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Papers

The geoenvironmental susceptibility of the Lajeado creek watershed – Tocantins

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Abstract
The geoenvironmental study through the integration of natural elements with the use and land cover is a methodological proposal for strategic planning. In this sense, the objective of this article is to perform an analysis of geoenvironmental susceptibility from the use of multicriteria in the watershed of Ribeirão Lajeado. For this, the organization of cartographic materials was carried out, such as the drainage network, slope, lithology, soils, land use and cover and access routes, where normalized weights were established from the technique of the Hierarchical Analytical Process (AHP). This crossing generated the geoenvironmental susceptibility map, defined in four units, namely: I) low (flat top area with vegetation cover and no proximity to the access roads); II) medium (places with some human occupations or with wavy smooth relief); III) high (areas with wide occurrence of roads and abundant drainage network, susceptible to anthropic intervention, mainly related to agricultural activities and urban areas) and IV) very high (places with roads and portions of agricultural use with slopes greater than 15%, presence of fire scars and urban areas. Thus, the AHP technique presents itself as an important tool for geoenvironmental, especially in defining weights for the factors analyzed.

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INTRODUCTION

From the integration of human activities with natural elements, it is possible to develop zoning of environmental susceptibilities regarding the conservation of nature, in the strategic planning and management for human occupation and use.

Integrated analysis of the data obtained and knowledge of the potential of natural resources include studies of all components of the geographic stratum, considering the principle that nature has intrinsic functionality among its components (ROSS, 1994).

Thus, the geoenvironmental study stands out, which can be understood as the entire process involved in obtaining, analyzing, representing, communicating, and applying data and information from the physical environment, considering the strengths and weaknesses of the terrain, as well as the dangers, risks, impacts, and conflicts arising from the interaction between human actions and the physiographic environment (VEDOVELLO, 2004). According to Medeiros and Cestaro (2020), the geoenvironmental identifies units in an integrated way, considering the compartmentalization of a system based on the dynamic interaction of both physical and anthropic elements.

Carvalho et al. (2021) indicate that the geoenvironmental has gained importance in scientific studies, as it helps to understand the environmental conditions related to human actions. Highlighting the integrated study as the main characteristic of the geoenvironmental, Robaina and Trentin (2021) report that the analysis of the elements of the rocky substrate, relief, soils, and the use and cover of the land is fundamental for the understanding of the geomorphological dynamics, aiding in the management and planning of an area. For Abreu et al. (2020), the geoenvironmental is a fundamental methodological proposal for the strategic planning of the territory, in its different uses and levels of exploitation.

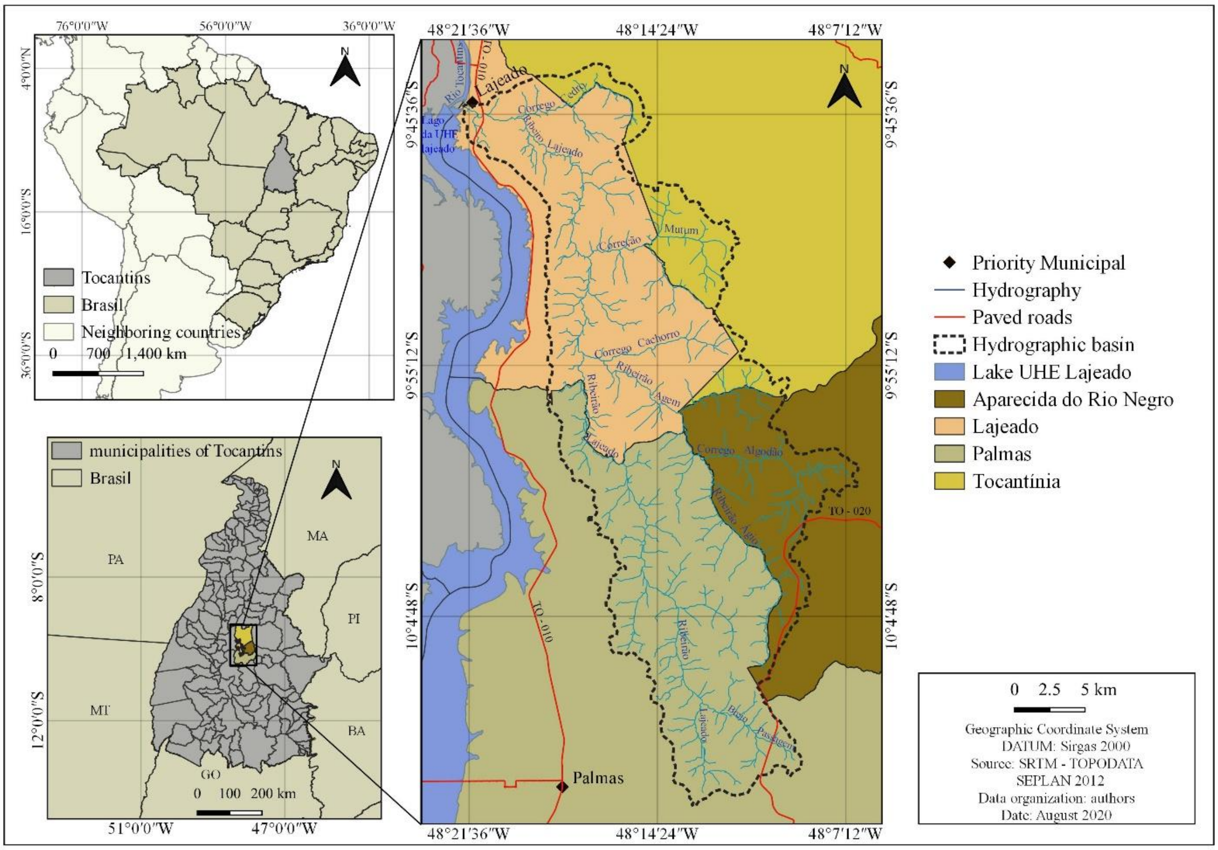
This study develops a geoenvironmental analysis in the Lajeado creek watershed, through zoning, by applying the Hierarchical Analytical Process (AHP), with a spatial modeling, in Geographic Information Systems (GIS) environment (SAATY, 1991).

