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Analysis vegetable coverage of the hydrographic microbasin riacho chafariz, through application of the Normalized Difference Vegetation Index (NDVI)

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Abstract

The Brazilian semiarid is characterized as an area with significant modifications in its natural aspects, mostly caused by anthropic actions to meet specific needs. However, these changes, especially in the Caatinga vegetation, occur in a way that causes environmental impacts that compromise the socioeconomic development of this geographic space. In view of this, this work has the objective of analyzing the spatiotemporal configuration of the vegetation cover in the hydrographic basin of Riacho Chafariz, for the years of 1984 and 2016. For this, LANDSAT images 5 and 8, respectively, of the dates of 17.06 were used. 1984, 25.06.2016 close to the rainy season. As methodological procedures, radiometric corrections and Normalized Difference Vegetation Index (NDVI) were used as results. NDVI maps were obtained for the years studied, where it was possible to observe important spatiotemporal changes of the vegetation cover in the microbasin. Therefore, this work was to understand the dynamics of the vegetation cover in the microbasin. In addition to promoting the development of other environmental research in this geographical area.

Keywords**:** Semiarid, Watershed, Remote Sensing.

1. Introduction

The Brazilian Semiarid (SAB) is formed by heterogeneous landscape units, in terms of its elements and geographic factors. This consists of an area with important socioenvironmental discussions, most of which causes a conception of environmental hostility.

According to Nascimento (2015) the SAB exposes a complex reality about the geophysical aspects, the human occupation and the exploitation of its natural resources. For, of course, semi-arid regions, including the state of Paraíba with approximately 80% of its territory, are defined according to the irregularity of rainfall, water scarcity, soils with low organic content, in addition to high temperatures.

These peculiarities impose the need for a better understanding so that the coexistence of man in this environment is possible. Oliveira (2013) stated that the understandings can be under two visions: what approaches the SAB problems from the natural aspects themselves, specifically the edaphoclimatic ones. And what it understands in a geosystemic way, pointing out different causes for the socioenvironmental problems that have occurred.

In this context, the Caatinga Biome according to its geographic disposition presents significant intensity of luminosity, high temperatures and little variable, spatially and temporally. Therefore, these conditions do not diminish the growth potential of the vegetation. Almeida et al. (2014) affirmed that the Caatinga vegetation is susceptible to environmental degradation processes, accentuating in the dry season. However, when the rainy season begins, the vegetation presents a partial recovery, with an imbalance between recovery and degradation, with negative interference of the anthropic actions. Thus, similar to other tropical vegetation, the Caatinga goes through exploratory processes for different purposes (agricultural, livestock, mining, ceramics, etc.) that compromise its biodiversity (Ferraz et al., 2014).

With the advent of technological innovations, more efficient remote sensors have emerged, generating more accurate information, providing more reliable analysis in time and space. It is in this scenario that the use of geoprocessing presents significant relevance in research aimed at the analysis of processes of environmental degradation in watersheds. Considering that these serve as spatial references for urban and rural territorial planning and management.

According to Francisco et al. (2012), the use of geoprocessing favors the integration of data, making it possible to carry out spatial analyzes based on processing techniques, considering that in the hydrographic basins, planning and / or planning actions are different elements of the environment.

The Remote Sensing, according to Florenzano (2011), consists of obtaining geospatial information from the terrestrial surface, through the capture and recording of energy reflected or emitted by the surface, without direct contact with the object to be studied. It plays an important role in the monitoring of several environmental phenomena, providing subsidies for territorial planning and management.

Thus, in the environmental analyzes of vegetation indices, they stand out as being one of the methods used for this purpose. Among them, the Normalized Difference Vegetation Index (NDVI) is widely used in biological studies in watersheds to analyze the spatiotemporal vegetation configuration, for example those developed by (Demarchi et al., 2011; Nascimento et al., 2014; Silva and Almeida, 2015; Birtwistle et al., 2016; Pereira Neto and Fernandes, 2016; Silva et al., 2016).

