Revista GEAMA
The Journal of environment

Vulnerability environmental and flood risk in rio Poti, Teresina, Brazil

Maria Suzete Sousa Feitosa[(1)], **Ranyére Silva Nóbrega**[(2)]* and **José Machado** [(3)]

[(1)] Department of Geography, Universidade Estadual do Piauí, Teresina, Brazil.
[(2)] Department of Geographical Sciences, Universidade Federal de Pernambuco, Recife, Brazil.
[(3)] Department of Rural Technology, Universidade Federal Rural de Pernambuco, Recife, Brazil. josemachado@ufrpe.br
*E-mail: ranysn@gmail.com

ABSTRACT

Floods are natural events associated with urban peculiarities become sources of danger, worsening the population's living conditions in the city. In Brazil, the scenarios of environmental degradation resulting from social inequalities and poor infrastructure, coupled with the occupation of spaces problems highlight risks and vulnerabilities that often coincide with urban river environments. So the objective of this study is to analyze the flooding of the river Poti and the risks and social and environmental vulnerabilities present in Teresina, about urban stretch of the curve São Paulo to the confluence with the Parnaíba, for understanding the interfaces of vulnerabilities and exposure to environmental risk certain areas and population groups. The methodology involves statistical techniques to categorize precipitation (quantile) and analyze the changing trend (ClimDex), and multivariate analysis to classify the social vulnerability, fieldwork and newspaper survey. In the precipitation analysis it was found that the total rainfall follows trend of slight growth, with attention for the urbanization and the occurrence of flood disasters. It is concluded that there are strong similarities between the districts subject to high risk of flooding and neighborhoods with high social vulnerability.
Keywords: Urban environment, natural disasters, risk, flood.

INTRODUCTION

At present the study of city environments, especially Brazilian city, refers to the diversity of spaces and the most significant social characteristics of the population in each of these environments, that is the social expression (re) produced in the complex reality and transformed, refers Lombado (1985) cited Zanella (2006). In this sense, to Santos (1994), the city is an environment built fundamentally unequal, complete Rodrigues (1998). These are questions of the complex relationship between society and nature that offer high degree of dangerousness and risk as acid rain, pollution, floods, landslides, among others. Such events are specific environmental responses and obvious consequences of the organization of each place that locally they measure environmental changes and dialectically reproduce the spatial consequences of all - the urban environment.

Under the paradigm of the relationship urban society-environment, because of which establishes this environment, there is consensus to claim that human action denotes from this relationship new processes, new structures on which constitutes a system of responses by the natural system that is not passive to the actions of society that appropriates it (SILVEIRA; Sartori, 2010). In this perspective, the fact is urban spatial concreteness relevant expression of these new scenarios produced by the man in the natural landscape.

This second nature combined with use and disorderly occupation of land attributed to the removal of vegetation, waste production, dumping of sewage, among other factors, results in changes in natural processes and, consequently, entails environmental imbalances in ecosystems. And in the urban ecosystem, the concreteness of this nature has humanised the city its most striking developments, as have already been mentioned, and are objects of interest to study the new situations and processes that are peculiar.

The question here treated relates to the socioeconomic and environmental situation basically verified in Brazil, which until the mid-twentieth century configured a rural context. However, the incentives adopted by the policy of modernization in the country attracted a population group increased industrial activity. This advent made much of rural people move to live in the cities, because the mechanization of the field, which went to expel that population of the countryside, made the cities gradually to increase in number of inhabitants and economic importance (KEYS; LOPES, 2011). More recent records indicate that most of the population resides in urban areas, which caused in Mendonça (2004) understand the XXI century "the city of the century", as the twentieth century, in turn, would have been the urbanization .

Another factor associated with increased and population concentration in cities was and remains the search for a better life. This results in the importance that is now given the cities, which is due to the fact that contemporary society is predominantly urban. This fact makes the city space, in the sense given by Christofolleti (1997) a large mosaic, a large ecosystem, where the natural and the built share a single locus. Still following this reasoning, Chaves (2009) argues that although the city is a human construct subject to the various forms of organization of urban space, its ambience depicts the inseparable link of the elements of the natural environment and the built environment. Nature is part of the city, and the last, a modified environment, which in its construction, the natural was mischaracterized the nature became urbanized, integrated in the city to form the civilized reinforces Milk (1997).

