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Social vulnerability of the city of Teresina, Piauí

Vulnerabilidade social da cidade de Teresina, Piauí

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Abstract: The disorderly occupation of Brazilian cities has increased the number of people affected by floods and the occupation of the larger bed of urban rivers by poor populations has contributed to the sharpness of the damage generated. Socio-environmental vulnerability studies have become a valuable tool in the search for mitigating the effects of floods, as they bring together social, economic, and environmental indicators, revealing the response capacity of those affected to cope with disasters. Thus, this study aimed to analyze the socio-environmental vulnerability of Teresina, Piauí, to recurrent floods. For this purpose, alphanumeric data of 11 variables were used, grouped into 4 criteria: demography, education, income, and housing conditions, for the 110 neighborhoods in the municipality of Teresina. The socio-environmental vulnerability index (IVSA) equation for the municipality of Teresina was based on a simple arithmetic mean. The refined data of the 11 variables and IVSA were spatialized via QGIS tools. It was found that the neighborhoods of Itararé, Angelim, Santo Antônio, Promorar, and Mocambinho are the most vulnerable to floods in Teresina, as they presented low rates in the dimensions evaluated, making it essential the intervention of the public power on them, to increase the response capacity through the materialization of the disaster.

Keywords: Vulnerability; Flood; Teresina.

Resumo: A ocupação desordenada das cidades brasileiras tem aumentado o número de pessoas afetadas por desastres, e a ocupação das áreas de riscos por populações pobres tem contribuído para a agudização dos danos gerados. Estudos de vulnerabilidade social têm se tornado valioso instrumento na busca da mitigação dos efeitos dos desastres, uma vez que aglutinam indicadores sociais e econômicos, revelando a capacidade de resposta dos afetados para o enfrentamento dos desastres. Desse modo, objetivou-se, com o presente estudo, analisar a vulnerabilidade social de Teresina, Piauí, ante a ocorrência de inundações. Para tanto, foram utilizados dados alfanuméricos de 11 variáveis, agrupadas em 4 critérios: demografia, educação, renda e condições habitacionais, para os 110 bairros do município de Teresina. A equação do índice de vulnerabilidade social (IVS) para o município de Teresina se baseou em média aritmética simples. Os dados refinados das 11 variáveis e IVS foram espacializados via ferramentas do QGIS. Constatou-se que os bairros Itararé, Angelim, Santo Antônio, Promorar e Mocambinho são os mais vulneráveis à desastres em Teresina, pois apresentaram baixos índices nas dimensões avaliadas, tornando essencial a intervenção do poder público sobre os mesmos, com o intuito de aumentar a capacidade de resposta mediante a materialização dos desastres.

Palavras-Chave: Vulnerabilidade; Inundação; Teresina.

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1. Introduction

There are frequent reports of disasters in urban areas in Brazil, resulting from excess or scarcity of precipitation. Between 1990 and 2010, more than 10 million people were affected by floods in Brazil, 4 million of them in the Northeast alone, the region with the highest occurrence of disasters in the country. Droughts accounted for 78% of the total occurrences in the region; and floods, 21% of the occurrences (CEPED/UFSC, 2012; BRASIL, 2014, Moura et al, 2016).

The United Nations Office for Disaster Risk Reduction (UNISDR) defines disasters as the result of the combination of exposure to hazards, the presence of conditions of vulnerabilities, and insufficient capacity to deal with the negative consequences. It involves human, economic, material, and environmental losses that exceed the ability of the affected society to recover from the damage using its own resources (UNISDR, 2009).

Meanwhile, numerous studies on the occurrence of disasters have emerged in recent years, with emphasis on the areas of greatest recurrence, the most frequent types of disasters and the profile of the affected population. It is within this context that the paradigm of socio-environmental vulnerability emerges, a valuable tool used to point out the areas of cities most susceptible to disasters. Alves (2010), analyzing the metropolitan region of São Paulo, Almeida (2010), the metropolitan region of Fortaleza, Hogan (2007), the metropolitan region of Campinas (SP) and Deschamps (2006) in Curitiba, are examples of successful studies of socio-environmental vulnerability, which analyzed the coexistence of irregular occupations on slopes or waterways, absence of basic sanitation and drinking water supply, among other indicators.

Mendonça (2004) states that vulnerability involves portions of society that are exposed to problems related to the environment (environmental risk); to poverty; to urban management and to the organizational form of the city, i.e., it corresponds to the exposure of part of society to the occurrence of an event and the way it reacts to its materialization.

There is a consensus in the vast literature that vulnerability has a multifaceted character, encompassing several dimensions, from which it is possible to identify situations of vulnerability of individuals, families or communities. These dimensions concern aspects linked both to the characteristics of individuals or families themselves, and to their assets and socio-demographic characteristics. They contemplate the overlapping processes of urban expansion, involving the spatial dispersion of the population in areas of environmental risk and the lack of urban infrastructure services. However, what is perceived is that the attribute related to the ability to respond in the face of risk situations is the central axis of its scope, that is, the differentiated ability of individuals to recover reflects the heterogeneous structuring of vulnerability (CUNHA, 2004; MAIOR, CANDIDO, 2014).

In Brazil, floods are the most recurrent disasters, according to the Emergency Disasters Data Base (EM-DAT), an international database that compiles information on the most varied disasters from 1900 to the present day. Classified as hydro-meteorological disasters, although not an event that causes most fatalities, they generate significant material and economic damage. Kobiyama et al (2006) conceptualize flooding as the increase in the level of rivers beyond their normal flow, succeeding in the overflow of their waters over surrounding areas, being, therefore, events that involve extreme episodes of precipitation.

