GEOTEMAS

Geotemas, Pau dos Ferros, RN, Brasil
ISSN: 2236-255X, v. 16, 2026.

MORPHOMETRIC ANALYSIS OF THE ARROIO SARANDI SUB-BASIN, RIO GRANDE DO SUL, BRAZIL

Análise Morfométrica da Sub-Bacia Hidrográfica do Arroio Sarandi, Rio Grande Do Sul, Brasil

Análisis morfométrico de la subcuenca hidrográfica del Arroio Sarandi, Rio Grande do Sul, Brasil

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Article History
Received: 08 march, 2026
Accepted: 11 may, 2026
Published: 13 july, 2026

https://doi.org/10.33237/2236-255X.2026.7864

ABSTRACT

This article aims to identify the morphometric characteristics of the Arroio Sarandi sub-basin using MDE SRTM data made available through a Geographic Information System (GIS). In addition to delineating the sub-basin, the study identified physical parameters regarding its geometric, hydrographic, and topographic characteristics. The final analysis revealed that the sub-basin has an elongated, narrow shape, with low drainage density and low susceptibility to flooding under normal precipitation conditions. Morphometry characterization is, therefore, indispensable for understanding the sub-basin's water dynamics, just as the watershed scale is effective for verifying local interactions among environmental factors and diagnosing their vulnerabilities.

Keywords: Geographic Information System; Morphometry; Physical parameters.

RESUMO

Esse artigo objetiva identificar as características morfométricas da sub-bacia hidrográfica do Arroio Sarandi através de dados do MDE SRTM viabilizado pelo Sistema de Informações Geográficas (SIG). Além da delimitação da sub-bacia, foram encontrados parâmetros físicos relacionados com suas características geométricas, hidrográficas e de relevo. A análise final revelou que a sub-bacia apresenta formato alongado e estreito, com baixa densidade de drenagem assim como baixa suscetibilidade à ocorrência de enchentes em condições normais de precipitação. A caracterização da morfometria é, portanto, indispensável para a compreensão da dinâmica hidrológica da sub-bacia em questão da mesma forma que a utilização da escala de bacia hidrográfica é eficiente para verificar a interação local entre os fatores ambientais e diagnosticar suas vulnerabilidades.

Palavras-chave: Sistema de informações geográficas; Morfometria; Parâmetros físicos.

RESUMEN

El objetivo de este artículo es identificar las características morfométricas de la subcuenca hidrográfica del Arroio Sarandi a partir de los datos del MDE SRTM, gracias al Sistema de Información Geográfica (SIG). Además de delimitar la subcuenca, se han determinado parámetros físicos relacionados con sus características geométricas, hidrográficas y de relieve. El análisis final reveló que la subcuenca presenta una forma alargada y estrecha, con baja densidad de drenaje, así como baja susceptibilidad a la ocurrencia de crecidas em condiciones normales de precipitación. La caracterización de la morfometría es, por lo tanto, indispensable para comprender la dinámica hidrológica de la subcuenca en cuestión, del mismo modo que el uso de la escala de cuenca hidrográfica resulta eficaz para verificar la interacción local entre los factores ambientales y diagnosticar sus vulnerabilidades.

Palabras clave: Sistemas de Información Geográfica; Morfometría; Parámetros físicos.

1 INTRODUCTION

As an agent that models and modifies the landscape, water assumes different states and trajectories throughout its cycle, from entering terrestrial systems, through precipitation, until it reaches the ground and infiltrates (Botelho, 2011). In the terrestrial phase, the water basin is a fundamental element for analyzing qualitative and quantitative aspects of water resource management and planning.

Silveira (2001) defines the basin as a natural water catchment area, topographically delimited, composed of a set of surfaces called slopes and a drainage network formed by watercourses that converge to form a single exit bed, the outlet. It is in the basin's outlet where all the processes that are part of its system are represented and, consequently, everything that occurs there is a consequence of the territory's forms of occupation and the use of the waters that converge there (Porto; Porto, 2008).

In studies involving watersheds, it is possible to draw conclusions about the environmental quality of the space and the effects of its occupation, as watersheds are understood as entities where the interaction between water and the physical and social environment occurs. However, the perception among individuals that they are part of a water basin, inhabit it, and interact with its territory, as well as that their actions condition its functioning, is poorly established (Botelho, 2011).

In solving socio-environmental problems, the versatility of scales is an important factor, as it enables the delimitation of basins and sub-basins, whose interconnection occurs through water systems, which can be important for more specific management solutions for that context, avoiding generalizations (Porto; Porto, 2008). Factors such as climate, hydrography, relief, soil, vegetation cover, and human interference—which interact through land use and management—are also important parameters to be considered from this perspective (Villela; Mattos, 1975; Silveira, 2001).

The use and occupation of land are also influential factors in watersheds, and their proper use and conservation are important for regulating the processes that act on them. In addition, the planning and management of watersheds must incorporate all the natural and environmental resources of the drainage, not only water resources (LorandI; Cançado, 2002). According to this conception, the use and occupation of land, especially urban land, should be conditioned by the characteristics of the water basins, especially the sub-basins, determining their potentialities and limitations, as well as the means for conflict resolution.

