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MORPHOMETRIC ANALYSIS OF THE IGARAPÉ REDEMPTION WATER BASIN IN RIO BRANCO, ACRE STATE, BRAZIL

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Abstract: The present study aimed to carry out a morphometric analysis of the watershed of the Redenção stream in the municipality of Rio Branco, state of Acre. Satellite image was used as a basis for interpreting the characteristics of the basin, as well as for mapping land use and gauging linear and area measurements. In addition, Acre state databases were used in QGIS *software* to interpret soil type, geomorphology and geological formation. The main river in the basin is the Redenção stream, of fifth order. The basin has an area of 194.26 km² and a perimeter of 68.38 km, elongated shape and low susceptibility to flooding. There is a predominance of luvissolhypochromicorthic and eutrophic red argisol , lower sol imões geological formation and predominantly homogeneous relief, with little declivity. It has human occupation, with predominance of pasture areas and patches of urban occupation, in addition to scarce dense vegetation cover.
Keywords: Anthropization; Morphometry; Water resources

INTRODUCTION

The hydrographic basin is a territorial unit that drains a system of water courses for a single outlet. The availability of water resources in a watershed, both in terms of quality and quantity, can be influenced by natural or anthropogenic factors.

Due to its importance for the management of natural resources and the landscape, the watershed is the object of studies related to the assessment of environmental impacts and damage caused by human activities (SILVA & MEDEIROS, 2017; MEDEIROS et al., 2017; FENGLER et al, 2015).

A methodological approach used in environmental diagnoses of watersheds refers to morphometric analysis. Such an approach has applications in the analysis of risks of floods and erosive processes (COSTA & LEITE, 2020; TESEMA, 2022), environmental and territorial management (SILVA & MEDEIROS, 2017; SHIVHARE et al., 2022), and forest hydrology (CARDOSO et al. al., 2006).

Different morphometric parameters have been used in studies related to watersheds, highlighting the area, shape, drainage system and relief (TESEMA, 2022). The use of technologies such as the geographic information system (GIS) and remote sensing enhanced the morphometric analysis for studies in watersheds (SILVA & MEDEIROS, 2017; FENGLER et al., 2015).

In the Amazon, the urbanization process poses challenges for territorial planning and management, due to environmental vulnerability due to the rainfall index, the highest in Brazil, which can vary from 1900 to 3100 mm per year (ALVARES et al., 2013). In this bias, the morphometric analysis in hydrographic basins can provide important subsidies for the environmental planning of this region.

The objective of the present work was to carry out a morphometric analysis of the watershed of the Redenção stream in the municipality of Rio Branco, capital of the state of Acre.

1:5000 scale *Google* satellite image integrated with the free *software* QGIS was used as a basis for interpreting the characteristics of the watershed, as well as for mapping land use and gauging linear and area measurements. With this, it was made its delimitation and identification of watersheds and rivers. A study of land use and occupation was also carried out with the mapping of cuts of dense vegetation cover, patches of urban occupation and areas without dense vegetation or intended for pasture.

METHODOLOGY

The study area is the watershed of the Redenção stream (Figure 01), located mostly in the city of Rio Branco, state of Acre. This basin is part of the Acre River watershed.

For the characterization of the watershed, bases of the state of Acre extracted from the Ecological Economic Zoning - ZEE 2010 (ACRE, 2010) were used, integrated to the QGIS *software* for interpretation of the soil type, geomorphology and geological formation of the basin region.

In addition, the morphometric parameters were considered according to the analysis proposed by Tesema (2022) and Silva & Medeiros (2017), which are presented in Table 01.

