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GEOENVIRONMENTAL ANALYSIS OF THE BELEZA STREAM BASIN IN JUSCIMEIRA, MATO GROSSO, BRAZIL

Análise Geoambiental da Bacia do Beleza em Juscimeira, Mato Grosso, Brasil

Análisis Geoambiental de la Cuenca del Arroyo Beleza en Juscimeira, Mato Grosso, Brasil

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ABSTRACT

Recognizing the fragility and potential of different land surfaces is essential for effective decision-making on the use of natural resources. Morphometric analysis within a watershed framework has provided significant contributions to defining possible strategies for spatial use and occupation. From this perspective, this study conducted an analysis of the geoenvironmental profile of the Beleza Stream Basin in Juscimeira, Mato Grosso, Brazil, focusing on morphometric elements (hypsometry and slope gradient) across its two main morphological units. The methods included bibliographic surveys, the development of a cartographic base and morphometric maps, the collection and interpretation of satellite imagery data, the compilation and analysis of thematic maps, and fieldwork. At the regional scale, the basin integrates the morphosculptural units of the Rondonópolis Interplateau Depression and the Guimarães Plateau and Chapada. The Rondonópolis Interplateau Depression exhibits more intense environmental dynamics and lower susceptibility to mechanical erosion than the Guimarães Plateau and Chapada, particularly due to the diversity of geomorphic elements. However, owing to the geographical location of this drainage system, plateau surfaces also impose usage constraints, making it necessary to conduct further studies to better determine the optimal management and occupation conditions for both units.

Keywords: Cerrado; Geography; Geotechnologies.

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RESUMO

Na conjuntura das tomadas de decisão sobre a apropriação dos recursos naturais, o reconhecimento da fragilidade e da potencialidade das diferentes superfícies é indispensável. A análise morfométrica, no contexto de uma bacia hidrográfica, tem oferecido contribuições significativas para a definição de possíveis estratégias de uso e ocupação dos espaços. Nessa perspectiva, o presente estudo realizou uma análise do contexto geoambiental da bacia hidrográfica do Córrego Beleza (Juscimeira – MT), considerando os elementos morfométricos — hipsometria e clinografia — presentes nas duas principais unidades morfológicas dessa bacia. Para tanto, foram realizados levantamentos bibliográficos, elaboração de base cartográfica e de mapas morfométricos, interpretação de imagens de satélite, análise e compilação de mapas temáticos, além de trabalhos de campo. Em termos regionais, a bacia integra as unidades morfoesculturais da Depressão Interplanáltica de Rondonópolis e do Planalto e Chapada dos Guimarães. Conforme discutido neste estudo, a primeira unidade apresenta maior dinâmica ambiental e menor suscetibilidade a processos erosivos mecânicos em comparação às superfícies da segunda, especialmente em razão da diversidade de elementos geomórficos. Contudo, em virtude da localização geográfica do sistema de drenagem, as superfícies do planalto também impõem restrições ao uso, sendo necessário o desenvolvimento de estudos complementares para melhor estabelecer as condições ideais de manejo e ocupação de ambas as unidades.

Palavras-chave: Cerrado; Geografia; Geotecnologias.

RESUMEN

En el contexto de la toma de decisiones sobre la apropiación de los recursos naturales, el reconocimiento de la fragilidad y el potencial de las diferentes superficies es indispensable. El análisis morfométrico, en el marco de una cuenca hidrográfica, ha aportado contribuciones significativas para la definición de posibles estrategias de uso y ocupación del espacio. Desde esta perspectiva, el presente estudio realizó un análisis del contexto geoambiental de la cuenca hidrográfica del Arroyo Beleza (Juscimeira – MT), considerando los elementos morfométricos — hipsometría y clinografía — presentes en sus dos principales unidades morfológicas. Para ello, se efectuaron levantamientos bibliográficos, elaboración de una base cartográfica y de mapas morfométricos, interpretación de imágenes satelitales, análisis y compilación de mapas temáticos, además de trabajo de campo. A nivel regional, la cuenca integra las unidades morfoesculturales de la Depresión Interplanáltica de Rondonópolis y del Planalto y Chapada dos Guimarães. Según lo discutido en este estudio, la primera unidad presenta una mayor dinámica ambiental y menor susceptibilidad a procesos erosivos mecánicos en comparación con las superficies de la segunda, debido especialmente a la diversidad de elementos geomórficos. No obstante, debido a la ubicación geográfica de este sistema de drenaje, las superficies del planalto también imponen restricciones de uso, por lo que es necesario desarrollar estudios complementarios para establecer con mayor precisión las condiciones ideales de manejo y ocupación de ambas unidades.

Palabras clave: Cerrado; Geografía; Geotecnologías

1 INTRODUCTION

The spatial distribution of morphometric parameters is an inherent characteristic of natural dynamics, reflecting the resilience of environmental regulatory processes and constituting the very foundation that supports terrestrial life (Drew, 1986). This conception is used to underscore the vigorous social and, consequently, economic growth that has

treated nature as a resource for exploitation, often in an unbalanced and uncontrolled relationship (Vitte, 2008). Such a perspective is reaffirmed in the scientific understandings and consensuses developed throughout human evolution in addressing the society–nature dichotomy (Reis Jr., 2012; Suertegaray & Nunes, 2001; Ferreira, 2010).

In Brazil, the main natural base that supported—and still largely sustains—this late colonization process is the Cerrado biogeographic system (Chaveiro & Barreira, 2010). This system possesses soil, climate, physical, biotic, and vegetation conditions that are highly favorable to agricultural development. Technological investments such as biotechnological propagation, mechanization, input use, and national and international financial support have further strengthened these advantages. As a result, this region has become a core area of agricultural and livestock production in the country, including commodities such as soybean, corn, cotton, sugarcane, eucalyptus, beef, pork, and poultry. It is no coincidence that the Cerrado has been dubbed the "breadbasket of the world" (Castilho, 2007; Ferreira, 2009; Silva et al., 2013).

In recent decades, Mato Grosso State has emerged as an important reference for the implementation of the modern, highly mechanized production model. Its prominence is explained by the geoenvironmental characteristics of its landscape units, which support the high agricultural yields demanded by the market. The advantages offered by climatic and morphopedological conditions are effectively harnessed in the Guimarães Plateau and Chapada and the Parecis Plateau, located in the central-eastern and central-northern portions of the state, respectively (Ross, 1992; Jesuz et al., 2013). The surfaces of these two morphosculptural units are widely used for large-scale, technology-intensive agriculture and extensive beef cattle ranching. The soil, climate, and morphometric conditions that constitute the landscape framework of these areas serve as major attractors for national and international agribusinesses (Jesuz & Cabral, 2016). In general, these surfaces are relatively resistant to agents responsible for the loss of soil productivity (Latrubesse et al., 1998).

Topographically, the Guimarães Plateau and Chapada and the Parecis Plateau correspond to broad interfluves covered by soil profiles with favorable physical properties (Ross, 1992) and experience well-distributed rainfall throughout hydrological cycles. The agricultural calendar in these areas is structured around the timing of crop sowing and rotation, starting in late September or early October, rotating in February/March, and ending between June and July. August and the first half of September are typically reserved for the mandatory fallow period for pest and disease control in soybean and cotton crops (Tarifa, 2011).

