Mapping and analysis of the erosion susceptibility perimeter urban Catalão (GO), with geoprocessing aid

Cartographie et analyse du périmètre de susceptibilité à l'érosion urbain Catalão (GO), avec aide géotraitement

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ABSTRACT: The increase of vulnerable areas to the occurrence of erosive features is an increasingly present reality in urban centers. This happened due to the accelerated growth of the cities, which resulted in the lack of planning and the management of urban space. In view of the above, it is necessary to carry out studies that contemplate the factors that favor the formation of erosive processes. In this way, this work has the objective of identifying areas more susceptible to erosion in the urban perimeter of Catalão (GO) and for this purpose, the techniques used for GIS based geoprocessing, through ArcGIS 10.2.2 software, for the elaboration of the thematic maps of declivity, pedology, geomorphology and land use and occupation. Then, from the crossing of the maps and in the determination of the weights for an application of the systematic of multicriteria analysis, it was possible to make the final map of susceptibility to erosion, which characterized as areas of study in low, medium and high susceptibility to the occurrence of erosive processes.

RÉSUMÉ : L'augmentation des zones vulnérables à l'apparition de traits érosifs est une réalité de plus en plus présente dans les centres urbains. Cela est dû à la croissance accélérée des villes, qui a entraîné le manque de planification et de gestion de l'espace urbain. Compte tenu de ce qui précède, il est nécessaire de réaliser des études qui envisagent les facteurs favorisant la formation de processus érosifs. De cette façon, ce travail a pour objectif d'identifier les zones plus sensibles à l'érosion dans le périmètre urbain de Catalão (GO) et à cet effet, les techniques utilisées pour le géoprocessage basé sur le SIG, à l'aide du logiciel ArcGIS 10.2.2, pour l'élaboration du les cartes thématiques de déclivité, la pédologie, la géomorphologie et l'occupation et l'occupation du sol. Ensuite, à partir du croisement des cartes et de la détermination des poids pour une application de l'analyse systématique multicritère, il a été possible de faire la carte finale de la susceptibilité à l'érosion, qui se caractérisent comme zones d'étude en basse, moyenne et haute susceptibilité à l'apparition de processus érosifs.

KEYWORDS: Erosive Processes. Catalão (GO). SIG. Map of Erosion Susceptibility.

1 INTRODUCTION.

Erosions are natural processes, however, those present in urban areas are generally accelerated by anthropogenic intervention in the environment. The urbanization process that has taken place in Brazil in the last three decades has triggered the intense and unequal growth of the cities, which has led the less favored population to occupy places that often present unfavorable aspects to the occupation. This growth has caused negative impacts to the urban space, where there was a modification of the natural dynamics of the environment, promoting the degradation of the natural resources of the soil and resulting in the formation of erosive features in the landscape (CARVALHO & GALVÃO, 2006).

For this reason, control of the occupation of unstable areas is fundamental; Therefore, it is necessary to know the geological and geotechnical conditions of these areas, for a later characterization of the involved processes, resulting in information about the risks of the occurrence of geotechnical events. Thus, the geological-geotechnical mapping of areas at risk of erosion are important tools for the planning of municipal areas, since the map illustrates the possible most susceptible areas, helps in the monitoring and research of the study area (FONTES, 2011).

In view of this, the present study followed the systematic work of Iwasa and Frendrich (1998) for the analysis of the susceptibility to erosion, applying it in the urban perimeter of Catalão. Thus, the application of a GIS-based computational tool, the ArcMap 10.2.2 software of the ESRI company's ArcGIS package, was used in the study to use the Weighted Multicriteria Analysis method. In view of this, it is possible to propose more appropriate measures regarding the use and occupation of the areas with regard to municipal planning.

