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MORPHOMETRIC ANALYSIS OF THE BASIN LOW MIDDLE SÃO FRANCISCO RIVER

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Abstract

This study aimed to generate the components for morphometric analysis of the watershed of the São Francisco River Lower Basin from geoprocessing and remote sensing surface. SRTM data were used for preparation of digital elevation model (DEM), elements such as flow accumulation, flow direction, flow length and others were obtained by processing ArcHydro tool of ArcGIS 9.3 software. The results showed that the São Francisco River Low middle Basin has a total area of 110.446,0 km ² and a perimeter of 3.834,8 km, the drainage network is moderately branched having a total length of 22.283,6 km with a main course of 720 km, the basin showed a more elongated shape, with a density of less than 0.2 km/km^2 drainage as well as low-density area, the predominant class of slope is the floodplain type and plan to undulated represented about 90% of the total area the basin. Classes roofing composed of arborel and shrubby Caatinga, shrubby low Caatinga and Grasslands dominate the landscape occupying an area of 60.385,7; 18.998,5 and 22.737,5 km^2, respectively. Different landforms were identified in the watershed based on SRTM (DEM) data with 90 m spatial resolution. GIS techniques were thus characterized by high precision mapping and measurement of morphometric indices and revealed themselves as a tool with great potential for watershed management.

Keywords: Drainage network, elevation digital model, geoprocessing

Introduction

The morphometric analysis is the measurement and mathematical analysis of the configuration of the earth's surface, thus describing the shape and the size of its landforms. Great emphasis on geomorphology over the past decades comes from the development of quantitative methods for describing the physiographic and / or behavior of the surface drainage networks (Pareta et al., 2009).

The origin of the formation of the network of drainage basins has been discussed by several authors who base their studies predominantly by components of river runoff by climatic factors and then the geological composition of biological effects, Pareta (2011).

The morphometric characteristics of basins may contain important information regarding their training and development, because all hydrological and geomorphological processes occur within the basin. The morphometric analysis of a watershed provides a quantitative description of the drainage system, which is an important aspect of the characterization of river basins (Strahler, 1952). Currently using georeferencing tonou is a very important tool to evaluate various parameters of the terrain and morphology, watersheds, since they provide a flexible environment is a powerful tool for the manipulation and analysis of the spatial information. Such analyzes allow the upgrade of the drainage basin, or the generation of information for little basins studied. Knowledge of the drainage network of river basins is important in any hydrological process, because it enables the assessment of potential groundwater and groundwater management.

Several hydrological phenomena can be correlated with the physiographic watershed as the size, shape, slope of the drainage area, drainage density, size and length of the tributaries (Rastogi & Sharma, 1976).

With the advent of satellite sensors, elevation models, which allow the determination of the drainage network could be extracted by interferometry. This process is the mode of operation of some imaging microwave sensors, such as the SRTM - Shuttle Radar Topographic Mission, or stereoscopy through optical sensors that acquire images with reprocessing, like the ASTER / Terra - Advanced Thermal Emission Spacebone and Reflection Radiometer (Fuckner et al., 2009).

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The SRTM mission was conducted to acquire data from altimetry entire globe from active sensors (radar). The original resolution of the generated images is 30 meters; however, for South America NASA released images with a resolution of 90 meters. The product is georeferenced to the WGS84 datum, in decimal geographic coordinates and can be obtained via the Internet.

The ASTER GDEM are produced through a consortium between METI - Ministry of Economy, Trade and Industry of Japan and NASA - National Aeronautics and Space Administration, United States, for construction of a digital elevation model of global free access. Starting on June 29, 2009, digital elevation models, built from stereo pairs of images derived from the EOS AM-1 platform with the ASTER instrument, VNIR sensor was available for free and unrestricted (Rodrigues et al. 2010).