The AHP process focuses on the study of systems through a sequence of comparisons, in pairs, of the constraints (elements) that influence the considered system. Marques and Zuquette (2004), Marchiori-Faria and Augusto Filho (2010), Paula and Cerri (2012), and França et al. (2019) discuss the use of AHP in the selection and prioritization of areas with different objectives.

The Lajeado creek watershed (Figure 1) covers an area of approximately 616.29 km², which is located in seasonal central portion of the state of Tocantins - Brazil, in the municipalities of Aparecida do Rio Negro, Lajeado, Tocantínia and Palmas. The presence of two Natural Unidades de Conservação (UC – protect area) stands out: a Proteção Integral (Integral Protection) one, the Parque Estadual do Lajeado (PEL – a State Park) and a Uso Sustentável (Sustainable Use) one, the Área de Proteção Ambiental (APA – environmental protection area) Serra do Lajeado, demonstrating its importance as the main hydrographic system of the UC.

UC are territorial spaces that have natural resources with relevant characteristics. Such areas are used as strategic for the protection of nature. In this context, the use of geotechnologies, such as Geographic Information Systems and Remote Sensing, optimizes diagnosis and environmental monitoring (DIAS *et al.*, 2020).

Figure 1 - Location of the study area.



Source: The authors (2020).

MATERIALS AND METHODS

For the study of geoenvironmental susceptibility, information on the drainage network, slopes, lithologies, soils, land use and land cover were integrated. These data were organized in the QGIS software in version 3.14.16, where it was possible to the apply the automatic crossing of this information of normalized weights for each map, defined by the AHP method.

The radar image of the Shuttle Radar Topographic Mission (SRTM), with a 30-meter spatial resolution, was obtained on the Topodata platform, at the Instituto Nacional de Pesquisas Espaciais (INPE - Brazilian National Institute of Space Research). This data was used as a basis for the elaboration of the Digital Elevation Model (DEM) that made it possible to generate information about the drainage network and the delimitation of the basin and relief (declivity).

The declivity was defined based on the work of Ponçano et al. (1981), who established the classes <5%, 5 – 15%, and >15%. The authors Santos et al. (2020) also used these same intervals in the geomorphometric compartmentalization of the Jaguari River watershed, in the western RS.

The lithological information was obtained from the Companhia de Pesquisa de Recursos Minerais (CPRM - (Brazilian Mineral Resources Research Company) website, on a scale of 1:250,000 and in shapefile format that corresponds to the geological maps of Porto Nacional (SC.22-Z-B) and Miracema do Norte (SC-22-X-D). In the hydrographic basin, the Lateritic Detritus Coverage, the Pimenteiras Formation, the Jaicós Formation, and the Granitoides were identified.

Data on soils were obtained through the work of Sousa et al. (2012), representing the Secretaria do Planejamento e Orçamento do Tocantins Tocantins (SEPLAN - State Secretariat of Planning and Budget). Information on soils and slopes was compared in the watershed. Some adjustments were made according to the soil-slope relationship. According to Nowatzki and Santos (2014), the different types of soil can be compartmentalized according to the characteristics of the relief. In this sense, the soil data were adjusted based on the slope and with the support of fieldwork, defining the following classes: Latosol, Plinthosol, Neosol-Cambisol association, and Argisol-Cambisol association.

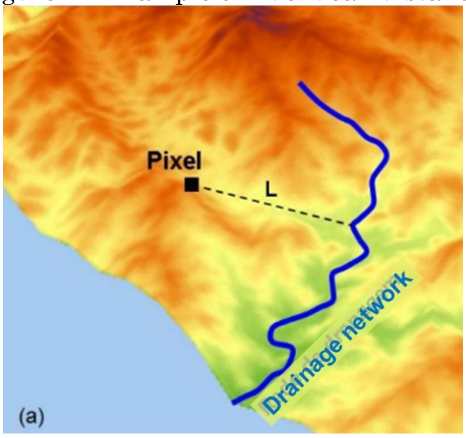
Through the website of the United States Geological Survey (USGS), the Landsat 8 image, from July 2021, with a spatial resolution of 30 meters, was downloaded. Then, bands 6, 5, and 4 were used in the respective order to generate the RGB composition. A supervised classification was generated, which provides information on land use and land cover in the Lajeado creek watershed in the following classes: Forest Formation, Savannah-Campestre Formation, Agriculture, Livestock, Fire Scars, Water Bodies, and Urban Areas.

