OPEN JOURNAL SYSTEMS
ISSN:2237-2202

Available on line at Directory of Open Access Journals

Journal of Hyperspectral Remote Sensing 12 (2012) 083-097

Journal of Hyperspectral Remote Sensing
www.ufpe.br/jhrs

USE OF GIS IN IDENTIFICATION OF RISK AREAS AND SOCIAL VULNERABILITY DUE TO LOCAL RAINFALL

Lidiane Cristina Félix Gomes[*], Glauciene Ferreira Justino da Silva[**], Virgínia Mirtes de Alcântara Silva[***], Victor Herbert de Alcântara Ribeiro[****], Raianny Leite do Nascimento Wanderley[*****]

[*] PhD student at the Graduate Program in Geography, Federal University of Ceará - UFC. Campus do Pici - Fortaleza - Ceará, Brazil. Phone: 55+8388448170
[**] Masters student in Geography, Federal University of Paraíba - UFPB, João Pessoa - Paraíba, Brazil. Phone: 55+8387173529
[***] Student expertise Geoambiência Semiarid and Water Resources, State University of Paraíba - UEPB, CITY - Paraiba, Brazil. Phone: 55+8386908364
[****] Graduate Student in Agroecology, Paraíba State University – UEPB, CIDADE – Paraíba, Brazil. Phone: 55+8386908364
[*****] MSc in Meteorology, Researcher, University of São Paulo - USP, São Paulo - São Paulo, Brazil. Phone: 55+11951065227

Received 05 December 2011; revised 11 April 2012; accepted 21 April 2012

Abstract

This study aimed to present the contributions of GIS to detect areas of risk and social vulnerability in João Pessoa City, according to obtained data from civil defense. The spatial distribution of the region's communities was accomplished and extracted risk areas that have been affected with the precipitation anomalies occurred in the years 2011 and 2012. Also, maps of topography were obtained and slope hypsometric eminent assess the risks of irregular occupations in the study area. Finally, João Pessoa lacks management policies for the appropriate use of the soil and for natural disaster prevention.

Keywords: GIS, Social Vunerability, Natural Disasters.

Introduction

Over the years, the urbanization process and disordered occupations have aggravated the duration, intensity and frequency of natural disasters caused by heavy rains as landslides, floods and landslides. This could be caused by the high surface temperature of the city, which increases global warming, but also due to the heat which is irradiated by the heat engines and refrigeration systems (Lombardo, 1985).

In Brazil, this process is characterized by the intense pace and acceleration (Santos, 1990), being product of speculative logic that results in urban voids, concentrations of noble

Corresponding author: lidiane.geo@gmail.com.

areas in poverty with inappropriate occupation of urban sites (Carlos, 2001); becoming in hazardous environmental areas with growing vulnerabilities (Veyret, 2007; Beck, 1986).

In recent decades, the record number of natural disasters in various parts of the world is considerably increasing. This is due mainly to the increase in population, disorganized occupation and the intense process of urbanization and industrialization. Among the main factors that contribute to lead to these disasters in urban areas are the soil sealing, densification of buildings, conservation of heat and air pollution. (Kobiyama, *et al*., 2006).

Kobiyama *et al*., (2006) defines disaster as a result of adverse events, or natural order caused by human action on a particular ecosystem (designated vulnerable) causing damage human, material and environmental and consequent economic and social losses.

According IPCC (2007) is expected a higher frequency of heat waves in urban areas, with greater intensity and duration, accompanied by further deterioration of air quality and increase risk areas, particularly in tropical cities, increasingly subject to intense rains that can cause slope landslides and floods.

Another consequence of climate change will be the increased frequency of heavy rains, which have already been a big problem in many cities in Brazil. In the state of Santa Catarina in 2008, heavy rains caused severe flooding and mudslides that affected 1.5 million people and resulted in 120 victims and 69,000 homeless people, where most of the fatalities were caused by landslides (Marengo, 2009).

The increase in emissions of greenhouse gases as a result of human action, has intensified and can bring negative consequences for natural ecosystems. For this reason, climate change and global warming are beginning to be widely studied by many researchers around the world (Lohmann *et al*., 2006; Chavas *et al*., 2009; Harmsen *et al*., 2009; Campos et al., 2010).

The Intergovernmental Panel on Climate Change (IPCC), by means of mathematical models based on data recorded in the oceans, biosphere and atmosphere, indicated an increase between 1.4 and 5.8 °C global temperature by the end of the XXI century (IPCC, 2007).

For Latin America, it is expected an increase of 2 – 6 ^{o}C in the surface temperature and increased frequency and intensity of extreme events such as heat waves /cold, drought, floods, and especially hurricanes and tropical storms. The magnitudes of these predictions are still uncertain, because there is little knowledge about the processes of heat exchange, carbon and solar radiation between different ecosystems (Silva *et al*., 2010).

In this context, urbanization is a phenomenon due to population growth, impacting the environment, in particular by changing climatic conditions, when soil surfaces are replaced by different forms of occupation and use by changing natural conditions of the local environment. Studies indicate that urbanization and human activities affect the urban climate, bringing several consequences. Monteiro (1976); Landsberg (1981); Mascaró (1996); Romero (2001); Sorre (2006); Barbirato, Souza & Torres (2007) addressed the issue of urban climate and found that urbanization and human activities are consequences this process. Due to removal of the canopy and the new paving streets, soils are increasingly impervious, as well as drainage systems become increasingly inefficient. What has caused major disasters in recent years is the disorderly occupation along the riverbanks and buildings in inappropriate areas such as hills and slopes. These areas are known as areas of risk, employed according to social vulnerability of the population, and these areas are also susceptible to natural disasters such as landslides and floods.