Feature	Parameter
geometric	Area
	Perimeter
	compactness coefficient
	form factor
	circularity index
	Axial length of the basin
	thalweg length
	elongation ratio
from the relief	altimetric range
	Relief reason
	roughness index
From the drainage network	Length of waterways
	drainage density
	bifurcation relationship
	Sinuosity and Sinuosity Index

Table 01: Morphometric parameters evaluated in the Redenção stream basin, in Rio Branco, state of Acre

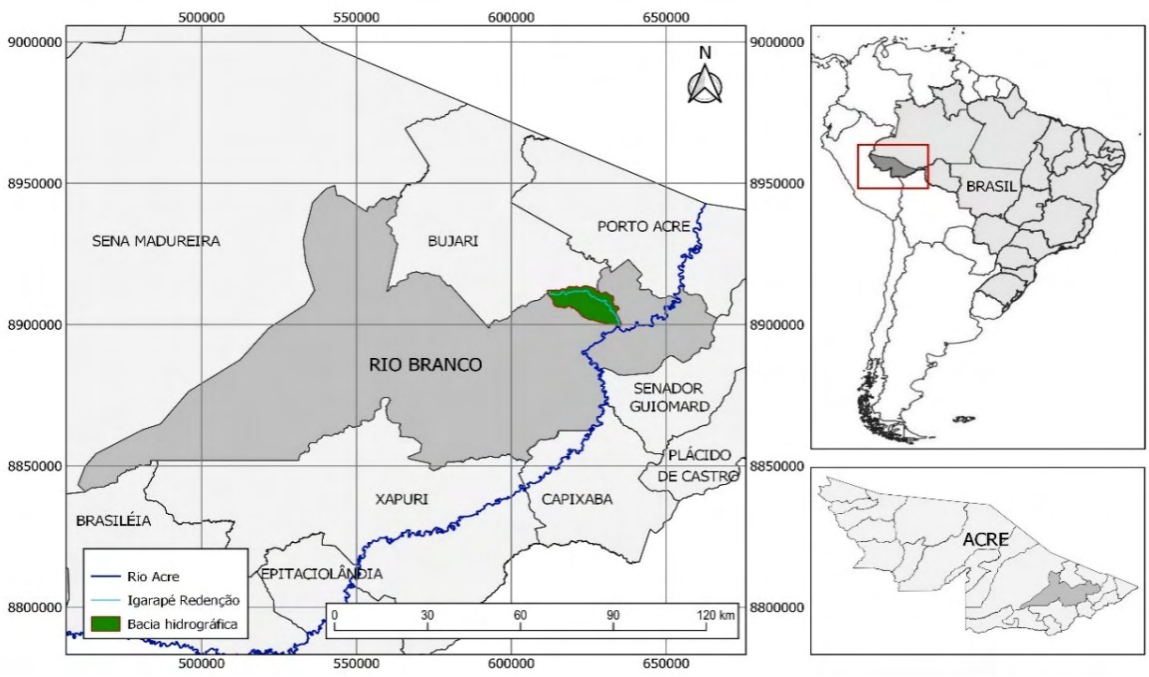

Figure 01: Location of Igarapé Redenção, in Rio Branco, state of Acre.

Compactness coefficient (Kc) (Villela and Mattos, 1975):

$Kc = 0{,}282\frac{P}{\sqrt{A}}$ Where: P = basin perimeter (km) and A = basin area (km²).

Form factor (K_f) (Villela and Mattos, 1975):

$K_f = \frac{A}{L_A{}^2}$ Where: A = basin area (km²) and L_A = axial length (km).

Circularity Index (CI):

$IC = \frac{12{,}57A}{P^2}$ Where: P = basin perimeter (km) and A = basin area (km²).

Altimetric amplitude (Δa) according to Teodoro et al. (2007) corresponds to the difference between the highest and lowest altimetric elevations of the hydrographic basin.

Roughness index (HD) (Castro & Carvalho, 2009):

$HD = \Delta a * D_d$ Where: Δa = altimetric amplitude (m) and Dd = drainage density (m/m²).

Relief ratio (Rr) (Costa & Leite, 2020):

$Rr = \frac{\Delta a}{L_A}$ Where: Δa = altimetric amplitude (m) and L_A = axial length (m)

Drainage density (Dd) according to Cardoso et al. (2006):

$Dd = \frac{L_{TR}}{A}$ Where: L_{TR} = total length of rivers in the basin (km) and A = basin area (km ²).