As a method of analysis, morphometric characterization of a water basin enables verification of environmental and territorial dynamics within its coverage area, through the diagnosis of hydrological and/or environmental aspects. Studying morphometric characteristics is, therefore, fundamental for the development of environmental studies and for determining the potentialities and limitations of using local soil, assisting in adequate planning for the functions developed there (Fraga *et al.*, 2014). In addition, water basin morphometry studies can be used to compare one or more basins, enabling the identification of hydrological data, albeit indirectly, in areas without information (Villela; Mattos, 1975).

In addition, the advancement of the Geographic Information System (GIS) and the emergence of the Digital Elevation Model (DEM) were essential for the morphometric characterization of watersheds, integrated with relief information, bringing speed in data collection, execution, and reliability in the results (Cardoso *et al.*, 2006). This study aims, therefore, to identify the morphometric characteristics of the sub-basin of the Arroio Sarandi River, located in the north of the state of Rio Grande do Sul, in the municipalities of Rondinha and Ronda Alta.

The decision to conduct the study in the sub-basin of the Arroio Sarandi is partially justified by the absence of any studies on this basin. In addition, the study of morphometric indices of a water basin, such as area, relief, slope, and drainage, associated with factors such as pedology, land use and cover, and climatic and rainfall data, can help detect physical and environmental vulnerabilities. Additionally, morphometric characterization is indispensable for understanding the basin's water dynamics.

2 METHODOLOGY

The Quantum GIS software (QGis 3.16 "Hannover") was used for this research. As auxiliary tools for watershed identification, data from HIDROWEB, the National Water Agency (ANA), and Google Earth satellite images were used to obtain the outlet coordinates and facilitate subsequent delimitation. The Digital Elevation Model used in this study was the SRTM, with a 30-meter spatial resolution.

The sub-basin delimitation followed the methodology proposed by Sobrinho *et al*. (2010). It can be divided into four steps using SAGA GIS tools: fill skins, flow direction, flow accumulation, and delimitation. To carry out this last step, the outlet point was specified, and the *software* delimited it based on the elevation provided by the DEM.

In the definition of the watercourses, the *r.stream.extract* tool from *GRASS* was used, with the elevation map and the accumulation of the minimum flow 150 of inputs, resulting in a satisfactory density. By this procedure, the result is already given in a *vector*, without the need for conversion. Subsequently, the smoothing tool was used, with 3 interactions and 0.50 displacement.

The methodology proposed by Strahler (1957) was used for the hierarchical classification of watercourses. According to this methodology, each initial watercourse receives a value of 1. When courses of the same order meet, the classification index increases; when courses of different order meet, the one with the highest hierarchical order remains. The projection chosen was the *Universal Transverse Mercator* (UTM) and *Datum* WGS 1984, zone 22s, based on the proximity of the parameters to *the Datum* SIRGAS 2000.

The slope classes of the sub-basin area were classified according to the proposal of Ramalho Filho and Beek (1995), where from 0 to 3% is flat, from 3 to 8% is gently undulating, from 8 to 13% moderately undulating, from 13 to 20% is undulating, from 20 to 45% is strongly undulating, and above 45% is mountainous and steep. DEM and the *r.slope.aspect* tool, from GRASS, with the format *percent*, were used to generate these classes.

For the morphometric classification of the sub-basin, the following indices were used: total area of the basin (A), perimeter (P), maximum altitude (Hmax), minimum altitude (Hmin), average altitude and altimetric amplitude (ΔH), length of the main river (Lc), axial length, measured from the highest point of the main channel to the lowest, in a straight line (L), total number of drainage channels (Nt), total length of the channels (Lt) - obtained by means *of the Qgis* software *raster* calculator. Table 1 presents the formulas for parameters such as compactness coefficient (Kc), form factor (Kf), roundness index (Ic), roughness index (Ir), elongation ratio (Re), drainage density (Dd), hydrographic density (Dh), relief ratio (Rr), bifurcation ratio (Rb) and maintenance coefficient (Cm).

Table 01 – Formulas used to calculate the sub-basin indices

Table of contents	Formula	Concept
Compactness coefficient (Kc)	$K_c = 0.28 * \frac{P}{\sqrt{A}}$	Relationship between the perimeter and the total drainage area of the watershed (Villela; Mattos, 1975).
Form factor (Kf)	$K_f = \frac{A}{L^2}$	Relationship between the total drainage area and the axial length of the watershed (Villela; Mattos, 1975).
Circularity index (Ic)	$IC = 12{,}57 * \frac{A}{P^2}$	Relationship between the total drainage area and the perimeter of the watershed (Cardoso *et al.*, 2006).
Elongation ratio (Re)	$Kc = 1{,}128 * \frac{A^{0{,}5}}{L}$	Relationship between the diameter of the area and the watershed axis length (Souza *et al.*, 2017).
Drainage density (Dd)	$D_d = \frac{L_t}{A}$	Correlation between the total length of the outflow channels and the area of the river basin (Christofolettl, 1980).
Hydrographic density (Hd)	$D_h = \frac{N}{A}$	Relationship between the number of watercourses and the area of the watershed (Horton, 1945).
Roughness index (Ir)	$Ir = H * Dd$	Product between altimetric amplitude and drainage density (Azambuja and Conceição, 2023).
Relief ratio (Rr)	$R_r = \frac{\Delta H}{L_c}$	Ratio between the altimetric amplitude and the total length of the hydrographic basin (Schumm, 1956).

continued

continued

Bifurcation ratio (Rb)	$Rb = \frac{Nu}{Nu+1}$	Relationship between the total number of segments of a given order and the total number of segments of the order immediately above (Christofoletti, 1980).
Maintenance coefficient (Cm)	$\frac{1}{Dd} * 1000$	It provides the minimum area required to maintain one meter of drainage channel (Christofoletti, 1980).