Remote sensing data can be used in conjunction with conventional data for delimitation of the courses of the rivers, characterization of the order of priority of use assessment, evaluation and management of potential needs, identification of areas prone to erosion, optimizing strategic decisions of water conservation, as well as the selection of sites for the construction of dams and reservoirs, (Dutta et al., 2002). Ramu & Jayashree (2013) studied the morphology of the drainage basin of the Tungabhadra River in India used SRTM data. Rao et al. (2009) using techniques of morphometric analysis demonstrated a dynamic balance that has been achieved due to the interaction between matter and energy to understand the geo-hydrological characteristics of drainage basins. In further analysis Somashekar & Ravikumar (2011) to assess the geo-hydrological characteristics of four sub-basins of the Agra district in India used techniques of remote sensing and GIS

Thus, this study aims to determine the morphological and physiographic characteristics of the drainage basin of the Lower middle São Francisco River that aims to contribute to studies on planning and watershed management in semi-arid regions.

Material and Methods

Study Area

The São Francisco River Low middle Basin covers areas of the States of Bahia and Pernambuco, stretching from the town of Backwater to the city of Paulo Afonso both in the state of Bahia (Figure 1), 110.446,00 km^2, or 17% of area of the São Francisco Basin. It is 440 km long and its population is 1.944 million people. The region consists of the sub-basins of Pontal, Herons, Bridget, Pajeú, Moxotó Xingó and rivers from the left margin; while on the right bank are the sub-basins of Tourão Salgado, Vargem, Curaçá, Macuru Long and Well (CODEVASF, 1999).

Relief

The altitude ranges from 200 to 800 meters in the Cretaceous of the Chapada Araripe, which extends east across the Sierra of Cariris, carved in granite and gneissic rocks of Precambrian age. The south side, we emphasize the tabular forms of Raso da Catarina, carved in sediments Tucano Basin, with altitude ranging 200-300 m (CODEVASF, 1999).

Topographically, the study area is characterized by a wavy relief plan with very open valleys. This characteristic is due to a lower resistance to erosion of the shales, which brings curved shapes carved in granitic and gneissic rocks. Most of the region is inserted into the depression Country, which is a surface pediplanation (peripheral depression San Francisco) in which ridges and residual mounds (CODEVASF, 1999) occur. Large inselbergs are not observed, being the busiest phases of relief observed on slopes where the geological formation appears to be richer in quartz and quartzite, more resistant to erosion (Silva et al., 2000).

Climate

The climate of the region is semi-arid, with average annual temperature of 27 ° C, rated Bswh by Koeppen. Depending on the characteristics of climate and temperature associated with the intertropical geographical location and atmospheric clarity most of the year, the potential evapotranspiration is very high, especially in the northern part of the Valley, being of the order of 3.000 mm annually CODEVASF (1999). Heat stroke is high and the relative humidity is low. The dry period is prevalent, with about 6-8 months and may reach up to 11 months in areas of greater aridity CODEVASF (1999). The average annual rainfall is around 400-650 mm, which occurs irregularly and concentrated form in 2-3 months of the year, heavy rainfall (120-130 mm) may occur within 24 hours CODEVASF, (1999).

Morphometric analysis of watershed

For the extraction of drainage networks was used GIS ArcGIS 9.3, in order to generate the "maps of direction and flow accumulation" was first necessary to convert the MDE to GRID format. With GRID format was possible to generate maps containing the directions of flow and totalized flow through the hydrologic analysis of ArcGIS 9.3 module. The map of cumulative flow was classified and drainages above 1.000 were extracted. The value 1.000 is an arbitrary limit adopted in this study relates to the minimum number of cells required to generate the land drainage cell. The method employed for automatic delineation of the boundary of BHSRSF was the order of the fluvial hierarchy based on the proposed classification of Strahler (1952). Then was the BHSRSF bounded together with their subdivisions through the Menu "Hydrology" in the "Watershed" tool. Later using the GIS resources were calculated some physical parameters such as area, perimeter, length of drainage networks, number of segments of rivers, and such data were the basis for many calculations to determine some physical parameters of the watershed under study (Table 1).

