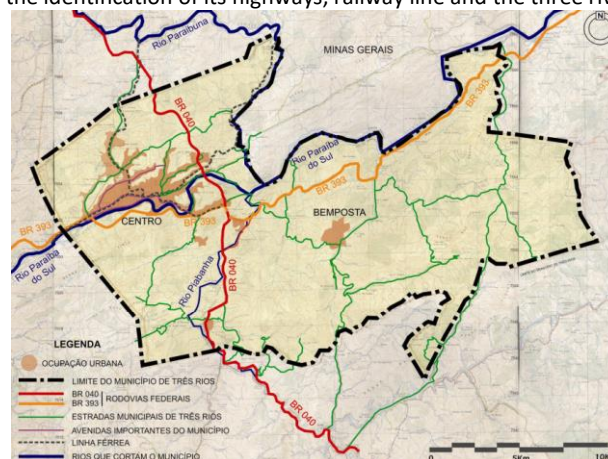
The dominance of natural space directly affects everyday life: the search for economic growth is a double-edged sword, on the one hand it offers opportunities, on the other it shows perversion... floods, landslides, violence, segregation¹. How to identify the criticality of a place? And its support capacity? The relationship between the two requires interdisciplinary studies, in order to understand the levels of socio-environmental vulnerability that a place may be subjected to, the basis of this research in the development of the concept of vulnerability of the place, worked from the analysis of demographic, morphological, cultural characteristics, resources available resources and infrastructure in Três Rios, a city in the interior of the State of Rio de Janeiro. To this end, studies were developed on the process of formation, organization and evolution of the city and the production of georeferenced cartography to support studies of soil, water bodies and their relationship with the urban fabric. Thus, arriving at indications of urban improvements.

KEYWORDS: Três Rios/RJ. Socio-environmental vulnerability. Criticality. Supportability. Slips. Floods.

1. INTRODUCTION

The city of Três Rios, located in the Central-South Fluminense region of the state of Rio de Janeiro, has been marked since its foundation by a junction character. In 1867, its lands were crossed by the D. Pedro II Railway, and traces of that time still permeate its urban fabric. The Centro-Leste and MRS railways continue to cross the city, which in turn is crossed by major roads, such as BR-393 and BR-040, facilitating access to significant commercial centers and establishing itself as one of the most significantly road-rail junctions in Brazil, as evidenced in the map in Figure 1.

Figure 1 - Três Rios and the identification of its highways, railway line and the three rivers that cross the region.



Source: The author, 2021.

The region initially designated as Entre Rios received its name due to its location at the confluence of three significant rivers in the area: Paraíba, Paraíba do Sul and Paraíba do Norte, which, when they meet, form a rare triple river delta (Figure 1).

¹ To find out more: https://www.scielo.br/scielo.php?script=sci_arttext&pid=S0100-19651997000300006

The Estrada de Ferro D. Pedro II, a railway of great importance in the 19th century, established the connection between Rio de Janeiro and Minas Gerais. Initially used to transport coffee production, the railway became vital for the transport of industrial inputs and products. Its expansion enabled the interconnection of several regions of Brazil, including São Paulo, Bahia and Pernambuco.

The connections contributed to the industrial growth of the region, attracting factories. The presence of the renowned Fábrica Santa Matilde stands out, specializing in wagons and railway components. This contributed to the development of a strong commercial center and an industry-oriented economy.

The economic crisis of the 1980s led to industrial decline, including the bankruptcy of Fábrica Santa Matilde. The closure of other businesses contributed to the recession. The city sought to recover its industrial park with tax incentives and strategic location. Industrial revitalization and tax incentives associated with the city's privileged location were able to revitalize the industrial sector and make it attractive to workers and companies.

The Sustainable Development Goals (SDGs) defined by the UN (UN, 2015) and propose to its member countries that they establish a new agenda, the 2030 Agenda, which deals with actions for sustainable development over the next 15 years. The 17 objectives also address social issues; however, in this observed scenario, two objectives that were not directly met can be identified. They are Goal 6, which aims to ensure the availability and sustainable management of water and sanitation for everyone, and Goal 11, which seeks to make cities and human settlements inclusive, safe, resilient and sustainable.

Reflections based on a reading of the morphology of Três Rios, which outlined the urban conformations or natural transformations, indicate that these may be contributing to the increase in environmental problems in the city. Therefore, the objective here is to draw an overview of the socio-environmental vulnerability observed today in the city of Três Rios, by surveying the formation and expansion of the city and mapping areas of greater vulnerability to disasters.

Given the situation of constant alert, there are signs that the Trirriense population is being increasingly exposed to different risks, whether geotechnical, environmental or arising from underserved urban growth. This scenario has already led to public petitions such as that from Camilla Pecene de Lima André ²to A PCON-Desastres (Disaster Knowledge Platform) ³, under the prerogative of a municipal risk reduction plan: "the city is divided by the rain, we need an overflow canal, according to city hall publications. The municipality does not have a project, the works secretary told me that they do not have a technical team to develop this project" (PECENE, 2021).

²Trirriense, teacher at the Três Rios municipal school system. Available at: https://www.pcon-desastres.poli.ufrj.br/map_pins/camilla-pecene-de-lima-andre/ and <https://www.diariocidade.com/rj/tres-rios/eleicoes/2020/candidates/councilman/camilla-andre-22122/>. Accessed 05/2021.

³It is a platform linked to UFRJ that, in its words, aims to facilitate the integration of efforts between public authorities, teaching/research institutions, community organizations, other institutions and individuals who work or are interested in topics related to disasters. To find out more: <https://www.pcon-desastres.poli.ufrj.br/sobre-o-projeto/>

The search for understanding events of this type led organizations such as the UN (United Nations) to create centers such as UNDRO ⁴(United Nations Coordination Agency for Disaster Relief, 1971) and OCHA ⁵(Office of Coordination of Disaster Relief Humanitarians, 1998), to understand, monitor and face calamity situations. The first is based on a method of prevention and preparation for disasters, the second takes care of different humanitarian emergencies ⁶. To deal with these issues, UNDRO recommends: identifying and analyzing risks to generate prevention measures, planning for emergencies, public information on the topic and training ⁷.

