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Geoprocessing applied to the physiographic characterization of the Lontras River Basin

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ABSTRACT

The morphometric characterization is considered an important tool in the management of river basins, and it provides relevant information to decision making by managers who are associated with the geographic divisions. The use of Geographic Information Systems (GIS) and remote sensing tools, widespread in monitoring and spatial analysis, is characterized as a facilitator component in the search for characterization and identification of factors which influence the geomorphometric parameters of the territory. The current spread of geoprocessing and GIS in general, culminate in a wide availability of storage systems and computer programs for data processing and conversion. Based on the above, this study aimed to morphometric and rainfall characterization of the Salto do Lontra watershed, which covers the municipalities of Salto do Lontra and Nova Esperança do Sudoeste located in West Region of Paraná State, Brazil, using the software Qgis 2.14. In this regard, the Digital Elevation Model (DEM) was used with a spatial resolution of thirty meters, provided by the National Institute for Space Research and historical precipitation data provided by the Paraná Water Institute. Through the MDE an altimetric data correction was performed obtaining a Hydrologically Consistent Digital Elevation Model (HCDEM), in which were obtained by manipulating data in a GIS environment, physical variables to determine the morphometric parameters. The results demonstrated that the Salto do Lontra watershed has a drainage area of 177.54 km² and a perimeter of 99.29 km. The compactness coefficient obtained was 2.09, the form factor 0.19 and circularity index 0.23, indicating that the basin has elongated shape and low propensity to flooding. The drainage density was 0.85 km $(km^2)^{-1}$, time of concentration 535.59 min. and sinuosity index of 40.57%. In addition, the data obtained in this study indicated that the average annual precipitation was 1896.85 mm, watching orographic effect on its distribution.

Keywords: morphometry, geoprocessing, remote sensing, precipitation.

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INTRODUCTION

The National Water Resources Policy, established by Law No. 9.433, of January 8, 1997, provides the principles and standards for water resources management by adopting the definition of river basin as the basic unit of study and management, ideal for management planning of natural resources and the monitoring of changes introduced by man and the respective nature answers (CUNHA & GUERRA, 1996; TEODORO et al., 2007).

According to Neto et al. (2015), the morphometric characterization of a watershed is the starting point for studies on the environmental dynamics thereof, since associated with pluviometric data enables knowledge of hydrology in the basin, facilitating better management and utilization of natural resources. These data may be obtained and displayed in a simplified manner by using GIS tools and remote sensing, which facilitates the handling of spatial data, such as the creation of isohyets maps, which consists of isolines of the same height precipitation, for a specific time period (SOTÉRIO, PEDROLLO & ANDRIOTTI, 2015).

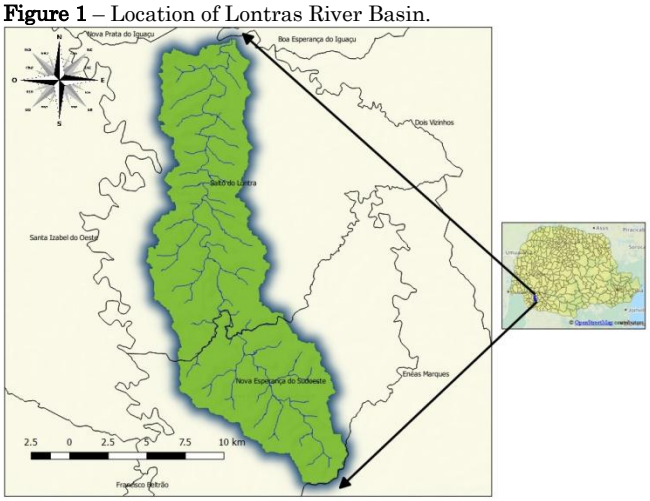
Neto et al. (2015) emphasize that the Geoprocessing has been an effective aid tool to public management and water studies. In accordance with Ferreira (1997), Geographic Information Systems (GIS) can be considered instruments for mapping and response to several questions about urban and regional planning, rural areas and survey of renewable resources, by describing the mechanisms of changes that operate in the environment, and assisting the planning and management of natural resources in specific regions.

Given the above, the aim of this work comprised the collection and analysis of morphometric characteristics of Lontras River Basin from estimate of the following parameters: compactness coefficient, form factor, circularity index, drainage density, time of concentration, sinuosity index, drainage patterns and declivity of the main river course.

MATERIALS AND METHODS

The study area, shown in Figure 1, coverd the Lontras River Basin, which involves the municipalities of Salto do Lontra and Nova Esperança do Sudoeste, in southwestern Paraná.

Figure 1 – Location of Lontras River Basin.



The procedures adopted in the research include the use of GIS and numerical equations for morphometric characterization of the basin. To this end, an altimetry data processing provided by the database Brazil (2016), the National Institute for Space Research (INPE), in the form of a Digital Elevation Model (DEM) was performed, using the software Qgis version 2.14. (QGIS DEVELOPMENT TEAM, 2016).

