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Hyperspectral analysis in areas of Caatinga degraded in the municipality of Sertânia - PE

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Abstract

The brazilian region semiarid has as predominant vegetation the caatinga. The Caatinga Forest has one of its striking features its excellent adaptation to arid conditions. This exclusively brazilian ecosystem has a great biodiversity, but promote their preservation is a major obstacle to be overcome, one is the best knowledge of their chemical and physical processes. Thus the hyperspectral remote sensing can help enough in the characterization and monitoring of this ecosystem, where the hyperspectral data collected by these sensors can be transformed into different information biophysical aspects of vegetable toppings. In this work was used images hyperspectral of the Hyperion Satellite Earth Observing1 sensor (EO-1). The software utilized for analysis and the pre-processing of the image was the ENVI 4.4. Software where we generated the NDVI vegetation index (Normalized Difference Vegetation Index) and the indexes of leaf pigments PRI (Photochemical Reflectance Index), SIPI (Structure Insensitive pigment Index) and CRI (1 Carotenoid Reflectance Index).The indices generated answered well to the structure of the cover and characteristics vegetation. Allowing this way, get more accurate data of vegetation indices and leaf pigments such, as chlorophyll and carotenoids.

Keywords: Caatinga; hyperspectral; hyperion; pigments; remote sensing

1. Introduction

The region semiarid of Brazil has as predominat vegetation the caatinga, ecosystem that extend for almost all Northeasterns states and goes until the North of Minas Gerais. The caatinga vegetation is undergoing a historical process of degradation for the implementation of agricultural practices and agricultural activities, which occupy vast tracts of land. The region economy is strongly linked to the exploration of the natural resouces, developed most times without any major concerns with the conservation of ecosystem (Santos et al., 2009; Albuquerque et al., 2010).

Caatinga Forest has one of its striking features its excelent adaptation to arid conditions and has a varied physiognomy. This ecosystem is greatly importance from the biological point of view , thereby, through studies on the fauna and flora, noticed a considerable number of endemic species (Silva et al., 2010).

In spite of being the only exclusively brazilian ecosystem, little attention has been given to the conservation of caatinga, as only 1% of its area is protected by conservation units. Caatinga is also the least known ecosystem scientifically and one of the most anthropized, surpassed only by Atlantic Forest and Cerrado (Cavalcante, 2009). It is notewothy that, in respect to vegetation recoverability, an area with 21 hectares of caatinga cleared for logging, will only have a similar volume production after 15 years (Sá et al., 2010).

Promote the caatinga conservation is not simple, since major obstacles must be overcome. One of them is a better knowledge of physical and chemical processes of vegetation. Infornations about these properties, such as inter al structure and leaf pigments, are very important, but difficult to access because it requires a long time do obtain these data by traditional methods.

The hyperspectral remote sensing has become a very useful tool in monitoring of terriestrial ecosystem. With great potential for advancement in the research of physical and chemical knowledge of forest in large spatial scales. The data collected by these hyperspectral sensors have a large number of narrow spectral strips and can be turned into different information biophysical aspects of green roofs. Researches about the vegetation gain prominence, to seek knowledge of its variations, distribuition pattern, cicle, and physilogical and morphological changes, from this important element of ecosystem (Galvíncio et al., 2011; Espíndula et al., 2012).

Given the above, the objective of this study is to determine the interference of physical and chemical properties of caatinga vegetation, as its spectral behavior.

2. Materials and methods

The study area is part of the municipality of Sertânia, located in Pernambuco Sertão do Moxotó microregion (Figure 1). The municipality is limited to the north with Iguaraci, the south is limited with Ibimirim, Tupanatinga, Buíque and Arcoverde, west with Custódia and the east with state of Paraíba. The region covers an area of 2421.51 km², with geographical coordinates ("08º 04 '25 "S; 37º 15' 52"; 558m), and is part of the river basin Moxotó. Also its climate is semi-arid with an average temperature of 25 °C and rainfall of 635 mm. The predominant vegetation is the caatinga hiperxerófila.

We used to performing the work a hyperespectral image of Hyperion sensor, aboard the Earth Observing Sattelite 1 (EO-1) of the National Aeronautics and Space Administration (NASA), launched on 21 April 2000, with aim to realize a technological mission that lasted one year. After completing their mission, the purpose of project EO-1 was to provide the acquired images for the scientific community.This sensor has 242 spectral bands, of which 198 are calibrated, and thus divided between bands of the visible infrared, infrared near (VNIR) and shortwave infrared (SWIR). The individual bands has the width of 10nm with a spatial resolution of 30 meters, operating in an orbit of 705 km, covering 256 pixels of image.