In João Pessoa, PB, there is also the inordinate use of soil in some areas of the city. In most cases, risk areas are directly linked to the social conditions of the population. Martine (1993) and Smolka (1993) says that rapid urbanization on the natural environment, so cluttered and segregated, has been not only a key driver of environmental problems, but also a producer of social imbalances, involving poverty, risk and vulnerability in its many faces. According Umbelino et al. (2007), urban growth alters the landscape elements: soil, geomorphology, vegetation, fauna, hydrology, air and climate. The disorderly occupation in urban centers is a major source of environmental problems in cities, characterized by high inequality in terms of income distribution, poor housing and limited access to public services, particularly in the share of the poorest and vulnerable in social and environmental.

It is extremely important to involve the study of geomorphology within the context of the theme. Few publications in this area deal with this issue (Okuda, 1970; Verstappen, 1989; Rosenfeld, 1994).

Flooding associated with hydrometeorological phenomena such as tropical storms, or hurricanes, monsoons, the El Niño or La Niña are considered hazardous natural events (Ayala, 2001).

Approaches to understand these processes include the study of previous events. Moreover, using flood simulations, forecasting and flood maps prepared with the help of Geographic Information Systems (GIS), radar and remote sensing (Merzi & Aktas, 2000) techniques are crucial in the development and evaluation of risks and public management.

Regarding the problem that occurred in various parts of Brazil and managerial accountability, the geoprocessing techniques are contributing to the organization of urban space, the identification of risk areas susceptible to landslides, floods and landslides. As the weather in the forecast of torrential rain control and time series of rainfall site.

This work has as study area João Pessoa City - PB, aiming to use GIS techniques to identify areas of risk in vulnerable conditions according to the heavy rainfall, as well as to report the occurrence of rain and disorders occurred between the years 2011 and 2012.

2. Material and Methods

2.1 Investigation Area

João Pessoa City (Figure 1) is located at the eastern end of the state of Paraíba, between the coordinates 08° 07 'south latitude and 34° 52' west longitude. It borders to the north with Cabedelo City, across the Jaguaribe river, to the south with Conde City, by the Gramame river, on the east by the Atlantic Ocean, and on the west with Bayeux City, by the Sanhauá river and Santa Rita City by the Mumbaba river and Paraíba river.

It has a population of 723.515 inhabitants and the area of the territorial unit is approximately 211.474 km² and population density 3421.30 (inhabitants/km²) (IBGE, 2010). Due to urban growth, the city grew eastward and currently presents a diverse urban site at the foot of the slopes, and coastal plain boards.

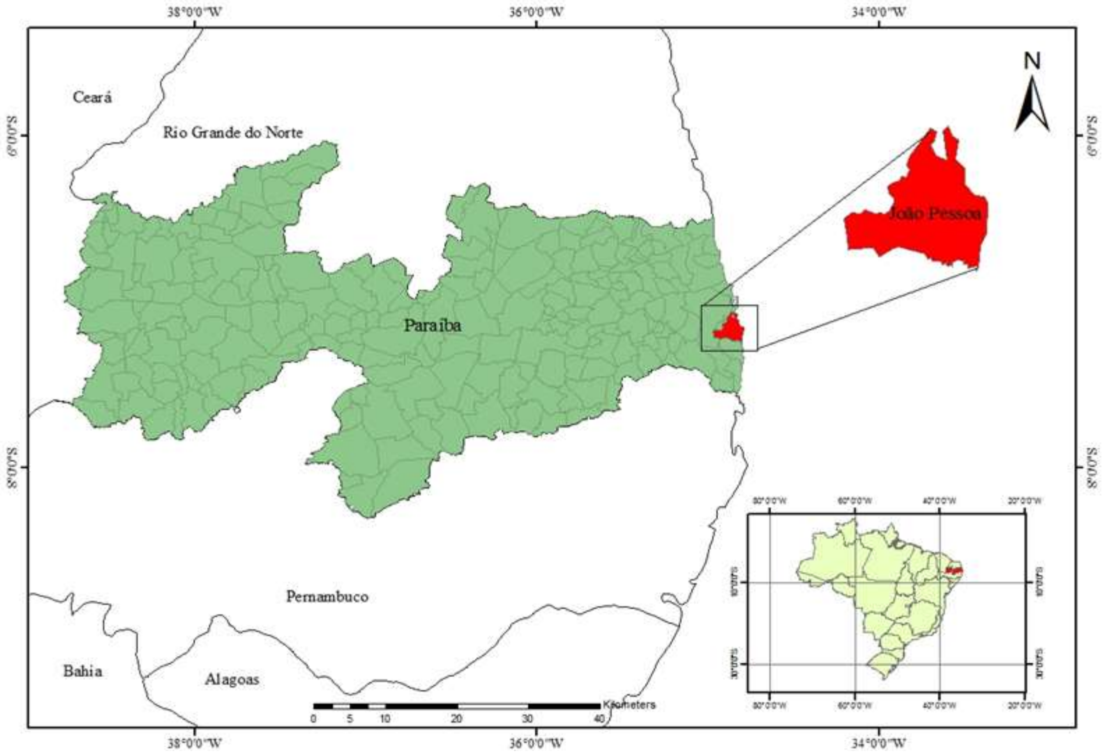


Figure 1: João Pessoa city's location map.

According to the Köppen's classification, climate is tropical rainy AS ', hot and humid, with rains of autumn-winter, the dry season is 3-4 months per year, and a rainy period comprising the months of May, June and July . The total annual rainfall is approximately 1.700mm. The average minimum temperature is 23 ºC and a maximum of 28 ºC and relative humidity is about 80%. In the city can still found remnants of Atlantic Forest biome heavily impacted by urbanization occurring in the coastal zone. According to the profile of the municipality prepared by the municipal government has João Pessoa, the city has 49.69 km² of environmental preservation.

2.2 Raster and vectors data

To develop this study, has been used shapefiles from João Pessoa City and their communities, which were made available by PMJP, information risk areas, type of risk, historical occurrences of disasters granted by the Civil Defense of the Municipality, rainfall data obtained by AESA and data relief surface extracted from SRTM images, of the Embrapa's site.