The aforementioned production model, combined with rainfall conditions and the local agricultural calendar, intensifies sediment production in degraded areas and directs it toward lower-altitude morphosculptural units, such as the Cuiabana Depression and the Pantanal Plain, which are depositional in nature. Regionally, the base level and the large aggradational system of sediments derived from the higher-elevation surfaces of the south-central portion of the state (e.g., Guimarães Plateau and Chapada, Paraguay–Araguaia Orogenic Belt, and Serra de São Vicente Intrusive Suite) have the northern Pantanal as their final destination (Brasil, 1982; Sales, 2017).

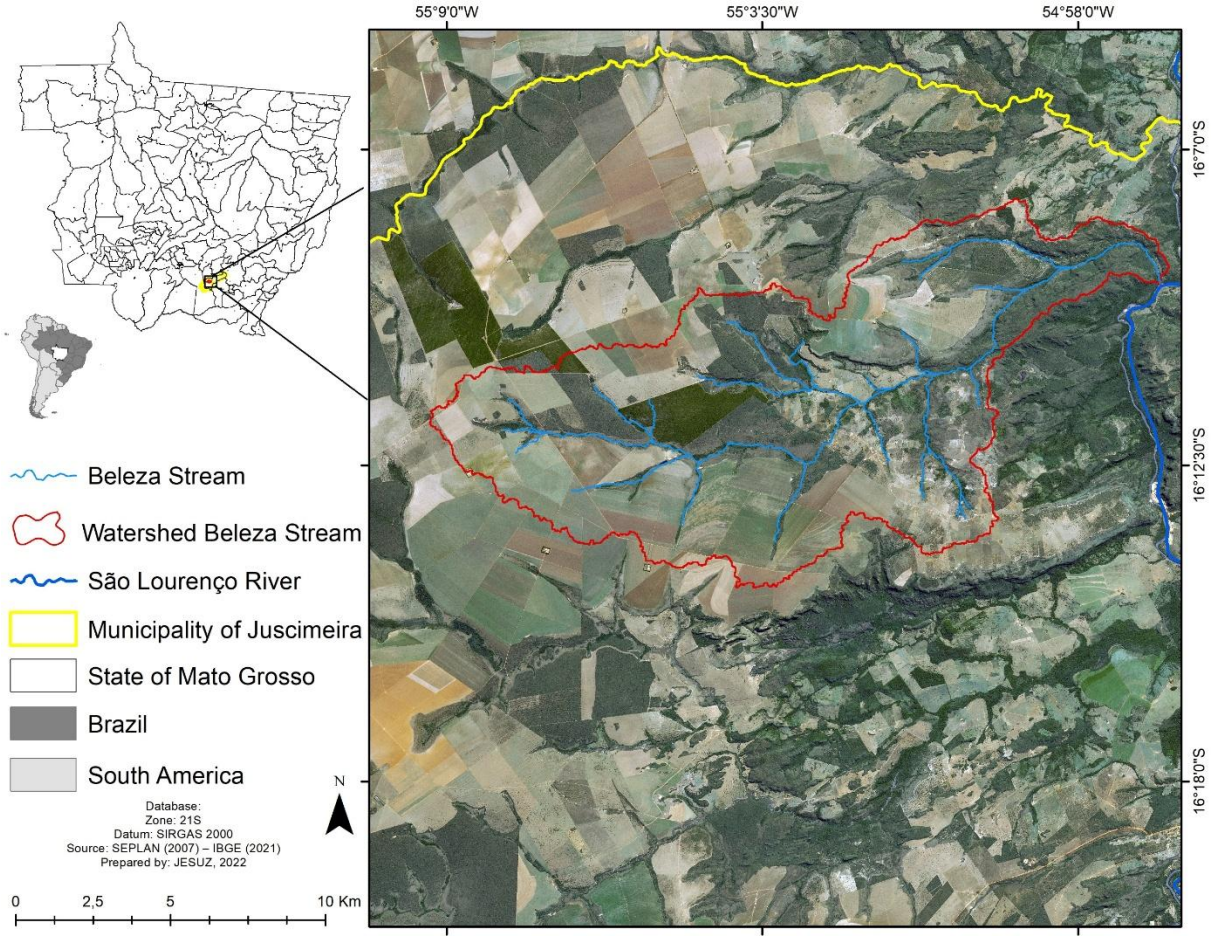
Given this scenario, it is crucial to establish consistent and representative geographic databases for the region, particularly considering the complexity of basin systems such as the Beleza Stream Basin (Vicente, 2015). The Beleza Stream is a direct tributary of the São Lourenço River, which, in turn, is one of the main pathways for water and sediment flows that supply the northern Pantanal (Hunke et al., 2015). In light of these considerations, this study aimed to analyze the geoenvironmental profile of the Beleza Stream Basin based on morphometric elements characterizing its two main morphological units.

2 GEOGRAPHIC SCOPE

The studied drainage basin is part of the hydrographic system of the São Lourenço River, which flows into the Northern Pantanal and is included within the Upper Paraguay Basin. The Beleza Stream Basin is located 28 km northwest of the municipal seat of Juscimeira and 160 km east of the state capital, Cuiabá. The study area covers approximately 138 km^2 and is located between latitudes 16°11′49.52″S and 16°8′54.84″S and longitudes 54°59′6.35″W and 54°56′43.06″W (Figure 01).

Most of the basin area is situated within the geomorphological unit of the Guimarães Plateau. The Beleza Stream is a right-bank tributary of the São Lourenço River, which, together with the Cuiabá River Basin, supplies the northern portion of the largest floodplain on the planet—the Pantanal. The drainage system of the Beleza Stream exhibits diffuse headwaters, with an elevation range of 630 to 660 m.