Source: Adapted by the authors (2024).

2.1 Location of the study area

The study area comprises the sub-basin of the Arroio Sarandi, one of the several water basins that are part of the drainage system of the Várzea River Basin (U100), in the north of the state of Rio Grande do Sul, whose area of 9,479 km² runs through the territory of 54 municipalities, with more than 600 thousand inhabitants. More broadly, the so-called Hydrographic Region of the Uruguay River Basin is incorporated, where watercourses drain towards the homonymous river both on the Brazilian border, with the state of Santa Catarina, and in countries such as Argentina and Uruguay (IBGE, 2022; SEMA, [s.d]).

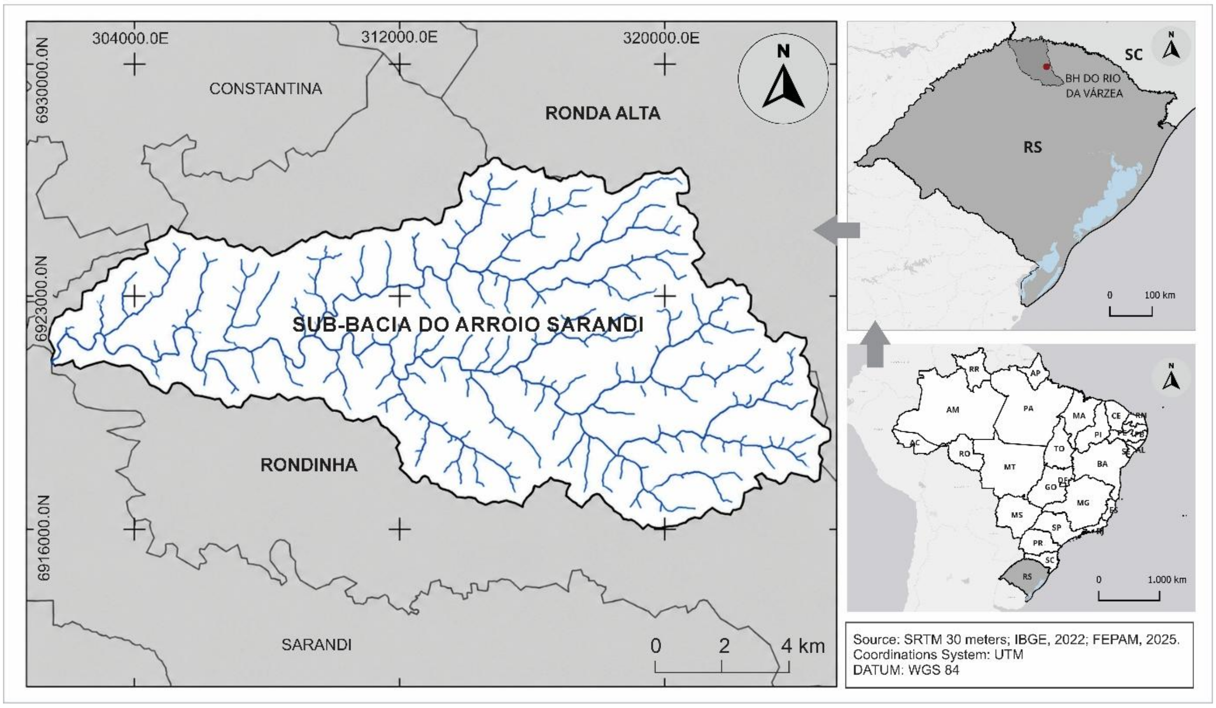
The sub-basin of the Arroio Sarandi partially encompasses the municipalities of Ronda Alta and Rondinha, as Figure 1 shows. The sub-basin's land use is mostly rural, for agropastoral activities, with Rondinha being the only urban headquarters incorporated into it and even crossed by the Sarandi Stream to the north. The drainage direction of the sub-basin is east-west towards the Várzea River, the main watercourse in the region, downstream of Rondinha’s urban area.

As for the geomorphological and geological aspects, the sub-basin of the Arroio Sarandi is located in the Araucaria Plateau, specifically within the Dissected Plateau of the Uruguay River unit. This plateau is located in the north and northwest of Rio Grande do Sul and extends through the state of Santa Catarina and is predominantly composed of volcanic flows of the Serra Geral Formation (São Bento Group) from the Mesozoic Era, composed mainly of basalts and andesites (Gramado and Paranapanema facies), and, to a lesser extent, of rhyolites and dacites (Caxias and Chapecó facies) (IBGE, 2003a; IBGE, 2003b; CPRM, 2010).

The elevations of this plateau range from 300 to 700 m, and its landscapes are marked by plateau surfaces defined by the tributary drainage network on the left bank of the

Uruguay River, resulting in a complex relief of dissected hills and mounds. The predominant soils of the Dissected Plateau of the Uruguay River are dystroferric red latosols (Oxisols), due to the high chemical weathering in a less cold climate on terrains based on basic rocks rich in iron (Santos *et al.*, 2018).

Figure 01 – Map of the location of the Arroio Sarandi sub-basin



Source: IBGE data (2022). The authors (2024).