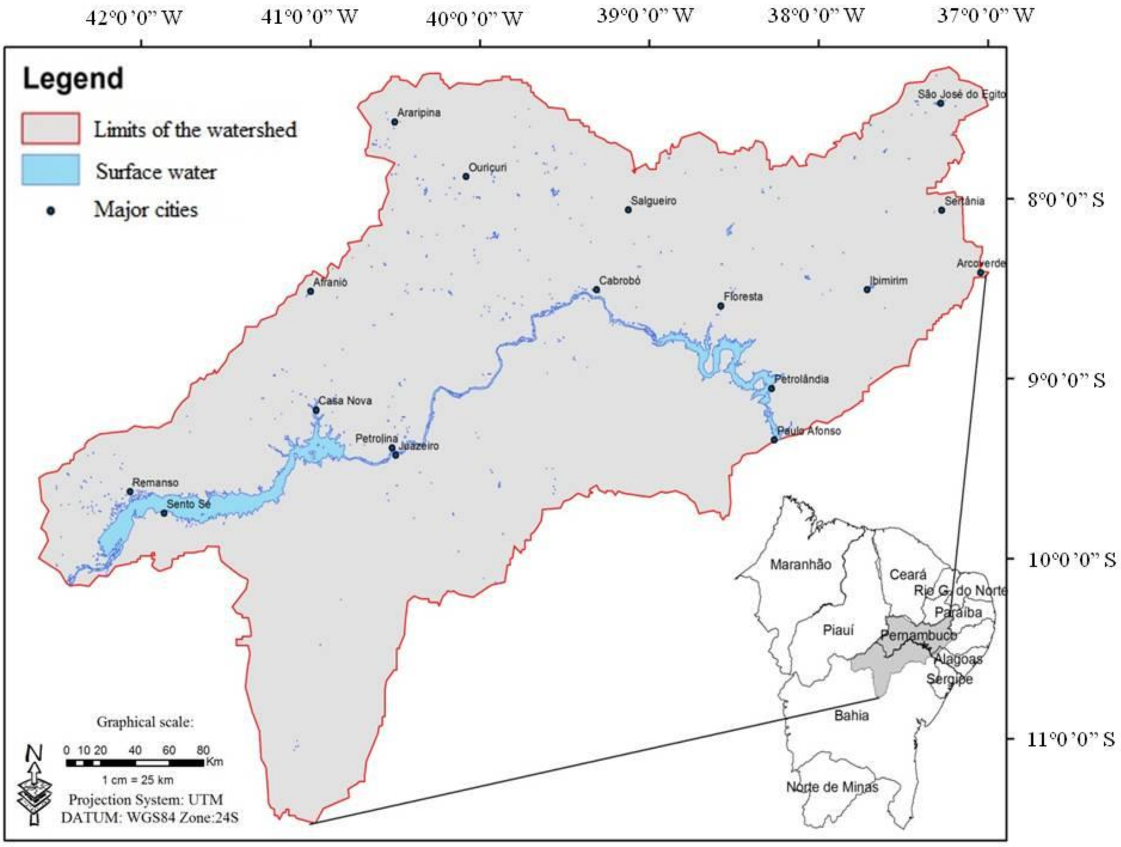

Figure 1. Map of the study area.

Table 1. Morphometric characteristics were evaluated in São Francisco River Low middle Basin

Morphometric characteristics	Description	Equation	Citation
Dd - Drainage density	Ratio between the length of the network drainage (Cr) and the basin area (A)	Dd = Cr /A (km/km²)	Horton (1945)
Dh – Hydrographic density	Relationship between the number of segments of rivers (Nt) and the basin area (A)	Dh = Nt/A (km²)	Christofoletti (1969)
T - Texture ratio	Relationship between the number of segments of streams (Nt) and the perimeter of the basin (P)	T = Nt/P (km)	França (1968); Smith (1950)
Kf - Form Factor	Relationship between basin area (A) and the length of the axis of the basin (L)	Kf = A/L² (m²/m)	Horton (1945)
Kc - Coefficient of compactness	Relationship between the perimeter (P) of the basin and the basin area (A)	Kc=0,28(P/√A) (m/m²)	Lima (1969)
IC - Circularity index	Relationship between basin area (A) and perimeter (P) of the basin	IC = 12,57 (A/P²)	Miller (1953)

Results and Discussion

According to Table 2 the drainage basin of the São Francisco River Low middle Basin has an area of 110.446,00 km², with a total of 3.834,8 km perimeter 3.028 presenting segments of rivers, forming a network of drainage 22.283,6 km and its main river has a length of 720 km. The characteristics of the basin drainage system show that the drainage density was 0.2 km / km^2 according to the classification of Christofoletti (1969), the density of the drain bowl is low, it is less than 7,5 km / km^2. As for Villela & Mattos (1975), this ratio can vary from 0,5 km / sq km in basins with poor drainage, 3,5 km / km^2 or more, in exceptionally well drained basins, thus indicating that the basin in this study has low drainage according to this classification.