The Hyperion images are available in the United States Geological Survey website (USGS). The scene acquired for this work was the EO1H2150662002290110PZ_SGS_01 of the period from 17 October of 2002, orbit 215, row 66, available on the websit in Geotiff format.

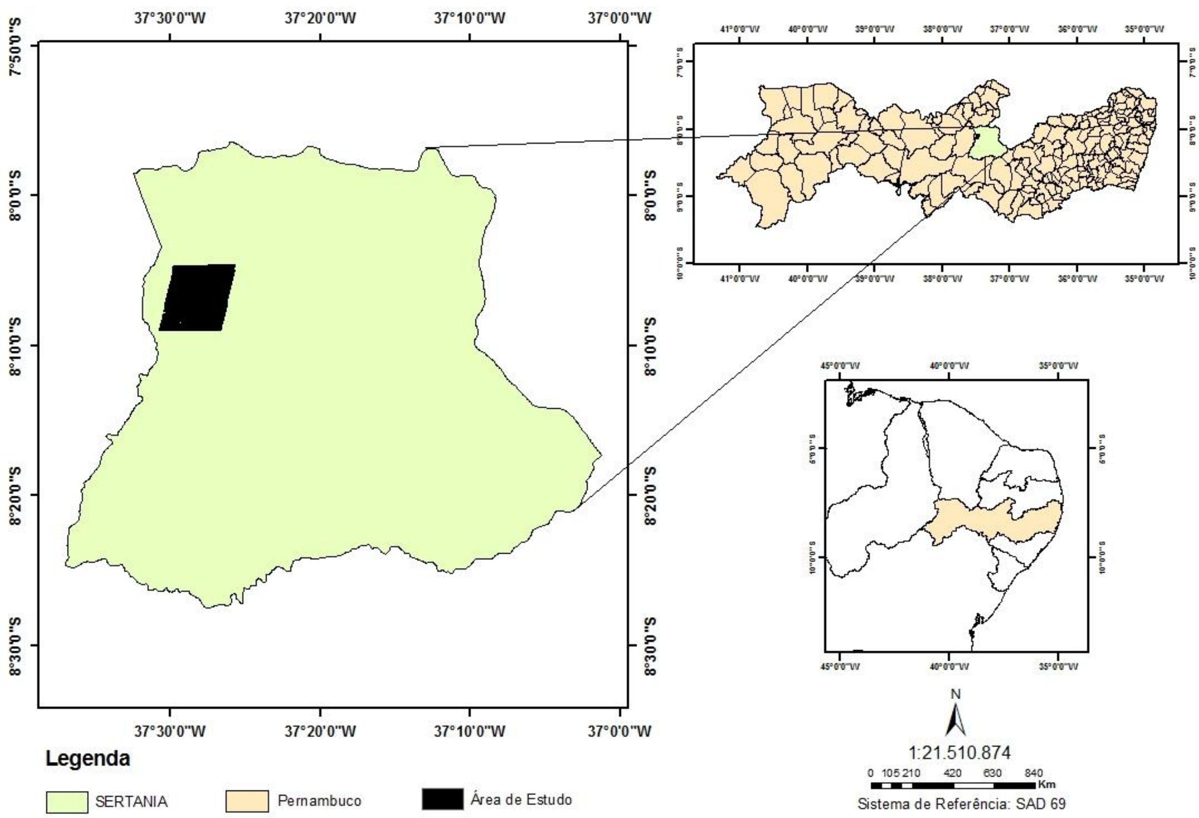

Figure 1-Localization map for study area.

We conduct the pre-processing of the images in the ENVI 4.4 software, licensed by the Remote Sensing Laboratory and GIS (SERGEO), located in the Department of Geographical Sciences on the University of Pernambuco (UFPE). The processing steps consisted in converting the images to ENVI format, utilizing of the IDL Hyperion Tools, which can be acquired at the following address: http://www.ittvis.com/UserCommunity/CodeLibrary.aspx.