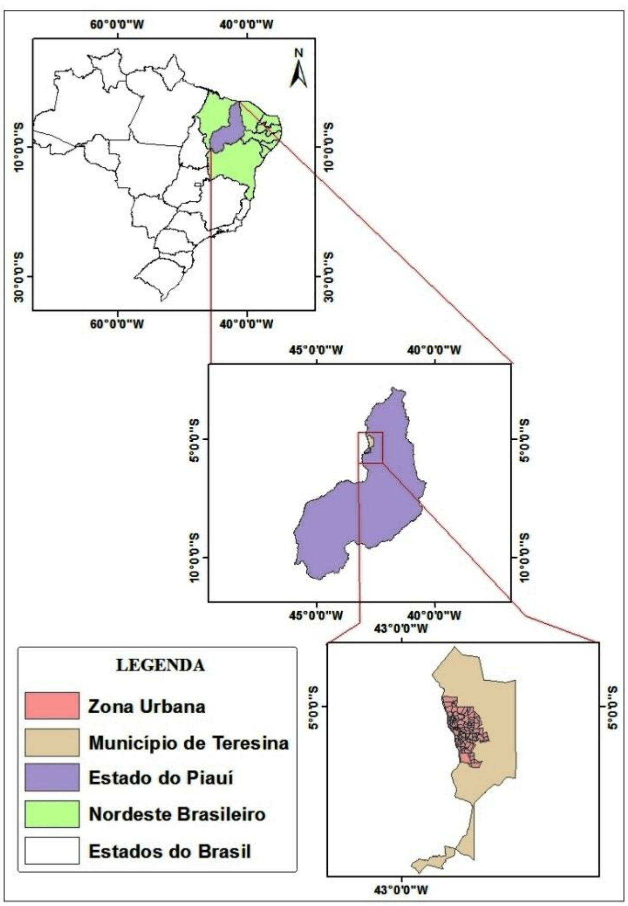
This is why the purpose of this article is to present the conceptual aspects of the relationship urban environment and environmental risks, based on literature review. In the discussion is explored the conceptual question of urban environment and natural disasters, and also environmental risks and vulnerability.

MATERIALS AND METHODS

1. The study area

Teresina, Piauí state capital, has coordinates 05 ° 05'12 " South and 42 ° 48'42 "West. The average altitude of the urban area is 72 m and the municipality of 100-150m. It occupies a land area of approximately 1,392 square kilometers with a population of 814,230 inhabitants and density of 585 inhabitants / km² (IBGE, 2011). This contingent 767,557 lived in the urban area and 46,673 in the countryside. Located in the northern part of Piaui, in a region known as the Mid-North, constituting a transition area between the semi-arid northeast and the Amazon region, setting typical physiographic evidence of damp northern Midwest and alternately dry periods and sub-humid northeast, according to Teresina (1993) (Figure 1).

Figure 1 - Location of the city of Teresina, Piauí.



Geographically, it is located on the right bank of the middle reaches of the Parnaiba river and the lower course of the river Poti and 5 ° 05'20'S and 42 ° 48 "07'O, seated in the sedimentary plain of the Parnaíba River, where elevations are less than 180 m above sea level and the lower slopes of 15%. Within the municipality, the Parnaíba travels about 90 km.

The urban area is crossed by two major waterways, which crosses the entire state of Piaui: the Parnaíba (S-N) and Poti (L-O). These fluvial channels print the main spatial arrangement observed in the capital, where the Parnaíba is variable width bed of 200-250 meters, but in confluence with the Poti reach 750 meters.

The river Poti tributary of the river Parnaíba, also highlights its importance in the city, it runs through much of the urban area to its discharge into the river Parnaíba, in the place known as Meeting of the Rivers, located in the north, a region that concentrates several ponds. Born in semi-arid region of Ceará reaching 450 km long, of which, 59 km within the Teresina area. The layout of this river is more rugged, with at least seven curves with 90 ° angles located at the confluence with the Parnaíba river and intermediate sections upstream of the system. The width of Poti trough along the urban area of Teresina varies between 150m-170m or so. His torrential regime conjugated to the flatness of the bed and the intricacies prior to its confluence results in extensive flooding during the floods. The formation of the meanders of the river Poti result of the natural work in its lower course and deviations made by the channel to find the low hills backed by ancient alluvial deposits (VIANA, 2013).

The Teresina relief is characterized by monoclinais and homoclinais structures covering layers of sediment, with a slight slope, forming a tabular topography and asymmetric (TERESINA, 2011). It consists of elongated morrotes and spikes, predominantly the interfluves and elongated tops, slopes with rectilinear profiles and high drainage and medium density, dendritic pattern and open valleys. Around the city low plateaus are individualized by the mentioned rivers and their tributaries smaller that cut the city (LIMA, 2002). The elevations range from 60 to 160 meters, highlighting the higher elevations in the east / southeast and also in the southern region of the city, which identifies the interfluves Poti / Parnaíba (TERESINA, 2011). The rainfall is predominantly convective mainly induced by the Intertropical Convergence Zone, the main atmospheric producer rainfall system.