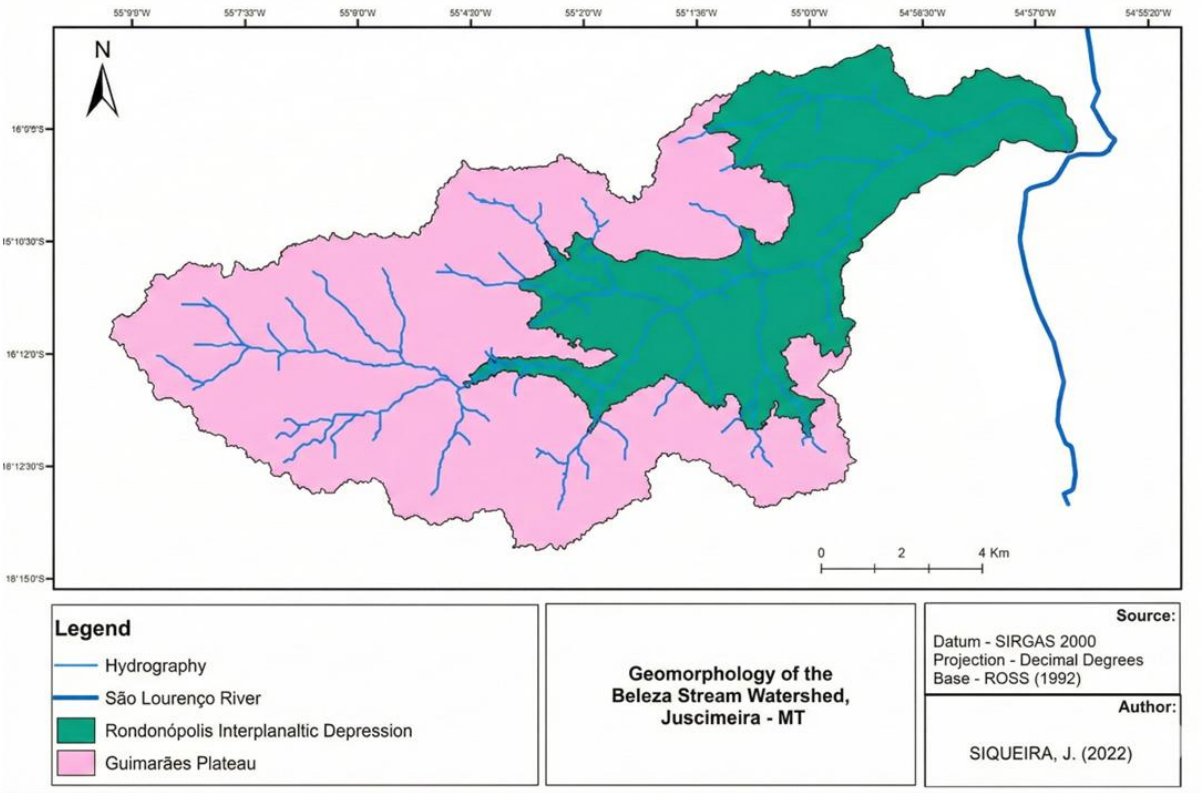
Figure 01 – Location map of the Beleza Stream Basin, Mato Grosso State, Brazil



Source: SEPLAN- MT, (2007).

According to data published by the State Department of Planning (SEPLAN -MT, 2007), the study area is located within the morphostructural domain of the Paraná Sedimentary Basin. This sedimentary basin comprises three basic geological formations: the Furnas Formation and Ponta Grossa Formation, both belonging to the Paraná Group (Devonian period), and the Cachoeirinha Formation (detrital–lateritic cover formed during the Tertiary–Quaternary period). In this context, the Paraná Supersequence (Devonian period) comprises the Furnas Formation (fluvial and transitional deposition of sandstone and conglomerates with abundant ichnofossils) and the Ponta Grossa Formation (composed mainly of shales). Thus, the Beleza Stream Basin features lithostratigraphic units corresponding to the Furnas, Ponta Grossa, and Cachoeirinha Formations (Figure 02).

Figure 02 – Lithostratigraphic units in the Beleza Stream Basin, Mato Grosso State, Brazil



Source: SEPLAN – MT, (2007)

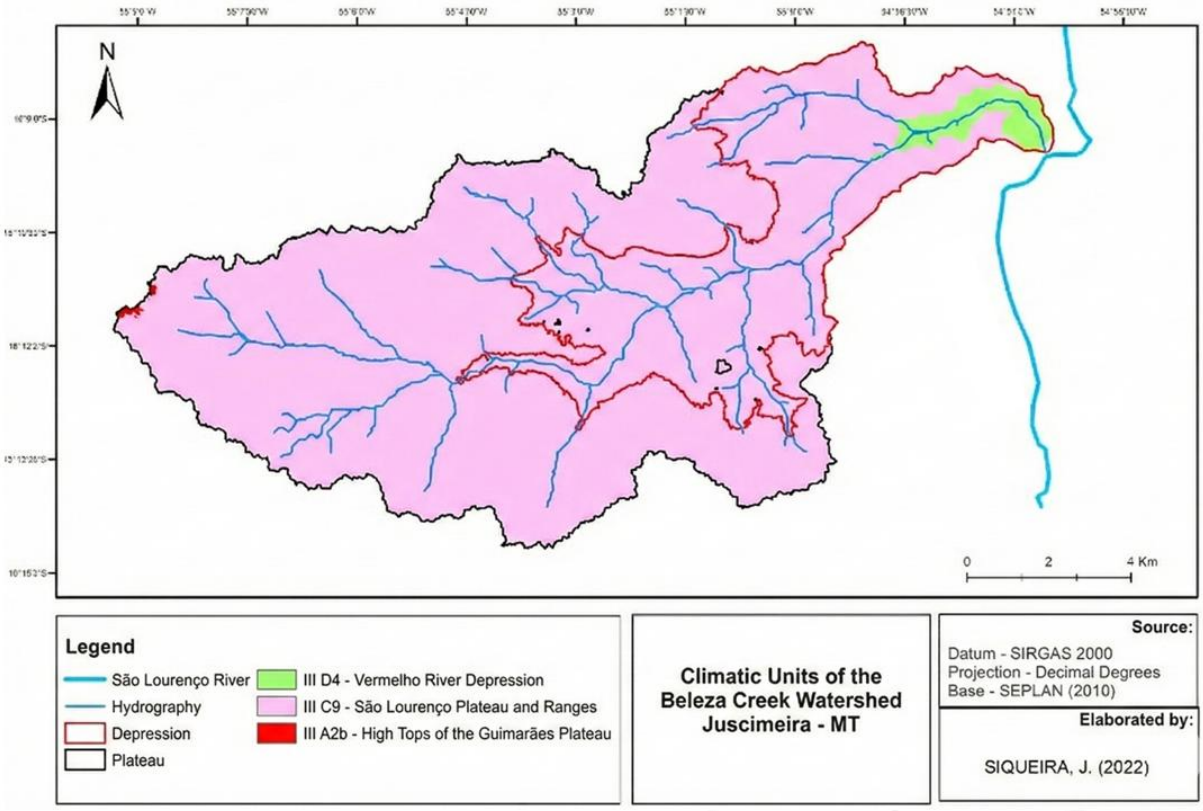
In terms of morphosculptural units, the Beleza Stream Basin is distributed across two major units: the Guimarães Plateau and the Rondonópolis Interplateau Depression. The Guimarães Plateau is a relief unit located along the northern edge of the Paraná Sedimentary Basin, formed through faulting processes and Meso–Cenozoic erosive activities of regional extent. Its surfaces are predominantly flat, with elevations ranging from 500 to 750 m, developed over sedimentary rocks from the Devonian, Jurassic, and Cretaceous periods (Ross, 2016). The relief of this unit exhibits smooth surfaces and some hypsometric discontinuities represented by erosive amphitheaters, generally located at headwater zones as a result of headward erosion. According to Ross (2006), the elevation of the Guimarães Plateau is around 800 m in the northern sector and 600 m in the southern sector. However, the hypsometric gradient is not abrupt but rather composed of gently leveled surfaces with a south–north topographic inclination.

The Rondonópolis Interplateau Depression is located at lower elevations (200 to 500 m) than the Guimarães Plateau and Chapada. The formation of this depression is linked to the action of drainage systems in the middle and lower courses of the Vermelho and São Lourenço Rivers and their tributaries (SEPLAN MT, 2000). These rivers act on Paleozoic

rocks belonging to the Furnas and Ponta Grossa formations.