After the conversion to ENVI format, was accomplished the cropping on the image to a smaller area, this area is inserted inside of the municipality of Sertânia - Pernambuco, where the biome *Caatinga* is predominant, however, is observed an advanced stage of degradation. Then we process the atmospheric correction using the module FLAASH ENVI 4.4 software, the more suitable for hyperspectral data correction. The paremeters used to make the correction were: lat (8°49’ 31’’S), long (37° 35’ 04’’W), sensor type (Hyperion), sensor altitude (705 Km), elevation ground average (0.5), pixel (30), date (10/17/2002), time (12:24:22), tropical atmospheric model, rural aerosol model, thickness of the water column (2) and initial visibility (30 Km). After the atmospheric correction, the next procedure was the exclusion of the bands uncalibrated of the visible infrared, near infrared and shortwave infrared, using only those that comprising the ranges of 8 - 57 (VNIR) and 77 - 224 (SWIR).

Following the steps of image calibration, we will begin the calculation of vegetation indices that are necessary for the purpose of this study, for which we used the vegetation tool "índex calculator", inserted in ENVI 4.4 software. The calculated indices were the Normalized Difference Vegetation Index (NDVI), Structure Insensive Pigment Index (SIPI), Photochemical Reflectance Index (PRI) and Carotenoid Reflectance Index 1 (CRI 1).

The NDVI - Normalized Difference Vegetation Index, initially proposed by Rouse et al (1974) has a capable of "measure" the spatial and temporal distribution of vegetation vigor. The same index can be estimated from the contrast between the maximum absorption in the red band, which if gives through the cell structure of the sheet (Haboudane et al., 2004). We use narrow spectral bands to quantify through of the equation described the below:

$$NDVI = (R_{800} - R_{670}) / (R_{800} + R_{670}) \quad \text{Eq 1.}$$

Where, R800 is the reflectance in the range of 800nm and R670 is the reflectance in the range of 670nm.

Regarding SIPI (Equation 2) and PRI (Equation 3), these were used according to relationship with efficiency in the use of light. The SIPI is a structural index that allows the comparison between carotenoids and chlorophyll. As to the PRI, it indicates the maximum use efficiency of photosynthetic active light, widely used in stress studies and vegetation productivity according to Galvíncio et al., (2011).

$$SIPI = (R_{800} - R_{445})/(R_{800} - R_{680}) \quad \text{Eq 2.}$$

Where, R800 is the reflectance in the range 800nm, R455 is the reflectance at 445nm and R680 is the reflectance in 680nm.

$$PRI = (R_{531} - R_{570})/(R_{531} - R_{570}) \quad \text{Eq 3.}$$

Where R531 is the reflectance in 531nm and R570 is the reflectance in 570nm.

The last estimate index, the CRI 1 (Equation 4), is the parameter for analyzing the absorption of the incident radiation and also the dissipation of excess energy absorbed (Amaral et al., 2009).

$$CRI\ 1 = \left(\frac{1}{R_{510}}\right) - \left(\frac{1}{R_{550}}\right) \quad \text{Eq 4.}$$

In which R510 is the reflectance on the 510nm range, and R550 is the reflectance on the 550nm range.

Have been followed the steps of estimating the indices of vegetation and pigments, the images were saved in Geotiff format and exported to the GIS plataform (ArcGIS 9.3 software), licensed with the Remote Sensing Laboratory and GIS - DCG/UFPE, where the images layouts were performed.

3. Results and discussion

In Figure 2, it is represented the Normalized Difference Vegetation Index (NDVI) for the clipping of the hyperspectral image, inserted in Sertânia-PE municipality. The NDVI can range from -1 to +1 and the closer to 1 the value of the index, the greater the density of the vegetation cover (Santos et al, 2009). For image analysis, the index values are ranging between 0.0001 to NDVI> 0.6, the negative values were excluded from the rating by match to the bodies of water present in the area.

The areas represented in the image by values ranging between 0.0001 and 0.2, refer to the exposed soil. The classification ranging from 0.2001 to 0.3 indicates ground exposed to the presence of sparse vegetation. These two initial classes correspond to larger spatial area of the analyzed image, which occurs for two reasons, besides the degradation occurrent in the municipality because, according to Calixto Junior and Drumond (2011), Sertânia is inserted in a region where there is strong exploration of native vegetation for charcoal production purposes. It is also necessary to take into account the fact that the image in question is dated the dry season, where the vegetation of Caatinga, being hyperxerophilic, lose foliage and ends up being classified by the vegetation index as exposed soil areas.

