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Method AHP to Flood Risk Map Approach

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Abstract— *The phenomenon of flooding is a natural event, given by the extravasation of water to the river bed. The main objective of this study was the analysis of susceptibility to flooding of the basin of Uraim River in the municipality of Paragominas Pará state based on the physical characteristics and morphometric basin. It used the Analysis method Hierarchical method for generating gas order susceptibility map of the basin. The AHP technique used to determine map algebra contributed to the analysis of the susceptibility to floods and was effective because it reduces and simplifies the proposed problem, which minimizes the errors of judgment during the process.*
Keywords*— *Mapping, Water Resources, Floodplains.

I. INTRODUCTION

The Uraim River, located in the municipality of Paragominas, northeast of the state of Pará, Brazil, is essential for the development of sanitation services in the municipality, since it facilitates the abstraction of water for public supply, as well as the release of domestic effluents treated at stations. In this way, preventive actions and care with this water body represent, besides a sustainable and conscious attitude with the environment, a fundamental act for the development of the Paragominas society, with quality of life and well-being (SANEPAR, 2014)

In view of the above, there is a need to map the areas that are most susceptible to floods, in order to prevent losses and avoid adversities. According to MENDES & CIRILO (2001), systematized information is essential to subsidize, for example, the prediction and control of natural or man-induced processes in the basins. In order to characterize the areas vulnerable to flooding, especially in the urban area, the present work aims at the morphometric characterization to evaluate its geological susceptibility to flooding and the mapping of these areas, using the methodology Analysis Hierarchical Process (AHP) to identify levels of susceptibility to flooding to which the river basin is subject, taking into account physiographic characteristics and soil sealing, which directly influence these occurrences. The methodological tool chosen has been used in several studies of flood maps analysis, such as by LEMOS & BISPO (2015) in the mapping of vulnerability to floods in the State of Para.

II. METHODOLOGY

To prepare the diagnosis of the areas most susceptible to flooding in the river basin, a methodological flowchart was conceived, contemplating 3 stages (Figure 01). In order to obtain the degree of relevance and weights of each criterion analyzed, the methodology proposed by SAATY (1990) was used, according to the structure of the decision hierarchy, construction of the paired comparison matrix, prioritization of alternatives and definition of the classes of susceptibility.

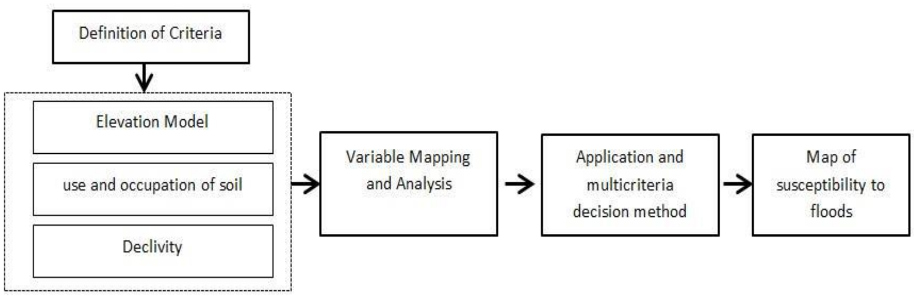

Fig. 1: Flowchart of applied methodology.

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SANTOS (2010) cites that the factors determined as important and that directly influence the level of water reached by a flood, regardless of the precipitation incident are.

2.1. Mapping and analysis of variables

The methodology used to map the variables that contribute to the occurrence of floods, as well as their division into classes. Therefore, thematic maps were prepared for the proposed variables based on the methodologies described below. Also, weights were assigned for each class of selected variables on a scale of 1 to 10, where 10 is the value with the greatest influence on floods and 1, the lowest value.ude, slope, land use.

2.2. Application of the multicriteria decision method

The flood susceptibility map will be the product of the spatial crossover of the three variables represented in the above methodology and will involve two distinct phases of work, the theoretical phase, in which the criteria for crossing will be defined, and the operational phase, where the crossing will be carried out of the thematic maps from the ArcGIS map algebra tool.

To set the relative importance of the criteria with regard to susceptibility to flooding, there was the comparison of criteria, using a value of 1 is equivalent to the minimum and maximum 9 importance of one factor over another. SANTOS (2010) mentions that the phase of allocation of values, based on the comparator scale, is considered one of the most important moments during the process of preparation of flood maps, since the importance of values of a interfered factor directly in income obtained. After the judgment of the elements, we have the comparison matrix table 1.

Table.1: Matched comparison matrix.

Criteria	Elevation	Declivity	Use and Occupation
Declivity	4	1	3
Use and Occupation	2	1/3	1
Elevation	1	1/4	1/2

The matrix is interpreted in such a way as to take the example of the comparison of the slope variable with land use and occupation. These comparisons in pairs provide weights for each alternative, within each criterion, after reciprocal comparisons. These weights are obtained by calculating the main vector auto of each square matrix, and are represented in Table 2. As for the order of importance of the variables, the slope was obtained first (56%), followed by Elevation (26 %), land use and occupation (18%).

Table.2: Weights for mapping the susceptibility map.