To access road information in the Lajeado creek watershed, it was necessary to perform the vectorization on Google Earth satellite images, available in the Quickmapservices plugin in the QGIS software. From these procedures, the spatial distribution of unpaved roads was mapped.

Linear information such as roads and drainage networks were transformed into a raster with a pixel of 30 meters, using an algorithm that calculates the Euclidean distance, a straight line in the horizontal plane.

The Euclidean distance (Figure 2) determines the degrees of influence, that is, the closer the distance from a given point (L) to the line of the vector of interest, the greater its influence, and, when the point of interest is farther away, the less will be the influence.

Figure 2 - Example of Euclidean distance.



Source: adapted from Sousa *et al.* (2015).

From the organization of all cartographic data, the AHP method was applied, which represents the judgment or the paired comparison between two elements that are in the same pair (that form the pair) (SAATY, 1991). The numerical comparison scale ranges from 1 to 9, meaning the importance of one criterion over another (Chart 1). These judgments are represented in a square matrix, with n (n - 1) /2, organized in an n x n matrix, where n is the number of rows and columns, where the participating analysts judge whether an element (A) dominates element (B). In environmental studies, the work of França et al. (2019), applied this method to analyze the environmental fragility of the municipality of Capelinha in Minas Gerais.

Chart 1 - Criteria comparison scale.

Intensity of importance on an absolute scale	Definition	Explicação
1	**Equal importance**	Two activities contribute equally to the objective
3	**Moderate importance of one over another**	Experience and judgment strongly favor one activity over another
5	**Essential or strong importance**	Experience and judgement strongly favor one activity over another
7	**Very strong importance**	An activity is strongly favored and its dominance demonstrated in practice
9	**Extreme importance**	The evidence favoring one activity over another is of tile highest possible order of affirmation
2, 4, 6, 8	**Intermediate values between the two adjacent judgments**	When compromise is needed

Source: adapted from Saaty (1991).

The AHP method starts with the elaboration of a weighted matrix, from which the calculation of the normalized weights (priority vector) for each criterion is obtained, calculating the average of the values of each line of the weighted matrix. It is these normalized weights (eigenvector) that indicate, to the decision maker, which elements should have greater importance (hierarchy), for automatic crossing.

To assign prioritization using the AHP technique, it is necessary to calculate the weighted matrix, where each element in the column is divided by the sum of the values in the column itself. The values obtained from this procedure make the sum of each column equal to one (1). Then, the *matrix.multi* function of the spreadsheet is used to obtain the product, which will be divided by the eigenvector and generate the *lambda* (λ).

In the *lambda* (λ) column, it is performed the *medium.geometry* function, which is subtracted by the number of elements analyzed. Finally, by dividing the same number of elements and subtracting 1, the Consistency Index (CI) will be generated. The CI measures the consistency of judgments – the closer the index is to zero, the greater it the overall consistency of the comparison matrix.

Thus, the Consistency Ratio (CR) is generated, obtained by dividing the CI by the Random Index (RI) of the AHP, defined as a function of the number (n) of elements compared, according to Saaty (1994) (Chart 2).

Chart 2 - Recalculated IR values.

N	3	4	5	6	7	8	9	10	11	12	13	14	15
IR	0.52	0.89	1.11	1.25	1.35	1.4	1.45	1.49	1.51	1.54	1.56	1.57	1.58

Source: adapted from Saaty (1994).

