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Use of geotechnology in analysis of forest biomass in the state of Paraiba

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ABSTRACT

The GIS is considered one of the most important tools for understanding the structure and dynamics of vegetation cover in various temporal and spatial scales, when used in the landscape's ecology provides information for man's relationship study of the environment, and to understand ecological processes. This study aimed to show the role of digital processing techniques of unsupervised images for multitemporal analysis of environmental degradation in the state of Paraiba. The study area for this work it was the state of Paraiba, in Mesoregions of Sertão Paraibano, Borborema and Agreste Paraibano. Rainfall is unevenly distributed throughout the year, with diverse climatic conditions, associated to the climate distribution with location, noting in the closer regions to the coast a humidity climate, although how further away from coast, drier is the regions. The methodology was based on temporal analysis of orbital images TM / Landsat - 5 for the dates in September 1998 and September 2009 for mesoregion of Sertão Paraibano, in October 1999 and September 2008 to the mesoregion of Borborema, and in April 1999 and July 2007 to the mesoregion of Agreste Paraibano, where the images used were obtained from the National Institute for Space Research (INPE). The results indicated that the temperature and rainfall are directly related to the amount of vegetation cover, increased sparse vegetation appears to be quite worrying because it is in this class that degradation levels can increase beginning to desertification cores. The work showed the great potential of using geoprocessing tools for spatial analysis of the study area and from that conduct a study on the dynamics of vegetation cover in the study area.

Keywords: remote sensing, vegetation cover, environmental degradation

INTRODUCTION

The Brazil suffers intense demand for biodiversity as a natural resource, cause it is considered one of the greatest countries in the world, showing essential to the efficient use of these resources. With the advancement of biotechnology, it was observed that the higher the biodiversity of a country, the greater the exploitation and use of natural resources, an important factor for economic development.

Thus, biodiversity can be understood as the versatility of living organisms from all sources, encompassing marine, land, ecological complex ecosystems, among others, may also be understood the diversity of species and ecosystems, which is related to all living resources on Earth and can be added value, depending on the human need (COELHO, 2014).

Techniques aimed at the rational exploitation of natural resources such as sustainable inventories and managements are increasingly necessary, because its rapid exploitation gradually increases the degradation rates in local, regional, national and global scales, generating impoverishment, erosion and soil compaction, beside reduces the socio-economic and technological levels of the rural population (RIBEIRO; CAMPOS, 2007).

One reason for removal of vegetation cover is the use as a source of renewable energy, driven by increased production in some sectors of industry, such as production of pig iron and red ceramic industries, it caused by the great need for products demand, seeking to reach high level of quality, enabling the exportation (FERREIRA, 2012).

It is essential to monitoring and planning the sustainable use of natural resources, linked to the management thereof, through agricultural, forestry or urban growth. Understanding the importance of vegetation cover and land use is necessary to identify information for understanding the physical, economic and social aspects observed at the level of local to the global scale (PEREIRA, 2008).

One of the tools widely used in Brazil to survey natural resources in large areas is remote sensing, providing the monitoring of the environment for the benefit of economic and social development (PINTO, 2001). Currently the problem of high costs in relation to field surveys, can be minimized by capturing the images obtained in the remote sensors, such as satellite LANDSAT, SPOT satellite, among others (RIBEIRO; CAMPOS, 2007).

The satellite images used in vegetation surveys allows the user to separate easily the physiognomy of the vegetation, which may classify the different profiles of the species found in the study area. This instrument overcomes obstacles and disadvantages of monitoring of forest fragments that changes the medium/long term, making it appropriate to examine inaccessible areas (LEE; YEH, 2009).

The use of GIS and remote sensing tools on the vegetation cover's study have been getting amazing results in information and understanding of environmental interactions with existing populations living there. From the satellite images are able to obtain data related to spectral behavior and the state of vegetation cover, can understand if the study area is healthy or not (OLIVEIRA; ZEILHOFER; SANTOS, 2007).