Variables	class weight	Variables
Elevation	0,26	X1
Declivity	0,56	X2
Use and Occupation	0,18	X3

With the choices of the weights of the criteria for drawing up the susceptibility to flooding map the AHP provides a ratio of consistency, which must be less than 0.10 (PROCHMANN, 2014). The consistency ratio obtained was 0.07, attesting to the consistency in the hierarchy of the Operational phase.

2.3. Operational phase

After the definition of the weights, maps were algebra for the generation of the map of susceptibility to floods through the process presented in Figure 14. To do so, we used the Raster Calculator tool of ArcGIS software.

The first step consists in capturing the values of the cells contained in the raster file referring to the classes of thematic maps. In the second step, these values are processed algebraically based on the equation below, where x1, x2 and x3 will be the previously obtained statistical weights.

$$SI = x1\ \textit{Use occupation} + x2\ \textit{Declivity} + x3\ \textit{Elevation}$$

Where: SI is the Susceptibility to floods.

Finally, in the third step the value is stored in a new raster file, which will give rise to the map of susceptibility to floods. The new cells contain values ranging from 0 to 10, where the values closest to 0 are related to areas with less susceptibility to flooding and the values closer to 10, with greater susceptibility to flooding. At the end of the execution of this routine, the map will be reclassified into five hierarchical categories, such as high elevation area, low susceptibility, medium susceptibility, high susceptibility and no susceptibility to flooding, as shown in Table 3.

Table.3: Reordering of susceptibility classes.

Values	Class
0 a 2	Too Low
2 a 4	Low
4 a 6	Avarage
6 a 8	High
8 a 10	Very high

III. CONCLUSION

By analyzing the obtained data, the study area presents for the most part (82%) between low and no susceptibility to floods. Areas with medium flood susceptibility cover 10% of the area, while areas with high susceptibility correspond to 8%.

According to the map of susceptibility to floods, the areas with greater susceptibility are more extensive in the areas with accentuated differences. The very high susceptibility class has a predominance of altitude varying from 0 to 50 meters (99%), and areas with low population density and with soil waterproofed by roads, sidewalks and alteration of ciliary vegetation are more susceptible to flooding.

The declivity was a determining factor for the separation of the high and medium susceptibility classes, where different relief types predominate and the other classes remain regular.

The average susceptibility was found predominantly in areas of agriculture and pasture where soil use influences the surface runoff and can alter the topography from the mechanization of soils, more in places with higher slopes the susceptibility is greater

The low susceptibility was found in areas predominantly of forests and successions where the soil is structured and the forest dorsel protects the soil avoiding erosion and reducing the impact of direct raindrops on the soil.

Based on the geolocation analysis and historical information of the city of Paragominas, it was verified that the neighborhoods most susceptible to flooding are the neighborhoods of Promissão, Uraim, Cidelândia, Angelim and Cidade Nova, in these neighborhoods are at lower levels what with high rainfall water and very intense and allied to the waterproofing of the soils can generate floods and disturbances to the residents.

The AHP technique used to determine the weights of classes contributing to the susceptibility to flooding was effective because it reduces and simplifies the proposed problem, which minimizes errors of judgment during the process.

The methodology applied in this research is usually used in mapping with a lower level of detail, and thus, the research carried out demonstrates the need to improve techniques and methodological proposals for the elaboration of flood susceptibility maps from the inclusion of variables not used here rainfall, river flow and soil classes, which can improve the estimates of areas susceptible to flooding.

The use of the soil in the basin is very diversified, showing that Paragominas continues being a great producer of grains and meat, it can be perceived that with the progress of the inspections the Permanent Preservation areas in rural areas are recovering or they are showy. The urban area needs recomposition of the PPAs and environmental education so that the water bodies are not compromised thus avoiding future floods.

For future work, it is also recommended to collect primary data such as drainage systems, sewage and rainfall in the region of flooded areas in occurrences so as to correlate with the areas most susceptible to the floods raised in the mapping.

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REFERENCES

[1] MENDES, C. A. B.; CIRILO, J.A. (2001) Geoprocessamento em Recursos Hídricos: Princípios, Integração e Aplicação. Porto Alegre: Associação Brasileira de Recursos Hídricos, 536 p.

[2] LEMOS, S. S.; BISPO, C. J. C. (2015) Geoprocessamento na caracterização física, uso e ocupação do solo da microbacia do rio Uraim, Paragominas-PA. In: simpósio brasileiro de recursos hídricos, 21., 2015, Brasília. Anais. Brasília: ABRH, 2015. p. 1 - 8.

[3] PROCHMANN, J. R. (2014). análise espacial da susceptibilidade à inundações na Bacia hidrográfica do córrego grande, Florianópolis – SC. Trabalho de conclusão de curso.

[4] SANEPAR (2014) - Agência de Saneamento de Paragominas. Bacia do Rio Uraim. 2014. Disponível em:<http://saneparagominas.com.br/agua/bacia_uraim/>. Acesso em: 23 ago. 2017.

[5] SANTOS, A. R. (2010). ArcGIS 9.3 Total: Aplicações para Dados Espaciais. 2. ed. Alegre: Caufes.

[6] SAATY, T. L. (1990) How to make a decision: The Analytic Hierarchy Process. European Journal Of Operational Research. North-holland, p. 9-26.