There is still the performance of squall lines, convective complex mesoscale eddies and cyclones of high levels (VCAS). Depending on runoff are identified three urban macrobacias, one direct contribution to the Parnaíba river and two direct contribution to the Poti river. It is noteworthy that the two rivers have numerous tributaries that are uncharacterized and hidden by urban occupation (TERESINA, 2011).

2.Categorization and trend Rain gauge

To define the years in which precipitation volumes are considered extreme were analyzed daily data of rain, the 30-year period (1981-2010), provided by the CPRM weather station Teresina and INMET temperature data. After organizing and tabulating the data were carried out analyzes of the rainfall characteristics through the technique of quantile (XAVIER, 2002), in order to contribute to an understanding of climate influence and the flood risk management associated with rains Teresina. It was also performed statistical trend analysis for the annual accumulated rainfall, rainy consecutive days and dry days in a row based on indexes suggested by the Expert Team on Climate Change Detection Monitoring and Indices (ETCCDMI), being dependent on the daily rainfall, with their definitions and units (RR is the value of daily precipitation; RR≥1mm is a wet day and RR <1mm, a dry day): rainy consecutive days (DCC), maximum number of consecutive days with RR> 1 mm; dry consecutive days (DCS), maximum number of consecutive days with RR <1 mm; Total annual precipitation in wet days (PRCPTOT) (Nobrega et al, in press).

After categorization, the results were crossed with communication vehicle information (newspaper O Dia and information available on DVD for TV Cidade Verde) to validate that the years of heavy rainfall produced social impacts, in order to filter the years that are used for the diagnosis of vulnerabilities. They were then selected year flood 1985, 1995 and 2009.

Fieldwork For the development of the field stage visits were made to the area studied in interleaved period August 2012 to July 2014 for recognition of existing interfaces in place and the main partner space activities and definition of the areas to conduct survey. It was used Garmin e-trex accurate to 8m for calculating the level reference data (altitude profile attachment point) of each working point.

Thirteen accomplishment sections of topographic profiles perpendicular to the riverbed were delimited within the lower course of the river area, taking sections left and right initially identified in the mapping of the CPRM (BRAZIL, 2012) and empirical perception. At this stage we used the description of the CPRM (population data, urban infrastructure and physical characteristics) and social and environmental conditions observed that aid in the interpretation and analysis of the area of behavior in relation to the forms of use and occupation, as well as vulnerability the risk of flooding.

The choice of the points of observation and description was defined according to visual observation along the lower course area. This observation was the main objective to find points of greatest change of the natural environment in relation to fluvial dynamics and human activities (installation of infrastructure, improper occupation of margins and permanent protection area, and implementation of various activities). Added to this account the identification of risk areas raised by the CPRM.

To trace the profiles perpendicular to the shore line, flush through horizontal target the following instruments were used: topographic level of the brand Kern, Al-Top Tripod and Mira Topographic, which help in altimetry design of the occupied banks and who may be under the influence the river floods. This procedure was to achieve a target every change in the morphology of the profile always ahead of the last point where the reading was made, perpendicular to the shore line, following the profile mooring area (always a fixed location such as poles, houses etc.) to the waterline. The data profiles were recorded in topographic profile sheets and these data were stored in Excel (Microsoft office) where the dimensions of the readings taken were corrected. Then the coordinates were plotted in Grapher program (Golden Software) that outlines more precisely the profiles and edited these profiles in a text editor which were placed the main features observed in each profile.

3. Diagnosis of Social Vulnerability

The notion of social vulnerability to emerging issue of today's natural disasters and in the area of population and development has varied meanings of interpretation at the time that becomes relevant in the analysis of phenomena and arguments to evaluate the quality of the vulnerable in the strict sense. Marandola Jr. and Hogan (2005) justify no relation to the socioeconomic aspects of the populations in the areas of risk, so that such characteristics are also indicators of social disadvantage, playing an important role in people's capacity to address environmental risks in place, namely to respond and adjust to environmental adversities.

For a better understanding of social vulnerability, aspects such as income, education, infrastructure and age were highlighted for identification and analysis of population living in risk areas bordering the Poti river, or the selected districts for the analysis highlighted in search.

The variables chosen for this study must have components that would require social and environmental vulnerabilities. Accordingly, certain variables were chosen to indicate social disadvantages relating to groups of people and households, which can refer both to homes and in some cases, the group of people. The variables with the economic and social components to the scale of households and groups of people were translated into 10 indicators presented in Table 1 aiming the application of multivariate analysis.

To identify from these variables which would be relevant to establish a typology of neighborhoods of Teresina, with respect to social vulnerability , multivariate statistical analysis was used .