Climatic information for the Beleza Stream Basin was obtained from the study of Tarifa (2011). According to the author, the basin encompasses three of the six inter-regional climatic units and is influenced predominantly by the Tropical Continental Alternately Humid and Dry Climate of the Chapadas, Plateaus, and Depressions, mainly classified as mesothermic, hot, and humid (category III C9), as depicted in the climate map of Figure 03.

Figure 03 – Climate units occurring in the Beleza Stream Basin, Mato Grosso State, Brazil



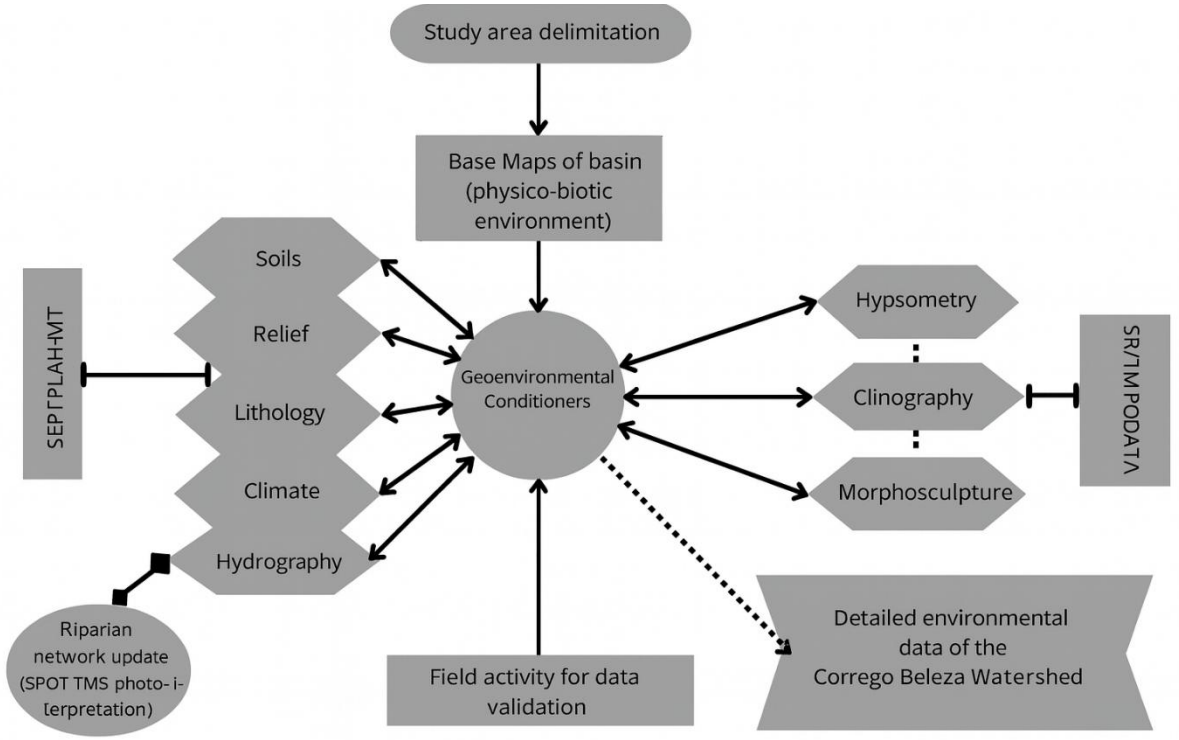
Sources: Tarifa (2011) and SEPLAN – MT (2007)

Regarding the distribution of soil types within the basin and their characteristics, data were obtained from documents published by BRASIL (1982), SEPLAN MT (2007), EMBRAPA (2006), and IBGE (2009). Four main soil types occur in the basin: Typical Dystrophic Red Latosols, Quartzarenic Neosols, Yellow Argisols, and a small patch of Alitic Cambisols.

3 TECHNICAL–OPERATIONAL PROCEDURES

Technical–operational procedures were organized in a hierarchical manner to clearly and accurately support the intended discussion (Figure 04).

Figure 04 – Synthesis of the methodological procedures adopted in the research



Source: prepared by the authors (2022)

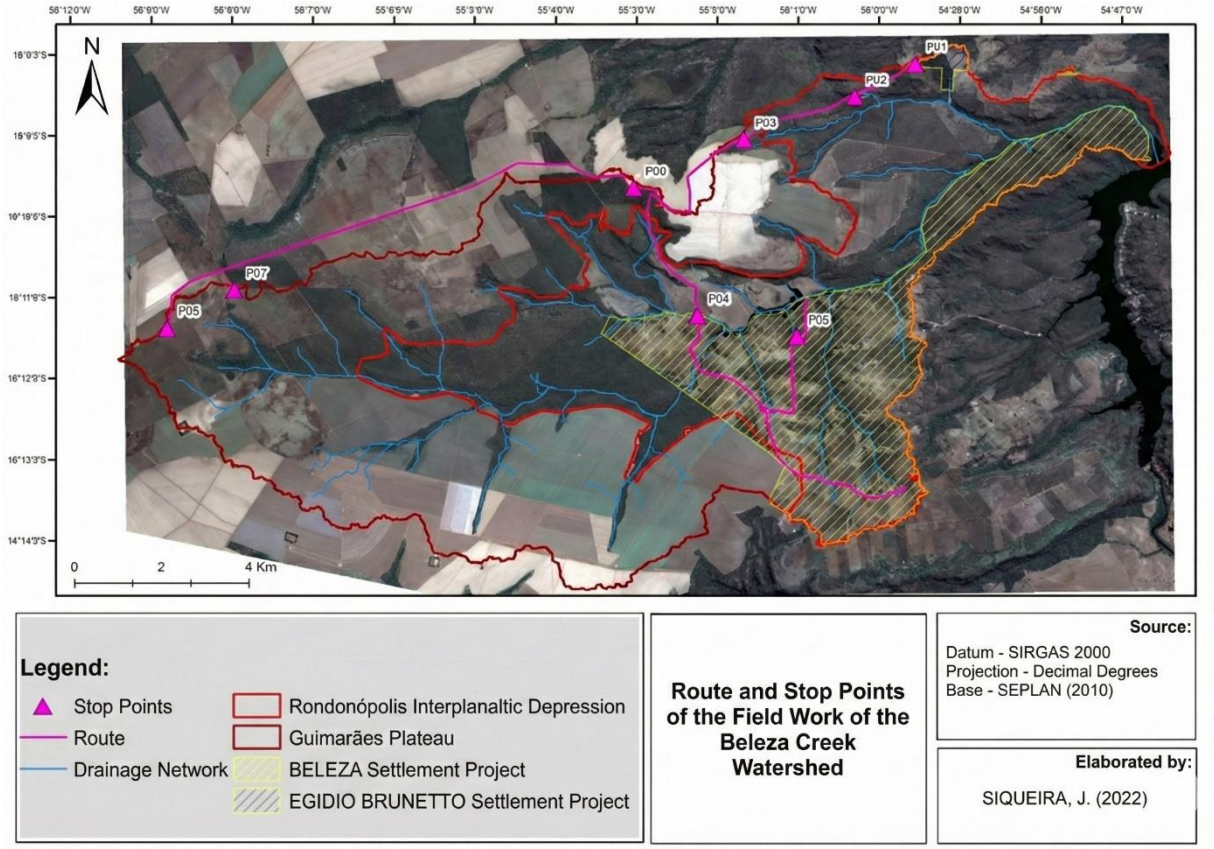
The first phase consisted of office-based activities aimed at obtaining secondary cartographic information on soils, lithologies, rainfall, and land use. Additionally, remote sensing imagery data were collected at the highest available spatial resolution to assist in identifying landscape units. Specifically, SPOT-TM5 images and data from SRTM/TOPODATA/INPE (Digital Elevation Model, DEM) with a 30 m spatial resolution were used.