2 METHODOLOGICAL ASPECTS

The first stage of work presents the field survey of the information regarding the presence of erosive features in Catalão, in addition to the physical characteristics of the region. The second stage refers to obtaining georeferenced base data (digital terrain model, soil classes, land use and occupation, geomorphology) related to relevant aspects for susceptibility analysis in ArcMap software 10.2.2. The third stage presents the generation of thematic maps through the discretization of the data obtained in the second stage. Finally, the fourth step presents the description of the weighted multicriterial analysis method used for the final elaboration of the map of susceptibility to erosion.

2 .1 *Analysis procedures*

The first stage consisted in characterizing the study area, in which data on location, economic and social territorial characteristics, physiographic aspects (climate, vegetation, geology, geomorphology, pedology and hydrography) were investigated, as well as erosion considerations in the urban environment of Catalão to correlate all the data and to verify next to the results if the final map generated is coherent with the reality.

For the second stage, the following databases (digital cartographic base) were used: Cartographic Plane of the State of Goiás in the scale of 1: 250,000, Geomorphological Map of the State of Goiás in the scale of 1: 500,000, Map of Soils in the scale of 1: 250,000 of the Master Plan of the Paranaíba River Basin, Land Use and Land Use Map of the State of Goiás 1: 250,000.

The third step consisted of editing the data obtained in the second stage and the subsequent use of the thematic maps of Pedology, Geomorphology, Declivity and Land Use and Occupation generated for analysis and production of the map of susceptibility to erosion in the studied area.

In this way, the step was started with the insertion of the cartographic bases in GIS / ArcGIS environment for the standardization of all the data, in order to facilitate the manipulation of the maps. For this, two initial procedures were performed: the reprojection of the bases for the same planimetric datum and the conversion of the vector data to raster format.

First, reprogramming of the cartographic databases was carried out using the Data Management Tools> Projections and Transformations> Raster> Project Raster tools, for the raster database and for the vector database, the Data Management Tools> Projections and Transformations> Project. From this procedure, all the maps for the Universal Transverse System of Mercator (UTM), Brazilian planimetric datum SIRGAS 2000, Zona 23 Sul were standardized. Then, we proceeded with the conversion of the vector files to raster format using From the Conversion Tools> To Raster> Polygon to Raster tool.

After the standardization of the cartographic data, the thematic map (Pedological, Geomorphological, Declivity and Land Use and Occupation) was edited using the GIS / ArcGIS drawing and editing resources.

The fourth step consisted of a description of the weighted multicriterial analysis method performed for erosion susceptibility map generation. According to Silva (2010), this method allows to combine a set of maps through a certain function, which does not present the work, will have the help of the GIS / ArcGIS for a generation of an output map.

In this way, this method consisted, firstly, in the attribution of weights to each map feature (Pedological, Geomorphological, Declivity and Land Use and Occupancy) and in the subsequent definition of levels of influence in the erosive process to each thematic map. With this, it was possible to cross the maps for the generation of the Map of Susceptibility to Erosion of the city of Catalão.

Before starting the weighted multicriterial analysis process, it was necessary to transform the attributes of each map into a single value format to represent each feature. This procedure was performed in GIS / ArcGIS using the 3D Analyst Tools> Raster Reclass> Reclassify tool.

For the determination of the criteria used in the attribution of weights to the features and in the determination of the influence of the thematic maps, we adopted parameters related to the level of physical and anthropic components performance against the development of erosive processes in the studied region. In this way, the following assumption was adopted that, the greater the interference of these components for the occurrence of erosions, the greater the weight attributed to that aspect.

In summary, for the definition of the criteria, values of weights and influences (%) were proposed to each map for the development of tests. These tests were carried out with the objective of finding a map of susceptibility that represented in a more plausible way the present reality in Catalão. In this context, all maps underwent a visual analysis comparing the input maps (Pedological, Geomorphological, Declivity and Land Use and Occupation) and relating the degrees of importance of each one to obtain a representative output map (Map of Erosion Susceptibility) derived from the previous crossing.