According to Blaschke (2010), the data acquired in the sensors of the satellites provide good results for analysis in various applications and vegetation cover sites, in local, regional and / or global scales of biodiversity, nature conservation, deforestation impacts and desertification.

Remote sensing techniques are employed since the late 60 in the delineation of several biophysical criteria of vegetation and can be evaluated by the vegetation indices, indicating the relative abundance and movement of green vegetation cover, covering the leaf area index, percentage of green vegetation, chlorophyll content, among others (JENSEN, 2009).

MATERIALS AND METHODS

Paraiba is located in Northeast Brazil, with an area of 56,372 km², corresponding to 0.662% of the Brazilian national territory. It lies between latitudes 6 ° 02'12 "S and 8 ° 19'18" S and meridians 34 ° 45'54 "W 38 ° 45'45" W (FRANCISCO, 2010).

A regional framework, the state of Paraiba has most of its territory occupied by the Caatinga, with varied physiognomy. This biome is very important because it is endemic of Brazil, being the least studied and protected of the existing biomes in Brazil. The Caatinga has undergone an indiscriminate use process, creating an environmental deterioration, changing biodiversity, providing the loss of endemic species and raising the desertification process (SOUZA, 2015).

1. Data collection

The images used were acquired in the database Image Catalog of the National Institute for Space Research - INPE (INPE, 2016). multispectral images were used satellite TM / Landsat 5 concerning the meso, according to Tables 1, 2 and 3.

Table 1. multispectral satellite images of TM/Landsat 5 referring to mesoregion Sertão Paraibano.

Sensor	Date Pass	Orbit	Score
LANDSAT 5/TM	10/09/2010	215	64
LANDSAT 5/TM	10/09/2010	215	65
LANDSAT 5/TM	01/09/2010	216	64
LANDSAT 5/TM	01/09/2010	216	65
LANDSAT 5/TM	28/09/1998	215	64
LANDSAT 5/TM	28/09/1998	215	65
LANDSAT 5/TM	10/09/1998	216	64
LANDSAT 5/TM	10/09/1998	216	65

Table 2. multispectral satellite images of TM/Landsat 5 referring to mesoregion Borborema.

Sensor	Date Pass	Orbit	Score
LANDSAT 5/TM	23/09/2008	215	64
LANDSAT 5/TM	23/09/2008	215	65
LANDSAT 5/TM	23/09/2008	215	66
LANDSAT 5/TM	29/08/2008	214	65
LANDSAT 5/TM	17/10/1999	215	64
LANDSAT 5/TM	17/10/1999	215	65
LANDSAT 5/TM	17/10/1999	215	66
LANDSAT 5/TM	23/09/1999	214	65

Table 3. multispectral satellite images of TM / Landsat 5 referring to mesoregion Agreste Paraibano.

Sensor	Date Pass	Orbit	Score
LANDSAT 5/TM	19/07/2007	215	64
LANDSAT 5/TM	19/07/2007	215	65
LANDSAT 5/TM	29/07/2007	214	65
LANDSAT 5/TM	08/04/1999	215	64
LANDSAT 5/TM	08/04/1999	215	65
LANDSAT 5/TM	17/04/1999	214	65

It was not possible to use TM / Landsat 5 images for mesoregion of Mata Paraibana, since the large amount of clouds on the coast prevented the acquisition of data.

The methodology for the visual interpretation of digital images it was based on Systematic Method developed by (VENEZIANI; ANJOS, 1982)]. This methodology consists of a sequence of logical and systematic steps that are independent of prior knowledge of the area and the use of photointerpretative keys.

The visual image analysis conducted a comparative study between the spectral and textural properties that each spatial phenomenon takes in several recorded scenes, involving different levels of reflectivity to the different phenomena, to the time acquisition of images related to the spectral targets.

Thus, the identification of units and / or thematic classes founded the isolated study of the various elements of interpretation and then the joint observation of these elements (drainage, relief, tone, photo-textured), being generated interpreting maps.