Table 1. Social Disadvantage Indicators

INDICADOR	DESCRIÇÃO
Rendimento médio padronizado (V1)	É o valor do rendimento médio de cada bairro, subtraído da média dos rendimentos médios dos bairros, dividindo tudo pelo desvio padrão, acrescentado uma unidade, e ao final tomando o inverso[1].
Porcentagem de analfabeto (V2)	Razão entre o número de pessoas de 5 ou mais anos de idade que não sabem ler e escrever, e o número total de pessoas de 5 ou mais anos de idade, multiplicado por 100.
Taxa de morador por domicílio (V3)	Razão entre o número total de habitantes de um bairro e o número de domicílio.
Porcentagem de domicílio Sem Energia (V4)	Razão entre o número de domicilio sem energia e o número total de domicilio, multiplicado por 100.
Porcentagem de domicílios referente a outras formas de Abastecimento de Água (V5)	Razão entre o número de domicílios referente a outras formas de abastecimento de água[2] e o número total de domicílios, multiplicado por 100.
Porcentagem de fossa rudimentar e outros (V6)	Porcentagem de domicílios que utilizam fossa rudimentar e outros, cujo escoamento se dá em vala, rio, lago ou outro escoadouro.
Porcentagem de queimadas e outros destinos do lixo (V7)	Porcentagem de domicílios, cujos destinos do lixo são queimadas e outros inadequados[3].
Razão de Dependência (V8)	Razão entre o segmento etário da população definido como economicamente dependente (os menores de 15 anos de idade e os de 60 e mais anos de idade) e o segmento etário potencialmente produtivo (entre 15 e 59 anos de idade).
Proporção de crianças de 0 a 14 anos de idade (V9)	Razão entre a população com idade entre 0 a 14 anos e a população total.
Proporção de Idosos 65 + (V10)	Razão entre a população com idade superior a 65 anos de idade e a população total.

1Rendimento médio é a única variável, cujo valor alto indica uma antagem, fez-se necessário tomar os inversos dos valores padronizados, com média em torno de 1 e desvio padrão 1, assim quanto menor o rendimento, maior será o seu inverso e indicando assim uma desvantagem. 2 Quanto ao abastecimento de água, considerou-se como inadequado aquele domicílio servido por rede geral, mas canalizada só na propriedade ou terreno, servido por poço, nascente ou outra forma.

To identify from these variables which would be relevant to establish a typology of neighborhoods of Teresina, with respect to social vulnerability , multivariate statistical analysis was used . It was then constructed a matrix containing 19 selected districts and 10 indicators. variables arithmetic mean statistics , standard deviation, Pearson's coefficient of variation , minimum and maximum were analyzed . Further analysis of the details can be found in Feitosa (2014) .

RESULTS AND DISCUSSION

With the technique of applying quantile it was possible to verify the percentage 15 % 20% (15 % - 35 %), 30 % (35 % - 65 %), 20 % (65 % - 85 %) and 15 % which are probabilities or expected frequencies for the events " very dry " , "dry" , "normal" , " wet " and " very rainy " , respectively, during a sequence of years for which the maintenance of the same characteristics for rain possible in the region considered , as shown in Table 2 below.

Table 2 - Classification of Percentages of Quantile.

15%	35%	50%	65%	85%
<--------	<--------	<------------>	-------->	-------->
MUITO SECO	SECO	NORMAL	CHUVOSO	MUITO CHUVOSO
954,97mm	1247,18	1383,65	1507,69	1806,75
Q(0,15)	Q(0,35)	Q(0,50)	Q(0,65)	Q(0,85)

Where: Very Dry = $Xi \leq Q\ (0.15) \rightarrow Xi \leq 954{,}97mm$; Dry $Q = (0.15) < Xi \leq Q\ (0.35) \rightarrow 954{,}97mm < Xi \leq$

1247,18mm ; Normal Q = (0.35) < Xi <Q (0.65) → 1247,18mm < Xi < 1507,69mm ; Rainy = Q (0.65) ≤ Xi <Q (0.85) → 1507,69mm ≤ Xi < 1806,75mm ; and very rainy = Xi ≥ Q (0.85) → Xi ≥ 1806,75mm . In the results, 15 % of the years analyzed were presented as very dry, dry 20%, 30 % Normal 20% wet and 15 % very rainy (Quadro 1) .

Quadro 1 - the Quantile rating applies the studied time series (1981-2010).