Understanding that research on environmental aspects needs to be developed so that it is possible to be aware of the situation of river basins. In this work, it is proposed from the NDVI application to analyze the spatiotemporal configuration of the vegetation cover of the hydrographic basin of Riacho Chafariz, for the years 1984 and 2016.

2. Materials and methods

2.1 Localization of study area

The hydrographic micro basin of Riacho Chafariz is located between the coordinates of the Universal Transverse System of Mercator (UTM) 9,240,000 mE – 732,200 mN and 9,220,000 mE – 744,800 mN. According to Nascimento (2015), this microbasin presents a drainage area corresponding to 215.6 km² comprising parts of the following municipalities: Junco do Seridó (70,1 Km²), Salgadinho (1,1 Km²), Santa Luzia (142,5 Km²) e São José do Sabugi (0,9 Km²), Inserted in the Geographical Meso-region of Borborema, State of Paraíba (Figure 1).

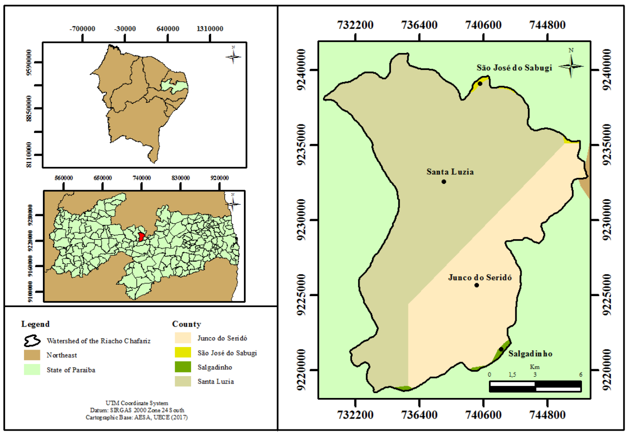

Figure 1 – Map of geographic location of the Riacho Chafariz watershed.

2.2 Materials

2.2.1 Rasters and vector data

For vegetation cover analyzes, orbital images were used corresponding to the post-rainy period in the hydrographic basin and without cloud cover. These are from the Land Remote Sensing Satellite (LANDSAT), acquired from the– National Institute for Space Research (INPE) and the United States Geological Survey (USGS) (Table 1).

Table 1 - Configuration of satellite orbital images LANDSAT.

Configurations	LANDSAT-5	LANDSAT-8
Date of the image	17.06.1984	25.06.2016
Orbit / Point	215/65	215/65
Geodetic reference system	*World Geodetic System* (WGS-1984)	*World Geodetic System* (WGS-1984)
Format	*Tagged Image File Format* (TIFF)	*Tagged Image File Format* (TIFF)
Sensor	*Thematic Mapper* (TM)	*Operacional Land Imager* (OLI)
Space Resolution	30 meters	30 meters
Temporal Resolution	16 days	16 day
Radiometric Resolution	8 Bits	16 Bits
Spectral Resolution (Micrometers)	Band 1: 0.45-0.52 Band 2: 0.52-0.60 Band 3: 0.63-0.69 Band 4: 0.78-0.90 Band 5: 1.55-1.75 Band 6: 10.4-12.5 Band 7: 2.09-2.35	Band 1: 0.43 – 0.45 Band 2: 0.45 – 0.51 Band 3: 0.53 – 0.59 Band 4: 0.64 – 0.67 Band 5: 0.85 – 0.88 Band 6: 1.57 – 1.65 Band 7: 2.11 – 2.29 Band 8: 0.50 – 0.68 Band 9: 1.36 – 1.38 Band 10: 10.60 – 11.19 Band 11: 11.50 – 12.51

Source: INPE/USGS (2016), adapted by the author.

Regarding the physical aspects of the Riacho Chafariz watershed, images from the Geomorphometric Database of Brazil (TOPODATA PROJECT) developed by INPE, which performed the Shuttle Radar Topography Mission (SRTM) data treatment were used. For that, the physical aspects of the microbasin were defined from the extraction of the Digital elevation model (DEM) whose spatial resolution is 30 meters and the TIFF format.