The shapes were acquired, entered into the GIS software, ArcGIS ®, allowing visualization of the spatial distribution of communities, as shown in Figure 2.

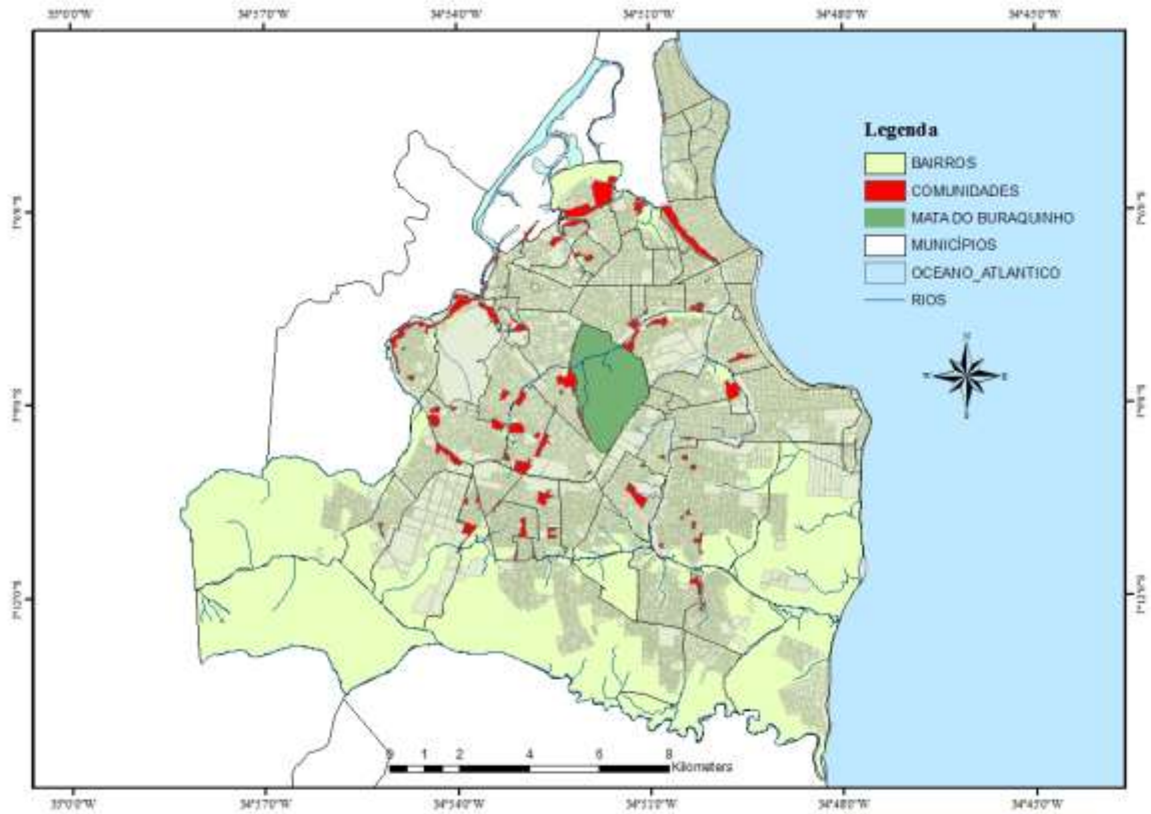
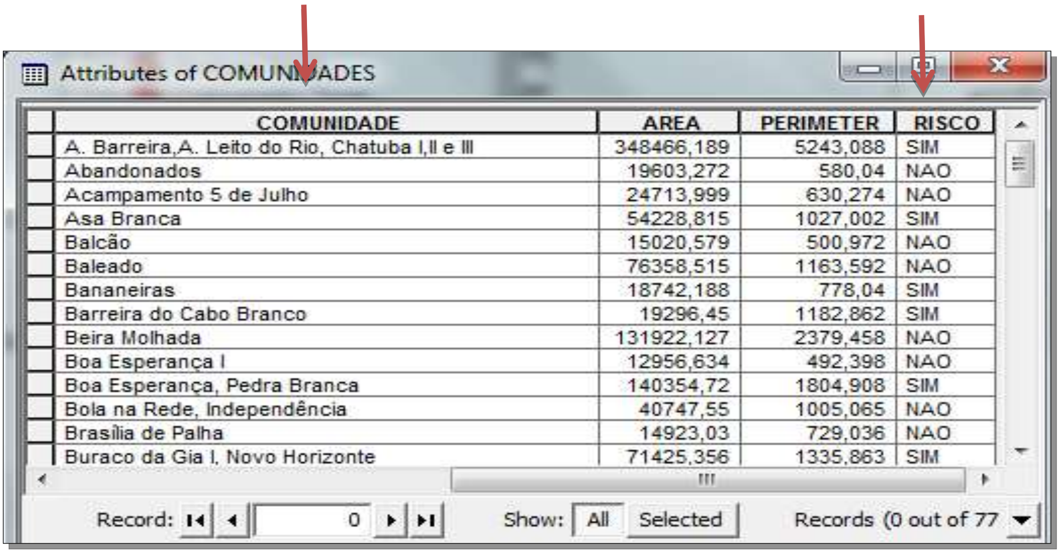


Figure 2: Map of the spatial distribution of existing communities in João Pessoa City.

The next step was to extract the database shapes in existing communities (Figure 3), the vulnerable areas indicated by the civil defense, indicated as risk areas.