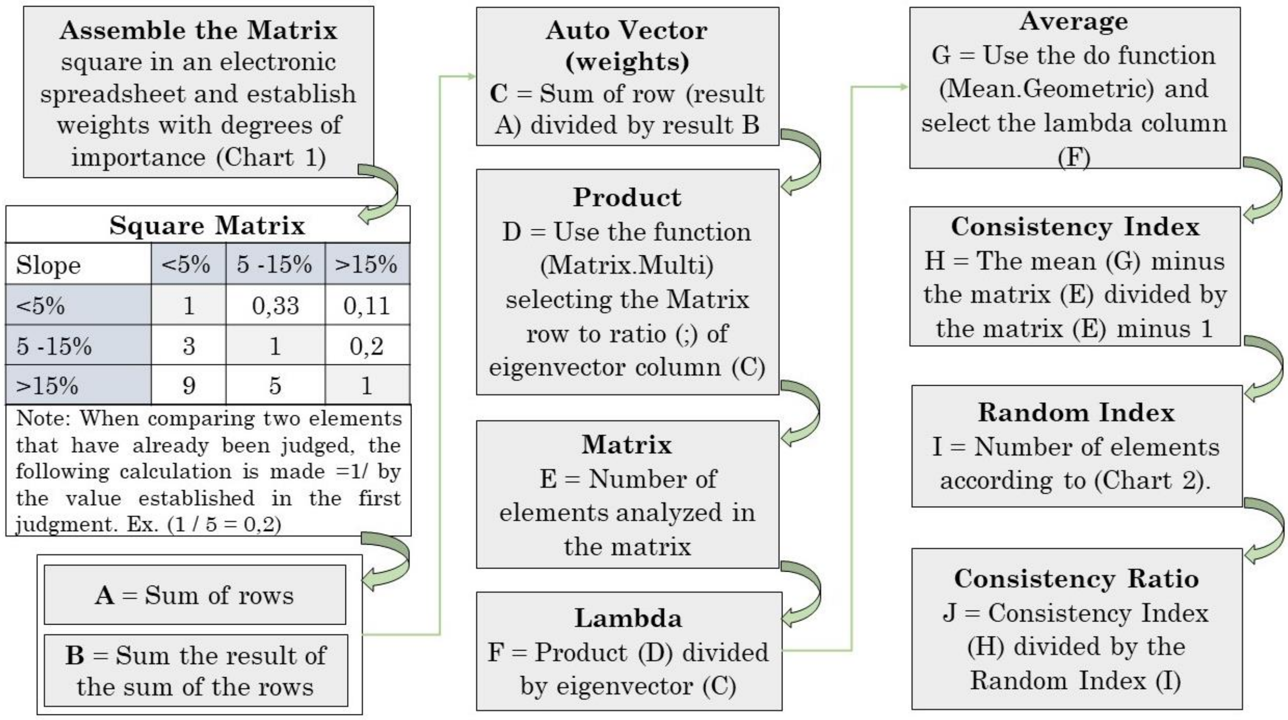
In general, Figure 3 exemplifies the routine of the AHP method to define normalized weights for land use and land cover, slope, soils, and lithologies in the Lajeado creek watershed.

The slope classes were judged based on different authors who discuss the formation of gullies (ALMEIDA FILHO, 2004; MARCHIORO et al., 2016; OLIVEIRA, 1994; 2007). Therefore, the class smaller than 5% weighted 0.07; the class from 5 to 15% was weighted 0.20; and the class greater than 15% was weighted 0.73.

Judgments of the different types of soils were based on information found in the work of Silva and Oliveira (2015), observing the degree of erodibility. this way, considered the Latosol with a weight of 0.04; the Plinthosol, 0.13; the Argisol-Cambisol association, 0.32, and the Neosol-Cambisol, 0.51.

The different susceptibilities of lithologies are related to disaggregation and erosion processes, thus the Crystalline rocks weighted 0.05; the Pimenteiras Formation weighted 0.14; the Lateritic Detritus Coverage weighted 0.30, and the Jaicós Formation weighted 0.51.

Figure 3 – AHP technique procedures.



Source: The authors (2022).

In terms of land use and land cover, it was considered the following classes, with their respective weights: Forest Formation (0.03); Savannah-Campestre Formation (0.08); Agriculture (0.21); Fire Scars (0.28), and Urban Areas (0.40).

After obtaining the weights for each class, the conditioning factors were aggregated by using the Weighted Linear Combination (WLC) method. For this purpose, the raster files of land use and land cover, roads, slope, drainage network, soils, and lithologies were standardized within the range of 0 to 1, using the Equation 1 in the raster calculator.

(R – lowest R-value) / (highest R-value – lowest R-value) (Equation 1)

In this equation, R is the raster that is being weighted.

The factors used for the geoenvironmental analysis are land use and land cover, roads, slope, drainage network, soils, and lithologies. Through these factors, normalized weights (Chart 3) were obtained. Thus, the weighted products are multiplied by their respective weights, obtained from the AHP method, as shown in Equation 2. For this crossing, the QGIS software raster calculator was used.

S = (Fus * 0,36 + Fe * 0,26 + Fd * 0,18 + Frd * 0,12 + Fs * 0,06 + Fl * 0,02) (Equation 2)

In this equation, S is susceptibility, Fus is use and cover, Fe is road, Fd is slope, Frd is drainage network, Fs is soil, and Fl is lithology.

Chart 3 – Judgment values and factor weights.

	land use and cover	roads	declivity	drainage network	soils	lithology	weights
land use and cover	1	3	3	5	7	9	0,36
roads	0,33	1	3	3	5	9	0,26
declivity	0,33	0,33	1	3	3	7	0,18
drainage network	0,20	0,33	0,33	1	3	5	0,12
soils	0,14	0,20	0,33	0,33	1	3	0,06
lithology	0,11	0,11	0,14	0,20	0,33	1	0,02
consistency ratio: 0,06							

Source: The authors (2022).

The last step to analyze the geoenvironmental susceptibility of the watershed consisted of carrying out three fieldwork in December 2021 to validate the information collected and automatically crossed in GIS.

RESULTS AND DISCUSSION

Analyzing the characteristics of the variables (Figure 4), we have data on natural aspects and human activities in the hydrographic basin.

Drainage network

The Lajeado creek hydrographic basin has a 6th-order river hierarchy, with the main channel extending for 27km. Susceptibility is indicated by the Euclidean distance from the drainage network (Figure 4A). The main drainage channels are represented by the Mutum and Algodão streams, Lajeado and Agem streams, in the 5th order, and the Cedro, Cachorro, Serrinha, Brejo da Passagem and Agem streams, in 4th order.