The 1st World Conference on Natural Disaster Reduction took place in 1994, in Yokohama, Japan, and was marked by the call for a global policy on vulnerability. This was done by promoting the development of educational, awareness-raising, preventive, training and research strengthening strategies, in order to mobilize resources and reduce vulnerability ⁸.

2 THE PLACE

For a long time, it was nature that determined the routine: harvests, seasons, animal life cycle, sunrise and sunset. With the advent of technical development, man improved ways of using natural resources and expanded his demands regarding the way of living, triggering a growing process of consumption and protagonism of urban centers, much more in line with this new world, as Marc says. Augé (2010), with great contributions on the process of globalization and contemporary times: it is the world of circulation, excess, speed, it is the fetish of urban life, seen as the place of opportunities. But it also has another face, that of enclosure and segregation... thus having an intrinsic vulnerability. Through Marc Augé 's third paradox , one can see, among others, a great contradiction, there has never been so much traffic and for the same reason, so much closure, referring to the loneliness of urban life, the violence and diseases of the century, in full latency, during the Covid 19 pandemic.

The Brazilian rural-city migration process is a demonstration that the place of opportunities is not homogeneous. Second, Ermínia Maricato “at the end of the 20th century, the image of Brazilian cities was associated with violence, water and air pollution, helpless children, chaotic traffic, floods, among countless other evils.” (MARICATO, 2003). This character of social injustices related to urban growth in developing countries is also addressed by Giddens (2008) when pointing out that “Although all cities face environmental problems, those in developing countries face particularly severe risks (GIDDENS, 2008).

⁴In English : *United Nations Disaster Relief Organization*

⁵In English : *United Nations Office for the Coordination of Humanitarian Affairs.* (<https://www.unocha.org/>)

⁶Information based on Chapter II of the thesis *The United Nations and the Challenge of Humanitarian Interventions*, by Renata A. Giannini. Available at: https://repositorio.unesp.br/bitstream/handle/11449/96286/giannini_ra_me_mar.pdf?sequence=1. Accessed on 05/2021.

⁷Excerpt based on the document *Capacity Building in Mapping and Risk Management* from the Ministry of Cities. Available at: <http://www.defesacivil.mg.gov.br/>. Accessed on 05/2021.

⁸Excerpt based on the Nations website *Encyclopedia* . Available at: <https://www.nationsencyclopedia.com/United-Nations/Social-and-Humanitarian-Assistance-INTERNATIONAL-DISASTER-RELIEF.html#ixzz6uy1BCzlt>

For Abiko and Moraes (2009), the concentration of the population in urban areas interferes with the natural environment. This occurs mainly in three ways: "a) through the use of natural soil as urban soil, b) through the use, extraction and depletion of natural resources and c) through the disposal of urban waste". All related to this increase in demands, to wanting more. However, although disorderly urban growth brings with it a series of concerns, it alone does not explain vulnerability from the point of view that will be considered here. Urban centers are heterogeneous, the city is the sum of subjectivities, of realities that can be better understood not because of their similarity, but because of what makes them different (OJIMA, 2011). In other words, socio-environmental vulnerability is, above all, contextual; It is individual and, at the same time, collective. It's about the neighborhood and how each person experiences it.

This brings about the need to analyze Três Rios through its parts, their discrepancies, similarities, aggregations and segregations. Because it is not homogeneous, how many scenarios can it contain? Therefore, at first, it is possible to identify a contradiction between the city that is an example of management and development and that which sees countless residents suffering from exposure to various dangers. Regarding this dual and contradictory relationship of the place that grows economically and expands its weaknesses, Milton Santos (1997) explains:

Public investment can increase in a given region, at the same time that the flows of surplus value that it will allow will benefit some firms or people, which are not necessarily local. This contradiction between the flow of public investments and the flow of surplus value enshrines the possibility of seeing an increase in the regional supply of constant capital at the same time that local society is decapitalized. Likewise, environmental vulnerability can increase with local economic growth. (SANTOS, Milton. 1997. p. 202)

According to Milton Santos, the Gini index (Figure 2) is an indicator of social inequality based on income, which demonstrates that economic growth alone does not guarantee quality of life for the entire population. Furthermore, when concentrated, it becomes a great potentiator of vulnerabilities.

Figure 2 - Gini Index



Source: Unknown author.

The Gini index scale goes from 0-1, the closer to one, the greater the concentration of income, and the further away the Lorenz curve is from the diagonal of equality. In other words, if income grows and is not distributed, there is no effective improvement for everyone. Based on IBGE, the Brazilian Gini index for 2021 reached a record low, reaching 0.67, placing Brazil

among the countries most affected by income concentration in the world ⁹. This already places Três Rios in a position prone to inequality and, consequently, vulnerabilities.

Since income, in our current system, is strongly related to the support or response capacity that a person or groups can generate in the face of countless adversities and problems to which they may be subjected. Being able to pay more means living better, having better food, a higher quality of life and less exposure to risks. This condition encourages another component in this balance of vulnerabilities: segregation.

The right to safe housing and an effective response to disasters are guaranteed by law by the City Statute (Federal Law No. 10,257 of June 10, 2001), and its precariousness is one of the biggest indicators of social decay and promotion of inequalities (Maricato, 2003). Therefore, socio-environmental concerns end up reflecting (UNFPA, 2007) more the exclusionary development model based on the economic system than a direct relationship between high population densities and poverty, environmental degradation, etc.

As Rodrigues states: “the environmental issue must be understood as a product of society's intervention in nature. It concerns not only problems related to nature, but problems arising from social action.” (RODRIGUES, 1998)

As Brazil is severely marked by environmental disasters caused by human interference, as we will see in the panorama of Três Rios, the predominance of a policy of controlling nature is notable, generating urban fragility regarding its natural environment. This can be configured as part of a socio-environmental vulnerability scenario, when in a generalized way, according to Yunes and Szymanski (2001), susceptibility to disorder and stress is considered.