Attributes of COMUNIDADES

	COMUNIDADE	AREA	PERIMETER	RISCO
	A. Barreira,A. Leito do Rio, Chatuba I,II e III	348466,189	5243,088	SIM
	Abandonados	19603,272	580,04	NAO
	Acampamento 5 de Julho	24713,999	630,274	NAO
	Asa Branca	54228,815	1027,002	SIM
	Balcão	15020,579	500,972	NAO
	Baleado	76358,515	1163,592	NAO
	Bananeiras	18742,188	778,04	SIM
	Barreira do Cabo Branco	19296,45	1182,862	SIM
	Beira Molhada	131922,127	2379,458	NAO
	Boa Esperança I	12956,634	492,398	NAO
	Boa Esperança, Pedra Branca	140354,72	1804,908	SIM
	Bola na Rede, Independência	40747,55	1005,065	NAO
	Brasília de Palha	14923,03	729,036	NAO
	Buraco da Gia I, Novo Horizonte	71425,356	1335,863	SIM

Record: 0 Show: All Selected Records (0 out of 77

Figura 3: Print screen of database used.

The procedure snip the risk areas was accomplished through a query attributes through SQL language and its mathematical operators, which own GIS software and this can be seen in Figure 4.

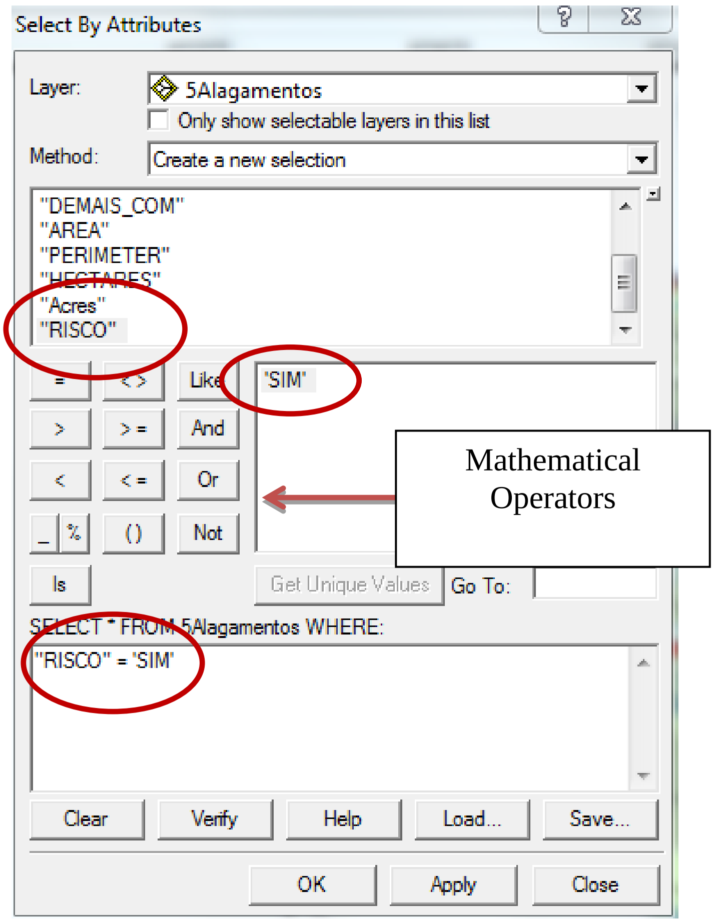


Figure 4: Print screen to query spatial risk areas in communities.

To obtain the images SRTM (Shuttle Radar Topography Mission), available at Embrapa: http://www.relevobr.cnpm.embrapa.br/download/index.htm, was downloaded, determining the Brazilian state of interest and quadrant within the state where it operates the study area, which in this case refers to the letter SB-25-YC. After choosing and downloading the file, the procedures were performed in ArcGIS ® software. Figure 5 shows the image SRTM in tiff added to ArcGis ®.

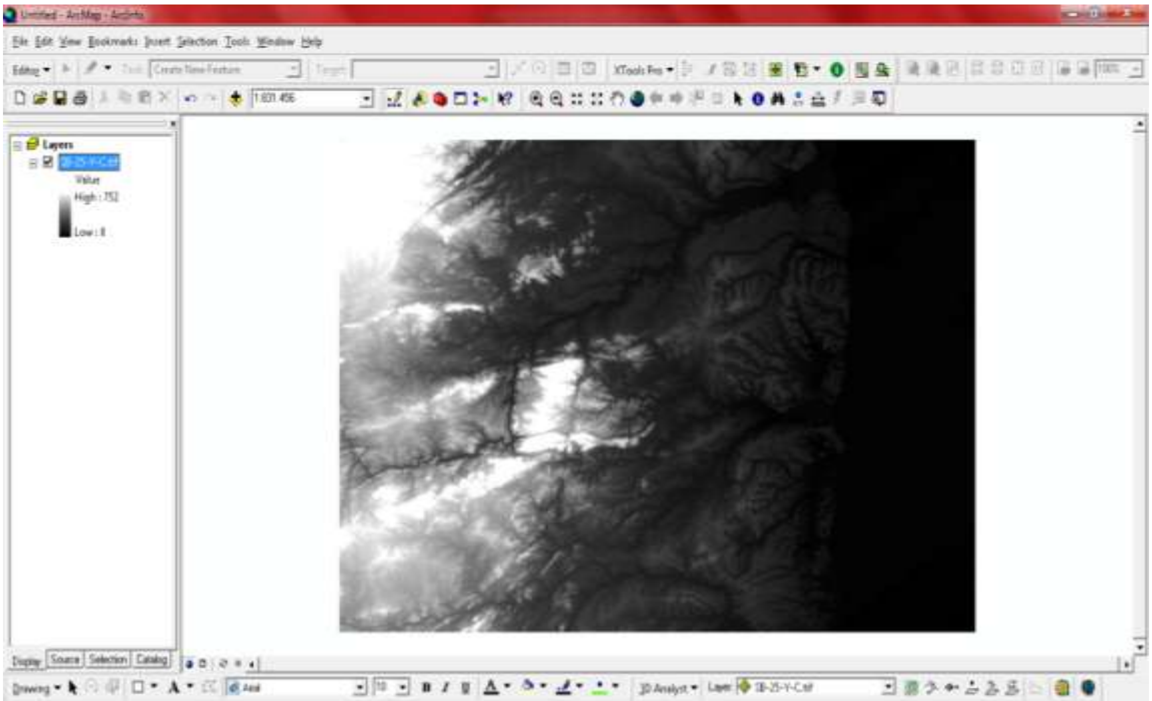


Figure 5: Picture SRTM added to ArcGIS ®.