In 2012, the Brazilian Atlas of Flood Vulnerability was prepared, a project of the National Water Agency (ANA), built in a participatory manner with the support of state and municipal civil defenses with the objective of identifying the floodable stretches, the degree of impact, and the frequency of floods in the various regions of the country, determining their degree of vulnerability. In Piauí, 561 floodable stretches were identified, in 52 water courses, in 91 of the 223 municipalities. Of the total, 33 (6%) were considered highly vulnerable to gradual flooding; 418 (74%), medium and 110 (20%), low. Along the Parnaíba River, 18 highly vulnerable stretches were identified. In Teresina, there are eight stretches of high and medium vulnerability, presenting high risk of damage to human life, essential services, facilities and public infrastructure works and residences (BRASIL, 2012).

In light of the above, this study aims to identify and characterize the areas susceptible to flooding in Teresina, Piauí, in the light of the paradigm of socio-environmental vulnerability. Teresina, capital of the state of Piauí, over the course of its 169 years, has registered, since its birth, frequent episodes of flooding that cause significant human, material, and economic damage. It is worth noting that the recurrent floods are the result of the inadequate occupation of the city's urban space, namely, the major bed of the Parnaíba and Poti rivers, densely urbanized areas susceptible to the occurrence of the event.

2. Methodology

2.1. Study Area

Teresina, capital of the State of Piauí, emerged in the mid-nineteenth century with the purpose of hosting the state capital, being the first Brazilian city with planned status. It is located in the Brazilian Mid-North, in the north-central mesoregion of the state, on the right bank of the Parnaíba River, 366 kilometers from the coast, and is the only northeastern capital that is not in a coastal area. It is conurbated with the municipality of Timon, in the west, and borders the following municipalities of Piauí: União and José de Freitas, to the north; Palmeirais, Monsenhor Gil, Nazária, Demerval Lobão and Curalinhos, to the south; Altos, Lagoa do Piauí and Pau D'Arco do Piauí, to the east (Figure 1). It has an average altitude of 74.4m and is situated between 05°05'21" South latitude and 42°48'07" West longitude, in the low interfluvial area that stretches near the confluence of the Parnaíba and Poti rivers (TERESINA, 2013; MOREIRA, 1972).

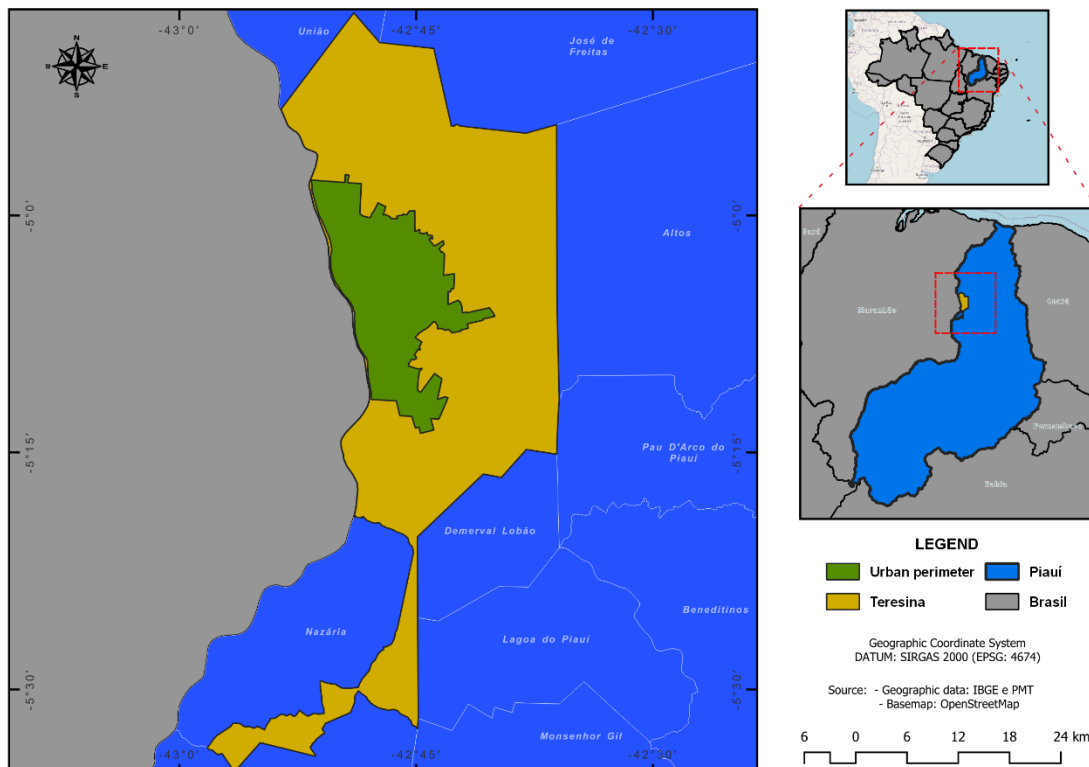


Figure 1 – Teresina location map, Piauí
 Source: The authors, 2022. Organized by Ramos, 2021.

It has a territorial area of 1,391.293 km². Of this, 17% (263.94km²) corresponds to the city's urban area. It currently has an estimated population of 871,126 inhabitants, distributed in the city's 123 neighborhoods, which, for administrative purposes, are distributed in five superintendencies (Figure 2) of decentralized administrative actions (SAADs,): center, north, east, southeast and south. In this study, such regionalization will be used for the purposes of locating the neighborhoods analyzed (IBGE, 2021).