Declivity

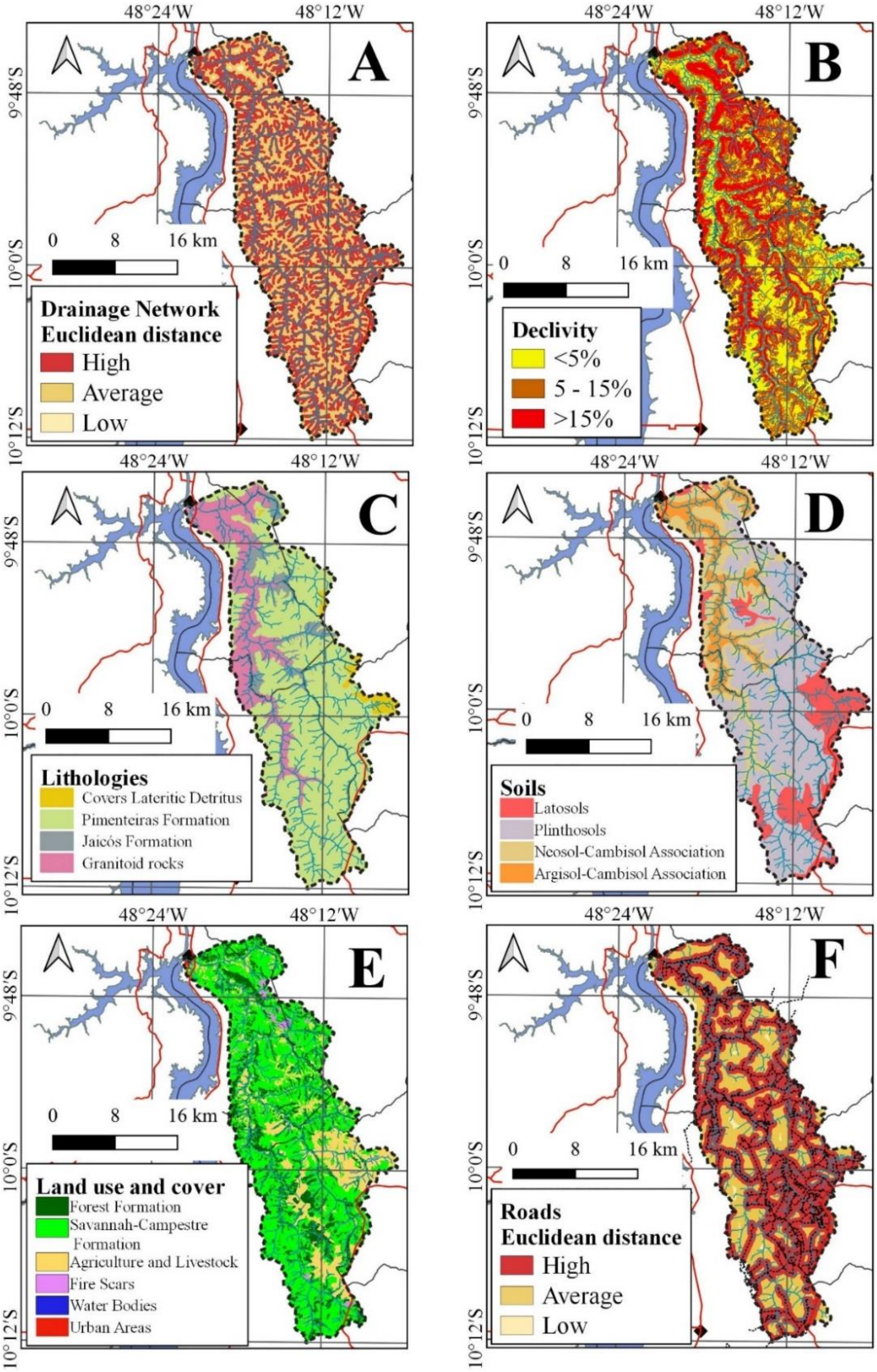
The mapping of the slopes (Figure 4B) shows that sites with <5% occupy about 33.23%, with predominance in the floodplain of Lajeado creek and in the tops that mark the sources of the main drainages of the basin. Slopes between 5 and 15% cover about 37.51%, distributed mainly in the middle and lower course. Areas with slopes >15% cover 29.26%, spatialized on the edge of the tabular reliefs where the steep slopes are found. They are located mainly in the middle and lower course of Lajeado creek, with greater concentration in both east and southeast portions of the research area.

Lithologies

The Lajeado creek watershed is inserted into the sedimentary basin of Parnaíba. Based on Ribeiro and Alves (2017), it covers the Lateritic Detritus, the rocks of the Pimenteiras Formation, the rocks of the Jaicós Formation, and Granitoid rocks (Figure 4C).

The Detritus Lateritic coverings are predominantly ferruginous lateralization and, when exposed or exhumed, they are lithified, forming ironstones. At the top of the Lajeado Range, they are exposed to a vast flat area at levels around 600 m (RIBEIRO; ALVES, 2017). In the Lajeado creek watershed, this coverage occupies an area of about 3.01%, spatialized in the eastern, portion, of the medium and lower course.