Sinuosity (Sin), according to Villela and Mattos (1975), relationship between its length and the length, in a straight line, from the source to the mouth:

$Sin = \frac{L_{RP}}{L_T}$ Where: L_{RP} = length of the main river (km) and L_T = length, in a straight line, from source to mouth (km).

In addition, the main river sinuosity index (IS) was obtained, expressed in percentage (%):

$IS = \frac{100(L_{RP} - L_T)}{L_{RP}}$ Where: L_{RP} = length of the main river (km) and L_T = length, in a straight line, from source to mouth (km).

Average extent of surface runoff (l), according to Villela and Mattos (1975):

$l = \frac{A}{4L_{TR}}$ Where: A = area (km²) and L_{TR} = total length of rivers (km).

RESULTS AND DISCUSSION

In the watershed of the Redenção stream, pasture occupation predominates (70.2% of the basin), followed by dense vegetation cover (15.1%) and urban occupation (14.7%), as can be seen in Figure 02 and Table 02 .

According to the basis extracted from the Ecological Economic Zoning (ACRE, 2010), the region has a predominance of luvisol hypochromicorthic and eutrophic red argisol. According to the publication, the argisols have moderate drainage and low or medium natural fertility, as they have a predominance of low-activity clay minerals and are soils susceptible to erosion. Luvisols , on the other hand , present high activity clay and eutrophic character . They are "normally associated with busier relief and shallow soils, giving them a relative degree of susceptibility to erosion, which, combined with the fact that they have poor drainage, restricts their agricultural use, despite their high natural fertility" (ACRE, 2010).

The study area has a lower Solimões geological formation, with "sedimentary rocks predominantly pelitic, highly fossiliferous, in the form of claystones with intercalations of siltstones, fine sandstones, limestones and carbonaceous material (lignite), micaceous" (ACRE, 2010).