The second phase involved the preparation of maps of soils, lithology, and climatic units (SEPLAN MT, 2007) at a scale of 1:250,000, as well as the land use map (WWF, 2014) at a scale of 1:50,000. In this phase, a slope gradient map of the study area was also produced. This map was generated from data provided by the Shuttle Radar Topography Mission (SRTM) DEM, obtained from the United States Geological Survey (USGS) Earth

Explorer platform, adopting the slope classes defined by Jesuz (2014). Accordingly, six slope classes were considered, as follows: (I) <3%, (II) 3%–7%, (III) 7%–13%, (IV) 13%–20%, (V) 20%–28%, and (VI) >28%. The proposed classification combines the steeper slope categories while providing greater detail for gentle slopes, better representing the predominantly flat topographic conditions of the Beleza Stream Basin.

The third phase consisted of field validation, carried out to relate and assess geoenvironmental data at several observation points within the basin (Figure 05). This step allowed establishing correlations with the information obtained during the office-based phase.

Figure 05 – Route covered in the Beleza Stream Basin, Mato Grosso State, Brazil, for validation of geoenvironmental data



Source: SEPLAN MT (2007)

The integrated treatment of information during the analysis of the drainage system made it possible to enhance our understanding of the studied themes and their

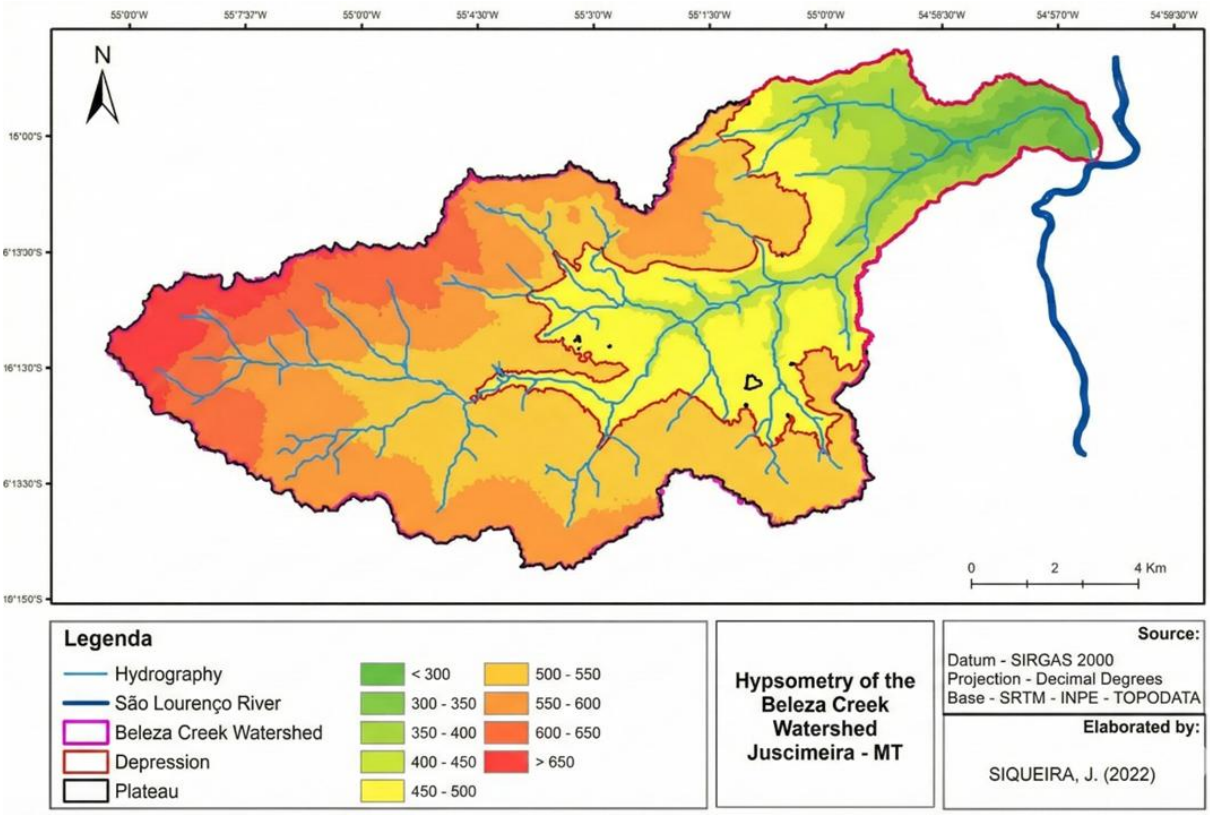
interrelations, which shape and determine the geoenvironmental components of the Beleza Stream Basin. This methodological approach enabled the identification and spatial interpretation of the main environmental attributes within the study area.

4 RESULTS

4.1 Morphometric analysis of the Beleza Stream Basin

The hypsometric profile of the Beleza Stream Basin was divided into nine classes, as represented in the map of Figure 6. It can be observed that the lowest elevation is 221 m and the highest 707 m, resulting in a total elevation range of 486 m. The hypsometric classes reflect, to a certain extent, the different morphosculptural units present in the area, as well as the mapped geomorphological features.

Figure 06 – Hypsometry of the Beleza Stream Basin



Source: prepared by the authors

Elevations above 500 m correspond to the upper sector of the basin, where the greatest number of springs is located (Jesuz & Cabral, 2016). In this part of the basin, the relief consists of gently undulating surfaces, typical of the Guimarães Plateau unit. Representing about 65.35% of the entire basin area, this unit contains surfaces that are highly valued and used for mechanized agriculture and extensive cattle ranching. However, it is important to note that 44.38% of the surfaces of the Guimarães Plateau within the basin are covered by Quartzarenic Neosols. In the Rondonópolis Interplateau Depression, these soils occupy approximately 58% of the area.