Finally, as a delimitation of the study area was used the corresponding vector database, in the shapefile format, generated by the – State of Paraíba Water Management Agency (AESA) and the State University of Ceará (UECE).

2.3 Methods

2.3.1 Radiometric Correction

Based on the availability of orbital data for the calculation of NDVI, in this work it was necessary to determine the radiance (Equation 1) and reflectance (Equation 2) from the digital number (ND) conversion in monochromatic radiance, according to (Markham and Barker, 1987).

$$L_{rad} = L_{i,min} + \left(\frac{L_{i,max} - L_{i,min}}{255}\right) \times NC_i \quad (1)$$

On what:

L_i is the spectral radiance in the band i in $Wm^{-2}sr^{-1}\mu m^{-1}$;

$L_{i,max}$ and $L_{i,min}$ Are the values of maximum and minimum radiance in band i, respectively and;

NC_i The gray level in the band i.

$$r_{o,i} = \frac{L_{rad} \times \pi}{E_{o,i} \times \cos\theta \times d_r} \quad (2)$$

On what:

$r_{o,i}$ is the spectral reflectance in the band i;

d_r the inverse of the square of the Earth-Sun distance in astronomical unit;

$E_{o,i}$ The mean exo-atmospheric solar irradiance in band i in W m^{-2} μm^{-1} (solar constant);
q, the solar zenith angle (calculated from the information of the solar elevation angle);
b, available in the image header file: q = (90°- b);
Li is the spectral radiance in the band i in Wm^{-2} $sr^{-1}\mu m^{-1}$.

2.3.2 Index of vegetation

For the calculation of the NDVI was used Equation 3 proposed by (Rouse et al., 1973):

$$NDVI = \frac{(NIR-RED)}{(NIR+RED)} \quad (3)$$

Where:
NDVI = Normalized Difference Vegetation Index;
NIR = Near Infrared Reflectance;
RED = Reflectance in Red.

According to Braga et al. (2014) the NDVI consists of the ratio between the reflectivity of the bands in the near infrared and in the red by the sum of these same reflectivities, with values varying in the interval of -1 to 1.

With the obtaining of the indices for each year studied the classification of the different types of vegetal cover was carried out according to the methodology proposed by the National Institute of the Semiarid (INSA, 2016). For this, the following classes were assigned Up to 0.1, 0.1 - 0.2, 0.2 - 0.4, 0.4 - 0.6, 0.6 - 0.8 and 0.8 - 1.0. That is, reflectance values near 0 (refer to vegetation without leaf, submitted to water stress condition due to water deficit in the soil) and close to 1.0 (relative to vegetation with leaves, without water restrictions and in fullness of their metabolic and physiological functions).

2.3.3 Thematic maps

In data processing a database was created for the organization and inclusion of vector data and rasters (images). For this, the UTM coordinate system and the Geocentric Reference System for the Americas (SIRGAS-2000), Zona 24 South was adopted.

This data was then processed and the thematic maps were generated using the ArcGIS 10.1 Geographic Information System (GIS) software, based on the license granted by the Federal Institute of Education, Science and Technology of Paraíba (IFPB) - Campus Picuí.

3. Results and discussion

3.1 Characterization of the study area

On the physical aspects of the Riacho do Chafariz microbasin, it is observed that in general, elevations between 296 m and 872 m of altitude are predominant in relation to sea level. Specifically in the southern portion, about 2%, which corresponds to 3.4 km² of the total area of the basin, the relief is irregular and heterogeneous.

This configuration takes place according to the remnants of the Borborema Plateau, characterized by high altitudes, with features in valleys forms where the sources of the tributaries of the Riacho Chafariz are. And the Northwest are the lowest altitudes, comprising 7%, approximately 16 km² of the total area of the watershed (Figure 2).