The morphoclimatic domain is the Subtropical Humid Plateaus of Araucaria Forest, with a subtropical, humid climatic regime characterized by well-distributed precipitation throughout the year (CPRM, 2010). Finally, regarding vegetation, it occurs in a transition zone between the Pampa (predominant) and Atlantic Forest biomes (IBGE, 2019).

3 RESULTS AND DISCUSSION

3.1 Analysis of geometric features

The following analyses present all the morphometric parameters found for the Arroio Sarandi sub-basin. The physical characteristics of a watershed are important factors in identifying its water behavior. In addition, quantitatively listing the aspects related to its shape, processes, and interrelations is necessary to understand the functioning of this sub-basin. The first characteristics considered were the geometric ones, as Table 2 shows.

Table 02 – Geometric characteristics of the Arroio Sarandi sub-basin

Parameter	Data obtained	Unit of measurement
Perimeter (P)	71.88	Km
Drainage area (A)	149.66	km²
Axial length (L)	22.49	Km
Coefficient of compactness (Kc)	1.64	Dimensionless
Form factor (Kf)	0.29	Dimensionless
Circularity index (Ic)	0.36	Dimensionless
Elongation ratio (Re)	0.64	Dimensionless

Source: The authors (2024).

In terms of dimensions, the sub-basins are drainage areas larger than 100 km² and less than 700 km², being the tributaries of the main watercourse (Faustino, 1996). The Arroio Sarandi sub-basin fits, therefore, into this category, since its total area is 149.66 km². Other geometric characteristics found were the perimeter, which corresponds to 71.88 km, and the axial length, 22.49 km, measured from the highest point of the main watercourse to the lowest of this sub-basin.

Considering the main indices that determine its shape, such as compactness coefficient (Kc), form factor (Kf), circularity index (Ic), and elongation ratio (Re), the values obtained make it possible to identify the basin's shape and tendency to flood peaks. For this sub-basin, the values of these parameters, as Table 2 shows, indicate a more elongated shape and a low tendency to flooding under normal precipitation conditions.

Vilella and Mattos (1975) use the values of the form factor (Kf), circularity index (Ic), and compactness coefficient (Kc) together to interpret the basin's tendency to flooding. Kf values below 0.30, Ic below 0.4 and Kc above 1.70 represent a basin with a long shape (elongated) and a tendency towards conservation. For Kf between 0.30 and 0.50, Ic between 0.4 and 0.6, and Kc between 1.70 and 1.50, the format assigned is oblong, with a low tendency to flooding. For Kf and Ic, the higher the values, the greater the tendency towards flooding; for Kc, the lower the values, the greater the tendency towards flooding.

The reference values used are found in Azambuja and Conceição (2023). In this case, those above 1.5 for Kc and below 0.50 for Kf indicate basins with little tendency to major floods. A value below 0.51 for the circularity index (Ic) indicates a moderately elongated basin. This characteristic is reinforced by the Re, whose values between 0.50 and 0.70 indicate, according to Schumm (1956), basins that also have this shape. This is because in a watershed with a narrower, more elongated shape, the water reaches the main channel at several points along it, unlike those with a circular shape, which tend to concentrate runoff at only one point (Villela; Mattos, 1975).

3.2 Analysis of soil characteristics

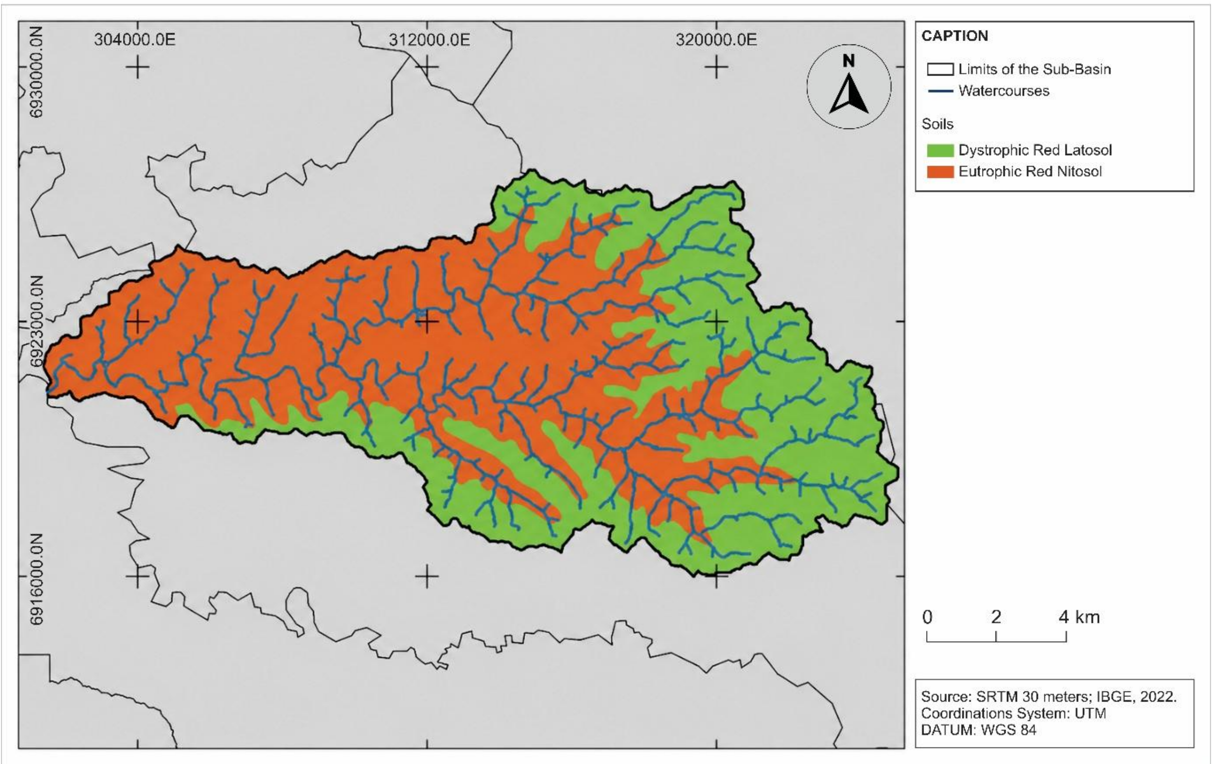
Of the two soil types found in the sub-basin area (Figure 2), the Dystroferric Red Latosol is characterized as a soil with base saturation < 50% and Fe2 O3 contents (by H2 SO4) of 180 g kg-1 to < 360 g kg-1 of soil, both in most of the first 100 cm of the B horizon (including BA). It is, therefore, soils of low fertility and high iron content, with uniform color, texture, and structure throughout depth. They occur predominantly in areas of flat, gently, undulating relief and are susceptible to compaction (Santos *et al.*, 2018).