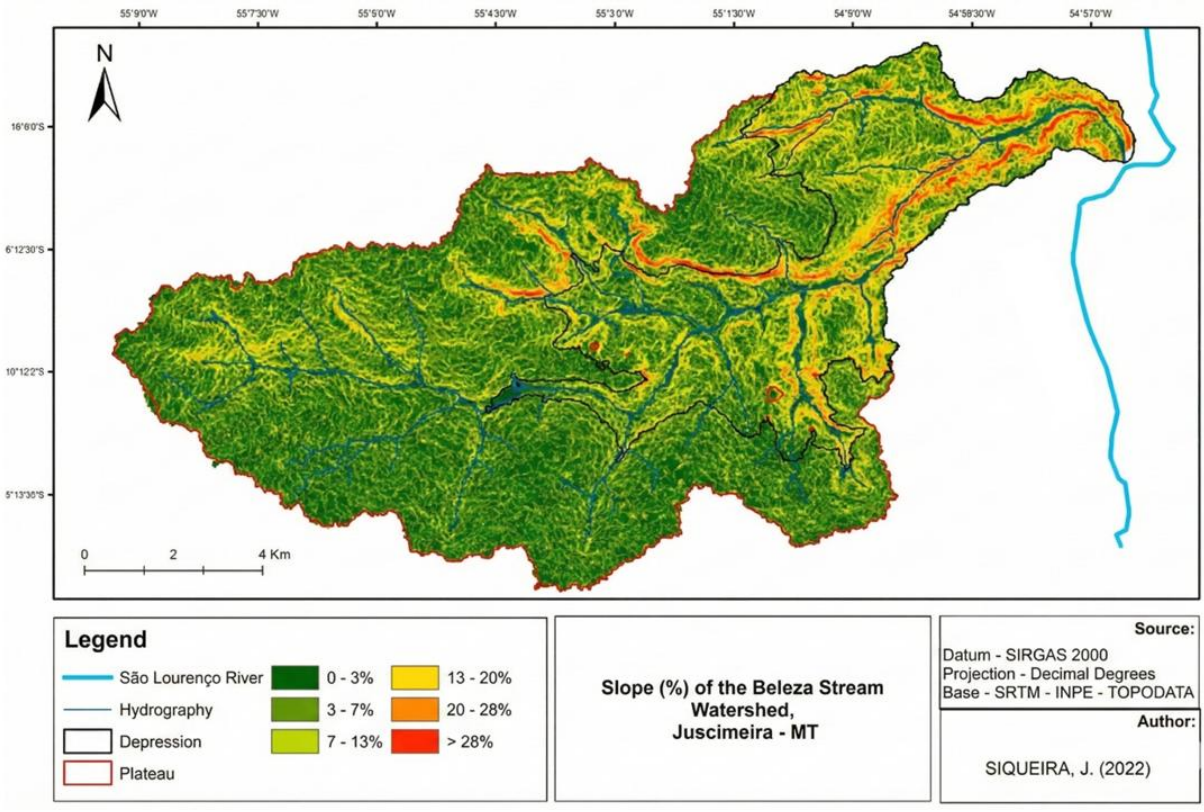
The 500–550 m hypsometric class corresponds to the transition zone between the Guimarães Plateau and the Rondonópolis Interplateau Depression. Denudation processes in the plateau areas have exposed the depression, forming dissected relief patterns. The basin shows strong structural control, with rivers incised along faults and/or fractures, often expressed by the concavity and convexity of the slopes.

The 550–600 m class corresponds to plateau areas where the surfaces exhibit greater planation, especially where Quartzarenic Neosols occur, resulting in concave slopes and entrenched valleys. Both the hypsometric variation and the slope classes reflect the dynamics of this morphosculptural system, which promotes the leveling of the plateau surface (Jesuz & Cabral, 2019). This unit is simultaneously subject to depositional and erosional processes, with erosion predominating. Thus, morphogenetic processes are more active, with higher erosive energy contributing significantly to the reshaping of landforms (Ross, 1994; 2016).

Slope mapping of the Beleza Stream Basin supported the analysis of relief variations and the identification of the morphological compartments of the Guimarães Plateau and the Rondonópolis Interplateau Depression, according to the working scale adopted (Figure 07).

The six slope classes adopted herein were appropriate, as they not only facilitated the analysis but also accurately represented the slope conditions within the two major geomorphological compartments. Based on the information shown in the map, it was found that approximately 70% of the total basin area consists of low-slope surfaces (3%–7%, 34.79%; 7%–13%, 35.66%). When combined with the 0–3% class (14.31%), the low-slope areas comprise about 85% of the basin. The 13%–20% class accounts for 9.80% of the total area, the 20%–28% class for 3.13%, and the >28% for 2.31%, totaling 15% of the basin area with steeper gradients.

Figure 07 – Slope map of the Beleza Stream Basin

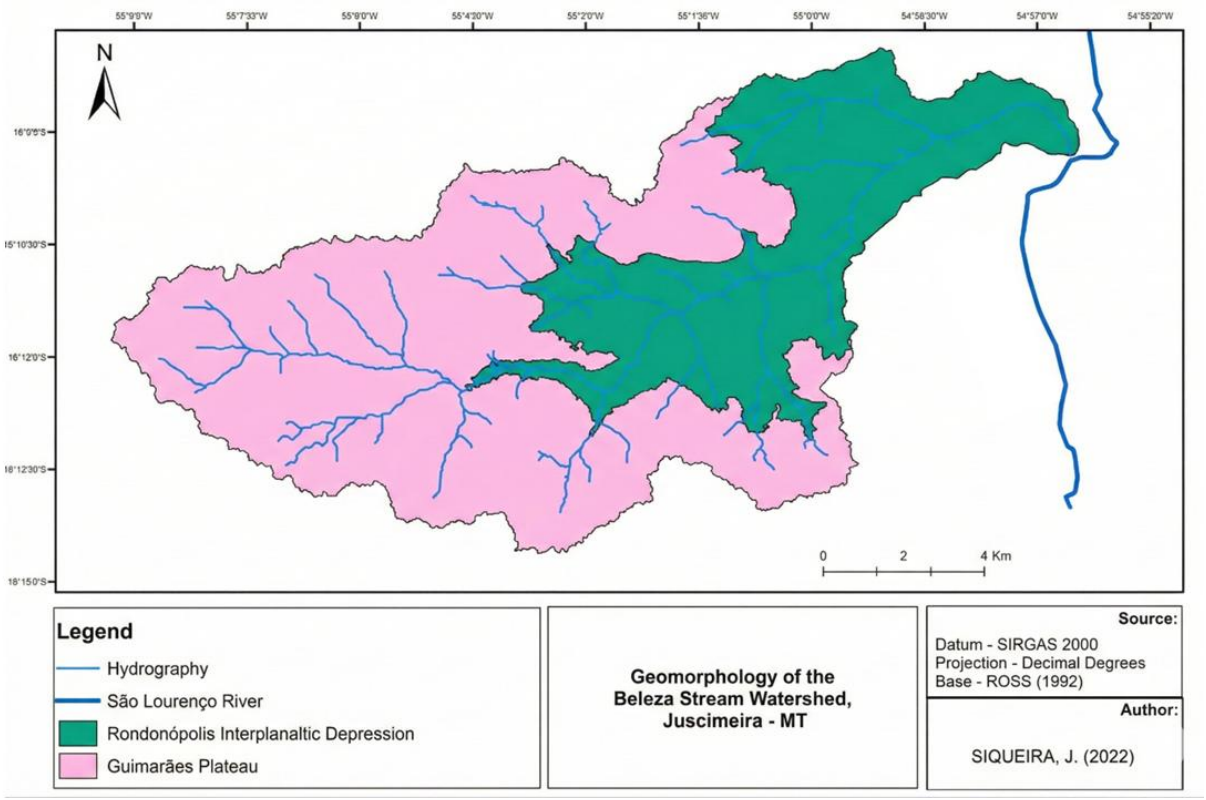


Source: prepared by the authors

Therefore, both slope and hypsometric data demonstrate the formation of two morphosculptural units: the Guimarães Plateau, covering an area of 90.043 km^2 (63.35%), and the Rondonópolis Interplateau Depression, occupying 47.746 km^2 (34.65%) (Figure 08).