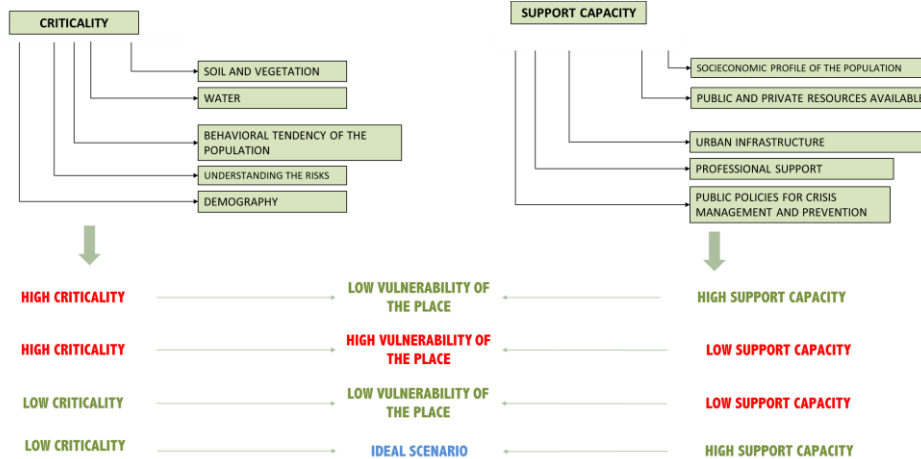
The Global Risks Report is an annually updated analysis of the biggest threats facing the world in the next decade. Presented at the World Economic Forum, it lists the ten largest in two categories, probability and impact. In its 2021 version, of the five most likely threats, four are environmental. And as for those with the greatest impact, natural disasters occupy fifth place.

A warning issue, especially in smaller cities (OJIMA, 2012), due to the lack of infrastructure and resources to respond and recover better. This can result in failures of essential services during calamities.

In short, the vulnerability of the place addressed in this work goes beyond the analysis of disaster probabilities. It is a multidimensional approach that considers social processes and urban morphology in the construction of place (MARANDOLA JR and HOGAN, 2006). The analysis relates local criticality to the capacity to respond to crises, considering land use, environmental conditions, demography, population behavior and risk perception. The carrying capacity, including public and private resources, such as infrastructure and disaster management policies, determines the vulnerability of Três Rios.

⁹www.redebrasilatual.com.br/economia

Figure 3 - Relationships for understanding the level of vulnerability of the place



Source: The author, 2021.

It is possible to affirm that in this work the vulnerability of the place is not restricted to a geotechnical analysis. The type of soil and the quality of water bodies are means of understanding the condition of life in cities and people's ability to resist, resist, and live in cities.

3 BETWEEN RIVERS AND THREE RIVERS

Despite the improvements and growth of the region, the current city only became a district of the municipality of Paraíba do Sul in 1890. Political independence was only achieved in 1938, when Entre Rios was dismembered, including the districts of Monte Serrat (currently Afonso Arinos), Areal and Bemposta . However, due to the existence of other Brazilian municipalities with the same name, the city began to be called Três Rios on December 31, 1943.

In 1946, the installation of Companhia Siderúrgica Nacional (CSN) in Volta Redonda marked the beginning of a new era for the region. In 1950, the Rio-Bahia Highway was inaugurated, also known as the Lúcio Meira section of BR 393, connecting Três Rios to Volta Redonda. A new highway cuts through the municipality and meets Estrada União Indústria, a segment of BR 040. These new highways and connections generated a significant change in the local economy, moving from a subsistence agricultural base to aligning with the Brazilian industrialization process . The city once again, as when the railway was installed, is linked to the transport of raw materials, goods and people, bringing enormous impacts on the landscape and urban life. This transformation took Três Rios from a city with a bucolic lifestyle to modernist progressivism.

The road-rail network boosted the region's industrial hub. The Companhia Industrial Santa Matilde factory, specializing in train cars, was opened in 1963. It expanded in the 1960s and 1970s, but suffered from the reduction in investment in the railway in the 1980s. The company began to disrespect labor rights , resulting in a strike in 1987. Trying to enter the automobile market, it launched a luxury car brand in 1978, but ended production in 1990 due to financial and competition problems. The weakening of the company brought a period of economic and social recession in the city.

The aura of crisis was not exclusive to Três Rios; All of Brazil was reaping the fruits of development plans. Thus, during the following years, the local Metalworkers' Union made numerous attempts to reactivate industrial production. With the weakening of the sector, several companies migrated to other urban centers, and the completion of BR-040 in 1985 generated more unemployment and the emptying of the city.

In one of these efforts, the industrial yard plant of the former Companhia Industrial Santa Matilde was rented by the company T'Trans in 1998. The arrival of T'Trans marks a new industrial market, before a career for the railways, now, with its increasing decadence puts emphasis on road transport. Since then, the place has received significant tax incentives, and several companies have started their activities on Trirriense land, creating industrial parks in different parts of the city. The map in Figure 4 allows us to understand the distribution of the city's main industrial points.

Figure 4 - Aerial view of the city's industrial clusters.



Source: Almeida, 2012.

In a second moment, it is observed, in addition to the occupations of the hills, that the terminal becomes secondary, beginning to demonstrate a lack of care. Now called Rodoviária Velha, it started to receive few bus lines until it closed its activities for renovation.