Figure 4 - Factors analyzed for geoenvironmental susceptibility.



Source: The authors (2022).

The red and dark gray shales, with intercalations of white to light gray sandstones and siltstones of the Pimenteira Formation, occur especially towards the top of the sequence. They represent shallow shelf deposition dominated by storms (VAZ et al., 2007). The Pimenteira Formation corresponds to 64.15%, being the main lithology in terms of area coverage. It is located mainly in the upper course, while, in the medium and lower course, it is found in smaller areas.

Conglomeratic sandstones and the conglomerate of the Jaicós Formation are dominant and constitute a large part of the verticalized escarpments of the Lajeado Range. In the study area, it represents 13.19%, being spatialized in a narrow strip in the upper course, and, from the middle course onwards, it widens representing a greater concentration in terms of area.

The crystalline rocks in the Lajeado creek watershed are represented by granites and gabronorites. Granite is an extensive body that surfaces for more than 60 km and disappears under the sub-horizontal layers of the sedimentary rocks of the Parnaíba Basin (CHAVES, 2003). The crystalline rocks in the hydrographic basin correspond to 19.65%, occurring from the upper and middle course along the Lajeado creek, widening in the lower course.

Soils

Soils in the Lajeado creek watershed can be classified as Latosols, Plinthosols, Neosol-Cambisol association, and Argisol-Cambisol association, shown in Figure 4D.

The Latosols in the watershed represent about 18.67%, spatialized in the upper course, eastern and western portions. In both middle and lower courses, they occupy the areas of the western portion of the tributaries of the Lajeado creek and part of the dividers in the northern portion.

The Plinthosols cover about 44.37% of the study area, spatialized mainly in both high and medium courses; in the lower course (eastern portion), they are associated with a gently undulating relief over a shale substrate with low permeability that restricts circulation. In addition, the climate generates variations in the water table and the formation of plinths in the subsurface horizon.

The poorly developed soils are the Neosols and Cambisols, which are characterized by the low intensity of action of pedogenetic processes. In the hydrographic basin, it corresponds to 22.30%, located in the upper course, following the Lajeado creek channel, in the medium and lower course, it encompasses other tributaries and has the highest concentration, in terms of area.

The Argisol-Cambisol association, in the study area, occupies about 14.66%. In short, it occurs in the middle and lower course, following the Lajeado creek channel and other tributaries in the middle and lower course.

Use and vegetable coverage

Land use and land cover in the Lajeado creek watershed can be observed in the following classes: Forest Formation, Savannah-Campestre Formation, Agriculture, Livestock, Fire Scars, Water Bodies, and Urban Areas (Figure 4E).

The Forest Formation, corresponding to 21.48%, is divided into riparian forests, gallery forests, dry forests, and cerradão (RIBEIRO; WALTER, 2008).

The Savannah Formation is divided into Cerrado *stricto sensu*, cerrado park, palm grove, and a phytophysiognomy with the Buriti palm tree (*Mauritia flexuosa*) emerging, amid more or less dense groups of shrub-herbaceous species (veredas). Campestre Formation is divided into dirty, rupestrian, and clean fields (RIBEIRO; WALTER, 2008). This type of vegetation (Savannah-Campestre) covers about 57.17% of the study area.

Agricultural and livestock use represents agricultural activities (planting soy, corn, and sorghum) and livestock (cattle and horse breeding) at about 19.94%. The fire scars in the Lajeado creek watershed are places that suffered the action of fire (by burning or forest fires) during a certain period of the year. Thus, around 1.13% of the area was covered.

The water bodies, in turn, are areas that represent dams and excavated tanks related to fish farming activities, which also contribute to the suppression of the local natural vegetation cover (FURTADO & CRISTO, 2018).

In the study area, the city of Lajeado is located, close to the mouth of the hydrographic basin, which corresponds to 0.22%. A place that underwent several economic transformations, mainly with the construction of the Luís Eduardo Magalhães hydroelectric plant, inaugurated in 2002 (SEPLAN, 2017).

Roads

The unpaved roads are distributed mainly in low and medium distances, where they have a length of 732.39 km (Figure 4F). The lower concentration of roads in the Western portion of the upper course is because it is an area destined for the PEL. The greater concentration of roads in the Eastern portion of the upper course can be explained by the presence of farms and access to areas with agricultural activities.

Geoenvironmental susceptibility of the Lajeado creek watershed

The geoenvironmental susceptibility of the Lajeado creek watershed (Figure 5 and Table 1) was defined from the intersection of land use and land cover (weight 0.36), roads (weight 0.26), slope (weight 0 .18), drainage network (weight 0.12), soils (weight 0.06) and lithologies (weight 0.02).

It is observed that the use and access roads had more weight concerning the other elements since human occupations are not always preceded by studies that consider the restrictions of natural resources, especially related to the fragility of lithologies and soils when subjected to certain uses (ROBAINA; TRENTIN, 2019).