On the other hand, eutroferric red nitosols have base saturation ≥ 50% and Fe2 O3 contents (by H2 SO4) of 150 g kg-1 to < 360 g kg-1 of soil, both in most of the first 100cm of the B horizon (including BA). They are soils of high fertility with a clayey texture, derived from basic and ultrabasic rocks, with horizons that are not very evident. They may pose a risk of erosion due to the rugged relief to which these soils are associated, unlike latosols, which are more resistant and require simpler conservation practices (Santos *et al.*, 2018).

The data shown in Table 3 relates to the sub-basin relief characteristics. The roughness index (Ir) is a useful tool to understand the interaction between relief and hydrological processes in a watershed (Souza *et al.*, 2017). It associates the availability of surface water runoff with its erosive potential, as expressed by the average slope. Thus, the higher this index, the greater the risk of basin degradation (Azambuja and Conceição, 2023). As with the roughness index, the relief ratio (Rr) parameter helps explain how basin topography influences water runoff (Schumm, 1956; Souza *et al.*, 2017).

In this study, the roughness index (Ir) for the Arroio Sarandi sub-basin was 517.52, indicating a drainage area with a moderate tendency toward erosive processes driven by surface runoff. The same occurs with the relief ratio (Rr) of 0.0154, which is classified as an average value (between 0.11 and 0.30) according to Piedade (1980). Nardini *et al.* (2013) and Pereira *et al.* (2024) use similar parameters to classify the relief ratio in their studies.

Figure 02 – Soil map of the Arroio Sarandi sub-basin



Source: IBGE data (2022). The authors (2024).

Table 03 – Relief characteristics of the Arroio Sarandi sub-basin

Parameter	Data obtained	Measurement unit
Roughness index (Ir)	517.52	Dimensionless
Relief ratio (Rr)	0.0154	Dimensionless

Slope	
Table of Contents	**Percentage**
Minimum slope	0
Maximum slope	63.76
Average slope	13.07

Slope classes			
Classes (%)	**Relief type**	**Area (km²)**	**Area (%)**
0 to 3%	Flat	7.26	4.85
3 to 8%	Gently undulating	32.06	21.42

continued

continued

8 to 13%	Moderately undulating	41.81	27.94
13 to 20%	Undulating	40.16	26.83
20 to 45%	Strongly undulating	28.15	18.81
Above 45%	Mountainous and steep	0.22	0.15