Table 2. Dimensional characteristics of the drainage network of the drainage basin of the São Francisco River Low middle Basin

Parameters	Value
Basin area (A)	110.446,00 km^2
Perimeter of the basin (P)	3.834,8 km
Shaft length of the basin (L)	490 km
Length of the main river (R)	720 km
Length of the drainage network (Cr)	22.283,6 km
Number of segments of rivers (Nt)	3028
Drainage density (Dd)	0,2 (km/km^2)
Drainage pattern	dendritic
Texture ratio (T)	0,79 (km)
Form factor (Kf)	0,46 (m^2/m)
Compactness coefficient (Kc)	3,2 (m/m^2)
Circularity index (CI)	0,09

The coefficient of compactness basin was found to greater than 1 (3.2) and shape factor was found to be low, 0,46. Through this result can be stated that the drainage basin of the São Francisco River Low middle Basin under normal rainfall conditions, ie, excluding events of abnormal intensities, is unlikely to flood. Thus, there is an indication that the bowl does not have circular shape, thereby having a tendency to elongate elliptical shape (Santos, 2001). Also the coefficient of compactness apparent that the basin has no near circular shape, ie has elongated shape. This fact can also be proven by the circularity index, whose value is 0,09. As can be seen in Figure 2, the predominant pattern of drain bowl is that the dendritic type. This type of drainage is well branched and resembles a tree, and develops on land with a predominance of more resistant rocks.