ANO	TOTAL ANUAL (mm)	CLASSIFICAÇÃO
1981	907,1	Muito Seco
1982	915,0	Muito Seco
1983	1051,2	Seco
1984	1499,3	Normal
1985	2561,7	**Muito Chuvoso**
1986	1573,9	Chuvoso
1987	1462,3	Normal
1988	1694,2	Chuvoso
1989	1875,2	**Muito Chuvoso**
1990	798,2	Muito Seco
1991	1262,4	Normal
1992	845,6	Muito Seco
1993	1010,4	Seco
1994	1616,1	Chuvoso
1995	1922,3	**Muito Chuvoso**
1996	1309,3	Normal
1997	1165,0	Seco
1998	975,9	Seco
1999	1286,3	Normal
2000	1567,3	Chuvoso
2001	1457,5	Normal
2002	1109,1	Seco
2003	1265,4	Normal
2004	1553,0	Chuvoso
2005	1553,8	Normal
2006	1492,6	Normal
2007	1413,5	Normal
2008	1770,9	Chuvoso
2009	2012,8	**Muito Chuvoso**
2010	1036,9	Seco

According to the quantile they were classified 4 years very dry, dry 6 years, 10 normal years, 6 rainy and very rainy 4 corresponding to the extreme class Very rainy (1985, 1989, 1995 and 2009). It is justified, however, that 1989 was not included in the analysis of rainfall because it was not considered impactful event year in urban areas, analyzed through consultations with vehicle information. This year, in particular, the volume of precipitation was seasonally better distributed.

Regarding the trend in precipitation, the results indicate that the cumulative rainfall has mild upward trend, not statistically significant. It is emphasized that although there was no statistical significance, such trends deserve attention when it comes to flooding and its relationship with urbanization and different environmental factors to join contribute to make it vulnerable to the occurrence of this type of disaster. The question of statistical significance may be conditioned by the quality of the series, and its interruptions due to lack of data. In turn, the tendency to dry and rainy days in a row indicates that the rains are becoming more distributed, with negative trend for both, and the DCC statistically significant.

As a small increase in the annual total, there may be important effect on increases in climate anomalies, thereby flood events may reflect the expansion of the possibility of flooding the soil is already wet.

By processing the data with all the variables used for the diagnosis of social vulnerability (V1 to V10), they are eliminated those whose commonality presented values below 0.60, as these are not explained by all the common factors. No variable was communality below 0.60 therefore no variable will be eliminated from the analysis. It has been determined, then the number of factors by the eigenvalues whose value was greater than 1.0 while retaining is thus only factors that were greater than a variable explanation may explain alone. The 10 variables yielded only three factors, ie, there is a strong correlation between the 10 variables chosen to determine and differentiate the degree of vulnerability of each of the studied areas. The three retained factors explained more than 80% of the total variance of the 10 original variables from the diversity found in 19 districts. The first factor, which has a more than 2 times higher than the second eigenvalue explains about 45% of the total variance, the second accounts for about 21% and the third accounts for about 14% of the total variation.

To identify the constituents of each factor with high factor loadings for each factor, we proceeded to the rotation of the reference axes using the varimax method, from the correlation matrix of 10 variables with three common factors not rotated. The factor loadings when the factor analysis of a correlation matrix are correlation coefficients between the variables and factors, expressing as an observed variable is loaded into a factor. So that the results show that the factor 1 is correlated with the following variables: standardized average income, illiterate percentage, resident rate per household, Dependency Ratio, Proportion of children 0-14 years old and Senior Proportion over 65 years of age. Factor 2 is correlated with the variables: Percentage of households with regard to other forms of water supply, rudimentary pit Percentage and others and Percentage of fires and other waste destinations. Factor 3 is correlated only with the variable home Percentage No Power.

It is observed that the first factor were grouped practically all socioeconomic variables , indicative of poverty , such as those related to income and illiteracy rate can be pointed out. So from now on, the factor 1 is to be called social disadvantage factor , which is the decisive factor in the classification of areas , and that explains 45.43 % total variance of the original set . Factor 2 , as can be seen , grouped most of the variables indicating lack of basic sanitation , indicative also of poverty , and social disadvantage factor and environmental quality . Factor 3 is related only to the variable percentage of households without power , which was called environmental quality factor. cluster analysis based on the final levels resulted in five quarters of relatively homogenous groups in accordance with Table 3 .

Table 3 - Number of second neighborhoods homogeneous groups.

GRUPOS	NÚMEROS DE ÁREAS	DENOMINAÇÃO DO GRUPO
1	2	Baixa Vulnerabilidade
2	7	Media Vulnerabilidade
3	9	Alta Vulnerabilidade
4	1	Altíssima Vulnerabilidade