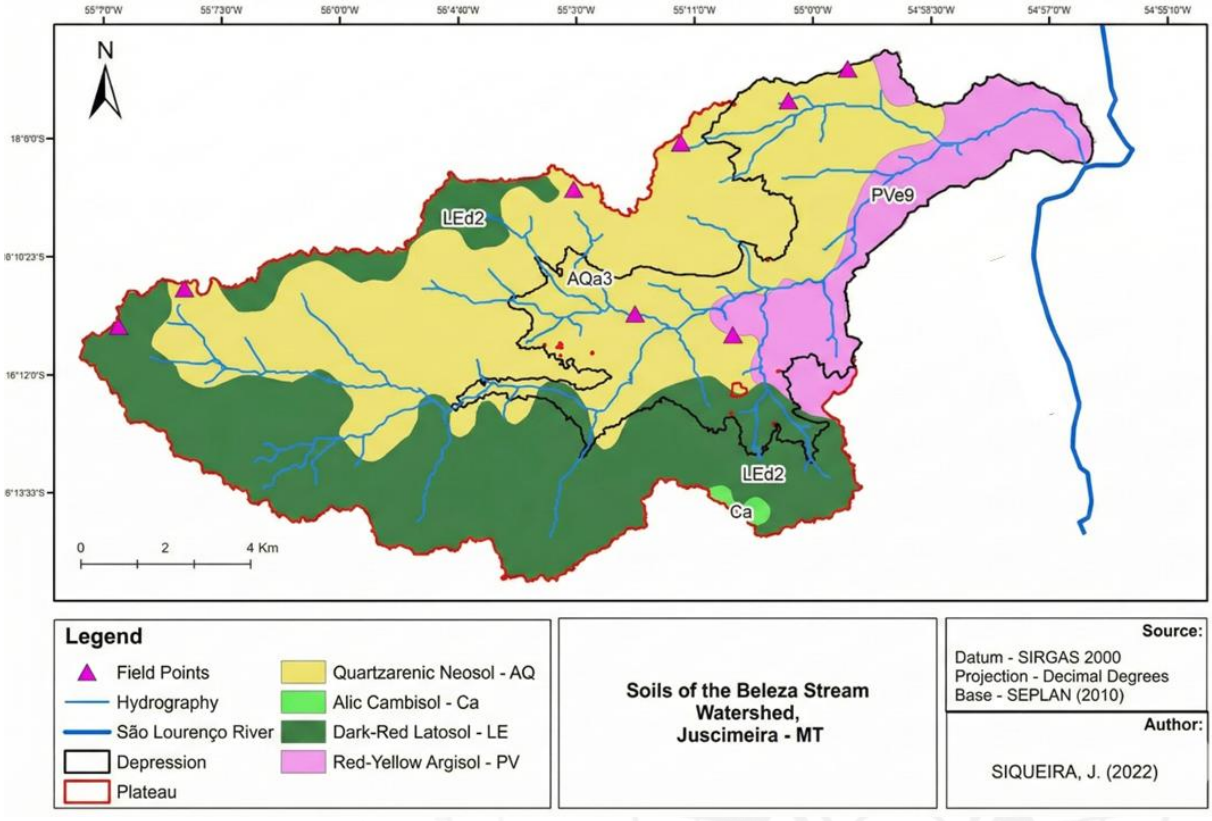
The spatial distribution of soil types across the basin is presented in the soil map of Figure 09.

Figure 08 – Morphosculptural units of the Beleza Stream Basin



Source: Ross (1992)

Figure 9 – Soil units of the Beleza Stream Basin



Source: SEPLAN -MT (2007)

The total area covered by Quartzarenic Neosols corresponds to 48.69%, nearly half of the entire basin (Table 01). However, when analyzing this class by relief unit, the plateau shows the predominance of Latosols (53.47%) and Neosols (44.38%). When grouping areas with moderate to very high vulnerability to mechanical and linear erosion, the plateau reaches 46.54%, nearly half of its total area.

Table 01 – Hierarchization of soil classes in the Beleza Stream Basin

Soil type	Total area (km²)	Relative area (%)	Plateau area (km²)	Depression area (km²)	Plateau (%)	Depression (%)
Quartzarenic Neosol	67,85	48,69	40,20	27,65	44,38	57,67
Latosol	53,32	25,29	48,43	4,42	53,47	6,48
Argisol	17,52	11,13	1,30	0	1,44	24,87
Cambisol	0,65	0,46	0,65	0	0,72	0

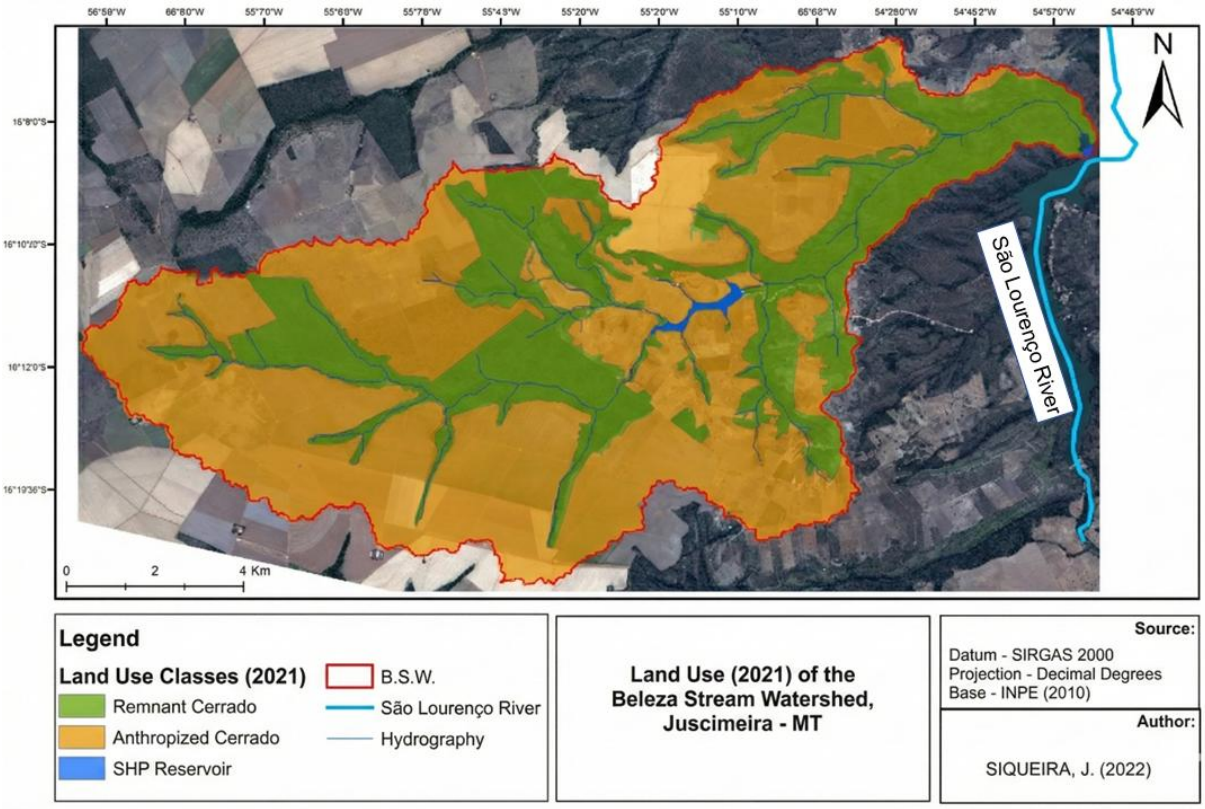
Source: SEPLAN -MT (2007)