From the image we extracted SRTM elevation contours and topographic map and made the slope with the aid of a tool that is in the software, the 3D Analyst, allowing the understanding of relief. Figure 6 shows the schema that must be followed to obtain the desired data.

Regarding the Civil Defense, information was obtained about the heavy rains during the period of 19 is January 20, 2011, with the 89.08 mm rainfall according to information obtained by the Executive Agency for Water Management in the State of Paraíba (AESA) caused serious damage, among them stood out as Civil Defense (2012), a series of floods, with several affected communities in the region, such as the São José, Tito Silva, Santa Clara, São Rafael and Novo Horizonte communities.

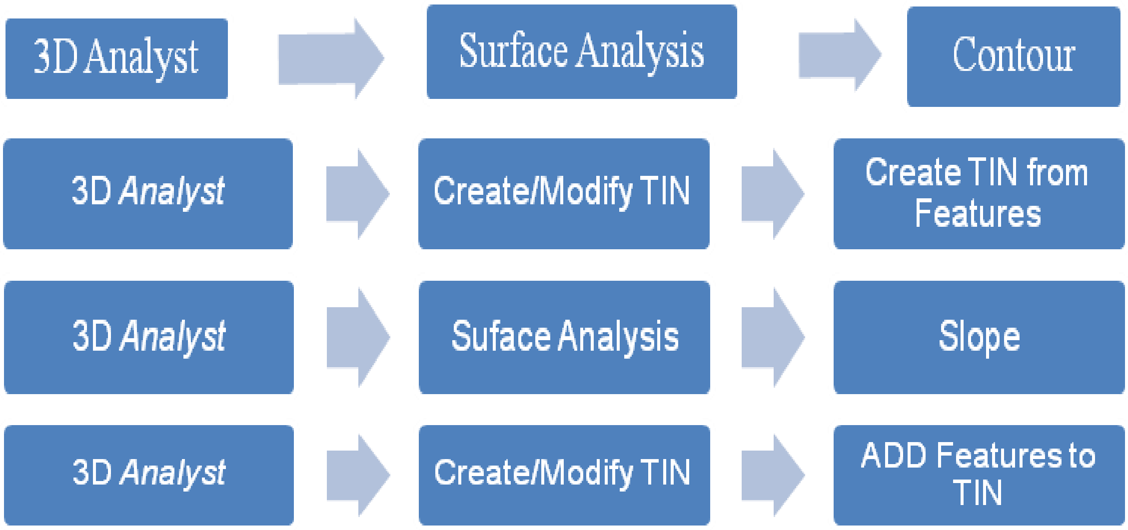


Figure 6: Scheme for relief informations extraction.

Already in 2012, the heavy rains that occurred on 27 and 28 June, accounted for a cumulative rainfall of the order of 541.1 mm in June, peaking at 131.0 mm (07/06) 111.4 mm (20/06), 151.6 mm (28/06), and a cumulative of 102.9 mm on 2 and 3 July, according to information obtained from the Executive Agency for Water Management in the State of Paraíba (AESA), which was considered for the Civil Defense, outside of normal for the period.

According to the Civil Defense (2012) occurrences of landslide barriers occurred in the communities of Timbó, São Judas Tadeu, Alto do Mateus, Barreira do Cabo Branco (Final Cabo Branco Avenue), Saturnino de Brito, 19 BR 230 Km / Castelo Branco, Róger, Mandacarú. And the neighborhoods that were affected by flooding was the center of the city, Solon de Lucena Park, Varadouro, Torre, Jaguaribe, Bancários, São José subdivision, Manaíra, Bessa, Cabo Branco, Castelo Branco, Cristo, José Américo, Novais, Mangabeira, Valentina Figueiredo, Mandacarú, Indústrias.

After analyzed the reports obtained in the Civil Defense of the affected areas with slopes landslides, mudslides and flooding for the years 2011 and 2012, we carried out a field visit to identify some disaster areas by the year 2012.

3. Results and Discussion

The operations of queries and extraction of information from risk areas, resulted in a map of the spatial distribution of communities, with their respective areas of risk, shown in Figure 7. Risk areas show no spatial correlation with each other, having effective characteristics related to social vulnerability and disadvantaged areas or unoccupied within the city.