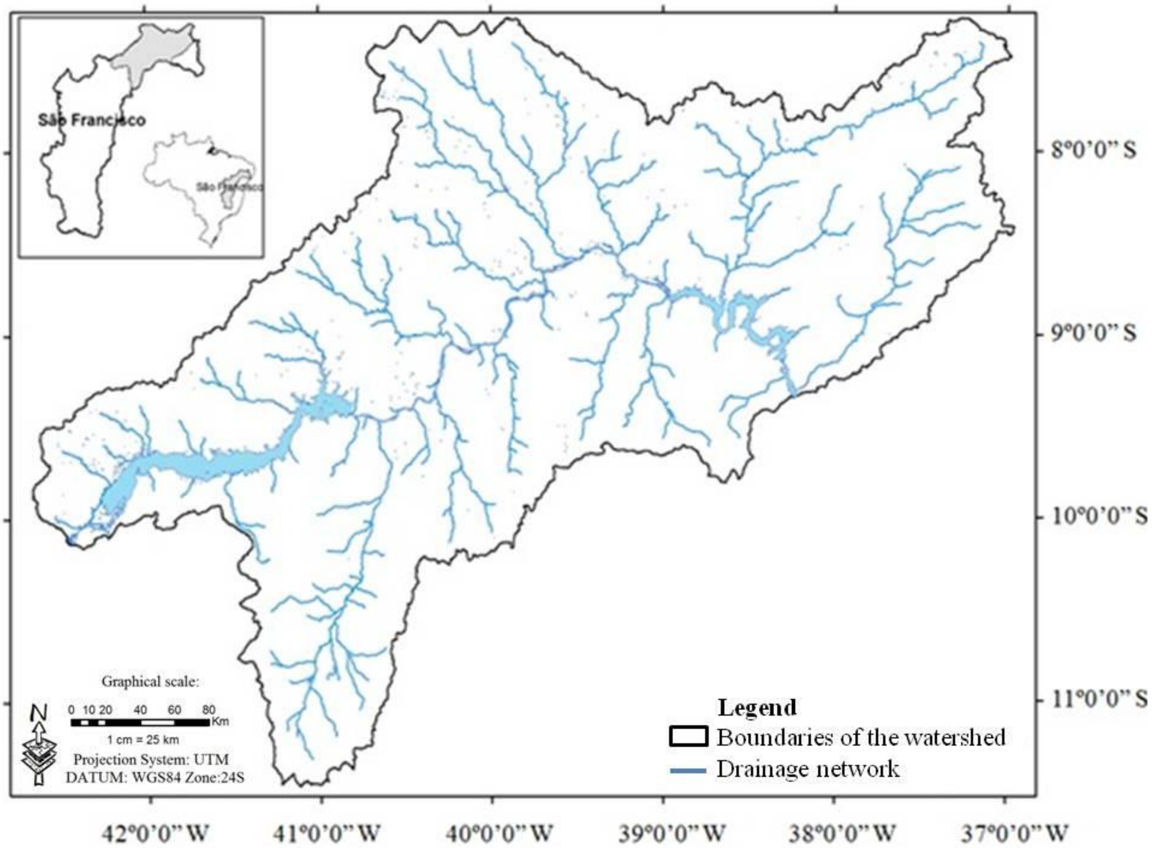

Figure 2. Network of Drainage São Francisco River Low middle Basin

The drainage São Francisco River Low middle Basin has considerable altitude variation, minimum and maximum of 173m 1280m, with an average altitude of 506m and a width of 1107m (Figure 3), which shows that some regions of the basin in question favors further loss of water runoff as a function of the slope of the ramp. Areas with altitude between 350 and 400 meters correspond to 17.605km^2, or 15.9% of the total and are mainly located in the central part of the basin in the drainage trough the São Francisco River. Already altitudes between 400 and 450m 24.705km^2 correspond to 22.4% of the total area. Areas with altitudes above 450m 60.000km^2 represent over 56% of the total basin area. Trentin & Robaina (2005) comment that the topographic map is of fundamental importance in the analysis of energy relief, indicating more favorable conditions for drying to the areas of higher altitude and accumulation to areas of lower elevation.

The maximum slope was 46%, whereas the average slope presented was 4.4% (Figure 4), more than half of the basin area (83%) had less than 6% slope, which corresponds, according to the classification of De Biase (1993), the relief floodplain and plan to undulated, corresponding to more than 90.000km^2. Then there are slopes in the range 6-12%, occurring in an area of 11.044km^2, corresponding to 10.0% of the total area. This class comprises areas with wavy and undulated, where water erosion problem and offers not only conservation practices (tillage and cultivation level) are required, except in erodible soils (sandy) with a length of very long ramp.

According to the distribution of land use classes identified in the study area (Figure 5), it is observed that the Caatinga arboreal e shrubby, Caatinga shrubby low e Grassland dominate the landscape occupying an area of 60.385,7; 18.998,5 and 22.737,5 km^2, respectively, totaling approximately 102.121,8 km^2, corresponding to 92.5% of the total area of the basin area. The Irrigated agriculture are found in the southern part near the São Francisco River Basin, this area corresponds to 3.079,1 km^2 representing less than 3% of the total area.