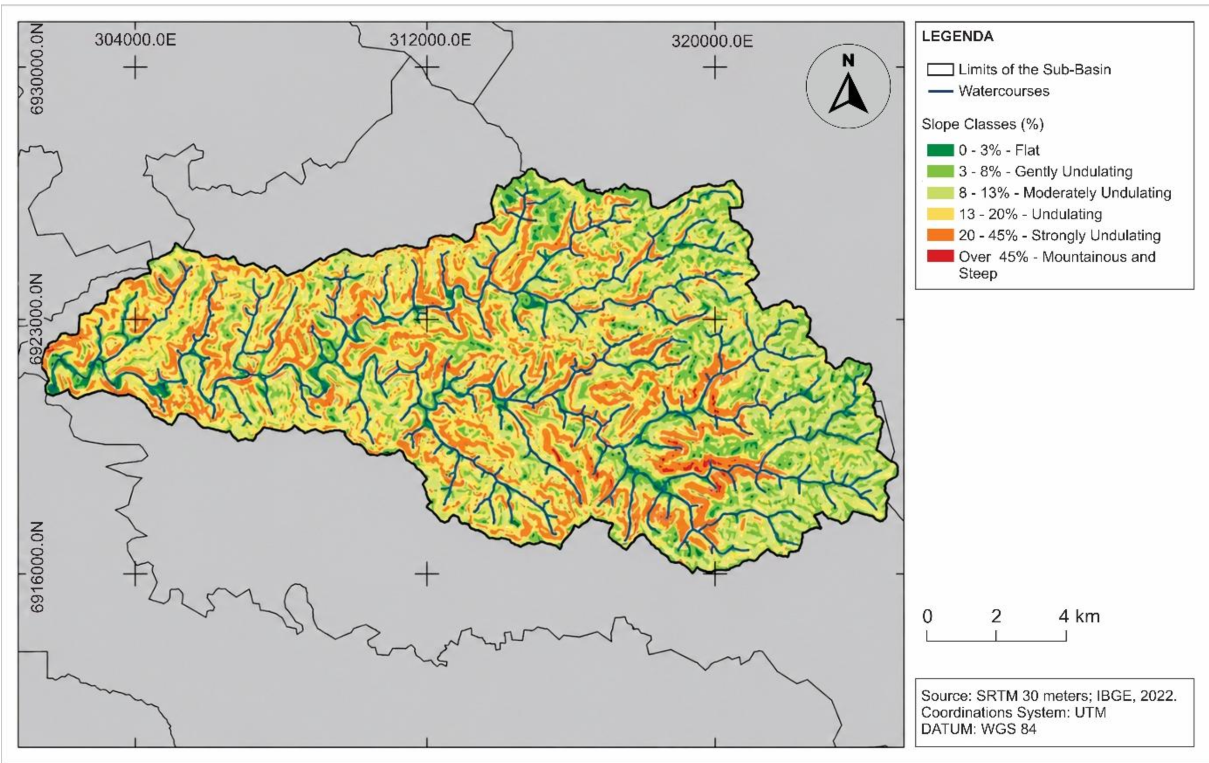
Hypsometry		
Parameter	Altitude	Unit
Minimum altitude	354.95	m
Maximum altitude	701.54	m
Average altitude	528.24	m
Altimetric range	346.59	m

Hypsometry		
Classes (m)	**Area (km²)**	**Percentage (%)**
350 to 400	6.58	4.40
400 to 450	18.20	12.16
450 to 500	26.74	17.87
500 to 550	34.57	23.10
550 to 600	22.27	14.88
600 to 650	27.24	18.20
650 to 702	14.06	9.29

Source: The authors (2024).

Although most of its area is at altitudes above 500m and the altitudinal range is 346m, the average slope of the sub-basin is 13%, contributing to reduced flow velocity and, in turn, lower erodibility rates. The occurrence of moderately undulating relief (Figure 3) is predominant in the sub-basin, occupying more than 27% of its area, with little variation in the undulating type, which, together, is more than half of its area. However, as Table 03 shows, the relief categories are generally concentrated between gently undulating and strongly undulating.

Figure 03 – Map of the slope of the Arroio Sarandi sub-basin



Source: SRTM and IBGE data (2022). The authors (2024).

The relief ratio and the slope are central factors to understand the dynamics of surface runoff and the erosive potential of a watershed. The relief ratio found for the Arroio Sarandi sub-basin, associated with the predominance of gently undulating to undulating relief, indicates a moderate probability of erosion, depending on soil cover and rainfall volume.

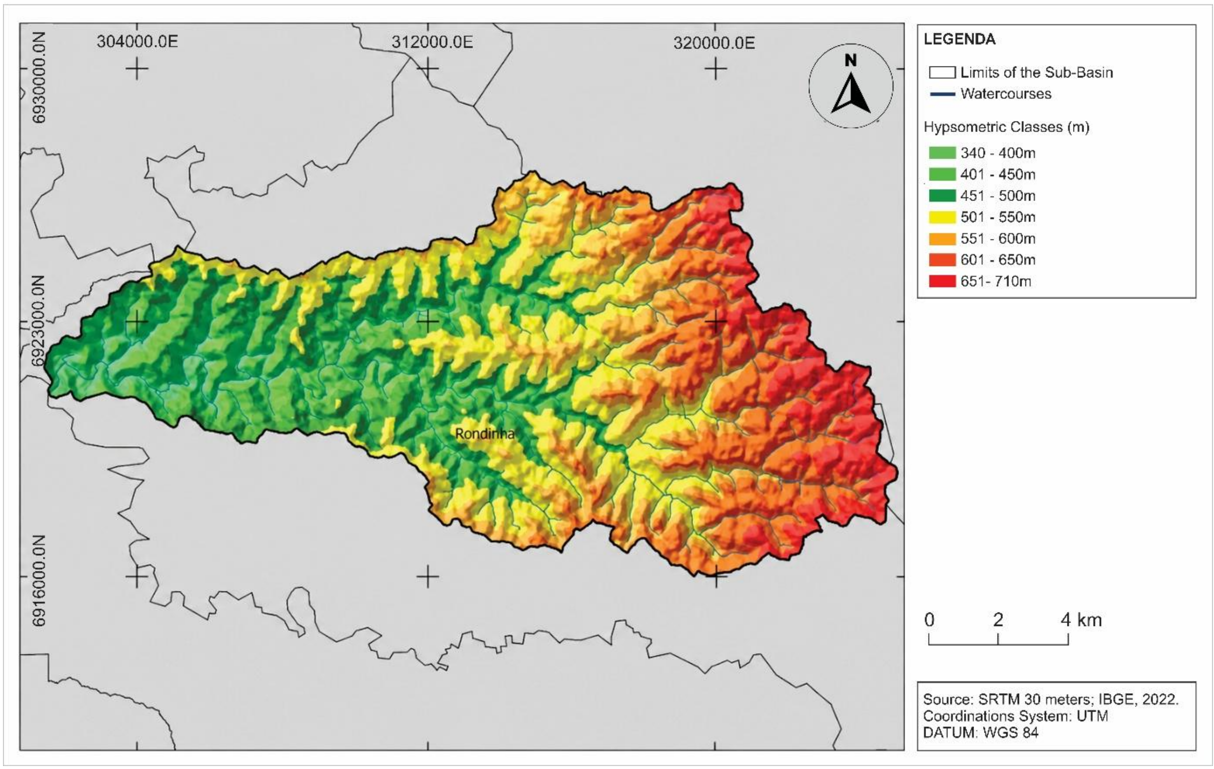
The altitude at which the minimum was identified was 354m, and the maximum was 701m; the mean was 528m (Table 3). Temperature, which influences water losses through evaporation and transpiration, and precipitation, which acts directly on surface runoff and infiltration, are related to altitude (Villela; Mattos, 1975).