For the satellite image choice Landsat 5 for the execution of the work, it was considered the fact that this product is the main working tool in geoprocessing in Brazil and in the world (RIBEIRO; CAMPOS, 2007), have satisfactory spectral resolution for the execution of work and to be available with changeover date updated in satellite imagery collection.

Through geoprocessing it was raised the real situation of vegetation cover and degradation of the three Mesoregions of Paraiba for two distinct periods, observing during this interval if there was commitment of resources vegetation, possible to characterize whether there were significant differences between these processes in mesoregion's study, thus being able to better distinguish the real state of Paraiba situation.

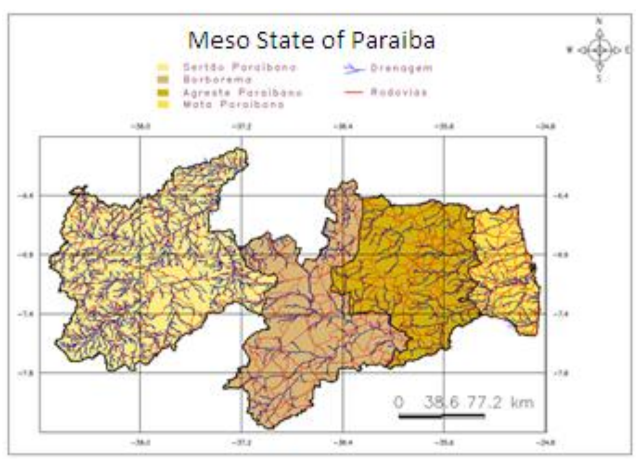
In quantifying of the vegetation, it was used as the multispectral information compositions set plan in RGB bands 1 to 3, NDVI bands 3 and 4. Since the characterization of the forming elements of the levels of degradation was defined according to shades of gray and grouped in regions counterparts, as the degradation levels recorded in orbital images of bands 3, 4 and 5.

Yet they have been adopted seven classes of measures (dense vegetation, semi-dense vegetation, sparse vegetation, bare soil, cloud, shade and water). The most critical vegetation cover classes are associated to the darker shades of gray detected in band 4 images; already the most preserved classes and the lower levels are associated to the lighter shades of gray.

RESULTS AND DISCUSSION

The results were obtained from the observation of the basic map of the state of Paraiba, aiming to improve the structural identification of each mesoregion, which obtained the thematic map of the state of Paraiba, as the drainage parameters, limits of mesoregion and roads (Figure 1).

Fig. 1. Digital map of the state of Paraiba structure



The generation of data from the normalized difference vegetation index were obtained from the application of the bands of red and infrared electromagnetic near spectrum (COELHO et al., 2015), where in the Sertão Paraibano, Borborema and Agreste Paraibano, it became clear the differentiation behavior of vegetation cover.

The satellite images are generated from the reflected electromagnetic radiation at targets on the surface, which are associated to the shades of gray. The higher the energy reflected by the target, the greater the radiation that reaches the sensor on board the satellite, itemizing a lighter gray shade, otherwise the lower energy reflected by the target, the lower the energy measured by the sensor, getting this target with darker shades of gray (SANTOS, 2013).

Comparing the images allows to observe the behavior of the vegetation cover of each mesoregion for the analyzed periods, showing exactly the situation of the landscape. It can be seeing that in all mesoregions there was a reduction of exposed soil area, but it is clear that the displayed vegetation cover is impaired, showing the large amount of vegetation in thin class. It is pertinent that the vegetation cover is deforestation and fires targets, irregularly plantations, culminating to the high levels of environmental degradation.

The distribution maps of vegetation cover classes (Figures 2, 3, 4, 5, 6 and 7) gives a better demonstration of the seven classes defined in the methodology (dense, semi-dense, thin, bare soil, cloud, shadow and water). Anthropic regions have pigmentation ranging from magenta to white, due to the large soil response, and white related to soil stretches of sandy or completely exposed. Certain disturbed regions show lighter green color, related to characteristic types of crops with dense foliage, finding the fraction of soil response in the picture, very low or nonexistent.