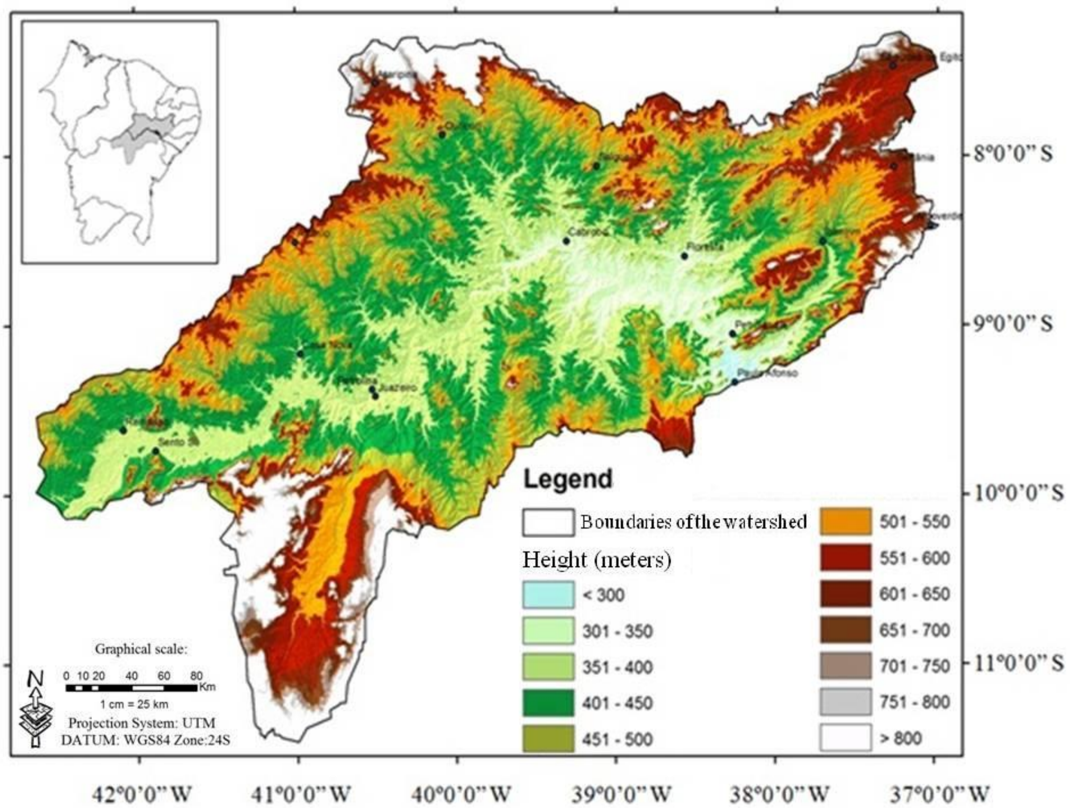

Figure 3. Altimetry map of the São Francisco River Low middle Basin

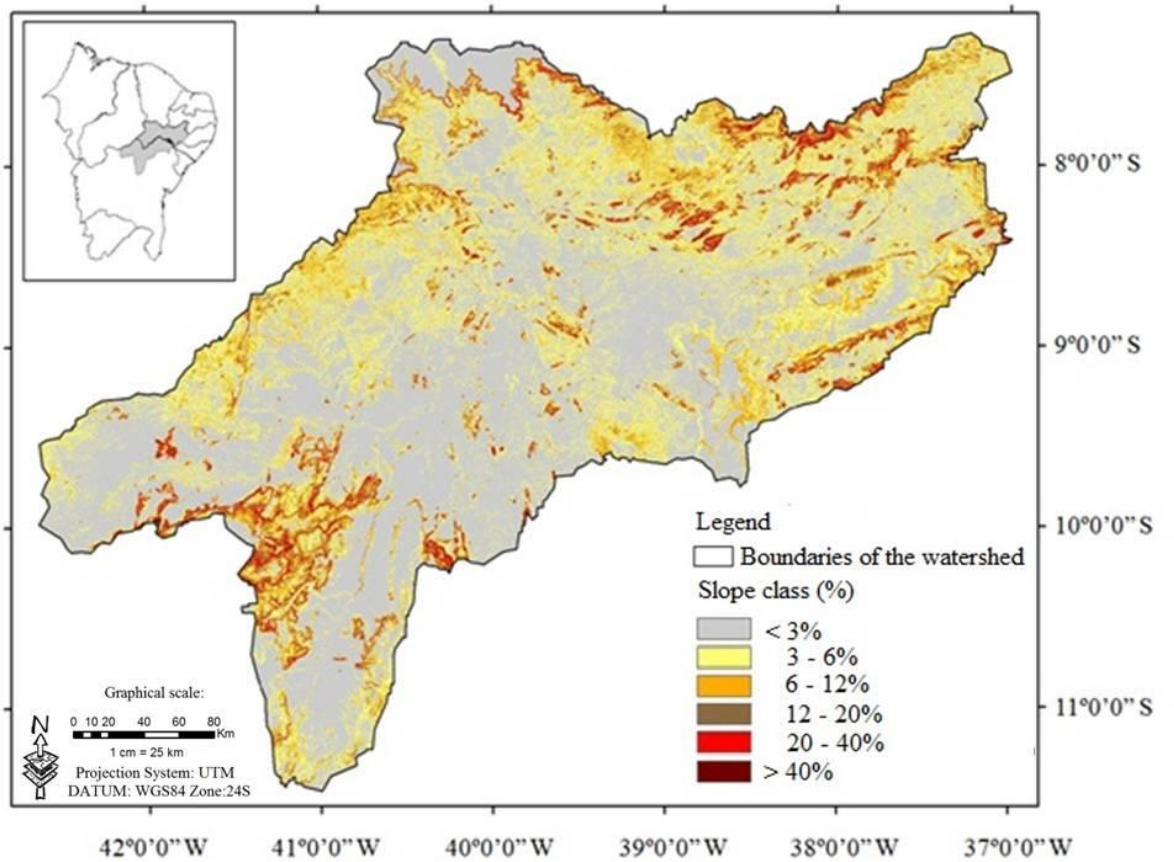

Figure 4. Slope map of the São Francisco River Low middle Basin.