The areas with a predominance of dense Caatinga vegetation have the NDVI values ranging from 0.3001 to NDVI> 0.6 in the image, revealing a more developed vegetation, represented in the classification in four shades of green and .

concentrated mostly near the watercourses, which probably resist the dry season in the region.

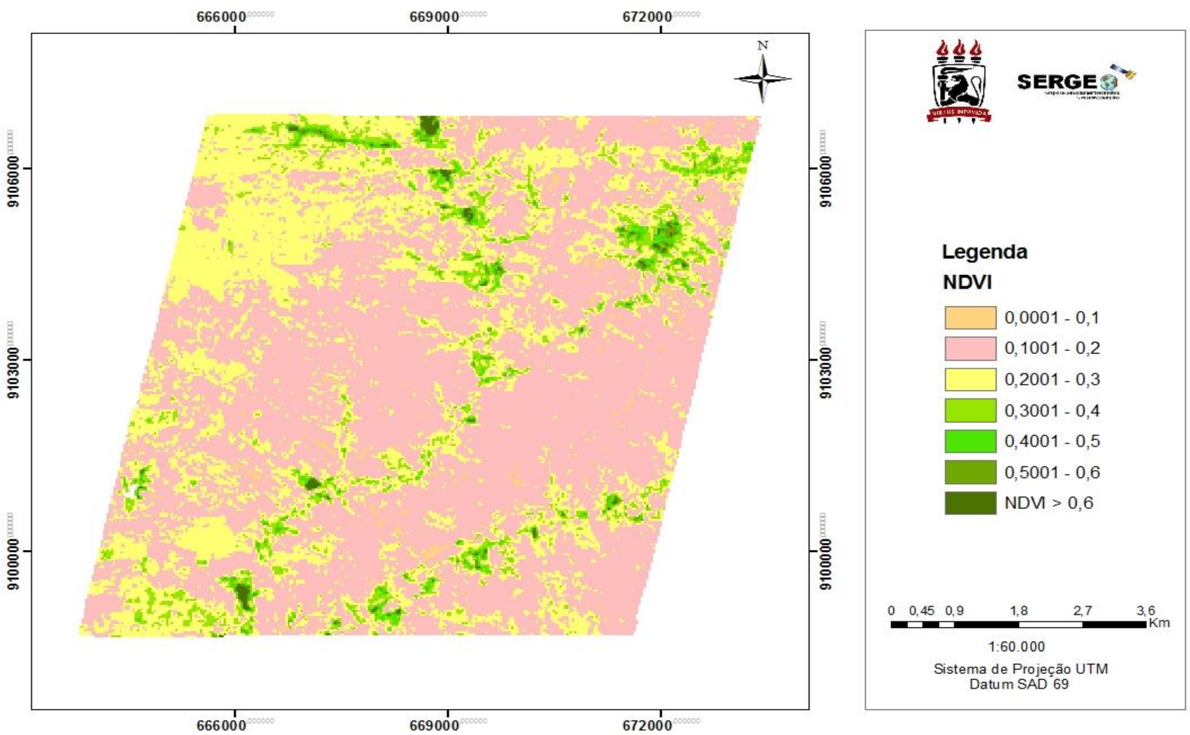

Figure 2 - NDVI for hyperion image of the municipality of Sertânia.

The pigment index represented in Figure 3, is the Photochemical Reflectance Index (PRI), which normally varies between -1 and 1, and can be observed in the image with values ranging between -0.2 and -0.03, the values are divided into three classifications, and express a good use efficiency of photosynthetic light by vegetation, the highest values ranging from -0.09 to -0.03 The highest values ranging from -0.09 to -0.03, represented by the darker green and distributed in most of the vegetation area present in the image.

The values of Structure pigment content Pigment Insensitive Index (SIPI) observed in Figure 4 can vary between 0 and 2. In the image below the values feature three classifications and are divided into SIPI <1.4; SIPI 1.4001 to 1.6 and> 1.6, appearing well distributed throughout the vegetation area in the image. Higher values exceeding 1.6, indicate a vegetation with higher concentration of carotenoids. Thus, it is understood that the vegetation it is realizing a larger dissipation of photosynthetically active radiation.