This information enables choice of possible areas of conservation and / or preservation, but also monitoring the vegetation in large areas and monitoring rivers, lakes, streams, etc.

Fig. 2. Digital map of vegetation cover classes of Sertão Paraibano in 1998

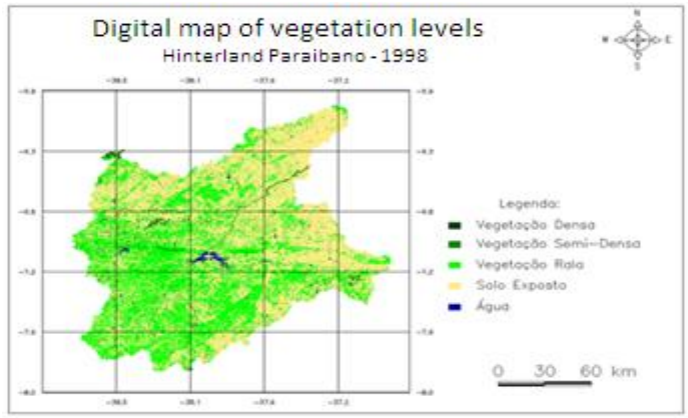


Fig. 3. Digital map of vegetation cover classes of hinterlands Paraibano in 2010

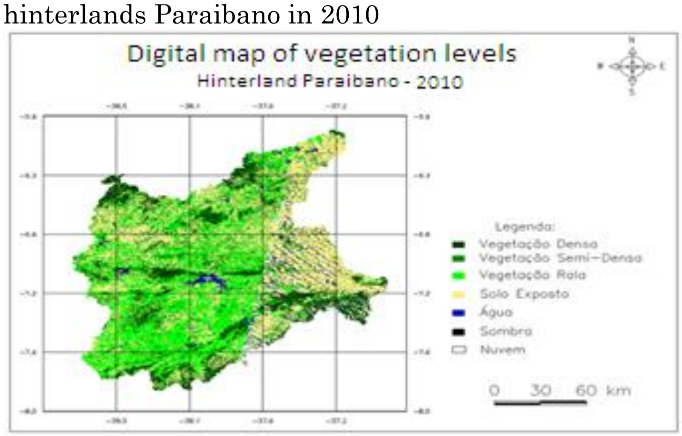


Fig. 4. Digital map of vegetation cover classes of Borborema in 1999.

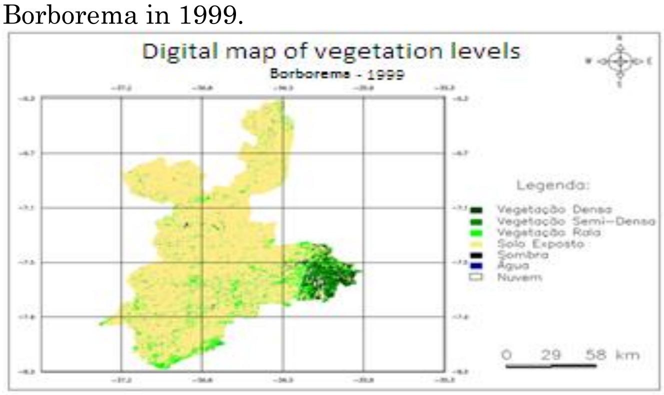


Fig. 5. Digital map of vegetation cover classes of Borborema in 2008.