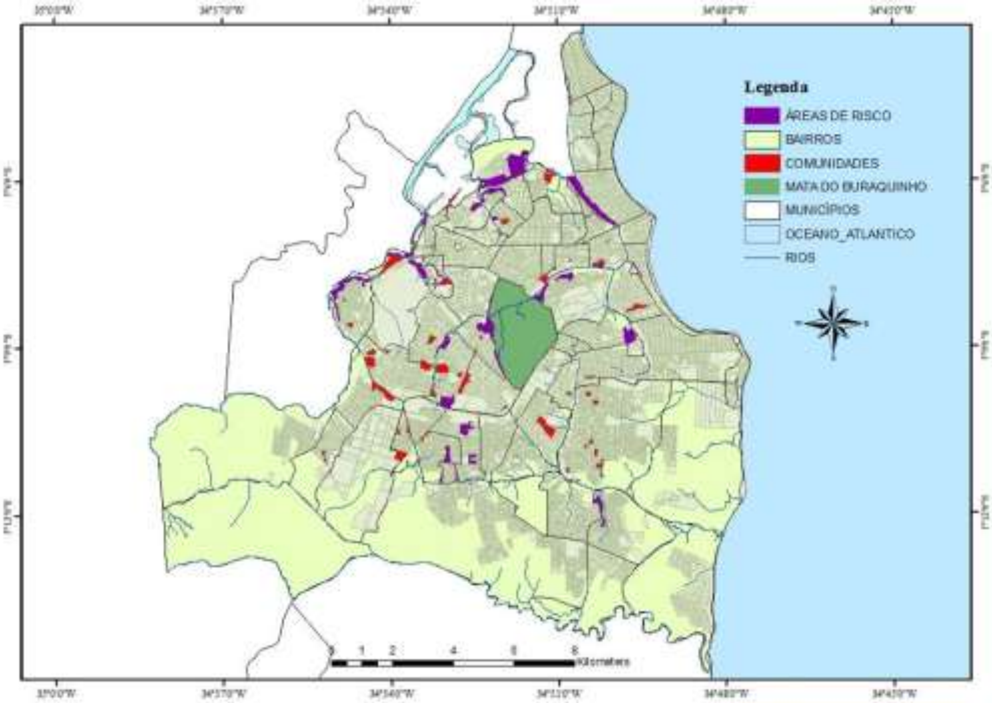


Figure 7: Map of the spatial distribution of communities of João Pessoa City and their respective areas of risk.

In total, 77 communities were recorded in which 26 are high-risk areas and can be viewed in Figure 8.

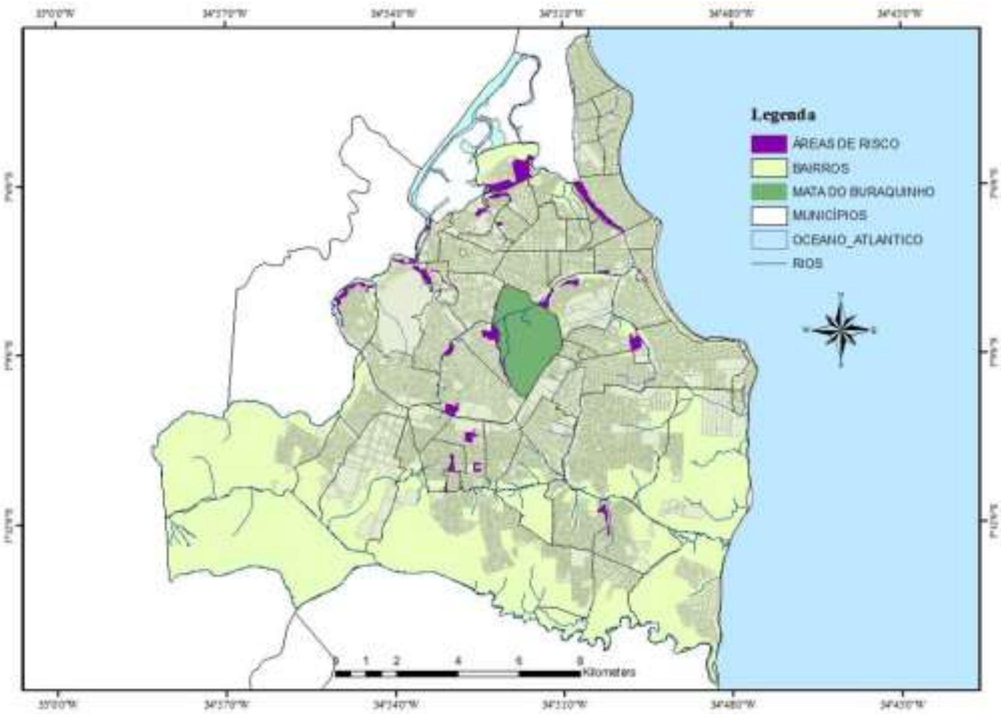


Figure 8: Map of the spatial distribution of risk areas in João Pessoa City.

The risk areas throughout João Pessoa City (Figure 8) show significant disparities relief. In the northern region of Figure 8, the communities are located in the lower regions of the city, as seen in the topographic map shown in Figure 9. In the central part of the map, as seen in Figure 8, near the forest reserve of Mata do Buraquinho, and in the southwestern region can be observed risk areas with higher elevation. As for clinografia of João Pessoa City presented in Figure 10, associated with the spatial distribution map of communities, it can be observed that most of the risk areas show effective risk of landslides and floods and this is due to the fact that these areas are located in areas with slopes above 45%.