About 65% of the sub-basin area is in hypsometric classes above 500m, which coincides with the western stretches closest to the springs and minor-order watercourses. It is where soils of the oxisol type, as well as areas of flat and gently undulating relief, predominate.

As the drainage network moves eastwards, hypsometry decreases, delimiting the main watercourses approaching its mouth and the most dissected reliefs (Figure 4).

Although the data from these relief characteristics and the soil typologies in the sub-basin indicate moderate vulnerability to erosion, erosive processes are still likely to be initiated.

Figure 04 – Hypsometric map of the Arroio Sarandi sub-basin



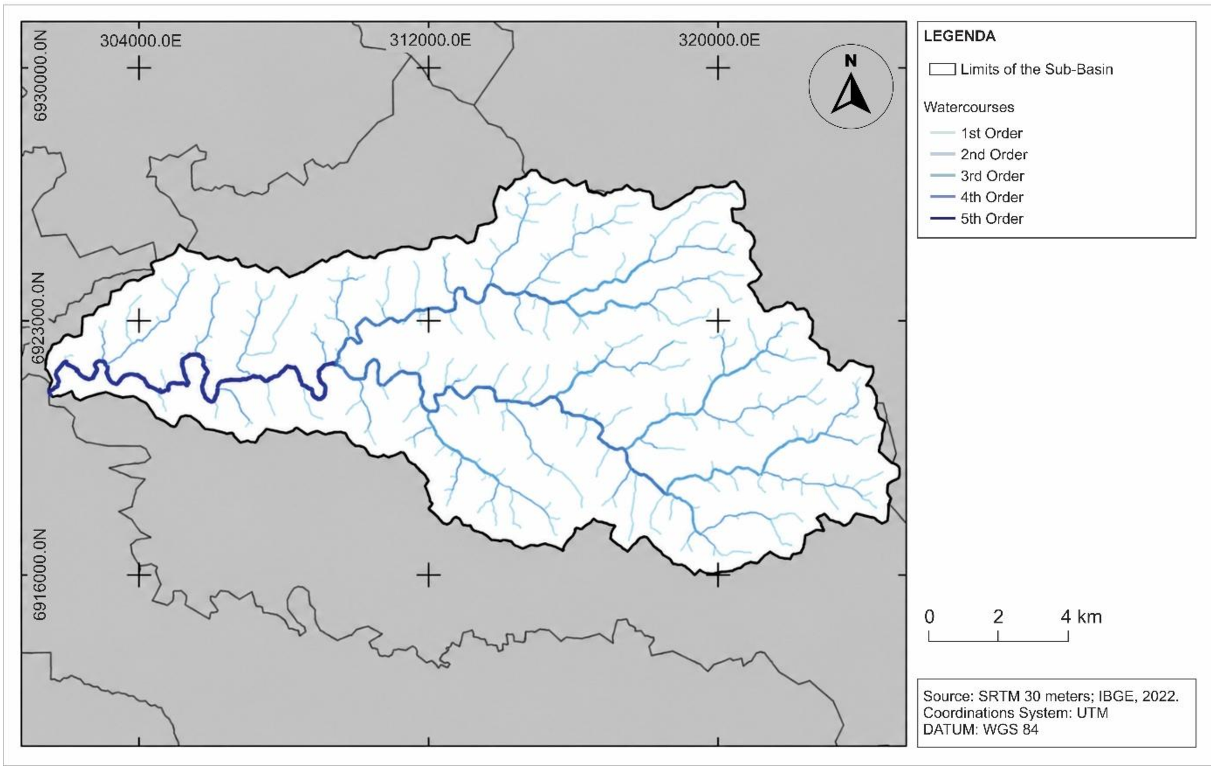
Source: SRTM and IBGE data (2022). The authors (2024).

These conditions are also linked to management, along with the forms of land use and occupation that may or may not contribute to their incidence. The importance of mitigating the occurrence of such events lies in how problems such as siltation and erosion make the condition of watercourses even more critical, as they interfere with flow and channel depth, facilitating the occurrence of floods (Botelho, 2011).

3.3 Analysis of hydrographic characteristics

The fluvial hierarchy of the Sarandi Stream sub-basin, in turn, is of the 5th order (Strahler, 1957), that is, well branched (Souza *et al.*, 2017) — which can increase the drainage capacity — in which the dendritic pattern prevails (Figure 5). Still in relation to the water network, the total number of channels (Tc) found in this sub-basin was 256, with those of 1st order being the most frequent, representing half of all existing channels, followed by 2nd order, 4th order, 3rd order, and, finally, 5th order. In this case, this same frequency hierarchy is also associated with the extension and quantity found of these channels individually in the sub-basin, as Table 3 shows.