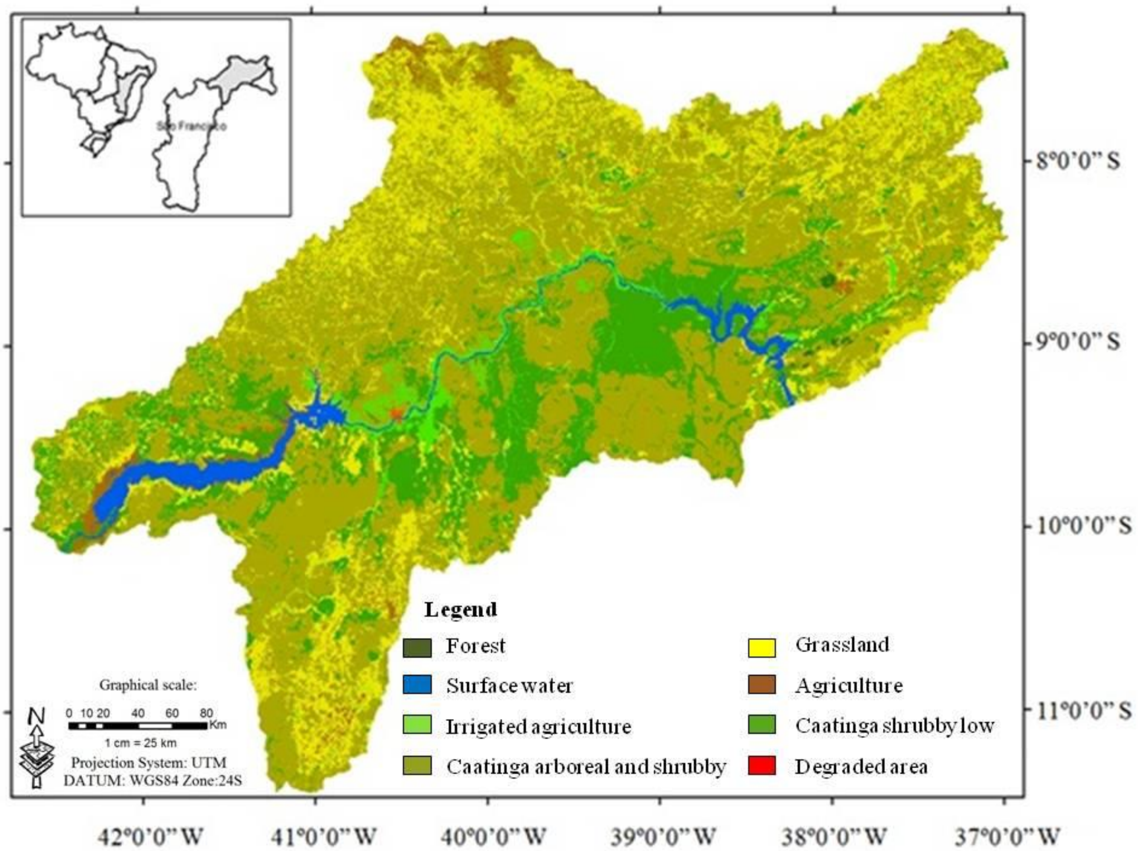

Figure 5. Landuse map of the São Francisco River Low middle Basin

Conclusions

The results of this study revealed the importance of using data from remote platforms in conjunction with GIS-based evaluation of morphometric parameters of drainage and its influence on landforms, soils and surface properties approach sensors.

GIS-based approaches enable the analysis of different morphometric parameters and explore the relationship between the morphology and drainage properties of landforms, soils and land cover. Different landforms were identified in the watershed based on SRTM (DEM) data with 90 m spatial resolution.

GIS techniques were thus characterized by high precision mapping and measurement of morphometric indices and revealed themselves as a tool with great potential for watershed management. The morphometric analysis of drainage network of the basin indicated predominance of dendritic pattern with low distribution segments of rivers.

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