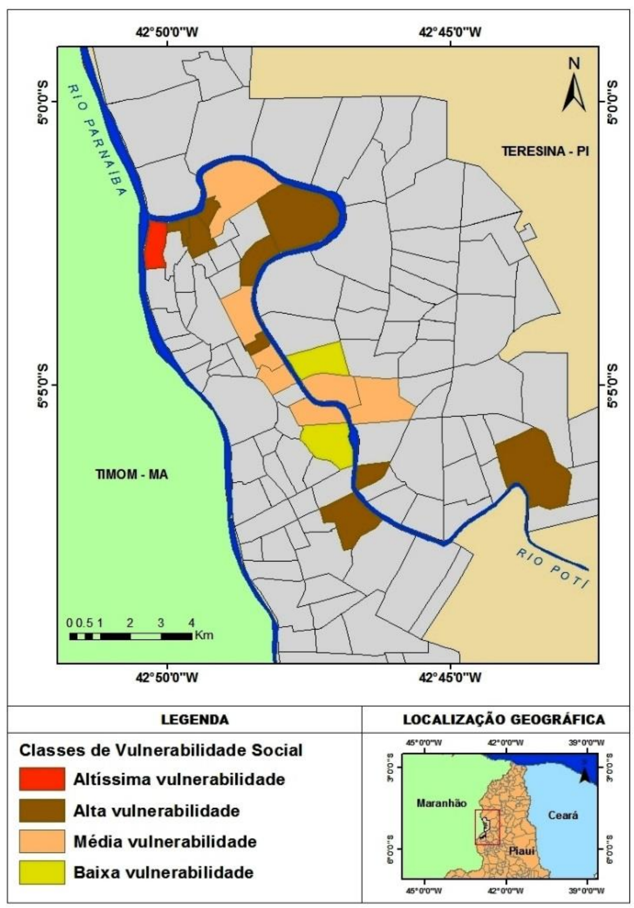
Table 4 presents the final index and the respective groups that were allocated each of the 19 districts , resulting in the production of social vulnerability map (Figure 2) .

Table 4 - Final score factor , final index and its homogeneous group , according to the neighborhoods of the search area - Teresina in 2010.

BAIRRO	ESCORE FATORIAL FINAL	INDICE FINAL	GRUPO	CLASSIFICAÇÃO
Jóquei	-1,23	0,00	1	Baixa vulnerabilidade
Cristo Rei	-1,07	0,06	1	Baixa vulnerabilidade
Noivos	-0,72	0,19	2	Media vulnerabilidade
Mocambinho	-0,40	0,30	2	Media vulnerabilidade
São João	-0,52	0,26	2	Media vulnerabilidade
Cabral	-0,66	0,21	2	Media vulnerabilidade
Primavera	-0,38	0,31	2	Media vulnerabilidade
Ilhotas	-0,28	0,35	2	Media vulnerabilidade
Porenquanto	-0,43	0,29	2	Media vulnerabilidade
Embrapa	0,17	0,51	3	Alta vulnerabilidade
São Sebastião	0,43	0,60	3	Alta vulnerabilidade
Poti Velho	0,18	0,52	3	Alta vulnerabilidade
Água Mineral	0,55	0,65	3	Alta vulnerabilidade
São Francisco	0,45	0,61	3	Alta vulnerabilidade
Morro da Esperança	0,35	0,58	3	Alta vulnerabilidade
Beira Rio	0,76	0,73	3	Alta vulnerabilidade
Alto Alegre	0,41	0,60	3	Alta vulnerabilidade
Catarina	0,86	0,76	3	Alta vulnerabilidade
Olarias	1,51	1,00	4	Altíssima vulnerabilidade

So far, you can check that exist in the urban stretch of the river Poti in Teresina, certain areas occupied by population groups of high and high social vulnerability . Especially the closer to find the areas of expansion of the urban area , especially in the North and East zones , the higher the incidence of indicators associated with social disadvantage , as evidenced aspects of social inequality. However , in addition to identifying the areas where the population is more vulnerable socially , the objective is also in this study to characterize those where there is occurrence of environmental risk.

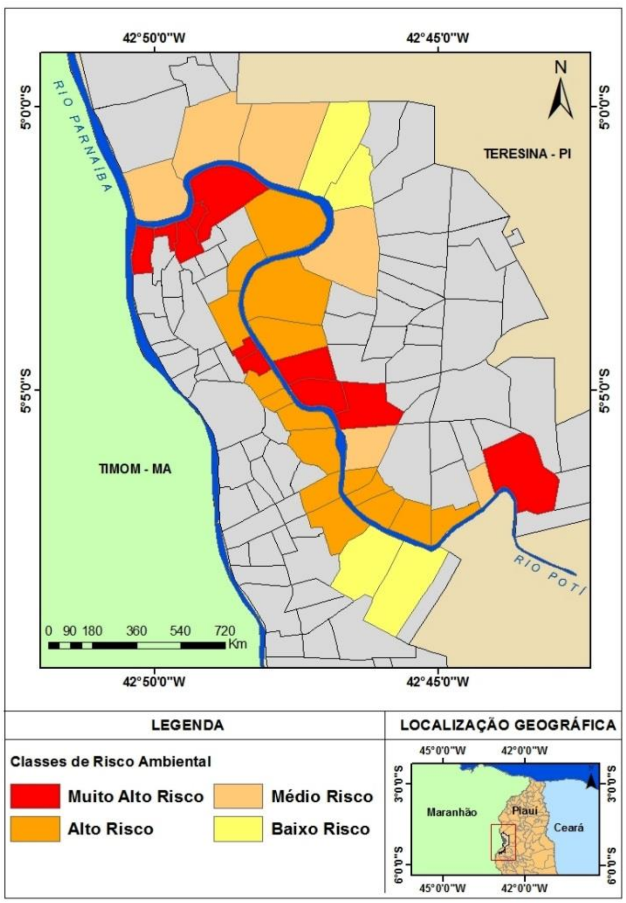
Figure 2 - Map of Social Vulnerability to the urban stretch of the river Poti , Teresina , PI.