3.1 Master Plans and the City

The process of evolution of cities necessarily involves the creation of laws capable of acting in a way that guarantees citizens their rights and duties before the State. This action at the municipal level takes place through Master Plans (PDs), which determine restrictions for development, expanded by other complementary laws that must be in accordance with the City Statute (Federal Law nº 10,257, 2001). The city of Três Rios had its first urban plan promulgated on December 31, 1968, through Law No. 788. However, as it covers only 25% of the municipality, it is observed that the majority of the city grew without support of any kind. legal parameter until 1990 (year of its review). The new adjustments include guidelines on sewage, public sidewalks and private circulation. In this way, the city began to adopt legal measures consistent with an ideal of environmental preservation, in order to guide its growth. However, the 1990 Master Plan did not take into account popular participation and land occupation, resulting in little applied legislation. This reflects the Brazilian reality, with many irregular or subnormal housing.

In 2001, with the promulgation of the City Statute, Federal Law No. 10,257, the responsibility of city halls in the development of cities was emphasized. The Statute highlights the importance of democratic land management, which includes popular participation, fulfillment of the social function of the city and property, as well as ensuring safety and environmental sustainability, among other aspects. The 2006 PD addresses issues related to heritage, mobility, culture and sport for the first time, incorporating aspects of the new Statute. The 2013 PD, highlighted in Law No. 3,906, of October 2, 2013, recognizes the need to reduce the housing deficit, with strategies aimed at reducing inequalities, such as social housing planning. Furthermore, it addresses the preservation of the city's historical heritage and vitality, dividing it into macrozones: urban, rural and environmental. The urban area is subdivided into consolidated, targeted and territorially expanding urban zones. The city's most recent legislation related to urban management are the Land Use and Parcelment Law (nº 4648, of December 30, 2019) and the Municipal Organic Law of 2019. However, according to the website of the Municipality of Três Rios, the Master Plan in force in 2021 is governed by Law No. 3,906, of October 2, 2013. When analyzing these laws, it is possible to state that land occupation restrictions in the city are still relatively recent. Its regulation has been in place for just over 30 years, which could contribute to the Brazilian scenario of more than 5 million irregular dwellings in 2020, according to IBGE. However, since the 2006 Master Plan, a paradigm shift has been guaranteed in relation to the city's usage rules, and it can be said that concern for environmental balance is formally represented.

4 VULNERABILITIES

A brief study of the soil and the course of the water bodies of Três Rios, analyzing their morphology, infrastructure and even support capacity in the face of public calamity problems.

4.1 Soil and vegetation

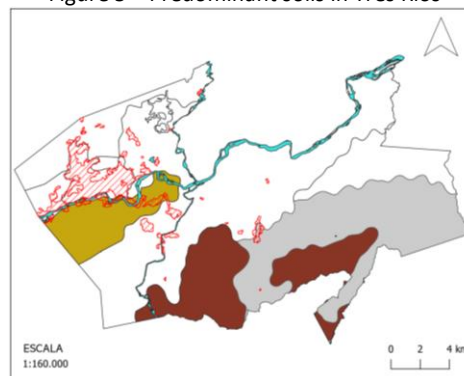
The soil has layers called horizons, which are classified according to their depth and common characteristics, such as texture, color, consistency, among others. Brazil has varieties of soil types, and, using the pedology map of the city Três Rios/RJ (Table 1), it was possible to identify four predominant types (Figure 5).

Table 1: Soil types identified in Três Rios

Soil type	Symbol
Dystrophic Red Clay Typical	PVd
Cambisol Haplicus Typical Dystrophic Tb	CXbd
Typical Dystrophic Red Latosol and Cambisolicos	LVd
Eutrophic Red-Yellow Clayey	PVAe

Source: The author with data from GeoINEA .

Figure 5 – Predominant soils in Três Rios



Source: The author , 2021.

The analysis of soil types is an important basis for understanding the properties and possible behaviors of local masses; however, a deep understanding of soil mechanics is extremely complex, due to its volatile nature (ALBUQUERQUE, 2020).

Every study developed here aims to correlate trends in soil behavior, its vegetative protection or lack of protection, occupation/use and the relationship between this and urban disturbances linked to land movements in the city. Infiltration and surface runoff are antagonistic phenomena; When there is good infiltration, surface runoff tends to be lower. While vegetation promotes good infiltration and soil agglutination, the type of soil and its slope directly influence erosion/landslides, as they are the result of the occurrence of water particles falling on the soil. Therefore, the relationship between the type of soil and its altimetry is closely linked, as stated by Barthold et al. (2008).

Embrapa - Brazilian Agricultural Research Company defines that the soil profiles of the Dystrophic and Eutrophic Group (Figure 6) are linked to the natural fertility of the soil. Eutrophic indicates high fertility, while dystrophic indicates low fertility and the need for fertilizer for agricultural use.¹⁰

The Typical Dystrophic Red Clay type (predominant) – is present in undulating and mountainous areas, with a medium/clayey texture. Its limitations are steep slopes and fertility deficiency; Eutrophic Red-Yellow Argisol - Predominant in rolling and mountainous areas of Três Rios. Despite its low fertility, due to its eutrophic specificity, it is more fertile than red. Suitable for sugar cane, fruits (jackfruit, mango, banana, sapodilla, citrus, coconut, acerola), some pastures (brachiaria, pangola and elephant grass), cassava, passion fruit and yam. Being a soil susceptible to erosion.¹¹

The Cambisol Háplico Tb Typical Dystrophic – is a soil in transformation, found in undulating/mountainous reliefs, but does not tolerate steep slopes. With stones due to its large Tb Dystrophic group. It has good consistency due to the high activity clay, however, low fertility.¹²

The Typical Dystrophic Red Oxisol and Cambisolicos – These are old and weathered soils, with good drainage and permeability. Smooth relief and texture similar to coffee powder. They have low fertility due to dystrophy and the presence of rock fragments and primary minerals that are little altered due to cambisolic traits.¹³

Figure 6 – Argisol, Cambisol and Oxisol



¹⁰Website:

https://www.agencia.cnptia.embrapa.br/gestor/solos_tropicais/arvore/CONTAG01_21_2212200611544.html

¹¹Website:

https://www.agencia.cnptia.embrapa.br/gestor/solos_tropicais/arvore/CONTAG01_21_2212200611544.html

¹²https://www.agencia.cnptia.embrapa.br/gestor/solos_tropicais/arvore/CONT000gn1sf65m02wx5ok0liq1mqzx3jrec.html

¹³https://www.agencia.cnptia.embrapa.br/gestor/solos_tropicais/arvore/CONT000fzyjaywi02wx5ok0q43a0r9rz3uhk.html

Source: Brazilian soil classes, FONTANA, Ademir; BALIEIRO, Fabiano de Carvalho (Embrapa Solos). PEREIRA, Marcos Gervásio (Federal Rural University of Rio de Janeiro), 2019.