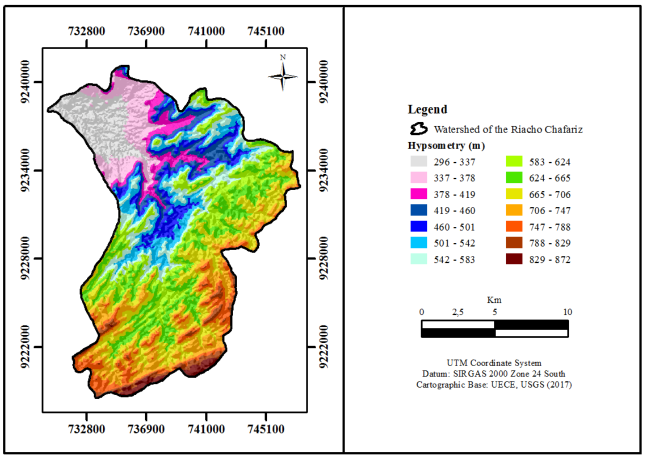

Figure 2 – Hypsometry map of the microbasin Riacho Chafariz.

In Figure 3, the slope of the relief, in its majority, according to the EMBRAPA classification (1979) was among the classes: flat (30.6%), smoothly wavy (33.4%) and wavy (19.2% %). Corresponding to 83.2% of the total area of the Riacho Chafariz watershed. It should be emphasized that these areas comprise the eastern and northwestern portions of the microbasin, with emphasis on the territories of the municipalities of Junco do Seridó and Santa Luzia, respectively.

The other 16.8% of the total area of the watershed, encompasses the areas classified with strong relief corrugated (10.5%), mountainous (4.6%) and steep (1.6%). These expose the remnants of the geomorphological features of the Borborema Plateau.

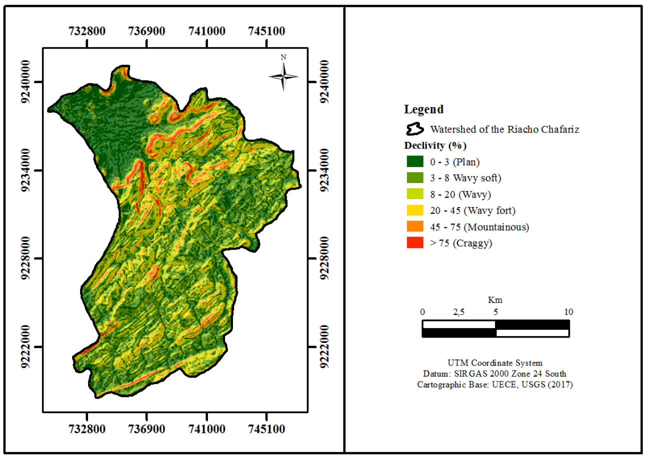

Figure 3 – Declivity map of the watershed Riacho Chafariz.

Figure 4 shows six classes of soils, according to the 3º categorical level (large groups) of the Brazilian soil classification system (EMBRAPA, 2013) in the Riacho Chafariz microbasin. Therefore, we find the CHRONIC LUVISSOLOS Optical representing 8.7% of the total area of the microbasin, constituted by mineral material, presenting a textural and non-hydromorphic B horizon.

YELLOW LATOSOLS Distrophic areas whose area corresponds to 2.5%, formed by mineral material, presenting a latosolic B horizon preceded by any type of horizon A. And the REGOLITICS NEOSOLS Eutrophic, FLUVITICS NEOSOLS Dystrophic, with areas of 5.8% and 2.9%, respectively. Beyond LITHOLIC NEOSOLS Dystrophic e LITOLIC NEOSOLS Eutrophic with areas corresponding to 11.2% and 68.9%, respectively. Those that are few evolved, constituted of mineral material or organic part with less than 20 cm of thickness, do not present any type of horizon B.