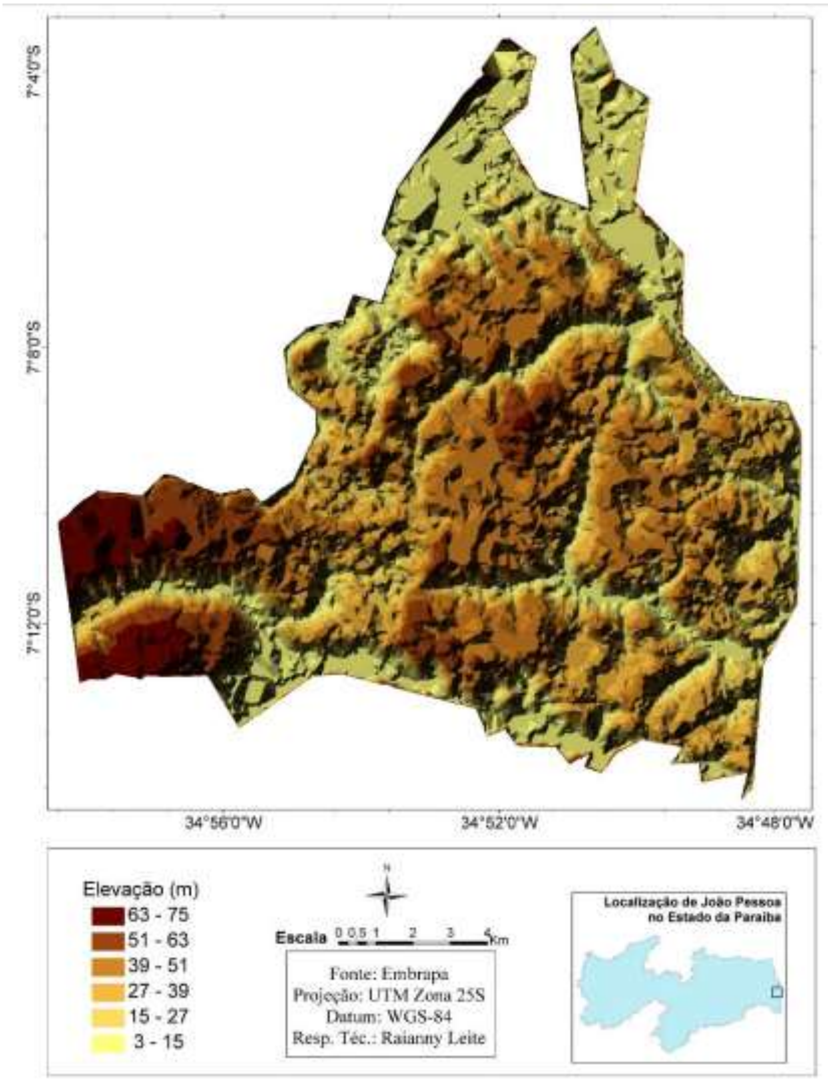


Figure 9: Hypsometric map of João Pessoa City.

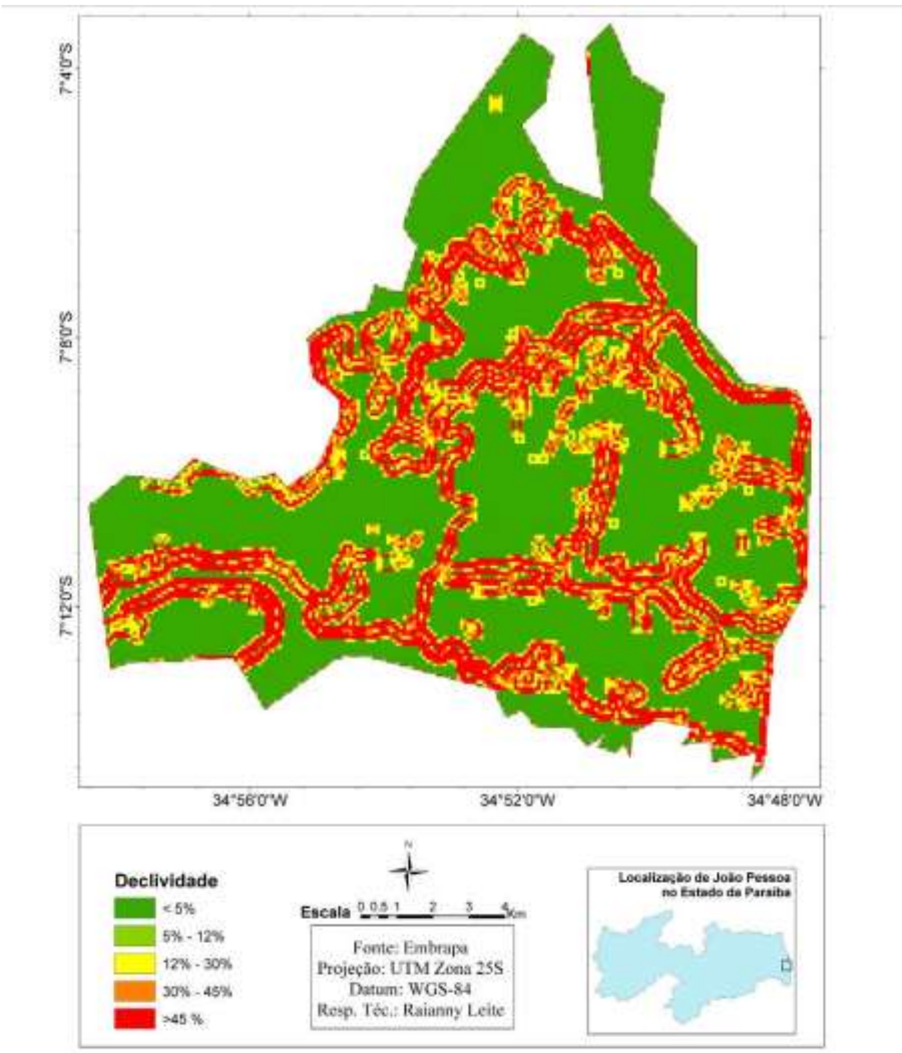


Figure 10: Slope map of João Pessoa City.

The risk areas of João Pessoa show no significant changes of expansion or emergence of new areas. In January (19-20), 2011, after a heavy rain, with the 89.08 mm rainfall, the Civil Defense starred in several areas of social vulnerability, recording some harmful consequences for society, as can be seen in Figures 11 (a) and 11 (b).

a)

b)

Figure 11 (a) and (b): Situation in the affected areas after heavy rainfall occurred in January 2011. Source: Civil Defense (2012).

In Figure 11 (a) can be observed that the water level reached at a residence Riachinho community. Already in Figure 11 (b) highlights an area interdicted by community residents Riachinho after disastrous consequences due to the occurrence of heavy rain. According to the Civil Defense (2012), torrential rain occurred in the current year natural disasters caused more visible to the city, as can be noted the landslide at a stretch in BR 230 Km 19, shown in Figure 12.

Figure 12: Landslide in João Pessoa City, BR 230 Km 19.

In Figure 12 can be seen an action to mitigate the landslide occurred after rain occurred on 27 and 28 June 2012. Even with the aim of containing the disaster, the attitude is only provisional, requiring the relocation of the residents of the building signaled above, the planting of new vegetation in the area of landslides, since the landslide occurred only where the soil had is exposed.

Some days before the anomalies of the indices of precipitation occurred in June 2012, also changed the daily pessoense population, as shown in Figure 13, where Solon de Lucena Park had its inner ring completely flooded, which is the public highway where bus travels and private vehicles, causing inconvenience to drivers, who tried to access the city's commercial center. The lagoon has overflowed as a vehicle driver diseases.1

Figure 13: Solon de Lucena Park flooded after torrential rains.
Source: http://g1.globo.com/pb/paraiba.