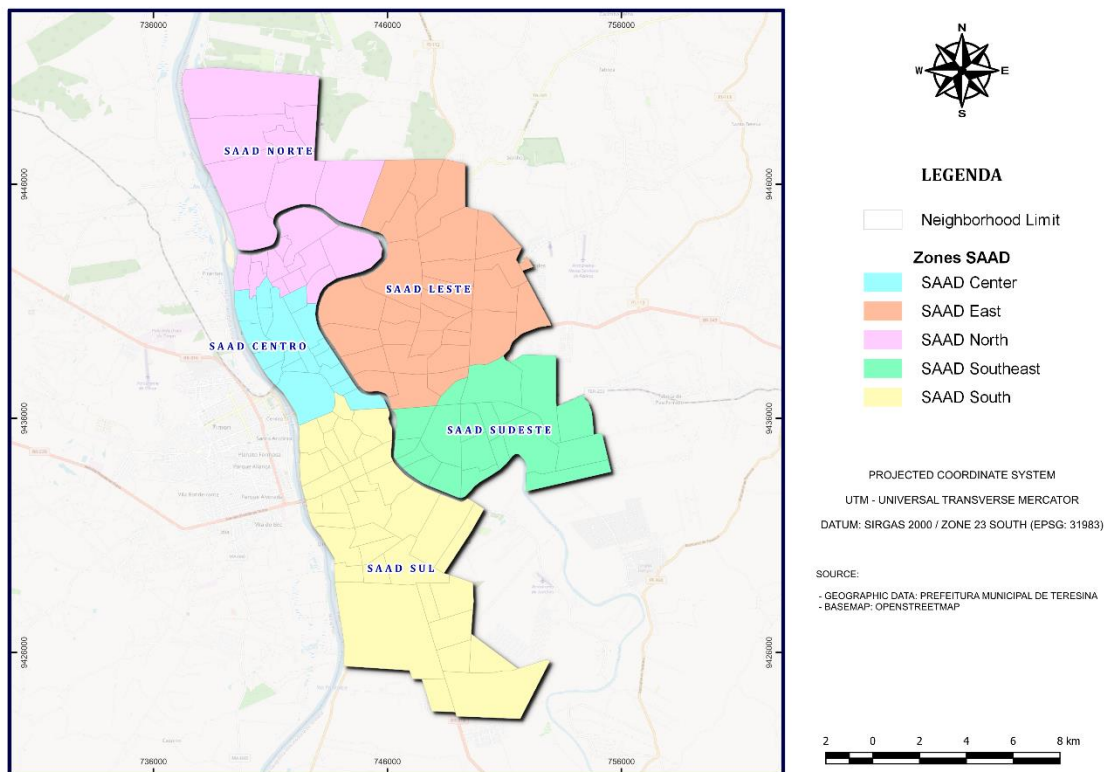


Figure 2 – Regionalization in Superintendencies of Decentralized Administrative Actions (SAADs) in the urban perimeter of Teresina, Piauí
 Source: The Authors, 2022. Organized by Ramos, 2021.

From the 1950s on, Teresina registered an intense population growth, when it obtained a demographic increase of 63% in just one decade, increasing the demographic pressure for housing. This increase resulted from the migratory flow of small towns and rural areas towards the capital, implying the emergence and/or growth of peripheral neighborhoods, occupation of risk areas, expansion of poverty pockets and slums (TERESINA, 2002a).

The geological and geomorphological conditions of its urban site are characterized by: the Parnaíba and Poti rivers, the alluvial terraces, the slopes, the low interfluvial levels and the plateaus. The Parnaíba River is considered perennial because it receives contributions from several tributaries and the underground water table all along its course, has an extension of 26,3km in the urban area of Teresina, constituting the western limit of the city and the border of Piauí and Maranhão (MOREIRA, 1972).

The Poti River is a tributary of the Parnaíba and rises in the eastern foothills of the Cuesta da Ibiapaba in Ceará State, at an altitude of 600m. It has an intermittent regime in some points of its course and a direction defined by the geological structure, fitting into regional fractures and faults until it forms a large canyon 300m deep, running for more than 20km between rocky walls until it penetrates the capital. In Teresina, where it runs for 24.4 km, it is considered perennial and forms several meanders until it flows into the Parnaíba, where it periodically floods the wide terraces due to the damming of its waters, especially during the flood season (TERESINA, 2002b; AZEVEDO, 2007).

The fact of being located near the equator, in the transition between the semi-arid sertão and the humid Amazon, and its position in the Parnaíba valley, gives Teresina peculiar climatic aspects, especially in relation to the relative humidity of the air, the rainfall, the absence of winds and high temperatures throughout the year. The rainy season goes from January to May and the rains are directly influenced by the action of the Intertropical Convergence Zone (ITCZ) and secondarily by the High Level Cyclonic Vortices (HVCAN). In the years when the ITCZ acts more to the south, the rainy season is characterized by constant and intense precipitation.

2.2. Materials and Methods

As Gil (2002) points out, this type of study is based on the description of the characteristics of a given population or phenomenon, in this case, the identification and characterization of socio-environmental vulnerability in the municipality of Teresina, since the variables listed tend to influence vulnerability to floods in the city.

For the operationalization of the research, it was necessary to acquire alphanumeric data for each neighborhood in the city of Teresina, via the database of the Municipal Secretariat for Planning and Coordination (SEMPPLAN). It is worth mentioning that, for data spatialization, 110 neighborhoods were considered, because they were the ones that presented data for all variables. In this sense, 11 (eleven) variables were listed that were grouped into 4 (four) dimensions (Table 1), according to the methodology proposed by Sousa and Santos (2019).

Table 1 – Variables used to construct the Social Vulnerability Index (IVS) of the municipality of Teresina.

Dimensions	Variable	Code
Demography	Demographic density	V01
	Resident population by neighborhoods 0 to 4 years old	V02
	Resident population by neighborhoods 60 years old and older	V03
Income	Total income of permanent private households	V04
	Permanent private households without income	V05
	Permanent private households with up to 1 minimum wage*	V06
Education	People 10 years old and older who are literate	V07
Living Conditions	Water supply from the general distribution network	V08
	Garbage collected directly by cleaning servisse	V09
	Sanitary sewage collected by the general sewage or rainwater network	V10
	Existence of electricity from the distribution company	V11

***minimum wage = minimum wage (in 2010 was R\$ 510.00).*

Source: The authors, 2022.