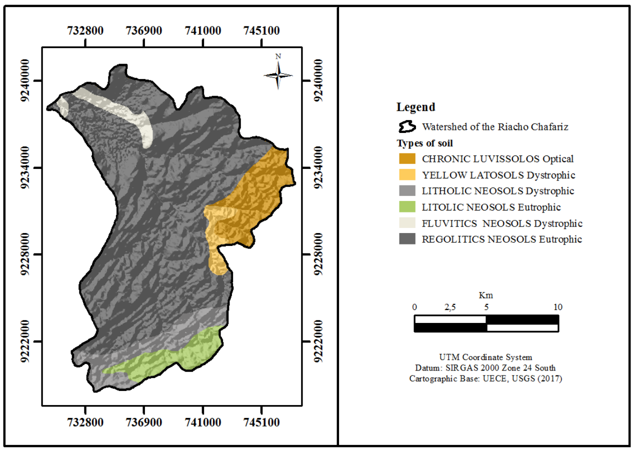

Figure 4 – Map of Soil types microbasin Riacho Chafariz

3.2 Spatial distribution of NDVI

The results obtained by the NDVI showed for the year of 1984 reflectance values that varied between -0.32 to 0.79. While in the year 2016 the values had a variation between 0.05 and 0.60 as shown in (Table 2).

Table 2 – Class of NDVI and reflectance values for the years 1984 and 2016.

Class of NDVI	**Reflectance values**	
	1984	**2016**
Até 0.1	-0,32	0,05
0.1 - 0.2	0,20	0,17
0.2 - 0.4	0,31	0,21
0.4 - 0.6	0,41	0,25
0.6 - 0.8	0,53	0,31
0.8 - 1.0	0,79	0,60

According to the results obtained, it can be stated that in the semi-arid regions, especially the study object area, vegetation is sensitive to climatic conditions. Demonstrating in an evident way its dynamics before the existence or lack of the rains. Figures 5 and 6 demonstrate NDVI maps with classes that correspond to the vegetation cover areas and water bodies for the years 1984 and 2016, respectively.

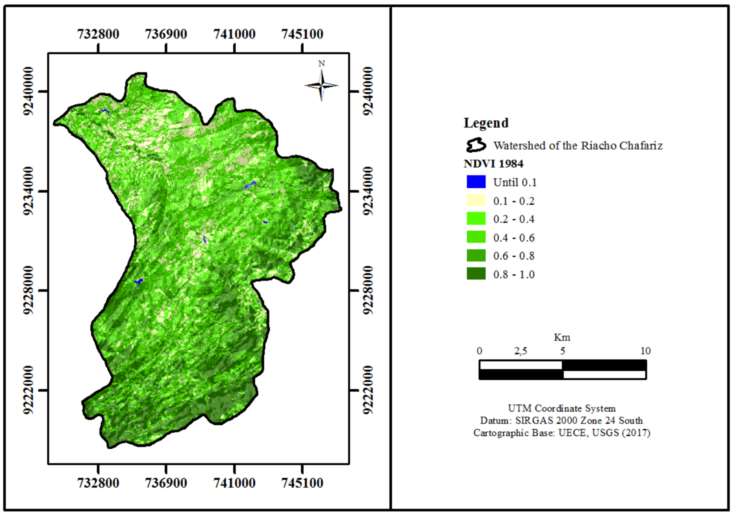

Figure 5 – Map of NDVI for the year 1984.

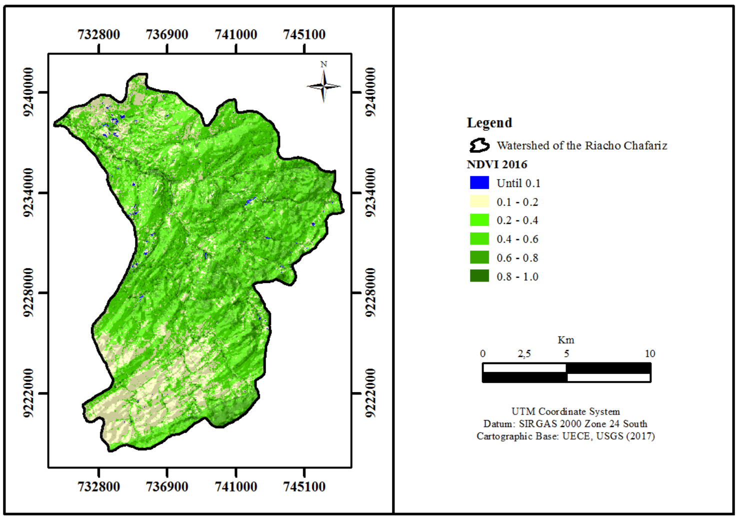

Figure 6 – Map of NDVI for the year 2016.