Initially, the DEM underwent a process of reprojection data, adopting the UTM coordinate system SIRGAS 2000 zone 22 south, and filtering

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(*r.fiil.dir*), which eliminated the spurious *raster* depressions, resulting in an MDE hydrologically consistent, called here MDEHC. The delimitation of the basin was performed by the *r.watershed* process, which resulted in the generation of sub-basins in the region and hydrography. Then, the sub-basins which compose Lontras River Basin were selected, obtaining the basin limits

After generating the limits, these were used as a clipping mask to define the drainage system, relief and other physiographic parameters required for morphometric characterization of the river basin, as shown in Table 1. Subsequently, a file based on MDEHC was generated with the terrain analysis tool Qgis resulting in a raster slope and then the resulting file was submitted to a reclassification with *r.reclass* tool in declivity classes standards established by EMBRAPA (1979), as shown in Table 2. After classification, a weighted average was calculated obtaining the average slope of the basin.

The average precipitation of the Lontras River Basin was obtained by precipitation data, available by Parana (2016), through a repository of information collected by pluviometric stations installed in and around the basin. Then, an interpolation was performed using the method IDW (inverse distance weight) in order to obtain a *raster* (matric) with average heights of annual precipitation. Based on this raster the Isohyets were obtained, with the heights of incident precipitation in the basin. With this data, a weighted average rainfall was calculated.

Table 1 – Physiographic parameters analyzed for morphometric characterization.

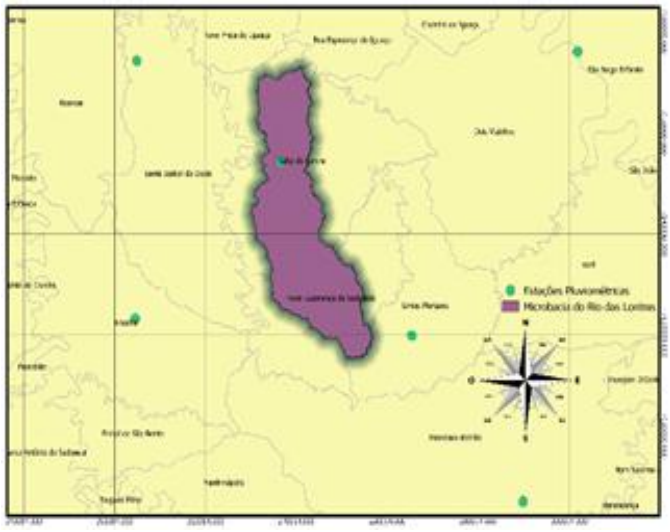
Parameters	Equation
Compactness coefficient	$\mathrm{Kc} = 0{,}28\ \frac{\mathrm{P}}{\sqrt{\mathrm{A}}}$
Form factor	$F = \frac{A}{E^2}$
Circularity index	$IC = \frac{12{,}57A}{P^2}$
Drainage density	$Dd = \frac{Lt}{A}$
Time of concentration	$Tc = 57\left(\frac{L^3}{H}\right)^{0{,}385}$
Sinuosity index	$Is = \frac{100(L - Lr)}{Dv}$

P – watershed perimeter, A – watershed area, E - watershed axial length, Lt – total length of water courses, L – length of the main watershed course, H – difference between main course quotas, Dv – vector length between extremes of the main course.

Table 2 – declivity classification according to Embrapa (1979).

Declivity (%)	Discrimination
0 – 3	Plan relief
3 – 8	Slightly undulate relief
8 – 20	Undulate relief
20 – 45	Strongly undulate relief
45 – 75	Mountainous relief
> 75	Strongly mountainous relief

Figure 2 - Location of pluviometric stations employed in reference to Lontras River Basin.



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RESULTS AND DISCUSSION

The values of variables required to calculate the parameters used in physiographic morphometric characterization are presented in Table 3.

A bacia hidrográfica do Rio das Lontras ocupa uma área de 177,44km² e um perímetro de 99,29km, The Lontras River Basin covers an area of 177,44km² and perimeter of 99,29 km, which is characterized as a small size basin. The drainage index found in the basin was 0.85 km/ km², which according to VILLELA and MATTOS (1975) refers to poorly drained basins. The low values found allied to an average declivity of 16%, which ranks the relief as undulate, provides evidence that the soils of the basin of Lontras River Basin have good infiltration capacity and initial resistance to erosion.

Silva et al. (2009) consider that the drainage density can be influenced by the lithological basis on which the channel is developed, which may indicate the degree of soil permeability.