The weights assigned to the characteristics of the Declivity Map are listed in Table 1

Table 1. Weights assigned to the Map of Declivity

Description	Degree of slope	Weights
Null	40	1
Light	30	2
Moderate	20	3
Strong	10	4

The weights assigned to the characteristics of the Pedological Map are listed in Table 2

Table 2. Weights assigned to the Map of Pedological

Description	Weights
Haplortox Soil	2
Paleudalf	3

The weights assigned to the characteristics of the Use and Occupation Map are listed in Table 3

Table 3. Weights assigned to the Map of Use and Occupation

Description	Weights
Annual Culture	4
Urban area	3
Forested savannah	2
Vegetation pothole	2
Pasture	2

The weights assigned to the characteristics of the Geomorphological Map are listed in Table 4

Table 4. Weights assigned to the Map of Geomorphological

Description	Weights
RSS* (high)	4
RSS* (medium)	3

* RSS: Regional Surfacing Surface

The levels of influence are listed in Table 5.

Table 5. Weights for Multicriteria Analysis

Physical aspects	Levels of Influence (%)
Declivity	40
Pedology	30
Use and Occupation	20
Geomorphology	10

After performing the procedures of attribution of weights in the previous item, it was possible to cross the thematic maps to obtain the desired exit map.

According to Silva (2010), the crossing of maps is performed by means of the calculation of the weighted average of the criteria defined for each map and it should proceed as follows: each group of input pixels, representing the reclassified features, receives a weight in the adopted scale of 1 to 5 and each map receives a weight in percentage.

The author further explains that in this method, each pixel of the output raster image receives a value, which is calculated by means of the weighted average of the values of the input pixels, that is, the value of the output pixel is equal to the sum of the multiplication of the values of each pixel by the percentage factor referring to the represented aspect, all being divided by the number of pixels added.

To support the weighted average execution process, which consists of the final step of the multi-criteria analysis for the generation of the Erosion Susceptibility Map, the GIS / ArcGIS software has a tool that allows to execute the whole procedure in a simplified way. Therefore, the tool used was Spatial Analyst Tools> Overlay> Weighted Overlay.

From this algorithm, it was possible to generate the Erosion Susceptibility Map of the urban area of Catalão, containing the classification of areas with high, medium and low susceptibility to erosion. This map will be shown in Figure 1.

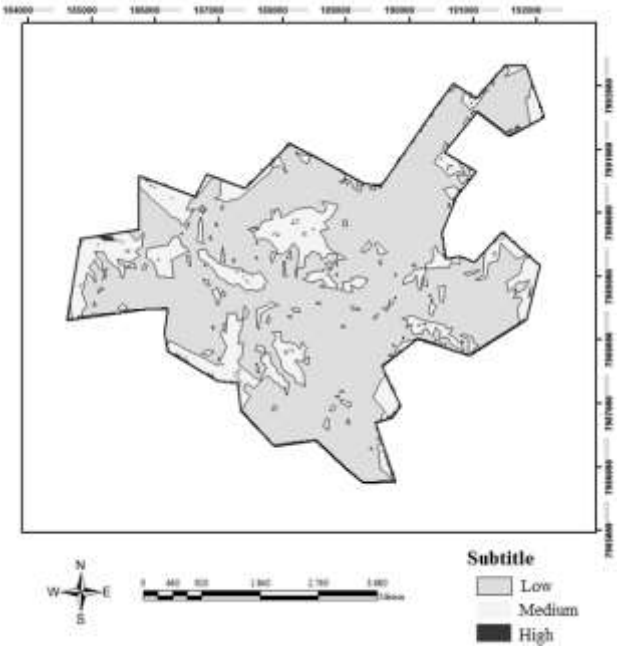

Figure 1. Map of Susceptibility to Erosion of the urban perimeter of Catalão.