It is important to highlight that, after the selection and organization of the variables, the initial values were converted to percentages to improve the representativeness of the variable value. In turn, the social vulnerability index (SVI) for the municipality of Teresina was based on the simple arithmetic mean, as shown in figure 3.

$$IVS = \frac{V01 + V02 + V03 + V04 + V05 + V06 + V07 + V08 + V09 + V10 + V11}{11} \quad Eq. [1]$$

Figure 3 – Simple arithmetic means that indicates social vulnerability.

Source: The authors, 2022.

The simple arithmetic mean was calculated by adding all the percentage values of each variable per neighborhood. Then, the result was divided by the number of variables, in this case, 11 (eleven). The QGIS, version 3.10, was used to prepare the maps for the eleven (11) variables and the SVI, particularly through the procedure of joining the vector file table to the neighborhood table (spreadsheet). Next, the slicing and definition of the 5 (five) class intervals was performed for each variable and SVI (Table 1).

Table 1 – Ranges and classes of the Social Vulnerability Index (IVS) of the municipality of Teresina.

Range	IVS categories
0,00 – 0,32	Very Low Social Vulnerability
0,32 – 0,90	Low Social Vulnerability
0,90 – 1,67	Average Social Vulnerability
1,67 – 2,83	High Social Vulnerability
2,83 – 4,29	Very High Social Vulnerability

Source: Adapted from Sousa and Santos (2019).

The way to perform the slicing of the classes for the variables and IVS considered the "graduated style", "color method" and "equal interval mode", also available in QGIS.

3. Results and Discussion

Socio-environmental vulnerability paradigms provide empirical basis for risk reduction public policymaking through metrics that analyze social vulnerability to risks and extreme events. They merge social conditions, such as, demographic and socioeconomic data and urban and household infrastructure from an integrative approach that reflect the complex interactions between social, natural and man-made systems (CUTTER, 1996). In this study, as alluded to in the methodology, social indicators were categorized in the dimensions of demography, income, education and housing conditions and will be described below.

3.1. Demography Dimension

The variables belonging to the demography dimension (demographic density; resident population aged 0 to 4 years old, per neighborhood; resident population aged 60 years or older, per neighborhood) added up to 33 neighborhoods (30%) with the condition of high socio-environmental vulnerability and 6 neighborhoods (5.4%) with the condition of very high vulnerability (Figure 4).

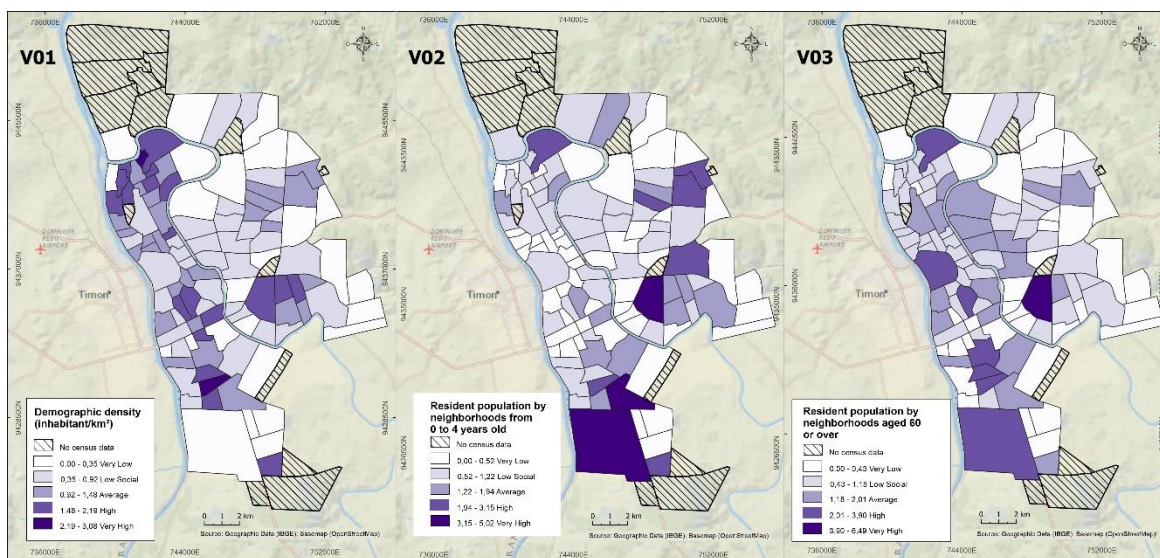


Figure 4 – Variables of the Demography Dimension

V01 - Demographic density / V02 - Resident population by neighborhoods 0 to 4 years old / V03 - Resident population by neighborhoods 60 years old and older.

Source: The authors, 2022. Organized by Ramos, 2021.

Indicators that involve population density influence the condition of high vulnerability, since neighborhoods with higher population density have more people exposed to disasters. Moreover, large families have higher expenses with food maintenance and basic services, contributing to greater vulnerability. Based on the population density variable, two neighborhoods (1.8%) were classified as very high vulnerability: Promorar, located in the southern part of the city, and Vila São Francisco, in the northern part. Seventeen neighborhoods (15.4%) were classified as highly vulnerable. This region is characterized by a fragile environment, composed of a lagoon system, small streams and creeks, lower altimetry and the confluence of the Parnaíba and Poti rivers.

The variable resident population of 0 to 4 years old, per neighborhood, indicated three neighborhoods (2.7%) as a very high vulnerability condition: Itararé, located in the southeast zone and Angelim and Santo Antônio, in the south zone. In the high vulnerability category, 7 neighborhoods (6.3%) were indicated. Of these, Promorar and Esplanada, two of the most populated neighborhoods in the city. The presence of children in homes contributes to the high vulnerability of the population, since they demand special care for their upbringing, require greater resources to meet basic needs, such as health and education, and have limited response capacity in the face of disaster (DESCHAMPS, 2004).