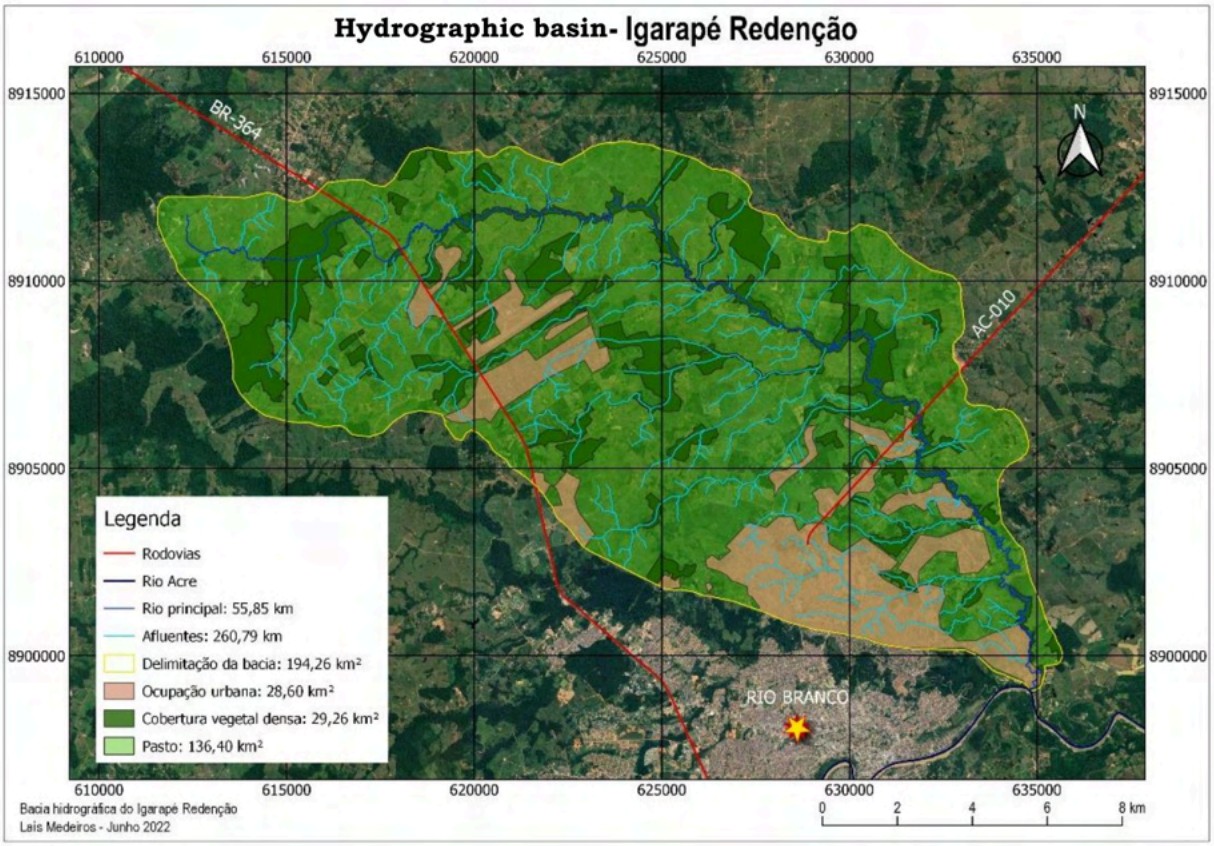

Figure 02: Watershed of the Redenção stream, in Rio Branco, state of Acre.

Use	Area (km²)	%
urban occupation	28.60	14.01
dense vegetation cover	29.26	15.06
Pasture area / without dense vegetation cover	136.40	70.93
Total area of the watershed	194.26	100

Table 02: land use and occupation.

As for the geomorphological characteristics, the watershed has a predominance of homogeneous relief, fluvial dissection that does not obey clear structural control, defined by the combination of top shapes, drainage density and depth of incisions (ACRE, 2010).

Morphometric analysis of the Redenção stream basin are presented in Table 03.

It is observed, with the data obtained in compactness coefficient, form factor, circularity index and elongation ratio, that the basin has an elongated geometry. The analysis based on its geometric shape, which distances itself from the circular shape, points to a lower tendency for flooding. However, its geological formation contributes to a high risk of flooding, as it is a sedimentary basin with an extensive drainage network.

As for the relief, an analysis of the altimetric quotas of the basin was carried out with the insertion of the SRTM scenes to the QGIS *software* , *in which the* maximum and minimum quotas of the hydrographic basin were verified. With this information, it was possible to calculate the altimetric amplitude, the roughness index and the relief ratio of the watershed. The relief is slightly uneven, with a maximum elevation of 237 meters and a minimum of 128 meters at the outfall , resulting in an altimetric amplitude of only 109 meters. The roughness index (0.177) indicates little slope of the watershed terrain and the relief ratio (0.004) confirms the slightly uneven relief, characteristic of the Amazon basin. The low-slope relief is also a factor that makes the basin vulnerable to flooding.

Parameter	Unit	Result
Area	km²	194.26
Perimeter	km	68.38
compactness coefficient	dimensionless	1.38
form factor	Dimensionless	0.27
circularity index	Dimensionless	0.52
elongation ratio	Dimensionless	0.59
axial length	km	26.80
thalweg length	km	25.81
altimetric range	m	109
roughness index	Dimensionless	0.18
Relief reason	dimensionless	0.004
drainage density	km/km²	1.63
Main river sinuosity	Dimensionless	2.16
Main river sinuosity index	%	53.79
Average extension of surface runoff	km	0.15
Number of waterways	und	186
Main river length	km	55.85
Total length of rivers	km	316.64
Average channel length	km	1.70

Table 03: Morphometric parameters of the watershed of the Redenção stream, in Rio Branco, in the state of Acre.