Figure 05 – Map of watercourses of the Arroio Sarandi sub-basin



Source: SRTM and IBGE data (2022). The authors (2024).

The bifurcation ratio (Br), shown in Table 4, indicates the number of confluences between the channels according to their order. The higher the values, the more significant the number of lower-order channels branching into higher-order channels. In this study, this indicates a sub-basin with a well-developed drainage network.

According to Strahler (1964), the bifurcation ratio typically ranges from 3.0 to 5.0 for basins whose geological structures do not affect the drainage system. The high values of this index are expected in regions of steep valleys and suggest elongated basins, which generally have numerous tributaries of small extent.

According to Christofoletti (1980), calculating drainage density is important for watershed studies because it has an inverse relationship with river length: an increase in density implies an almost proportional decrease in the size of fluvial components. This parameter also represents the degree of relief dissection and serves as a demonstrative index of fluvial surface-erosion activity, which is important for identifying possible *foci* of geomorphological susceptibility (Soares *et al.*, 2016).

Table 04 – River Hierarchy in the Arroio Sarandi sub-basin

Channel order	No. of Like-Order Channels	No. sections of same order	Channels' extension (km)	Frequency channel (%)	Relationship of fork (Rb)
1st	204	204	104.22	50.27	4.97
2nd	41	98	57.10	24.20	5.12
3rd	8	40	23.47	9.88	4
4th	2	43	23.99	10.61	2
5th	1	20	14.69	4.94	-
Total	256	405	223.47	100	-

Source: The authors (2024).

Table 5 shows more attributes related to the drainage network in the sub-basin studied. The drainage density (Dd) of 1.49 km/km² indicates that drainage in this sub-basin is low, as Souza *et al.* (2017) noted. Low drainage values are generally associated with regions of permeable rocks, such as the basalts and andesites that make up the Dissected Plateau of the Uruguay River, which have a porous structure that allows water to pass, favoring infiltration and underground runoff.

Table 5 – Characteristics of the drainage network of the Arroio Sarandi sub-basin

Parameter	Data obtained	Measurement unit
Total length of channels (Lt)	223.47 km	km
Main channel length (Lp)	30.3 km	km
Drainage density (Dd)	1.4932	km/km²
Hydrographic density (Dh)	1.7105	channels/km²
Maintenance coefficient (Cm)	669.70	$m^2/^{m-1}$

Source: The authors (2024).

The capacity to generate new watercourses in this sub-basin—visualized by the hydrographic density index (Dd) of 1.71 channels/km²—is also considered low (Souza *et al.*, 2017). Regarding the maintenance coefficient (Cm) found, at least 669.70 m²/m is required to maintain 1 m of drainage channel. The results of this index are inverse to the drainage and hydrographic density obtained, which were low, suggesting that the sub-basin has difficulty in renewing and forming new channels. This context is reinforced by the low slope and the low roughness index, both of which are greatly relevant to river flow and the formation of new watercourses (Silva *et al*., 2018).

The analysis of the drainage system of the Arroio Sarandi sub-basin, along with the other aspects mentioned above, is relevant to planning land use and occupation in the region. According to the Strahler (1952) method, the more branched the drainage network is, the more efficient the integration of the various components and processes within this sub-basin. Thus, this characterization is essential for measures to protect water resources and balance them with the economic activities there, especially agriculture.

FINAL CONSIDERATIONS

The investigation of the morphometric characteristics of the Arroio Sarandi sub-basin suggests that this area shows little tendency towards flooding and flash flooding, as indicated by the form factor, circularity index, and compactness coefficient. In addition, the basin has a lower risk of degradation to erosive processes due to flow's low speed, the soil's characteristics, with good permeability, and slope, presenting an average slope of 13.07%, where the highest percentages of areas are in the moderately undulating and undulating classes.

The erosive dynamics related to the Ir values of the basin indicate that even in a basin of relatively smooth relief, there is a moderate probability of occurrence of laminar and linear erosive processes, mainly due to the regional context and the soils characteristics of the soils, which, although fertile, are highly susceptible to water erosion. It is also noteworthy that low Rr indicates a lower average slope, favoring greater permanence of water on the surface and, consequently, greater infiltration with aquifer recharge, but when associated with moderate Ir, episodes of intense rainfall and large volumes, surface runoff can intensify rapidly.

The data also show that, naturally, there is a greater propensity for water infiltration in the face of less surface runoff. The gap left by this study regarding the analysis of the influence of use and occupation in the characterization of these aspects, combined with the fact that the sub-basin is little urbanized and its use is predominantly agricultural, collaborates with the idea of studies that can analyze this context, the relationship between land use and occupation in this area.

Even so, it is worth reinforcing that the use of the watershed scale is efficient for verifying the local interactions among environmental factors (soil, vegetation, hydrography, relief, among others) and diagnosing their vulnerabilities. This enables the planning and management of this territory, which are fundamental to resolving conflicts linked to the occupation and human interference in a water basin.

Acknowledgments: This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001 and the Fundação de Amparo à Pesquisa do Estado do Rio Grande do Sul (FAPERGS) [grant number 24/2551-0002330-5/ edital 06/2024].

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