Like the presence of children, the presence of the elderly greatly compromises the population's ability to respond to the event, since they require special care and have restricted mobility. However, they may be responsible for the family's sustenance, and retirement is often the only source of household income, which is insufficient to cover expenses with medicines, food, and basic services, such as water and electricity, compromising the quality of life. The study indicated the Itararé neighborhood, located in the southeast zone of the city, as having very high vulnerability in the indicator of resident population by neighborhoods, 60 years old and older. In the high vulnerability category, 7 neighborhoods (6.3%) were pointed out. Of these, most are concentrated in the southern part of the city, such as Promorar, Parque Piauí, Lourival Parente e Angelim, besides Mocambinho, located in the northern zone.

3.2. Income Dimension

The income dimension, composed of the variables total income of permanent private households, permanent private households without income and permanent private households with up to one minimum wage, indicated, in all, 6 neighborhoods (5.4%) in the very high vulnerability category and 28 neighborhoods (25.4%) in the high vulnerability category (Figure 5). Variables involving income measures are determinants for discussing socio-environmental vulnerability, since low incomes increase vulnerability. Cutter (1996) points out that if the population is wealthy, with considerable resources for disaster preparedness and response, the community will be able to recover quickly. On the other hand, if it has different social characteristics, it will take longer to recover, since the capacity of its inhabitants to absorb losses is limited. Such thinking also applies to schooling, since low levels of education can imply greater difficulties in disaster prevention and response, and even in preventing people from moving from the place at risk, if necessary.

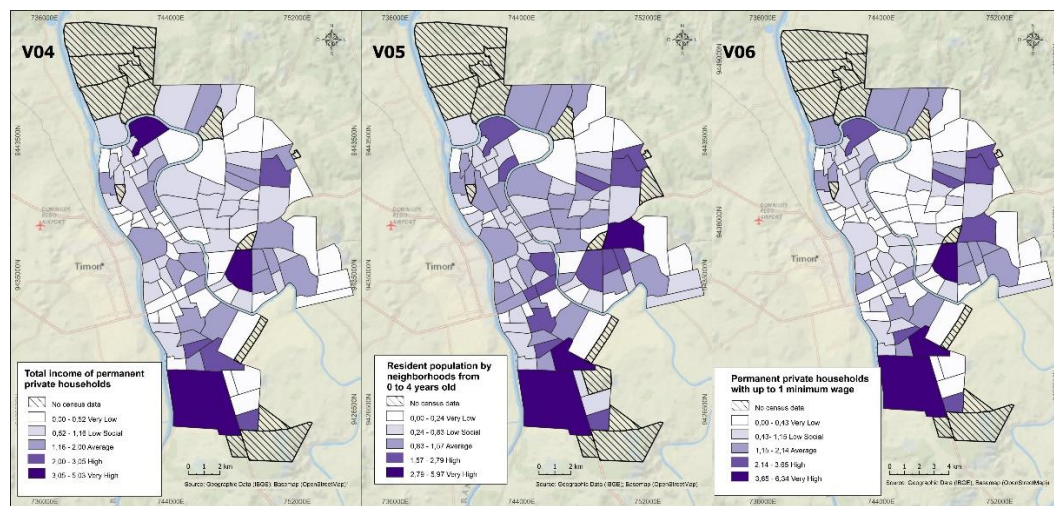


Figure 5 – Variables of the Income Dimension.

V04 - Total income of permanent private households / V05 - Permanent private households without income / V06 - Permanent private households with up to 1 minimum wage.

Source: The authors, 2022. Organized by Ramos, 2021.

The total income variable for permanent private households indicated the predominance of neighborhoods in the low vulnerability category, with 45 neighborhoods, corresponding to a little over 40% of the total neighborhoods studied. However, 3 neighborhoods (2.7%) were classified as very high vulnerability: Angelim and Santo Antônio, located in the southern part of the city, and Itararé, in the southeastern part. In the high vulnerability category, 17 neighborhoods (15.4%) were pointed out, distributed in all areas of the city.

Among the variables of the dimension, the variable involving people without income is determinant for the increase in the neighborhoods' vulnerability, since it exposes a condition of economic deprivation that compromises the quality of life of the population, limits the satisfaction of basic needs and makes them dependent on public policies. These are people who tend to be part of the informal market and, in general, survive on sporadic low-paid jobs. The study showed that most of the neighborhoods studied (40%) were classified in the very low vulnerability category. In the very high vulnerability category, three neighborhoods (2.7%) were identified: Angelim and Santo Antônio, located in the south zone, and Itararé, in the southeast zone; 7 neighborhoods (6.3%) were indicated as high vulnerability: Gurupi, Verde Lar, Vale Quem Tem, Samapi and Pedra Mole, located in the east zone, Mocambinho, in the north zone, and Promorar, in the south zone.

In the variable permanent private homes with up to one minimum wage, most neighborhoods (42.7%) were classified as low vulnerability, 3 neighborhoods (2.7%) were categorized as very high vulnerability: Angelim and Santo Antônio, both in the south zone, and Itararé, located in the southeast zone. In the high vulnerability condition, 7 neighborhoods (6.3%) were indicated: Gurupi, Verde Lar, Vale Quem Tem and Samapi, located in the eastern zone, and Esplanada and Lourival Parente, in the southern zone. It is observed that, in the last two variables analyzed, the neighborhoods classified as very high vulnerability were the same, which allows inferences about the high levels of economic deprivation of the highlighted neighborhoods.