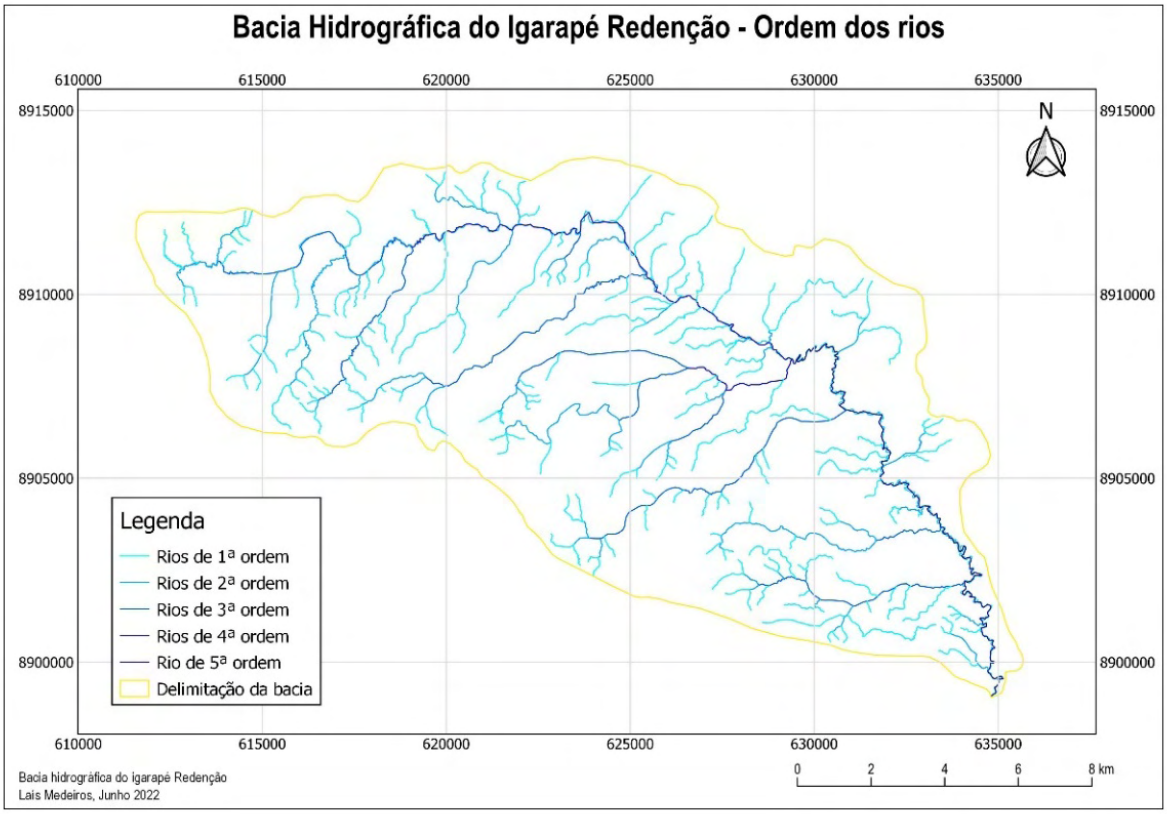

Figure 03: Order of rivers in the Redenção creek watershed.

As for the drainage network, it is a fifth order basin, with approximately 186 water courses (Figure 03). The main river, Redenção stream, has its source located to the northwest of the basin, running in a south-southeast direction until it reaches the mouth of the Acre River.

The Redenção stream presents high sinuosity, which can be confirmed with the data obtained from the calculation of the Sinuosity and Sinuosity Index of the main river, which reached the values of 2.16 km/km² and 53.79%, respectively.

CONCLUSIONS

Morphometric analysis allowed us to conclude that the watershed of the Redenção stream has low susceptibility to floods, due to its elongated geometry, the relief with low slope and drainage density. On the other hand, factors related to land occupation, due to the high anthropization in the region, associated with climatic factors, such as the pluviometric index of the Amazon region; and the sedimentary geological formation of the basin, increase the risks of flooding in the region. In addition, the characteristics of the basin's soils point to a high susceptibility to erosion. Thus, the importance of environmental monitoring for the maintenance of preserved areas and urban and regional planning as a tool for controlling anthropized areas is highlighted.

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