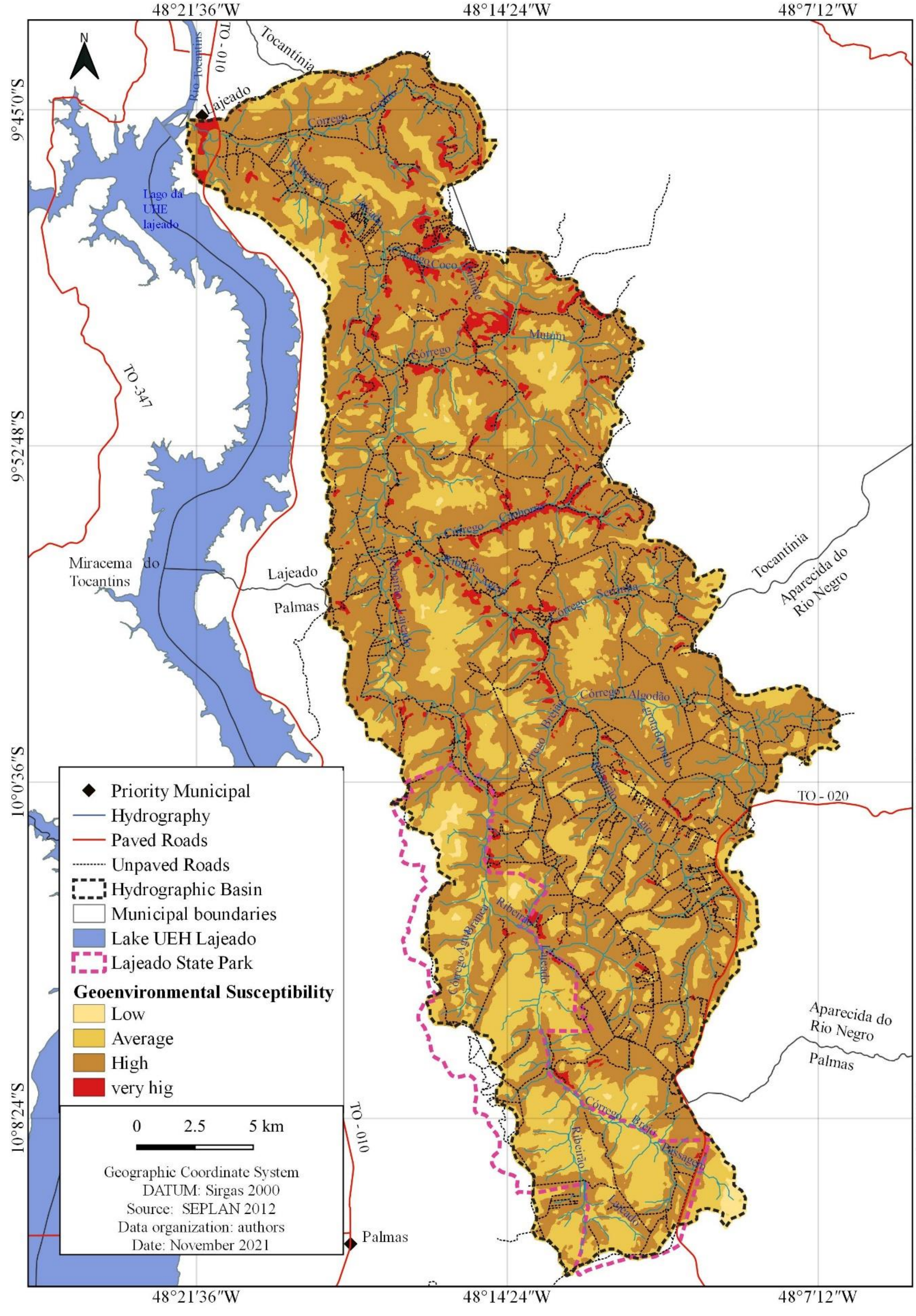
The result of these crossings showed the geoenvironmental susceptibility in four units: I low, II medium, III high, and IV very high.

Table 1 - Geoenvironmental susceptibility data of the hydrographic basin.

Susceptibility	Area (km²)	Area (%)
Low	4,86	0,80
Average	157,78	25,60
High	431,81	70,06
Very high	21,84	3,54
Total	616,29	100

Source: The authors (2022).

Figure 5 - Geoenvironmental susceptibility of the watershed.



Source: The authors (2022).

I - Low susceptibility

Low susceptibility (Figure 6) occupies about 4.86 km², that is, about 0.80%. In this unit, the main characteristics are the predominance of slopes with low slopes, less than or equal to 5%, with the presence of natural vegetation cover, and without any proximity to the roads.

Figure 6 - Low susceptibility.

Source: The authors (2021).

In these areas, the soil types are Latosol and Plinthosol, and the predominant lithology is from the Pimenteiras Formation.

The low-susceptibility unit occurs in the upper reaches (at some locations within the PEL). In the medium course, close to the water dividers. In the lower course, some sites appear in the Eastern portion of the watershed.

II - Medium susceptibility

The medium susceptibility unit (Figure 7) has an area of 157.78 km², which corresponds to 25.60%.

Figure 7 - Average susceptibility.

Source: The authors (2021).

In general, these places are vegetation covered, mainly of the Savannah-Campestre Formation type, and without any proximity to roads.