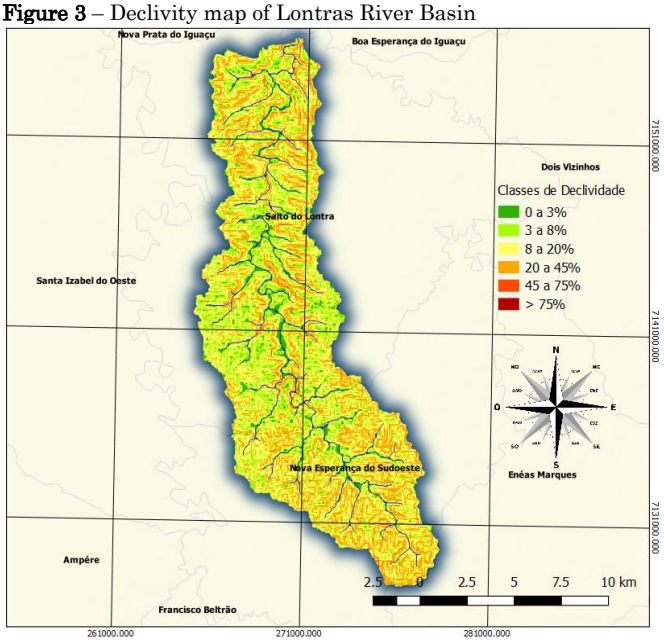
Along the entire length of the study area the presence of dendritic drainage and the drainage system was observed, in accordance with the hierarchy of Strahler, presented degree of branching of fourth order (Figure 3). According to Tonello et al. (2016), inferior order or equal to 4 is common in small watersheds.

Table 3 – Variables Calculation of the morphometric parameters of Lontras River Basin.

Variável	Valuation
Perimeter (m)	99290,6
Area (m²)	177536200
Axial length of the basin (m)	30961
Total length of water courses (m)	150893,4
Length of main course (km)	47,8279912
Quotas difference of main course (m)	325
Vector length between the extremes of main stream (km)	28,42

The declivity of the basin map can be seen in Figure 3, where it realizes the predominance of Class 8 - 20%. In accordance Tonello et al. (2006), the average declivity of a watershed is important in planning for both the compliance with the law as to ensure the effectiveness of man in the middle.

Figure 3 – Declivity map of Lontras River Basin



For the predominant class of declivity in the Lontras River Basin, taking as base Lepsch et al. (1991), it is recommended to grazing or silviculture activity, being able to have generally tillage if adopted intense practices of soil conservation.

The Lontras River Basin shown little susceptible to flooding under normal precipitation conditions. This inference is justified by the compactness coefficient away from the unit (2.09) and form factor near nullity (0.19). Thus, there is an indication that the basin does not have circular shape, having therefore an elongate configuration, which can be evidenced by the circularity index of 0.23. CARDOSO et al. (2006) indicated that basin with circular shape has higher possibilities of intense rainfall occurs simultaneously along its entire length, concentrating runoff generated at specific locations of the main tributary.

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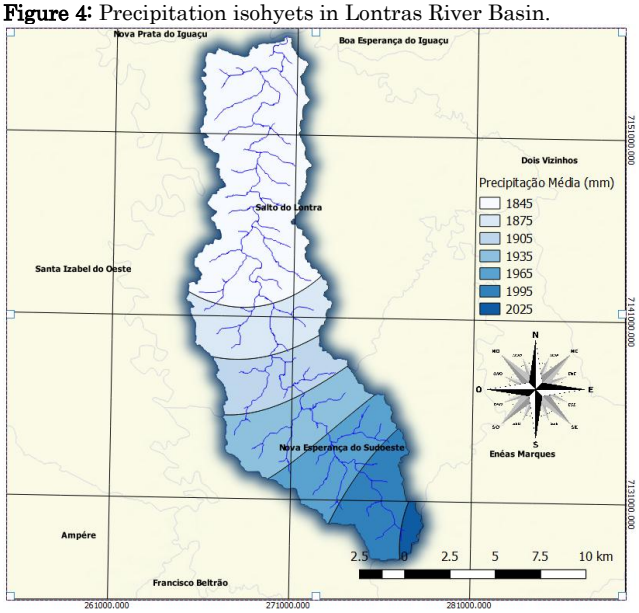
For the main tributary was found concentration time of 535 minutes and 40.57% sinuosity index. The high values found indicate that the main river is classified as sinuous, with low flow velocity for presenting low declivity.

In the declivity of the basin map can observe the low declivity of the main watercourse resulting in high concentration time to the size of the watershed.

The data obtained in this study indicated that The average annual precipitation is 1897 mm, watching orographic effect on distribution as shown in Figure 4, where the highest pluviometric indexes occurs at the head of the main watercourse reaching higher order than 2025 mm. This behavior favors the process of flooding and flooding in the basin, but which may be being mitigated by the elongated shape of the basin.

Figure 4: Precipitation isohyets in Lontras River Basin.



CONCLUSION

Based on the analysis of the results obtained in this study can be concluded that:

- The use of SRTM data in GIS environment using free software Qgis allowed the morphometric characterization of river basins.
- Analysis of the morphometric characteristics of the Lontras River Basin has shown that it has elongated shape, with low propensity to flood.
- The drainage pattern formed by watercourses was characterized as dendritic type, with low drainage density and degree of 4th order branch.
- The average annual precipitation is 1896 mm with orographic effect towards the mouth from the head of the river basin.

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