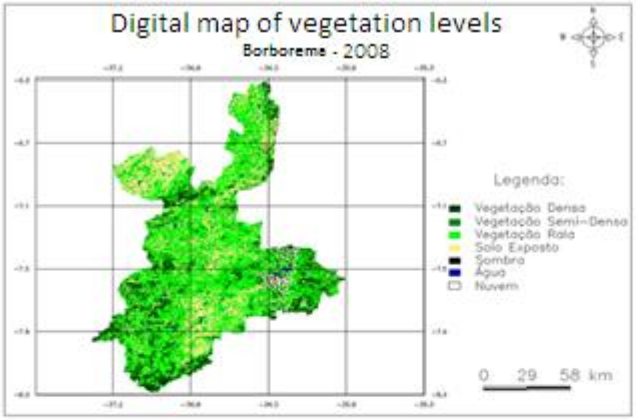


Fig. 6. Digital map of vegetation cover classes of Paraiba Agreste in 1999

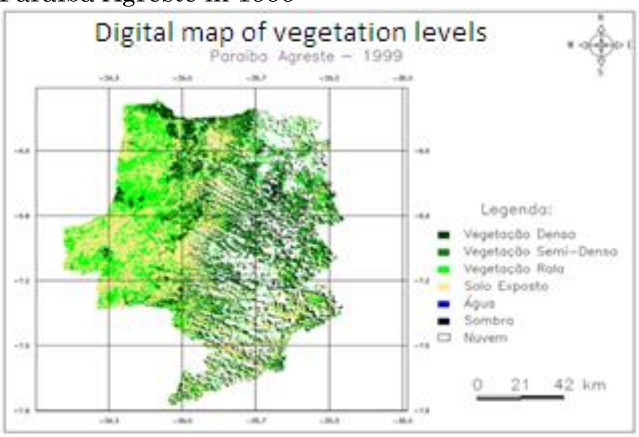
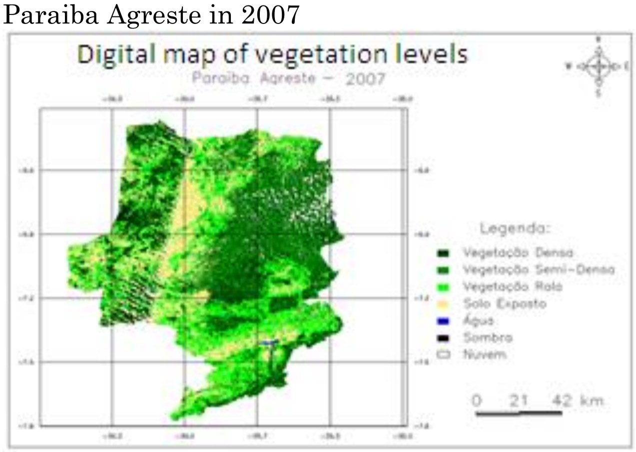


Fig. 7. Digital map of vegetation cover classes of Paraiba Agreste in 2007



In all mesoregions occurred differentiation in the values of classes of vegetation cover (Figures 8, 9 and 10), where the results for the Sertão Paraibano shows that there was an increase in the dense class and decrease in bare soil. A similar result it was observed in the mesoregion of Borborema, with the divergence of the increase in thin vegetation, which has low support values to the protection of soils against erosion. In the mesoregion of Agreste Paraibano stands out the large amount of clouds and shade, due to the closeness to the coast.

Fig. 8. Evolution dynamics of vegetation classes in the Sertão Paraibano between 1998 and 2010.

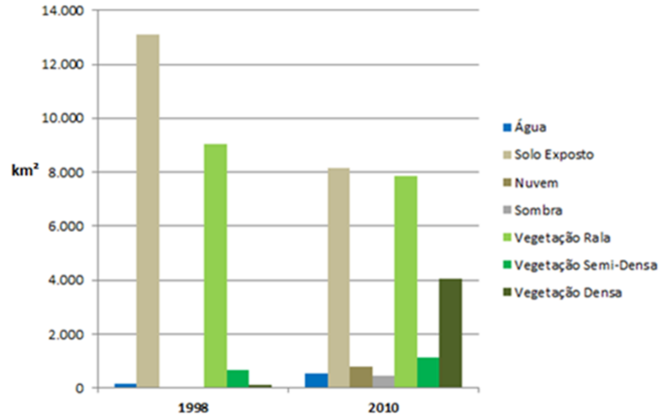


Fig. 9. Dynamic Evolution of vegetation classes in Borborema between 1999 and 2008.