4. Conclusions

The geoprocessing techniques are presented as promising tool in municipal management, identifying by studying the topography, areas susceptible to landslides and flooding, as well as the spatial distribution of areas with social vulnerability entered the city. From the reports obtained from the Civil Defense, it was found that currently exist measures to mitigate the tragedies occur when rainfall anomalies in the region, but João Pessoa City is still lacking social policies that identify risks and acting on disaster prevention.

5. Acknowledgements

The authors thank the Civil Defense and the Department of Planning of João Pessoa City for files transferred to this work.

6. References

Ayala, I. A. (2001). Geomorphology, natural hazards, vulnerability and prevention of natural disasters in developing countries. Department of civil and environmental engineering, Massachusetts Institute of Technology, room 1-330, 77 Massachusetts Avenue, Cambridge MA 02139-4307, usa. www.elsevier.com/locate/geomorph.

Barbirato, G. M; Souza, L. C. L. ; Torres, S. C. (2007). Clima e cidade: A abordagem climática como subsídio para estudos urbanos. Maceió: EDUFAL.

Beck, Ulrich. (1986). La sociedad del riesgo: Hacia una nueva modernidad. Barcelona: Paidós.

Campos, J. H. B. C., Silva, M. T., silva, V. P. R. (2010). Impacto do aquecimento global no cultivo do feijão-caupi, no estado da Paraíba. Revista brasileira de engenharia agrícola e ambiental, v.14, p.396-404.

Chavas, D.R., Izaurralde, R.C., Thomson, A.M., Gao, X. (2009). Long-term climate change impacts on agricultural productivity in and thestern China. Agricultural and forest meteorology, v.149, n.1, p.1118-1128.

Carlos, A. F. A. (2001). Espaço-tempo na metrópole. São Paulo: contexto.

Harmsen, E.W., Miller, N.L., Schlegel, N.J., Gonzalez, J.E. (2009). Seasonal climate change impacts on evapotranspiration, precipitation deficit and crop yield in Puerto Rico. Agricultural water management, v.96, n.1, p.1085-1095.

IBGE. (2010). Disponível em: http://www.ibge.gov.br. Acesso em 15 de julho de 2012.

IPCC - Intergovernmental panel on climate change - (2007). The physical science basis. Summary for policy makers contribution of working group i to the fourth assessment report of the intergovernmental panel on climate change. Http://ipcc-wg1.ucar.edu/wg1/wg1-report.html. Julho 2010.

Landsberg, H. E. (1981). The urban climate. New york: academic press, 285p.

Lohmann, S., schillings, C., Mayer, B., Meyer, R. (2006). Long-term variability of solar direct and global radiation derived from isccp data and comparison with reanalysis data. Solar energy, v.80, n.1, p.1390-1401.

Lombardo, M. A. (1985). Ilha de calor nas metrópoles: o exemplo de São Paulo. São Paulo: hucitec.

Kobiyama, M., Mendonça, M., Moreno, D.A., Marcelino, I.P.V.O., Marcelino, E.V., Gonçalves, E.F., Brazetti, L.L.P., Goerl, R.F., Molleri, G.S.F. & Rudorff, F. (2006). Prevenção de desastres naturais: Conceitos básicos. Curitiba: Organic Trading, 109p.

Mascaró, L. (1996). Urban environment. Porto alegre: Sagra, dc Luzzatto.

Marengo, J. A. (2009). Impactos de extremos relacionados com o tempo e o clima - impactos sociais e econômicos. Instituto nacional de pesquisas espaciais - centro de ciências do sistema terrestre. São Paulo, Brasil.

Merzi, N., Aktas, M.T. (2000). Geographic information systems (gis) for the determination of inundation maps of lake Mogan, Turkey. Water int. 25 (3), 474–480.

Monteiro, C. A. F. (1976). Teoria e clima urbano. IGEG-USP. Universidade de São Paulo. Instituto de Geociências, série teses e monografias, n. 25, São Paulo.

Okuda, S. (1970). On the relation between physical geomorphology and the science of natural disasters. Bull. Disaster prev. Res. Inst. 19 (25) part 5, Kyoto, Japan.

Romero, M. A. B. (2001). A arquitetura bioclimática do espaço público. Ed. Unb. Coleção Arquitetura e urbanismo. Brasília.

Rosenfeld, C.L. (1994). The geomorphological dimensions of natural disasters. Geomorphology 10, 27–36.

Santos, M. (1990). São Paulo: metrópole fragmentada corporativa. São Paulo: Nóbel.

Silva, V. P. R., Campos, J. H. B. C., Silva, M. T., Azevedo, P. V. (2010). Impact of global warming on cowpea bean cultivation in northeastern brazil. Agricultural water management, 97, p.1760-1768.

Smolka, M. (1993). Meio ambiente e estrutura intra-urbana. in: População, meio ambiente e desenvolvimento: verdades e contradições. MARTINE, G. (org.), Editora da Unicamp, Campinas.

Sousa Júnior, I. F. (2006). A influência da urbanização no clima da cidade de Campina Grande-pb. Dissertação (mestrado). P. 94. Universidade federal de campina grande. Campina grande.

Sorre, M. (2006). Objeto e método da climatologia. Tradução de José Bueno Conti, FFLCH, USP. Original em francês: Traitè de climalogie biologique et medicle. Revista do departamento de geografia, v.18p. 89-84.

Umbelino, G. Sathler, D., Macedo, D. & Felippe, M. (2007). Aplicação de técnicas de geoprocessamento para a preservação dos recursos hídricos e estudos de vulnerabilidade socioambiental. XIII Simpósio Brasileiro de Sensoriamento Remoto. Florianópolis.

Veyret, I. (2007). Os riscos. São Paulo: Editora Contexto.

Verstappen, H.T. (1989). Geomorphology, natural disasters and glob- al change. Symposium on aerospace survey and natural disasters. Itc j. (3–4), 159–164.