The most striking characteristics of this unit are the areas with a slope of less than 15%, specifically at the top of the hills, in which Plinthosol soils predominate, as well as the natural vegetation cover and distance from the roads. The low concentration of access roads is an important characteristic of this unit that allows the conservation of natural conditions.

In the upper course, the highest concentrations of this unit are in the eastern portion, an area that belongs to the PEL. In the middle course, they mainly occupy the water dividers of some tributaries of the Lajeado. In the lower course, the largest areas are in the sub-basin of the Mutum stream and the divisions of this stream with the tributaries of the Lajeado creek.

III - High susceptibility

The high susceptibility unit has an area of 431.81 km², that is, 70.06%. It occupies the largest class within the Lajeado creek watershed, occurring in areas, in which access is facilitated by the wide occurrence of roads. The drainage network is susceptible to anthropic intervention through accesses (Figure 8).

Figure 8 – High susceptibility caused by the confluence of roads and drainage network.

Source: The authors (2021).

The concentrations of this unit in the upper course are mainly in the eastern portion, in which there is a significant occurrence of roads, due to access to farms (Figure 9).

Figure 9 – Very High susceptibility roads and agricultural activities.

Source: The authors (2021).

IV - Very high susceptibility

Very high susceptibility has an area of 21.84 km², corresponding to 3.54% of the space, in which the main characteristics are determined by the type of land occupation and the access roads in places with slopes greater than 15% (Figure 10).

Figure 10 – High susceptibility on roads and slopes greater than 15%.

Source: The authors (2021).

Some places (Figure 11) with a significant erosive process cause silting up of the drainage network channels. Other aspects associated with this unit are the areas with the presence of fire scars and the urban areas.

Figure 11 – High susceptibility on roads with significant advances in erosion processes.

Source: The authors (2021).

DISCUSSION

In general, the environmental susceptibilities of a given environment can occur as a result of natural or anthropogenic causes. Thus, some locations already have susceptible areas due to natural causes (types of soil, slopes, etc.). With the participation of human activity, they become even more fragile and trigger erosion processes.

According to Alves and Silva (2017), one of the factors that can cause an increase in this susceptibility, due to anthropic causes, is the use of rural properties for agriculture and livestock.

These activities in the Brazilian Cerrado, according to Cunha et al. (2008), are marked by the intensive use of pesticides, fertilizers and correctives, uncontrolled irrigation, excessive trampling of animals, monoculture and large-scale culture, and inappropriate use of factors of production.

Mascarenhas and Farias (2018) highlight the removal of vegetation cover in the Cerrado, which is linked to the fragmentation of the biome, contributing to the loss of environmental quality through the reduction of central areas and increased isolation between the remaining fragments. Pina *et al*. (2021) report the removal of vegetation cover, in which landowners usually opt for a short-term return, removing the wood and subsequently implementing exotic pastures for raising livestock.

Other aspects can be associated with access roads, as they are places that influence the increase in susceptibilities, increasing the surface flow and contributing to the generation of erosion processes. Pires and Carmo Junior (2018) point out that some environmental damage caused by roads is often irreversible, due to the suppression of vegetation, soil exposure, interference in the habitats of native animals, changes in the soil itself, and deviations from natural drainages and dams of rivers.

Concerning the conservation units, it should be noted that in the PEL area, the main class was medium susceptibility, which can be explained by the presence of natural vegetation cover and few roads. The other parts of the hydrographic basin that belong to the APA Serra do Lajeado are the main high susceptibility class, related to natural weaknesses and the participation of human activities, because in this type of unit "Uso sustentável" is allowed.

FINAL CONSIDERATIONS

Observations carried out in the Lajeado creekwatershed showed the importance of integrated studies with automated crossings to identify geoenvironmental susceptibility. It is noteworthy that the characteristics of land use and land cover, compared in an integrated manner with the natural elements, made it possible to map the units of low, medium, high, and very high susceptibility.

Thus, one of the aspects that was important in defining the most susceptible areas occurred through this integration, mainly of accesses and uses on the slope.

In this sense, areas with slopes greater than 15%, containing human activities (Agriculture and Roads), were mapped as very high susceptibility units. Other important factors for this classification were Urban Areas and Fire Scars. In summary, actions can be developed to minimize these problems, especially in the face of fires, as it is an UC area that can have greater control over the issue of fire.

In automated crossing, the AHP technique is considered a fundamental tool in geoenvironmental analysis, considering that it is possible to define the degrees of importance of each element, based on brief knowledge of the study area, considering its specific aspects.

In addition, the AHP is conceived as a method that can contribute to territorial planning and management, which may become an important resource in identifying units susceptible to erosion processes and helping to create environmental policies aimed at the conservation of natural areas, whether in river basins, UC, municipalities, or other areas of interest.

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AUTHORS CONTRIBUTION

Lucas da Silva Ribeiro conceived the study, organized the data for automatic crossing, conducted fieldwork, analyzed the information and wrote the text. Luís Eduardo de Souza Robaina guided Lucas da Silva Ribeiro by indicating the literature, participating in organizing data for automatic crossing and reviewing the results obtained. Sandro Sidnei Vargas de Cristo guided Lucas da Silva Ribeiro, recommending literature and participating in the fieldwork and review of information.