In short, the soil types identified have low fertility and do not accept steep slopes, which are common in the city, as we can see in Figures 7a and 7b. The first depicts houses below street level, where mass landslides can lead to the burial of the residence. In this specific case, the penetration resulted in a fatal victim. In the second image, a retaining wall on a 90° slope, adjacent to the railway line, did not resist the efforts and collapsed, causing the line to be blocked. The risk for this type of housing is that the slope supports the weight of the building, and its instability can lead to structural collapse.

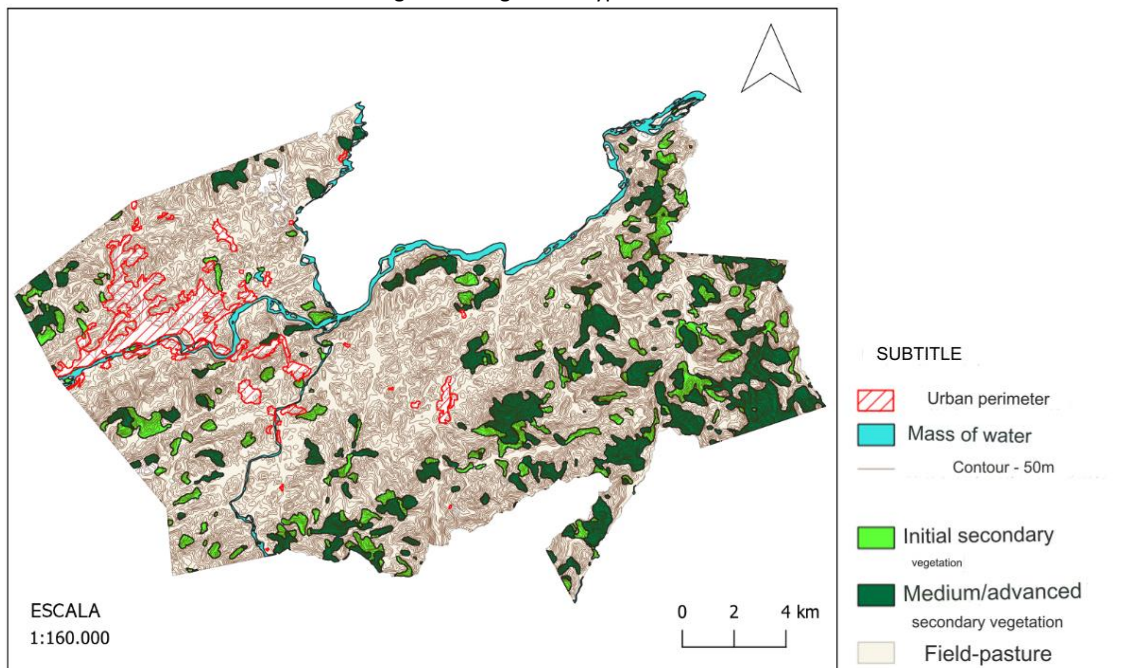
Figure 7 - Relationship of houses to the ground



Source: <https://g1.globo.com/rj/sul-do-rio-costa-verde/noticia/20192019/12/24/forte-chuva-causa-transtornos-em-bairros-de-tres-rios. ghtml>. 2019.

In this representation between soil and vegetation, the map in Figure 8 shows the city's secondary forest masses. Secondary forests arise from natural regeneration after the total cutting of primary forest or areas temporarily used for agriculture/pasture. They also include areas characterized by irrational logging or natural causes, with remaining trees.

Figure 8 - Vegetation types of Três Rios



Source: The author, 2021.

Forests have a vertical and shady characteristic, while the field is a biome with graminoid vegetation. Because it is exposed to the sun, it is subject to natural fires, which makes its trees and/or occasional shrubs have drier/yellowish characteristics. Due to its open-air nature, it is widely used for pasture. Even so, it has greater exposure to the elements and less capacity to support bearings, surfaces and the like, as it has slightly deep roots, with low infiltration capacity and a consequent increase in the speed of floods.

The city has a mountainous terrain, with extremely exposed soil and susceptible to movement, increased by improper use/occupation, both very present in the locality. This set of characteristics results in little water infiltration and an increase in migraines, which, when connected to an urban infrastructure that is poorly prepared for the diversion and collection of fluids, tend to result in floods.

4.2 Water in urban space

Named after three important rivers that intersect and meet within the city, Três Rios has built a regrettable history of floods and flooding, and it is no wonder that combating floods and flooding is one of the priorities of the current administration¹⁴, according to the City Hall website. The city has a vast drainage network, with worrying occupation and protection. Therefore, this section will briefly analyze the relationship between water and urban space.

Watercourses basically have the smallest and largest beds. The first is due to the normal running water level, that is, that which occurs most of the year. The larger bed is created by an expansion of the current water level and the consequent flooding of the floodplain areas, which

¹⁴<https://tresrios.rj.gov.br/index.php/2021/04/13/governo-joa-completa-100-dias-a-frente-do-executive-municipal/>

can reach the maximum level of the river's total channel. After an estimate of rainy seasons or any incident that may have generated the flood, the normal bed is restored. These areas around the watercourses, which are very suitable for agriculture, have undergone a process of waterproofing and occupation, causing urban flooding. Unlike floods, which are a natural process, floods are adjusted by overflowing beyond permeable areas, exceeding minor and major gutters and reaching agitated regions.