In order to illustrate the areas of risk profiles were developed with the description ruled field records , mapping CPRM (BRAZIL , 2012) and the elevations of the study area . Were then plotted profiles 13 based on the CPRM information , so that the resulting environmental risk map (Figure 3) . The profiles are available in Feitosa (2014).

The combination or superposition of elaborate maps with support in the statistical classification of Social Vulnerability and definition of Environmental Profiles in the classification of risk to flooding possible through these techniques identification and location of territorial spaces (districts) resulted in the cartographic representation of Vulnerability Map Social and Environmental (Figure 4).

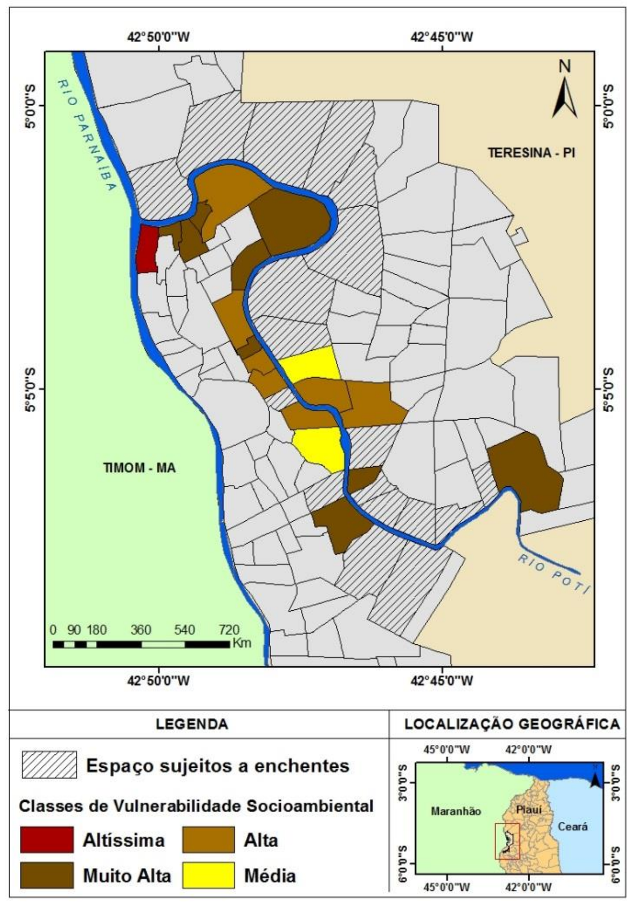
Figure 3 - Environmental Risk Map.



Initially, it defined the grouping of environmental vulnerability classes by association of vulnerability classes and risk . From that assumption elected to the intersection between these groups according to their similarities , and thus formed homogeneous groups of environmental vulnerability , following the principle of identification and location of areas that add both dimensions .

The Map of Social and Environmental Vulnerability lower course of the river corresponding Poti the study area , allows you to view four spatial scenarios distribution of vulnerable areas. The lack of data made it impossible to define the social vulnerability in all the districts of the study area.

Figure 4 - Environmental Vulnerability Map.



SCENARIO 1 - city areas in the riverbed Poti converging high environmental vulnerability located in the northern zone of very dense population concentration environments. Distributional aspects are due to the proximity of the mouth of Poti, the type of soil that favors the flooding, the lower elevations of the city. It involves the study the Potteries district.

SCENARIO 2 - Areas where overlap very high and high environmental risk subject to localized flooding in the high strata of social vulnerability. Therefore gives high environmental vulnerability neighborhoods Poti Velho, Alto Alegre, San Francisco, Embrapa, Mineral Water, Hill of Hope, Beira Rio, Catarina and San Sebastian.

SCENARIO 3 - Areas to the north, center and east of the city, characterized by environmental medium vulnerability are high sectors and very high risk and high exposure to the effects of flooding. They identify the Mocambinho neighborhoods Spring Porenquanto, Cabral, Grooms, Islets and St. John.