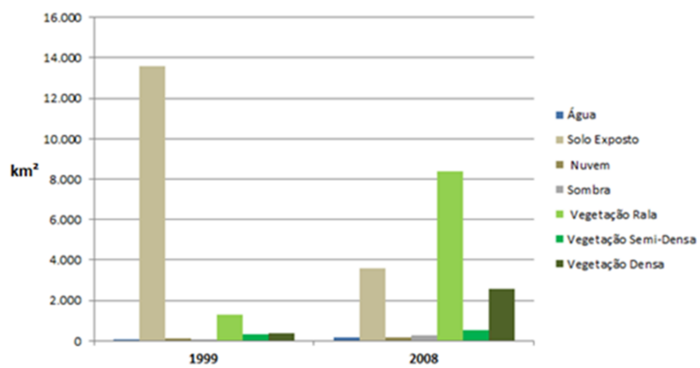
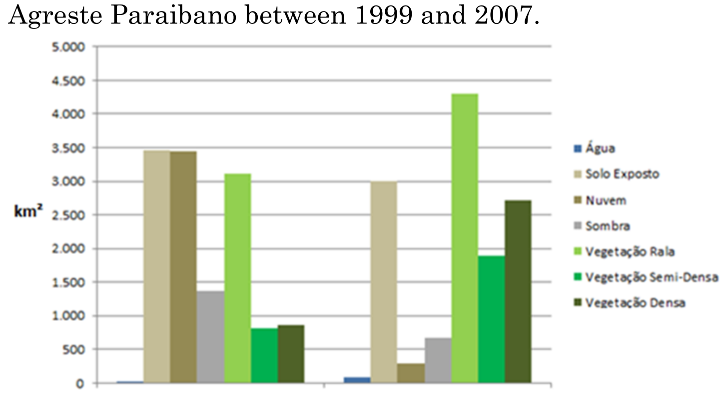


Fig. 10. Dynamic Evolution of vegetation classes in Agreste Paraibano between 1999 and 2007.



In the mesoregion of the Sertão Paraibano the dense vegetation class represented in 1998 approximately 119.62 km², corresponding to 0.6% of the total area, while in 2010 the same class had 4035.22 km², accounting for 17.6% of the total area. The same increase it was observed in the mesoregion of Borborema, where in 1999 there was approximately 356.80 km² of dense vegetation, equivalent to 2.3% of the mesoregion, however in 2008 the dense class showed 2592.23 km², which represents 16.2% of the total area. In Agreste Paraibano dense vegetation cover in 1999 was about 862.26 km², while in 2007 amounted to 2722.56 km², accounting for 6.6% and 21.0%, respectively, of the total area.

Corroborating our study, Francisco (2013) studying the temporal transformation of the vegetation of Paraiba's caatinga region between 1996 and 2009, testified the occurrence of significant changes in the areas of sparse undergrowth classes, undergrowth very thin and exposed soil generating an increase area of the other classes of more relevant biomass.

In the class of thin vegetation, was an increase of indexes, where the mesoregion of Borborema in 1999 there was 1301.32 km² and in 2008 about 8376.21 km², corresponding respectively to 8.24% and 53% of the total area. In the mesoregion of Agreste Paraibano this class in 1999 obtained 3112.26 km², corresponding to 23.79% of the total area, while in 2007 the area was of 4293.66 km², accounting for 33.2% of the entire area.

The increase of this class shows alarming rates because this vegetation suffers from the use of wood in small quantities by farmers. In the state of Pernambuco, large parts of rural households use firewood for cooking their food (COELHO et al., 2013), this factor is straightly related to increasing the levels of environmental degradation, as with the removal of vegetation, the reduction of soil fertility increases, making the use of the soil impracticable, even for the practice of agriculture, starting high core of desertification.