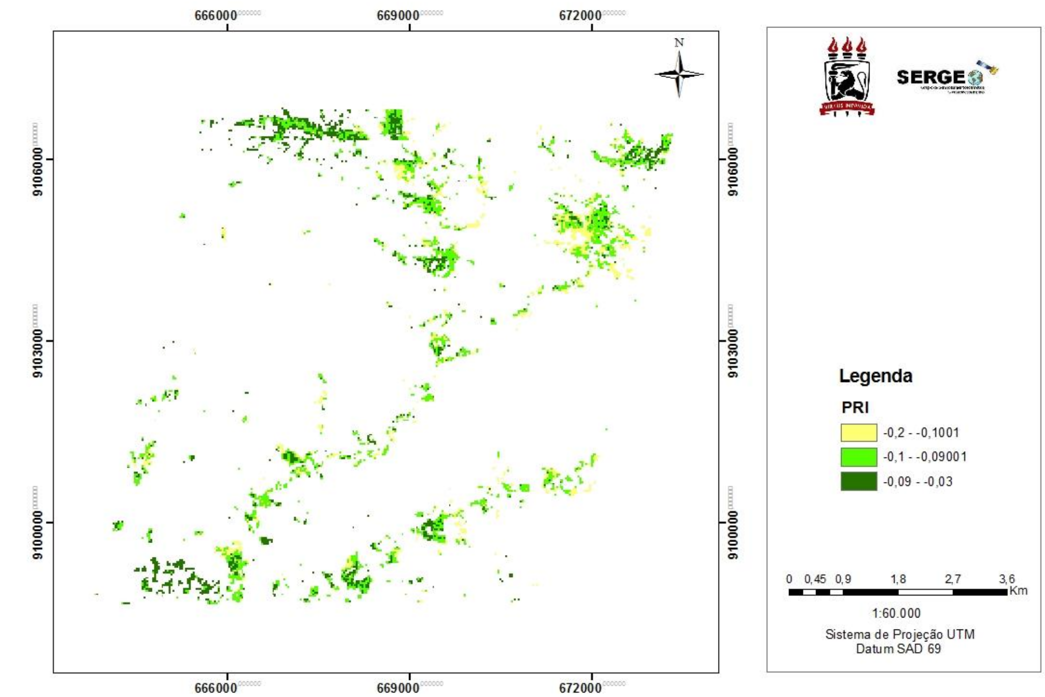

Figure 3 - PRI for hyperion image of the municipality of Sertânia.

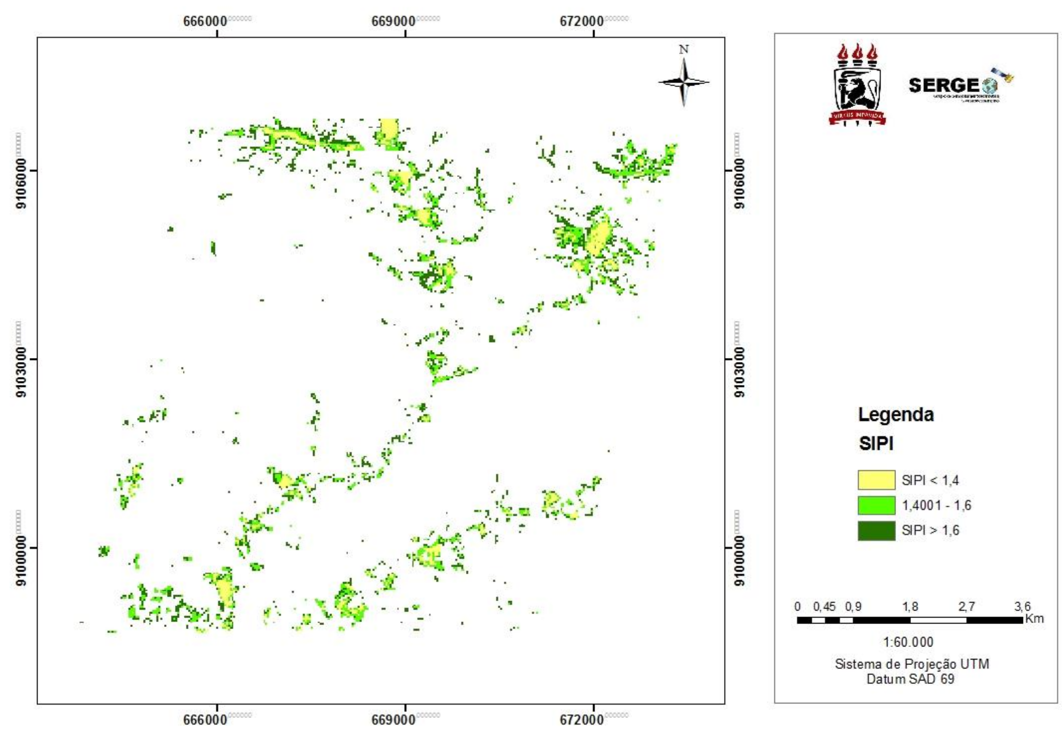

Figure 4 - SIPI for hyperion image of the municipality of Sertânia.