3.3. Education Dimension

The education dimension is composed of the variable people 10 years or older who are literate (Figure 6) and contributes to the vulnerability analysis, based on the assumption that people with higher levels of schooling are less vulnerable to disasters, since they enable better socioeconomic conditions and higher income jobs. On the other hand, low education is directly associated with low pay, since illiterate people tend to have less access to information and knowledge, factors that greatly influence the ability to respond to a disaster, in addition to limiting recovery and adaptation measures. Low levels of education also imply migration to informal work, without access to labor guarantees (CORREIA, 2016).

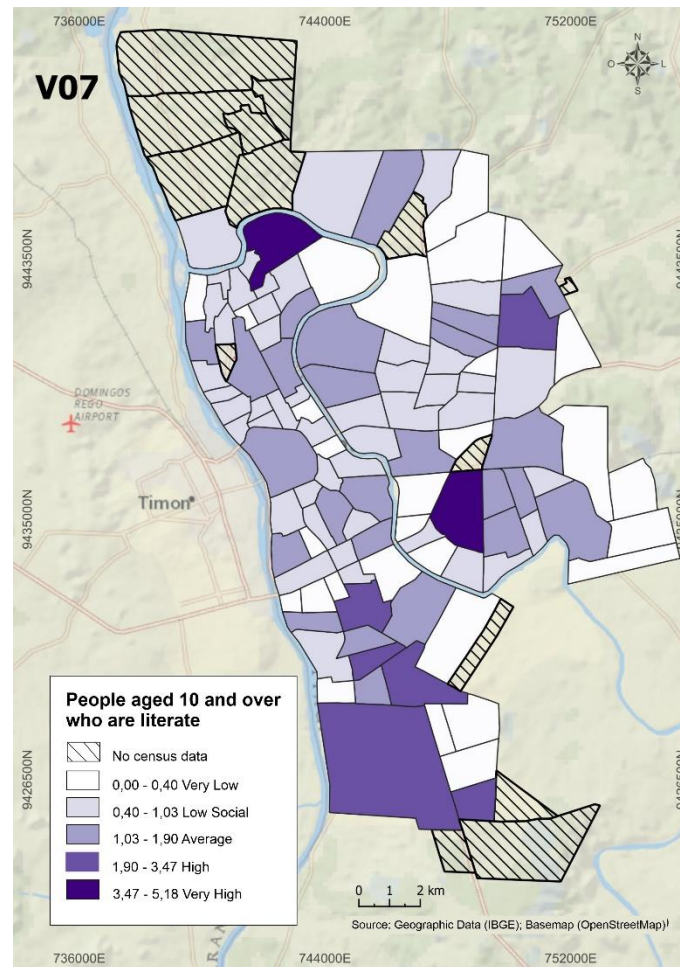


Figure 6 – Education Dimension Variable V07 - People 10 years old and older who are literate. Source: The authors, 2022. Organized by Ramos, 2021.

The analysis of the variable people 10 years old literate showed a predominance of 44 neighborhoods (40%) in the condition of very low vulnerability, contributing to the overall low vulnerability of the city. However, 2 neighborhoods (1.8%) were categorized as very high vulnerability: Itararé, located in the southeast zone, and Mocambinho, in the north zone. In the high category, 5 neighborhoods were pointed out: Angelim, Santo Antônio, Esplanada and Lourival Parente, located in the southern zone, and Vale Quem Tem, in the eastern zone.

3.4. Dimension Housing Conditions

The housing conditions dimension is composed of the following variables: water supply from the general distribution network, garbage collected by a cleaning service, sanitary sewage collected by the general sewage or rainwater network, and existence of electricity from the distribution company (Figure 7). Information about housing conditions and the supply of basic services, associated with economic and social analyses, is essential for the discussion of socio-environmental vulnerability as it reveals information about the quality of life and environmental security of the population. Regular garbage collection, legal electricity supply, sanitary sewage coverage, and water supply are essential services for the community and reduce the vulnerability of the population, since they support possible responses in the event of disasters.



Figure 7 – Dimension Variables Housing Conditions. V08 - Water supply from the general distribution network / V09 - Garbage collected directly by cleaning service / V10 - Sanitary sewage collected by the general sewage or rainwater network / V11 - Existence of electricity from the distribution company.
Source: The Authors, 2022. Organized by Ramos, 2021.

The variable water supply from the general distribution network showed a predominance of 44 neighborhoods (40%) in the very low category, demonstrating a certain efficiency in the distribution of the service since it is an essential service for improving the quality of life. However, 3 neighborhoods (2.7%) were categorized in the very high vulnerability condition: Itararé, located in the southeast zone, Mocambinho, in the north zone, and Angelim, in the south zone, neighborhoods characterized by being populated, revealing that a significant amount of people suffer with the absence of the service. In the condition of high vulnerability are the neighborhoods Vale Quem Tem (East zone), Promorar (South zone), Santo Antônio (South zone) and Esplanada (South zone).

Similar to the variable involving water distribution, the analysis of the variable garbage collected by the cleaning service classified most neighborhoods (43.6%) in the condition of very low vulnerability, however, two of the most populated neighborhoods of the city were classified as very high vulnerability: Itararé, located in the southeast zone, and Mocambinho, in the north zone. It is noted that Itararé and Mocambinho were also mentioned in the previous variable, deserving attention in terms of the demand for services and the reasons for not offering them. The neighborhoods Santo Antônio, Angelim, Esplanada and Promorar, all located in the south zone, and Vale Quem Tem, in the east zone, are in the condition of high vulnerability. The regular garbage collection coverage is important to measure socio-environmental vulnerability since its absence can clog storm drainage systems, causing flooding and promoting the proliferation of insects and water-borne diseases.