Law 12651/12, which provides for the protection of native vegetation, in its Chapter II: Permanent Preservation Areas, determines, in a very summarized way, that the Permanent Preservation Area (APP) is defined as marginal strips along the natural watercourses, with specific widths in relation to the watercourse channel. For watercourses of less than 10 meters, the APP is 30 meters; from 10 to 50 meters, it is 50 meters; from 50 to 200 meters, it is 100 meters; from 200 to 600 meters, it is 200 meters; and above 600 meters, it is 500 meters. Furthermore, areas around lakes and ponds have an APP of 100 meters in rural areas (50 meters for bodies of water up to 20 hectares) and 30 meters in urban areas.

Based on the legal parameters of the APPs, a Map of Três Rios Wetlands was constructed (Figure 9). Afterwards, in order to improve the visualization of the banks, 3 expansion points (Point 1, Point 2 and Point 3) were defined, indicated in Figure 10, allowing us to assess whether there is any level of criticality along the level of river destruction.

Figure 9 – Permanent protection area for water bodies in Três Rios/RJ

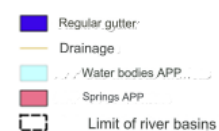
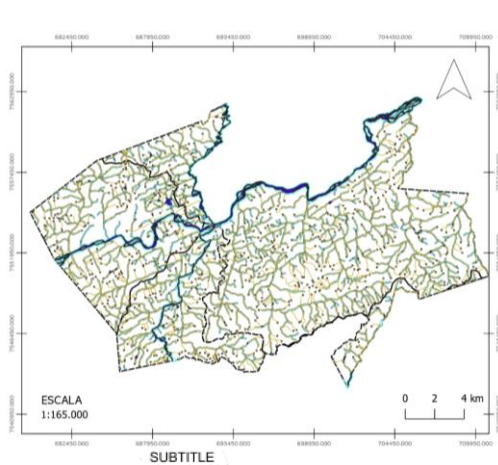
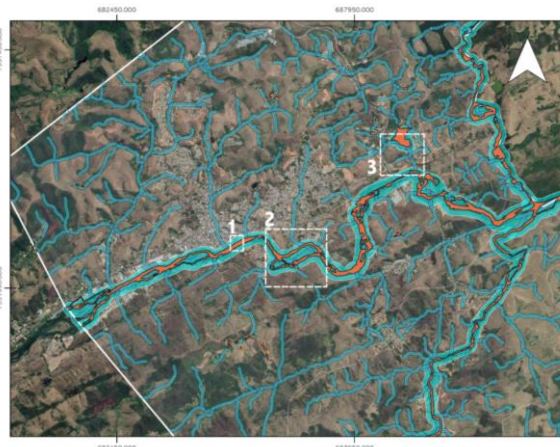


Figure 10 - Marking of enlarged regions

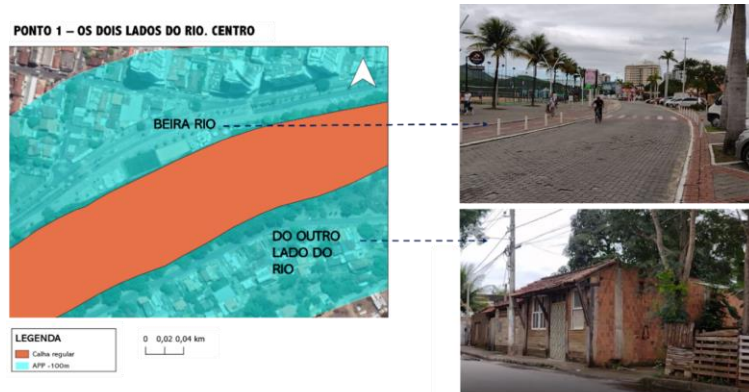


Source: The author. 2021

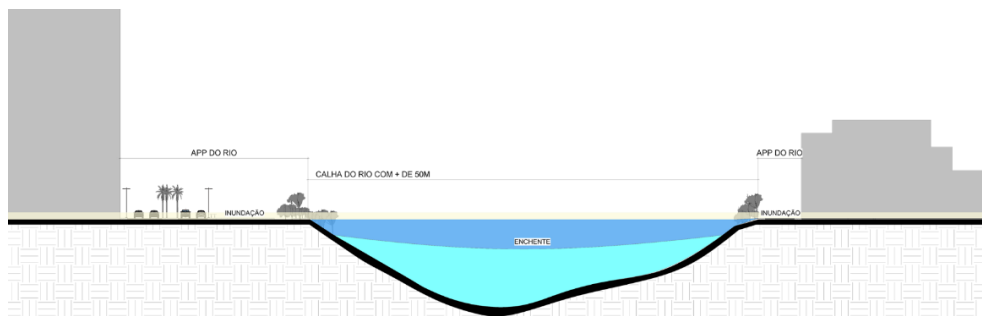
Point 1 - Figure 11 (Point 1) shows the first enlarged region, located in the city center, where it is notable that the river's permanent protection area is densely occupied, corresponding to the flood situation that the region often suffers in rainy seasons. The schematic section of the region of Avenida Alberto Lavinas (popularly known as Beira-rio) and Avenida Tenente Eneas Torno (popularly known as “on the other side of the river”) is shown in Figure 11b. It is plausible to highlight the discrepancy between the two banks: on Av. Alberto Lavinas, housing considered

formal predominates, with the majority of people living in multi-family houses (above 3m from the street). This avenue is the most valued in the city, with adequate pavement, cycle path, public parking and leisure areas on the banks. On the other side of the river, a paradigm shift can be seen, uniting Figures 11a and 11b, where the streets are narrower, the pavement is more obstructed and the lighting is scarcer. The cycle path also does not follow the same pattern on this side, as do the leisure areas along the banks. Furthermore, the buildings are closer to the riverbed and have a more single-family, single-family character.