These maps allow to observe that, in general, there is a significant dynamics in the vegetal cover between the years studied. Which is according to the model of organization of the geographic space, that is, the areas with presence of vegetation of Caatinga are probably occupied by different anthropic activities, especially agriculture, mining and ceramics; which promote significant deforestation.

This affirmation can be observed in the maps, where in 2016, in the southern portion of the microbasin there was a higher reflectance response in the class of 0.1-0.2 in relation to 1984, indicating a reduction of the vegetation cover in this area. Consequently the appearance of areas with sparse vegetation and / or exposed soil.

On the other hand, in the maps, in both years, it is also observed that the areas that have a lower reflectance correspond to the margins of watercourses, slopes and tops of hills. It should be emphasized that in these spaces, in turn, the Caatinga vegetation presents a smaller impact on the anthropic actions, which may explain its presence.

Regarding the spatial aspects, it is considered that the modifications in the configuration of the vegetation cover of the watershed of the Riacho Chafariz, for some classes were not significant. However, other classes presented values with expressive alteration (Table 3).

Table 3 – Spatial distribution of NDVI class for the years 1984 and 2016.

Class	1984		2016		Difference	
	Km²	%	Km²	%	Km²	%
Until 0.1	0,5	0,2	0,95	0,4	-0,45	-0,21
0.1 - 0.2	29,7	13,8	47,2	21,9	-17,53	-8,13
0.2 - 0.4	50,9	23,6	70,4	32,7	-19,49	-9,04
0.4 - 0.6	53,6	24,9	62,2	28,9	-8,63	-4,00
0.6 - 0.8	46,6	21,6	29,8	13,8	16,77	7,78
0.8 - 1.0	34,4	15,9	5,0	2,3	29,34	13,61
Total area	**215,6**	**100**	**215,6**	**100**	**0**	**0**

According to the results obtained, the classes that correspond to the water bodies did not have major evolutions, with areas of 0.5 Km² in 1984 and in 2016 of 0.4 Km². However, classes 0.1-0.2, 02-0.4 and 0.4-0.6, respectively, showed a significant increase among the studied years. This evolution can be explained by the conventional way of land use, which exposes and catalyzes its vulnerability, triggering erosive processes, reducing soil fertility for agricultural crops.

Thus, the modifications of the vegetation cover in the microbasin establish an inversely proportional relation in quantitative terms. For example, the class 0.2-0.4 in 1984 had an area of 50.9 km²; it became 70.4 km² in 2016, an increase of approximately 20 km². On the other hand, the class 0.8-1.0 in 1984 was 34.4 km², in the year 2016 occupies an area of 5 km², a reduction of 29.3 km². Thus, in the analysis of the vegetation cover of the Riacho Chafariz microbasin, it is understood that, although the results do not present expressive values for some classes of vegetation cover, it is evident the concern with the potential degradation processes. In view of, such changes are in interaction with other environmental elements, for example precipitation.

Therefore, the NDVI products for the years 1984 and 2016, correlating them with the period in which the study was carried out, near the rainy season, it can be affirmed that areas of denser vegetation show signs of degradation.

4. Conclusions

The results obtained from the methodological procedures applied in this work made it possible to present an understanding of the vegetation cover of the Riacho Chafariz watershed. As the use of geoprocessing techniques is considered satisfactory, since they allowed the generation of important information about the said microbasin, according to what was proposed in the objectives.

The use of images from the LANDSAT series proved to be efficient in achieving the objectives and obtaining the expected results. Since, it was possible to determine in classes the uses of the soil in the watershed.

With the results obtained from the use of NDVI, which allowed identifying the changes efficiently, it is understood that the constant monitoring of the vegetation cover is of fundamental importance for the microbasin.

Therefore, this work becomes relevant, because it presents a possibility to develop studies in the environmental area. Also, the importance of exposing information about an area of study with little scientific knowledge, contributing to the change of conception. In addition to stimulating the production of other research in the Riacho Chafariz microbasin.

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