SCENARIO 4 - In the central and eastern regions are areas of very high and high risk calls also, low socio-environmental vulnerability, these city sectors with high and medium exposure to the river Poti floods, both occupied by low vulnerability classes; in this case constitutes a restriction of the result of the study, since the social vulnerability was based on census data. These, however, do not always represent the actual socio-economic conditions and quality of life of the population, but an objectified sampling IBGE, aspect to be carried out more in the case of a management based on socioeconomic inequalities of these spaces. It is clear from these results that there is need for the establishment management compatible with the environmental resulting from urban territorial space, investments in priority sectors such as sanitation, education; promoting policies that benefit the poorest population and aimed at environments where it identifies risk of coincidence and vulnerability to flooding.

REFERENCES

BRASIL. Ministério de Minas e Energia, Serviço Geológico do Brasil – CPRM. *Ação Emergencial para Reconhecimento de Áreas de Alto e Muito Alto Risco a Movimento de Massas e Enchentes.* Teresina, 2012.

CHAVES, S. V. V. *A vulnerabilidade socioambiental em Teresina, PI.* Dissertação de Mestrado em Desenvolvimento e Meio Ambiente. Teresina: UFPI, 2009.

CHAVES, S. V. V.; LOPES, W. G. R. A vulnerabilidade socioambiental em Teresina, Piauí, Brasil. *Revista Geográfica da América Central.* Número Especial EGAL, 2011. Costa Rica, pp. 1-17.

CHRISTOFOLETTI, A. Impactos no meio ambiente ocasionado pela urbanização no mundo tropical. In: SOUZA, M. A. et al. *O novo mapa do mundo* – natureza e sociedade de hoje: uma leitura geográfica. São Paulo: Hucitec, 1997.

FEITOSA, M. S. Enchentes do rio Poti e vulnerabilidades socioambientais na cidade de Teresina-PI. Tese de Doutorado. Universidade Federal de Pernambuco, Recife, PE. 229p. 2014.

IBGE. Instituto Brasileiro de Geografia e Estatística. *Censo Demográfico 2010.* Rio de Janeiro: IBGE, 2011.

LEITE, M. A. F. P. A natureza e a cidade: rediscutindo suas relações. In: SOUZA, M. A. et al. *O novo mapa do mundo* – natureza e sociedade de hoje: uma leitura geográfica. São Paulo: Hucitec, 1997.

LIMA, I. M. M. F. Teresina: urbanização e meio ambiente. In: Scientia et Spes: *Revista do Instituto Camilo Filho,* v. 01. N. 02. Teresina – Pi: ICF, 2002, p. 181 -206.

MARANDOLA Jr, E.; HOGAN, D. J. Vulnerabilidade e riscos: entre a geografia e a demografia. *Revista Brasileira* *de Estudos Populacionais*. v. 22, n. 1, p. 29-53, jan/jun. 2005.

MENDONÇA, F. (org); MONTEIRO, C. A. F. et. al. (autores). *Impactos socioambientais urbanos.* Curitiba, PR: Ed. UFPR, 2004.

NÓBREGA, R. S. LIMA, R. F.; SANTOS, C. A. Variabilidade temporal e espacial da precipitação pluviométrica em Pernambuco através de índices de extremos climáticos. Revista Brasileira de Meteorologia, no prelo.

RODRIGUES, A. M. *Produção e consumo do e no espaço:* problemática ambiental urbana. São Paulo: Hucitec, 1998.

SANTOS, M. *A urbanização brasileira.* 2 ed. São Paulo: HUCITEC, 1994.

SILVEIRA, R. D.; SARTORI, M. G. B. Relação entre tipos de tempo, eventos de precipitação extrema e inundações no espaço urbano de São Sepé - RS. In: *Revista Brasileira de Climatologia.* Ano 6. Vol. 7 – set/2010.

TERESINA, *Legislação urbana de Teresina*, Lei N° 2.264, Lei N° 2.265, Lei N° 2.266, Diário Oficial do Município de Teresina, 1993.

TERESINA. *Banco de Dados de Teresina. Características Gerais.* Teresina, 2011. Disponível em http://pt.scribd.com/doc/75168326/CARACTERÍSTICAS-GERAIS-TERESINA. Acesso em março/2013.

VIANA, B. A. S.; ARAÚJO. J. L. L. Impactos socioambientais da atividade mineradora no meio ambiente urbano de Teresina – PI. In: FAÇANHA, A. C.; SOUSA, M. A. M. (org.). *Indicações geográficas e temas em foco*. Teresina: EDUFPI, 2011.

XAVIER, T.M.B.S. A Técnica dos quantis e suas aplicações em Meteorologia, Climatologia e Hidrologia, com ênfase para as regiões brasileiras. Brasília: Thesaurus, 2002. 143p.

ZANELLA, M. E. *Inundações urbanas em Curitiba-PR:* impactos, riscos e vulnerabilidade