Figure 11 – Both sides of the river, analysis of the Centro neighborhood



(a)

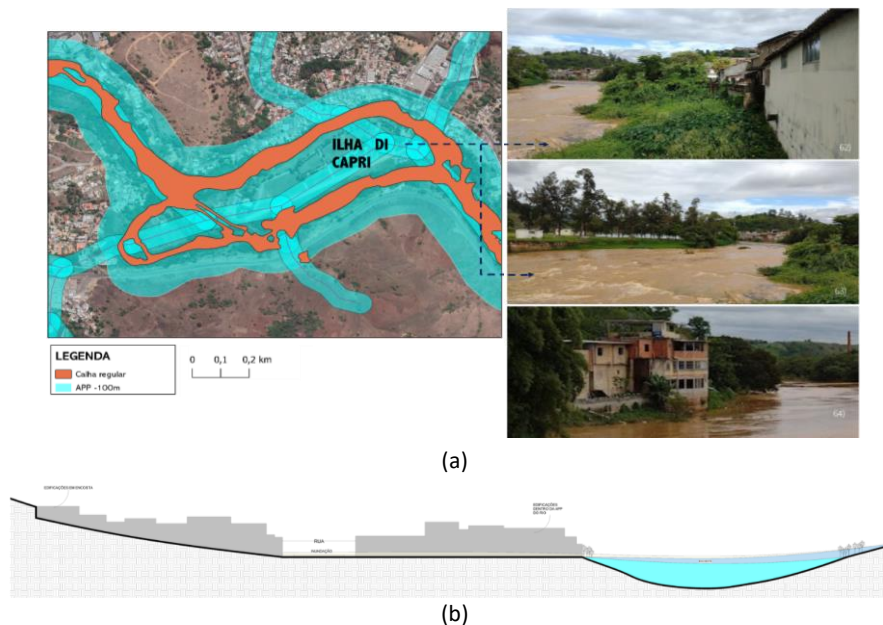


(b)

Source: The author, 2021

Point 2 - The second point of analysis corresponds to the region of the Triângulo neighborhood, close to the city center. Note that this area also has an island (Figure 10 and Figure 12a), frequently used for events and completely within the level of destruction of the water bodies that surround it. As in the center, the presence of many houses at risk of flooding and/or flooding is obvious (Figure 12).

Figure 12 – Analysis of the Triângulo neighborhood



Source: The author, 2021.

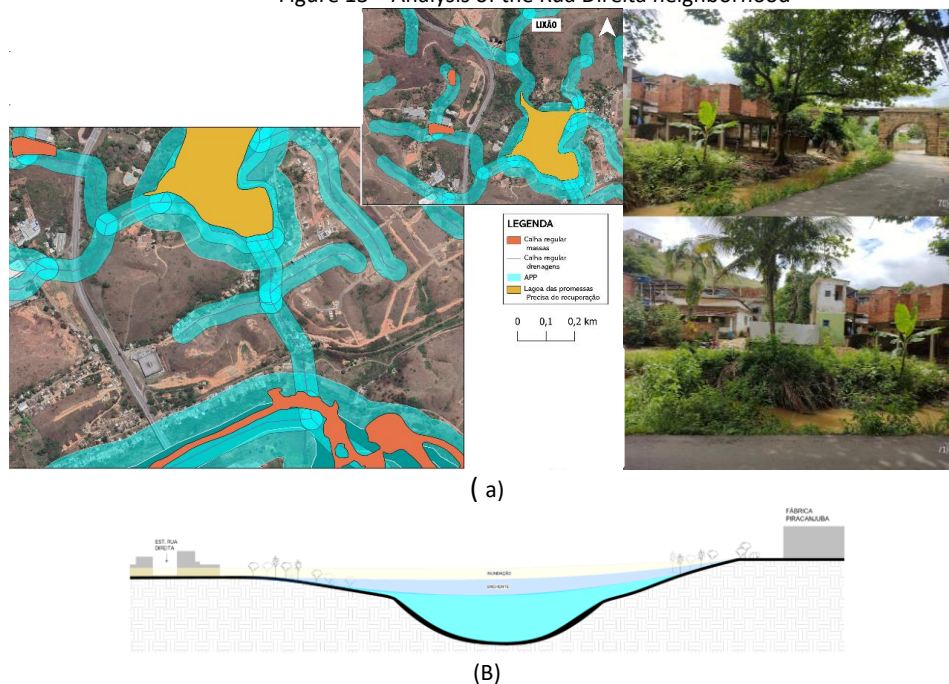
The neighborhood has intermediate infrastructure, with the majority of residences being one- or two-family, and has good real estate appreciation, being one of the main neighborhoods with intercity access to the city, in the Rio - Petrópolis direction. In addition to its relationship with the water bodies that border it, it also houses a significant number of residences located on rugged topography. Figures 12a and 12b help to elucidate this relationship, showing a neighborhood that developed along the banks of the river and the hillsides of Trirriense. In relation to its urban structure, it has reasonable sidewalks compared to other places in the city. The Center's cycle path is intercepted at the beginning, and leisure equipment is punctual. The street represented in the schematic section of Figure 12b is Av. Zoello Sola. As Figures 11, 12 and 13 present, in addition to the detail of the map of the region with flood area, photographs to help the reader understand the local dynamics, as well as the schematic section showing the river bed and its banks, completing the scenario local.

Point 3 - The map in Figure 13 shows a section of the Rua Direita neighborhood, which in addition to being intercepted by rivers, has Lagoa das Promessas, a reservoir that, due, among other factors, to its proximity to the city's landfill, had its sheet compromised, being threatened with definitive drought¹⁵. Lagoa das Promessas, also known as Lagoa do Caça e Pesca, is located in the¹⁶Municipal APA of Lago Caça e Pesca.