4.2 Geoenvironmental profile of the Beleza Stream Basin

To analyze the geoenvironmental profile of the Beleza Stream Basin, it is necessary to consider land use changes, particularly the removal of native Cerrado vegetation for mechanized agricultural activities. In 2021, the basin encompassed 88.61 km^2 (64.18%) of anthropized areas, 49.46 km^2 (35.82%) of Cerrado vegetation, and 0.45 km^2 (0.33%) of flooded areas (Figure 10).

It is evident that most remaining Cerrado areas are located within the Rondonópolis Interplateau Depression and its transition zones toward the Guimarães Plateau (Figure 11). These are primarily associated with smallholder or family-based agriculture, where Legal Reserves and Permanent Preservation Areas are more frequent. The spatial distribution of these small-scale systems is influenced by lot division, slope conditions, and soil and climate constraints on agricultural use, differing from the extensive, mechanized land use observed in the Guimarães Plateau.

Figure 10 – Land uses in the Beleza Stream Basin in 2021



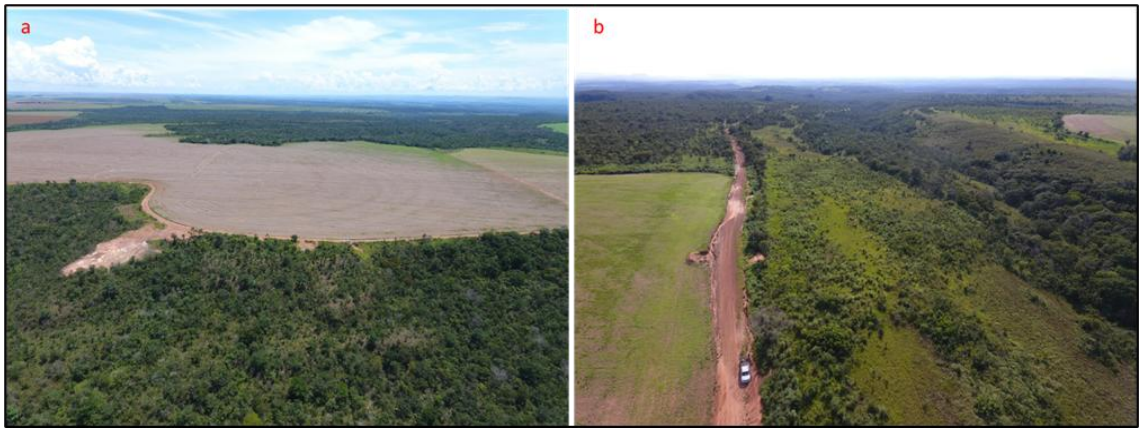
Source: WWF (2014)

Figure 11 – Representative photograph of the transitional surfaces between the Guimarães Plateau and the Rondonópolis Interplateau Depression, Mato Grosso State, Brazil

Source: photo taken by the authors, 2022

Flat or low-slope areas within the Guimarães Plateau morphosculpture are predominantly used for large-scale mechanized agriculture, favored by morphometric, soil, and climate conditions that are particularly suitable for this type of land use (Sales et al., 2020; 2021). Such characteristics include gentle slopes, broad interfluves, convex–flat hillsides, and deep, well-structured soils conducive to mechanization (Figure 12).

Figure 12 – Representative photographs illustrating land uses and morphometric relationships in the Beleza Stream Basin, Mato Grosso State, Brazil



Source: taken by the authors, 2022. **Legend:** (a) Transition of the Guimarães Plateau and the Rondonópolis Interplateau Depression in a headwater area in the Beleza Stream Basin. (b) Boundary of the Plateau Depression in the central sector of the Beleza Stream Basin.

Erosional processes in this area are continuous and vary according to stream energy and sediment size, both influenced by the basin's elevation amplitude. These zones play a crucial role in regulating the hydrological regime, facilitating water percolation into the bedrock, and sustaining the drainage network that feeds the Pantanal system. Data analysis also revealed the occurrence of the shutter ridge phenomenon, characterized by a convex slope wetland with a narrow interfluve, which favors the channelization and acceleration of surface runoff, intensified by the surrounding relief configuration (Figure 13).

This unit, located within the Rondonópolis Interplateau Depression, exhibits a convergent planform, directing higher flow toward the channels. It shows high morphodynamic activity due to the action of rivers influenced by geological faults and neotectonic movements, which create areas with diffuse springs and/or aquifer resurgence during certain periods of the year (Moraes & Cabral, 2022).

Figure 13 – Valley with shutter ridge in the Rondonópolis Interplateau Depression

Source: photograph taken by the authors (2022)

5 FINAL CONSIDERATIONS

The proposed research on the geoenvironmental characteristics of the Beleza Stream Basin, Mato Grosso, Brazil, was developed based on morphometric, land use, and land cover data, supported by remote sensing, geoprocessing, and field validation techniques. These procedures provided the foundation for the study's main objective: to evaluate the basin's geoenvironmental profile based on morphometric elements that characterize its two major morphological units.

The study area exhibits a dynamic set of processes resulting from its position along the northern edge of the Paraná Sedimentary Basin, where discrete tectonic activity can be observed. The configuration of landforms, which are frequently transformed into resources for various human activities, particularly industrial agriculture, poses significant challenges for the sustainable use of these surfaces. The contradictions between relief formation and transformation, and the corresponding soil types, warrant special attention, particularly in the transition zones between the Guimarães Plateau and the Rondonópolis Interplateau Depression, as well as within the latter.

Using a geoenvironmental analysis approach, it was possible to identify the different units and environments that comprise the Beleza Stream Basin, shedding light on their

respective fragilities and potentials. Due to the basin's geographic location and the interaction between its two regional morphological units, it was observed that the degree of environmental fragility and potential varies significantly across the landscape.

The surfaces comprising the Rondonópolis Interplateau Depression demonstrate greater environmental fragility and lower use potential compared with those of the Guimarães Plateau. However, even plateau areas exhibit use restrictions at certain sites, requiring complementary studies to more accurately define the optimal conditions for land management and occupation. Such information is valuable not only for this basin but also for others with similar characteristics.

From an applied perspective, the results obtained here contribute to territorial management, land use planning, and the formulation of local environmental policies. A detailed understanding of the fragilities and potentials of morphosculptural units within the Beleza Stream Basin provides valuable guidance for conservation strategies, environmental zoning, and sustainable agricultural practices, promoting a balance between economic productivity and the preservation of natural resources.

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