The analysis of the sanitary sewage variable collected by the general sewage network or pluvial network, although it has indicated 57.7% of the city neighborhoods in the condition of very low vulnerability, according to data from Agenda 2030, only 31% of the population has coverage of the service, with most of the population using septic tank systems and rudimentary, improper types that can promote the contamination of aquifers present in the city (TERESINA, 2013). In the very high vulnerability category, the Center neighborhood was pointed out, which is characterized by being one of the commercial centers of the city with few residences for housing. Already in the high vulnerability category, 11 neighborhoods (10%) were indicated, most of them located in the eastern part of the city, paradoxically, the most noble region of the city, with the presence of luxury properties and the most valued urban market. They are: Ilhotas, located in the central zone of the city, Cristo Rei and Morada Nova, in the southern zone, and Ininga, Fátima, Jóquei, São João, São Cristóvão, Horto, Morada do Sol and Santa Isabel, in the eastern zone.

The variable existence of electricity from the distribution company is an important indicator of vulnerability, since it is essential to the daily life of the population, facilitates nighttime commuting and contributes to public safety (TERESINA, 2015). The analysis of the variable indicated the predominance of neighborhoods in the very low category, with 47 (42.7%) of the 110 neighborhoods analyzed. In the very high category, 3 neighborhoods (2.7%) were categorized: Itararé (southeast zone), Angelim (south zone) and Mocambinho (north zone), neighborhoods frequently mentioned in the analyzed variables. In the condition of high vulnerability to the presence of electricity, the following neighborhoods were categorized and the indicated were Vale Quem Tem neighborhoods (east zone), Promorar, Santo Antônio, and Esplanada, these located in the south zone.

3.5. Social Vulnerability to Flooding

Based on the equation of the values belonging to each of the 11 variables analyzed, we observe a higher degree of social vulnerability to flooding in Teresina in the neighborhoods Angelim, Itararé and Mocambinho, located in the south, southeast and north zones, respectively (Figure 8). Therefore, these are neighborhoods whose population has a low response capacity upon the occurrence of the event, while presenting insufficient social, economic and housing indicators for this purpose. In the high vulnerability category, the following neighborhoods were highlighted: Centro, located in the central zone of the city; Vale Quem Tem, eastern zone; Gurupi, southeast zone and Lourival Parente, Promorar, Santo Antônio and Esplanada, all located in the southeast zone. Most neighborhoods in the city (39.1%) were classified in the low vulnerability category, distributed in the various zones of the city.

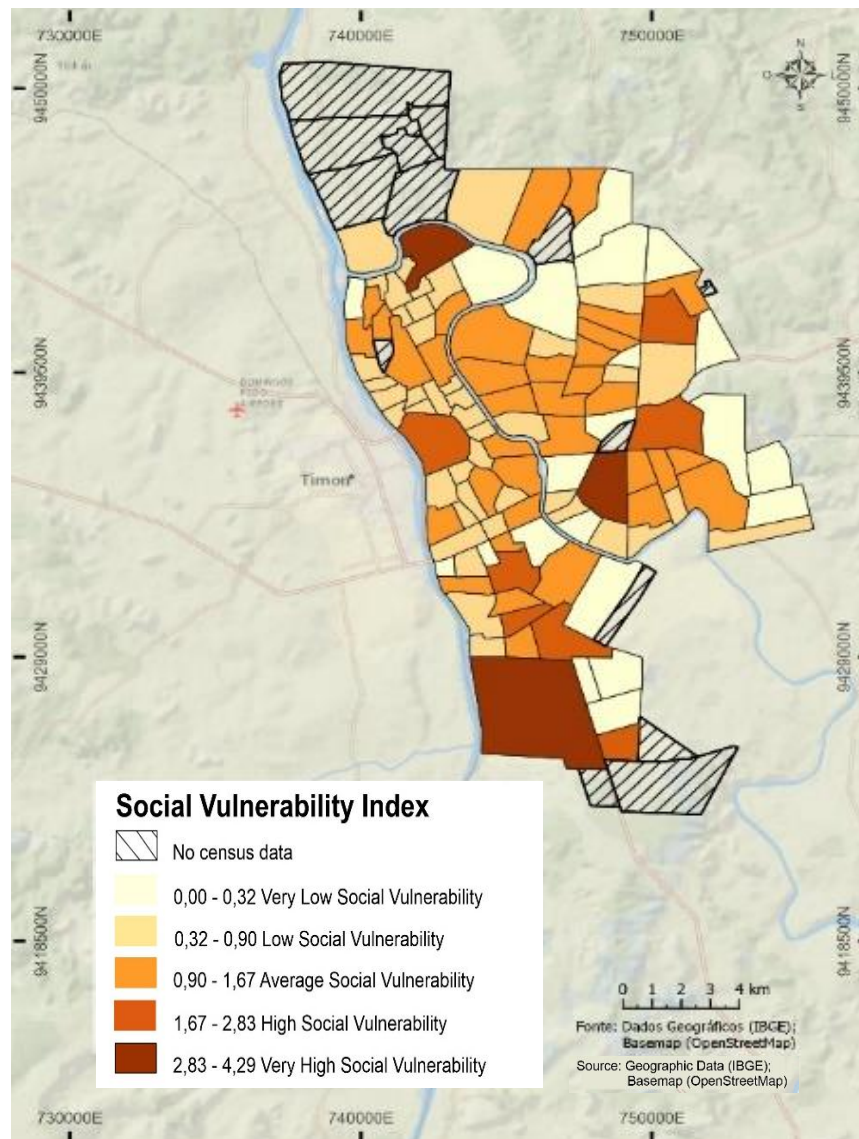


Figure 8 – Social Vulnerability in Teresina, Piauí
Source: The authors, 2022. Organized by Ramos, 2021.

Teresina, throughout its history, routinely presents episodes of flooding during the rainy season. Since its creation in the mid-nineteenth century, floods have been common in the various areas of the city, caused by the occupation of the floodplains of the Parnaíba and Poti rivers.