¹⁵See more in the video “Lagoa das Promessas total abandonment” by Rádio 3 Rios:
<https://www.facebook.com/watch/?v=2549922721772876>

¹⁶Environmental Protection area

Figure 13 – Analysis of the Rua Direita neighborhood



Source: The author, 2021

In the Centro and Triângulo neighborhoods, there are buildings and roads along permanent protection areas, which coincide with the chaotic scenario during the rainy season. Unlike previous sections, Rua Direita has less infrastructure, houses a landfill that increases crisis scenarios and, as it is a region further away from the Center, is less valued by the real estate sector. In general, its population has lower purchasing power compared to what was observed in previous sections. Observing the section in Figure 13b and the sequence of images presented in Figure 13a, we can notice its low-income single-family residential character, with areas without adequate pavement and houses with a high probability of suffering from flooding. The street represented in the section in Figure 13b is Estrada da Rua Direita, near the Piracanjuba brand factory.

This propensity for flooding, resulting from the irregular occupation of places that should be protected, can be increased in times of high rainfall, such as in the summer. The climate is mesothermal, with a minimum temperature of 14.4 °C, a maximum temperature of 37.4 °C and an occurrence of 1,300 mm per year (NASCIMENTO & MACHADO, 2009).

5 CONCLUSIONS

Given the chaotic scenario that Três Rios faces during the rainy season, this research was initiated with the aim of understanding which human, legislative interventions, urban conformations or natural transformations could be contributing to these growing problems and, from that, reach their level of criticality, its support capacity and, consequently, the vulnerability of the place. Therefore, the concept of vulnerability developed understands that there is a set of factors that can trigger a crisis, such as population behavior, their level of information and the

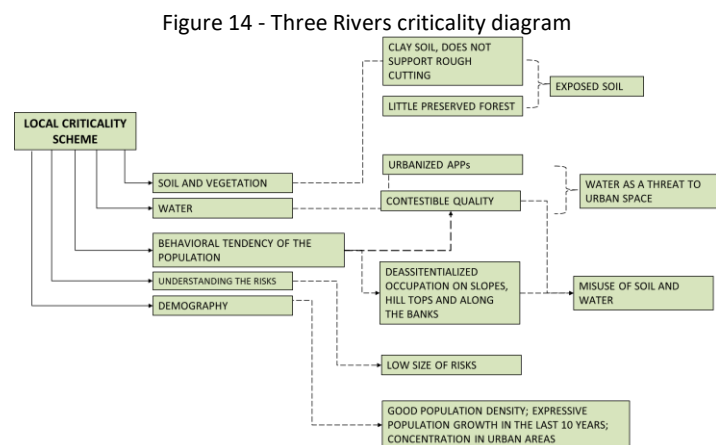
conditions of land use and occupation. Combining this with territorial conditions, such as financial and professional support, we arrive at how vulnerable a place can be.

Thus, in a panoramic study of the city, it is possible to list a trajectory in which bus transport overlapped even the same historical buildings, such as its first religious chapel, replaced by a bus terminal which, due to being outdated, is currently in ruins. In other words, initial evidence about criticality suggests urban growth with little emphasis on preservation and memory.

As for legislation, the city has been mostly regulated for just over 30 years, which is in line with many homes in inappropriate locations and/or outside current urban parameters. Today, concern for environmental balance is formally represented. However, low adherence to housing land use codes is still observed, generating many homes subject to different types of risks, as evidenced in this work.

Três Rios has a vast territory considered rural by its Master Plan, however, its population lives concentrated in urban clusters with distinct characteristics, which are reinforced through the formation of a road-rail ring that separates realities into “inside and outside” and “near or far from it. The understanding of the local scenario developed by this research is based on the relationship between criticality and support capacity. During the analysis of all the cartography produced, it was possible to identify a soil with little capacity to support the common steep cuts. The soil is highly unprotected, with scarce forestry and riparian vegetation, in addition to the river banks, which are highly urbanized and have questionable water quality.

In order to equalize the analysis of local criticality, the scheme (Figure 14) is presented with the condition of the items analyzed throughout the studies: soil and vegetation, water, behavioral tendency of the population, notion of risks and demography. From these indicators, one can understand a great exposure to urban dangers, reaching a highly critical scenario, which deserves public attention.



Source: The author, 2021.

The city of Três Rios presents significant challenges, reflected in a series of socioeconomic and environmental weaknesses. With more than 30% of the population living on a per capita income of half the minimum wage, the average salary of formal workers is one of

the worst in the state of Rio de Janeiro, despite an optimistic GDP. The city receives few federal public investments due to its medium size and low tourist attractiveness. Furthermore, the absence of continuous public policies for prevention and awareness about land use in risk areas, together with the lack of educational campaigns, hinders the development of manpower for crisis prevention and management.

The urban infrastructure of Três Rios reveals deficiencies, including drainage networks, sewage systems, coordinated housing and conservation of roads and sidewalks, impacting the city's resilience. The designed scenario highlights several weaknesses in different regions, such as the Centro, Triângulo and Rua Direita neighborhoods. These regions present different realities, responding in many different ways to the same events, but sharing susceptibility to problems related to water and/or slopes, making the rainy seasons moments of alert in different locations.

Nature demonstrates in this case study, its plural and democratic characteristic, reaching from less affluent regions to high standard roads. What is common to both parties is their high socio-environmental criticality, which can represent greater or lesser vulnerability, depending on the support capacity. Três Rios presents socio-environmental vulnerability, requiring strategies to mitigate critical scenarios, such as improper use of land, discovery of Permanent Preservation Areas of water bodies, lack of forest cover, low income and quality of life, absence of committed labor and action plan, precarious urban infrastructure outside the Consolidated Urban Zone, lack of preservation of material and immaterial assets, and disorderly urban expansion.

It seems necessary to improve awareness and information among the population and public managers about land use and occupation. Educational actions and promotion of these issues are essential to guide future decisions in the city. The union of educational institutions, from basic to higher education, can contribute through the creation of teaching material in partnership with universities, holding lectures and workshops in conjunction with schools, and developing an informative, visual and didactic leaflet for better understanding of the topic.

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