Thus, it is necessary to create public policies aimed to prioritize environmental protection as a solo devoid of vegetation becomes more prone to environmental degradation.

From conservation measures vegetation cover may, in medium and long term, improve the chemical and physical soil conditions, as well as reduce the erosion process, taking into account the edaphoclimatic aspects, where it is necessary in any scientific research to basis of a set of anthological and assumptions of human nature, this understanding is to great importance in the study of environmental degradation and disaster threat (DUARTE, 2003).

The digital maps of vegetation cover classes showed the seven classes studied, identifying significant differences for each mesoregion, this occurring by the display of their physical, chemical, climate action and mostly anthropogenic.

The class sparse vegetation and thin vegetation category it was introduced the values of pasture areas; the various types of vegetation in the study area, of various sizes and different biomass such as agriculture.

This way of measurement of environmental degradation through analysis of parameters using geotechnology (remote sensing, GIS and geographic information system) can generate a database with important information, enabling better decision making with more diverse circumstances, providing the basis for planning and use of recommendation and management of the environment.

According to Francisco (2013), the use of geo-technologies and procedures that describe and gathering data in the field, such as geoprocessing and medium spatial resolution satellite images and Difference Vegetation Index Normalized (NDVI) demonstrated the possibility to show the different types of scrub in the state of Paraiba, with good accuracy.

Monitoring areas with native vegetation is extremely important to maintain this vegetation, so that does not replace the dense native vegetation with low vegetation and / or exposed soil, because a soil devoid of vegetation becomes more conducive to degradation environmental.

The NDVI showed acceptable results for a monthly follow-up or at a particular time of phenological changes in vegetation, as well as the differentiation of the natural vegetation behavior and other analysis classes (reforestation, irrigation projects, annual crops, pasture, and bodies of Water).

The time scale analysis of each mesoregion allowed to ascertain between the years 1998 and 2010 (Sertão Paraibano), 1999 and 2008 (Borborema) and 1999 and 2007 (Agreste Paraibano) variation in NDVI over the difference in the behavior of different categories, that depending on the average values of precipitation and average temperature shows high vegetation indexes or suffer from the dry season.

The vegetation is considered a very complex subject, and fundamental analysis with more accurately, taking into account the various changes throughout the year, whether in the phenology of vegetation or due to seasonal period, but has been proven to geoprocessing efficiency through images TM / Landsat 5.

In these circumstances, the images TM / Landsat 5, demonstrated an important tool for monitoring and study of vegetation in local, regional and global level, contributing positively to environmental studies, such as climate changes, deforestation, reforestation, use and occupation land for grazing and agriculture.

The Landsat products have high application capacity in the characterization and survey of renewable natural resources, taking into account their spatial resolution of 30 meters, which offered conditions to quantify, evaluate and monitoring the changes caused in land structure due land use and vegetation cover, being widely used because it is free and purchased via the internet relatively easily.

The ability of remote sensing and GIS proved very useful from support to the monitoring of natural resources and use and occupation of land, due its convenience and speed, aiming to contribute to the new public policies.

The study showed that remote sensing data surveys in Caatinga presents influence of variations of air temperature and precipitation, directly influencing the data collection. It is evident the undeniable need for multidisciplinary studies for a better obtainment of the remote sensing data.

It is recommended to continue this study to analyze the opportunity to employ the NDVI time series for detection of environmental degradation related to the use and occupation of land in near real time. To this end, the use of images of other satellites with lower spatial resolution is essential to detect the pixels of a scene that are below the Landsat 5 image boundaries.

For better monitoring, confirmation in the field or use of RapidEye satellite images is necessary, which have a spatial resolution of 5 meters and often a day in areas where there is a greater centralization of pixels detected as deforestation.

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