Making a correlation between the neighborhoods indicated as high and very high social vulnerability found and the occurrence of floods (Figure 9), it can be seen that among the neighborhoods categorized as very high vulnerability, Mocaminho e Angelim are located on the floodplains of the Poti and Parnaíba rivers, respectively, and are therefore vulnerable to flooding. The Itararé neighborhood, also indicated in the survey as very high vulnerability, located in the southeast zone of the city, is far from the floodplain of the rivers. In relation to slope, the Angelim neighborhood, located in the southern part of the city, is classified as gently undulating topography and Itararé and Mocaminho, located in the southeast and north zones, respectively, are in a flat area, which tends to aggravate the effects of flooding, since the waters from the overflowing rivers accumulate in the inhabited spaces, forcing the resident population to withdraw from their homes.

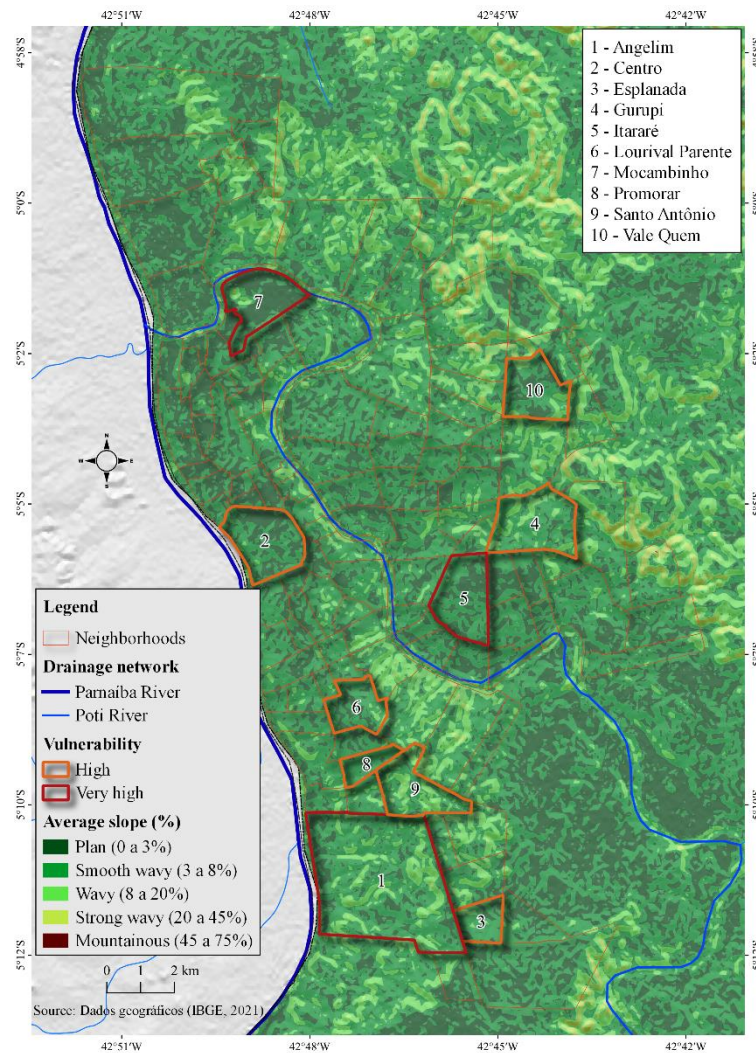


Figure 9 – Social Vulnerability to Flooding in Teresina, Piauí
Source: The Authors, 2022. Organized by Santos, 2022.

Among the neighborhoods categorized as highly vulnerable, only the Center is located in the floodplain of the Parnaíba River, and is therefore vulnerable to flooding. In relation to slope, the Center is located in a transition area, between gently undulating and flat topography, where, by presenting a small slope, it can minimize the effects of floods, since in steep areas the waters have an easier time draining away.

4. Final Considerations

Disasters occur frequently in urban areas in Brazil, especially during the rainy season, affecting a significant proportion of the population, making them vulnerable. Moreover, inadequate occupation of risk areas, such as steep slopes and flood plains, greatly increases the damage caused. In the meantime, studies that analyze social indicators and relate them to the occurrence of disasters become imperative for the reduction of damage generated as they provide subsidies for the elaboration of public policies of this nature.

It was found from the social indicators analyzed, a similarity in the neighborhoods categorized as very high and high vulnerability in the variables analyzed, being constantly mentioned the neighborhoods Itararé, located in the southeast zone; Angelim, Santo Antônio, Promorar, all located in the south zone, and Mocambinho, in the north zone. These

neighborhoods are characterized by being populated, with a significant number of children and elderly people, a considerable number of inhabitants with low income and education levels, and deficiencies in the supply of services that determine the housing conditions. To wit, these aspects provide a lower capacity to face the adverse effects generated by floods, making it essential to introduce measures that guarantee rights and circumvent the low indexes presented.

To wit, high vulnerability rates result from precarious living and social protection conditions, including work, income, health, education, as well as aspects related to infrastructure, such as healthy and safe housing, sanitation, among others, which make certain population groups, such as children and the elderly, especially among the poorest, the most vulnerable to disasters. The agglutination of conditions, such as economic deprivation, low levels of education, poor housing conditions and sanitation in areas susceptible to disasters, indicate an area of high vulnerability, since its carrying capacity is limited by the precarious socioeconomic characteristics of the population that occupies it. In this context, the neighborhoods indicated as high and very high vulnerability tend to present low social indicators, implying a limited response capacity in case of flooding.

Among the neighborhoods indicated as high and very high vulnerability, Mocambinho, Angelim and Centro deserve special attention from the public authorities in terms of the recurrence of floods, since, besides being located in river flood plains, they are installed in areas with flat topography, which requires an efficient drainage system, since in flat areas it is difficult for the waters to drain.

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