3 RESULTS AND DISCUSSIONS

By following the systematics proposed by Iwasa and Frendrich (1998), and using GIS techniques for the application of the Weighted Multicriteria Analysis method, the final product was satisfactorily obtained; The Erosion Susceptibility Map of the Catalão urban perimeter.

The map was generated through the correlation of the main physical characteristics (pedology, geomorphology and slope) and of the anthropic aspects that influence in a direct way the emergence of erosive processes in the city. In this way, it was possible to carry out the weighting of these aspects for the preparation of the final map with the representation of potentially stable areas, being able to plan with greater security the best treatment to be given to these regions. The Erosion Susceptibility Map, presented in Figure 1, contains three classes of susceptibility divided into: low, medium and high. Each class identifies and represents areas on the map that are not very or very vulnerable to erosion. These classes are described below:

Low Erosion Susceptibility: the areas with little susceptibility to develop erosive processes predominate in the urban perimeter of Catalão, being present in about 77.82%, or 17.37 km² of the characterized area. These less vulnerable areas are well distributed in the urban area of Catalão and are represented, for the most part, by the existence of neighborhoods with residential purposes with the presence of trades and service providers, therefore, not representing major impacts for the development of erosive features.

Medium Susceptibility to Erosion: the areas with presence of medium susceptibility to erosion are present in characteristic points of the city and have a predominance of about 22.04%, or 4.91 km², in relation to the entire territory studied. These sites are located along the main body of water that crosses the city, in places that have sharp slopes, in regions with presence of agricultural activities and also with predominantly sandy soil.

High Susceptibility to Erosion: areas with high susceptibility to erosion represent the lowest predominance in the map, occupying only 0.14% of the territory, which represents 0.03 km² of the area studied. These areas are located in the extreme east and west of the map. The presence of these regions of high susceptibility is explained by the combination of the most favorable conditions for the appearance of erosions, in relation to the analyzed aspects (slope, pedology, geomorphology and use and occupation). Thus, in these places there is the presence of declivity in the category of 13 to 25%, being characterized as wavy terrain, the presence of soils with sandy texture and the existence of agricultural activities.

4 CONCLUSION

The study of the characteristics and factors that lead to the emergence of erosions in a given location when subsidized by geoprocessing techniques with the support of SIGs results in a better digital representation of the analysis models for the characterization of spatial occurrences. In this context, the use of this tool was effective for the construction of a final map, based on the evaluation of quantitative (declivity) and qualitative criteria (soils, geomorphology and Occupation).

Through the interaction of the reference data and the analysis of its criteria, it was possible to correlate the information for the judgment of the results obtained in the elaboration of the map, regarding low, medium and high susceptibility to erosion. In this way, based on the results obtained, it can be verified that, in general, the city of Catalão has low susceptibility to erosion, due to the geomorphological and slope aspects, being present, mainly, in residential and commercial neighborhoods. Therefore, there are no erosive features at an advanced stage in these localities. However, there are regions with medium and high susceptibility to erosion, generally located in the central portion and at the extremities of the map, deserving attention and monitoring by the public power. These sites are found in areas with marked slopes, sandy texture textures and anthropic activities that favor the development of erosions.

Therefore, based on the results obtained, it can be stated that the union of the applied systematics for the execution of this study, based on the methodology proposed by Iwasa and Frendrich (1998), with application of Multicriteria Weighted Analysis were adequate to reach the proposed objective, Allowing the construction of a map of susceptibility satisfactory to what was intended in this study. It can still be said that this study can be tested as a model of analysis for other cities that intend to achieve the same purpose of this research.

Therefore, it is important to emphasize the need to apply this map of susceptibility in the planning and environmental management of the urban area of Catalão, taking into account

mainly those areas that present medium and high susceptibility to erosion. Thus, it is necessary to work jointly with municipal planning and inspection to minimize the damages caused by anthropic action, using this mapping tool to guide and identify potential areas for erosion occurrence.

5 REFERENCES

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