The Carotenoid Reflectance Index 1 (CRI 1), can range from 0 to more than 15 and is represented in Figure 5, that reveals the predominance of vegetation with lower values of carotenoid pigments in this area, however, there are areas with higher levels of carotenoids, which correspond to classification ranging from 8.2001 to CRI> 13.3, represented in the image by darker shades of green, presents in some points.

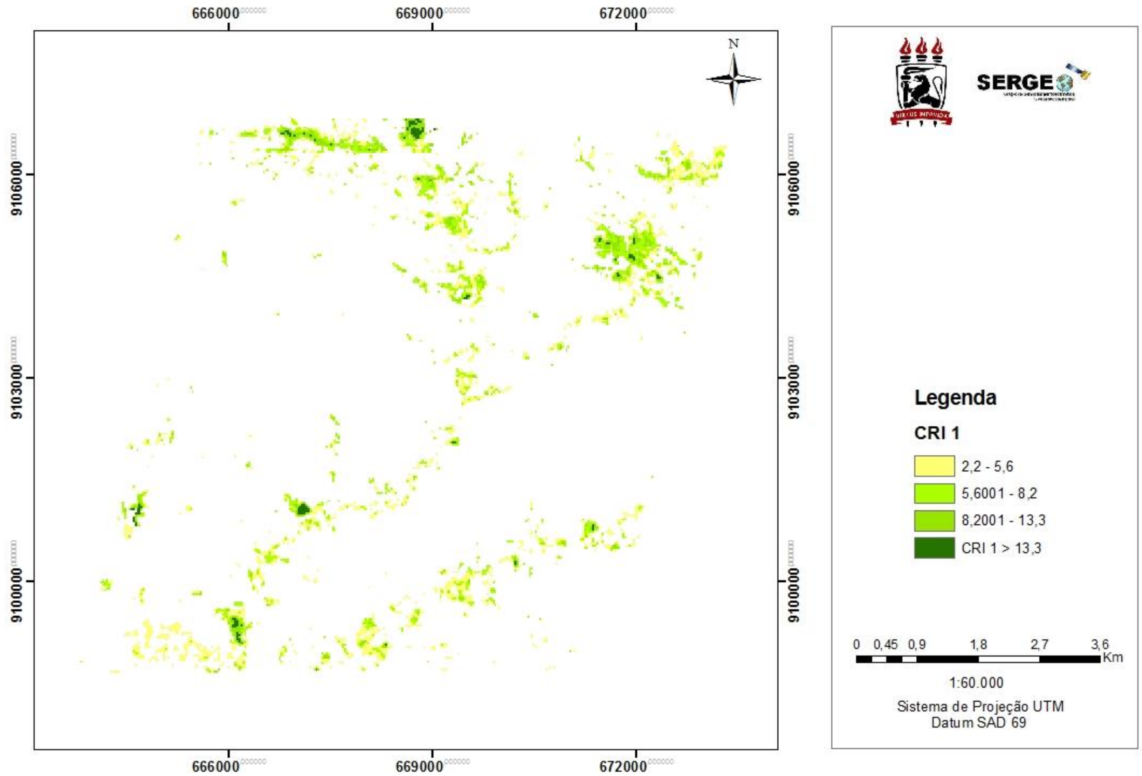

Figure 5 - CRI 1 for hyperion image of the municipality of Sertânia.

4. Conclusions

Considering the presented, it was observed that the indexes responded well the structure of the vegetation cover. With the use of hyperspectral remote sensing, it became possible to analyze spectral response of vegetation, through images that have high spectral resolution and space, enabling this way, get more accurate data of vegetation indices and leaf pigments such as chlorophyll and carotenoid, thus allowing, evaluate the interferences of the physical and chemical properties of the vegetation.

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