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ANALYSIS OF LAND COVER AND USE THROUGH THE SOIL-ADJUSTED VEGETATION INDEX (SAVI) IN THE CONTEXT OF ENVIRONMENTAL DEGRADATION IN THE MUNICIPALITY OF LAJEDO/PERNAMBUCO, NORTHEAST, BRAZIL

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RESUMO
A vegetação corresponde a um importante componente na dinâmica das paisagens, a partir disto, o presente estudo buscou reconhecer a cobertura do solo no município de Lajedo Pernambuco analisando os processos de degradação relacionado isto as condições de densidade vegetal por meio do índice de vegetação ajustado ao solo (SAVI). Como resultado, obteve-se as classes de vegetação densa (18,298km²) localizadas sobre as margens fluviais, áreas agrícolas com elevada atividade fotossintética (associado ao ciclo do Cultivo), cuja maior área encontra-se no extremo norte do município na zona rural; vegetação semidensa (39,188km²) esta classe contém espaçamento entre a vegetação, identificada maiormente em alguns pontos das margens fluviais e circundando os reservatórios hídricos constituído por extrato arbustivo e gramíneo; vegetação esparsa (109,106km²) refere-se as áreas sem vegetação adensada em maiores parcelas de solo exposto, tendo seu uso vinculado principalmente a pastagem com animais de porte diversificado, como também, áreas agricultáveis; e ausência de vegetação (22,450km²) composta por áreas construídas, reservatórios hídricos e solo exposto. O índice de vegetação corroborou na análise da cobertura do solo, sendo perceptíveis em campo alguns processos de degradação acertados com as classes que apresentou menor ou ausência de atividade fotossintética.
Palavras-Chave: Sensoriamento remoto; Geoprocessamento; Índice de vegetação; Degradação ambiental.

ABSTRACT
The vegetation corresponds to an important component in the dynamics of landscapes, from this, the present study sought recognize the soil cover in the municipality of Lajedo Pernambuco to analyzing the degradation processes related to the conditions of plant density through the vegetation index adjusted to the soil (SAVI). As a result, the classes of dense vegetation (18.298km²) located on the river banks were obtained, agricultural areas with high photosynthetic activity (associated with the Cultivation cycle), whose largest area is in the northern end of the municipality in the rural area; semi-dense vegetation (39.188km²), this class

contains spacing between the vegetation, identified mainly in some points of the river banks and surrounding the water reservoirs constituted by shrub extract and grass; sparse vegetation (109.106km²) refers to areas without dense vegetation in larger portions of exposed soil, with its use mainly linked to pasture with animals of different sizes, as well as arable areas; and absence of vegetation (22,450km²) composed of built-up areas, water reservoirs and exposed soil. The vegetation index corroborated the soil cover analysis, being noticeable in the field some degradation processes agreed with the classes that showed less or absence of photosynthetic activity.

Keywords: Remote sensing; Geoprocessing; Vegetation index; Ambiental degradation

INTRODUCTION

Landscape is a term widely used in geographic studies to analyze and understand the space around it. The landscape can be defined as an inheritance, an evolution over time through physiographic and biological processes or as a portion of space, resulting from dynamic and unstable combinations of physical, biological, and anthropic elements, making it dynamic and making it in perpetual evolution (AB'SÁBER 2003; BERTRAND 2004; MAXIMIANO 2004.)

In view of the multiple landscapes, the Brazilian semiarid region is distinguished by being a region that covers a good part of the central northeast, with remarkable climatic characteristics, with a maximum annual rainfall of 800 mm, which can reach 1000 mm in the areas of high swamps of altitude, with average annual temperatures from 23°C to 27°C, with strong insolation, relatively high temperatures and a rainfall regime marked by scarcity, irregularity and concentration of precipitation in a short period (SILVA *et al*., 2010).

The natural singularities of the semiarid region are essential to understand its potential, however, one should also pay attention to socioeconomic aspects, as they directly influence the appropriation of resources without necessarily recognizing their limitations. Thus, the demand for resources is intensified by population growth where depleting actions are commonly exercised in the environment, these changes are announced mainly by the extraction and replacement of natural plants (OLIVEIRA *et al*, 2020). In this regard, Guerra and Cunha (2004) point out that degradation must be understood as a process associated with the pressures exerted by society, linked to the patterns of land use appropriation.

In this perspective, the environmental conditions and their interactions can be visualized in the face of the vegetation aspects that match all the influences of the environment. Therefore, vegetation almost always behaves as a true synthesis of the landscape (BERTRAND, 2004).

Linked to this context, it is noted that the advancement of geographically based technologies (georeferenced) provide increasingly accurate diagnoses in a multiscale way in time and space. Among the various possibilities of using geotechnologies and geoprocessing for environmental studies, vegetation indices have been widely used to highlight aspects corresponding to plant density, inferring soil cover for various purposes of environmental planning and monitoring (FITZ, 2020; SANO *et al*. 2019).

In view of the above, the present study sought to analyze the soil cover considering the plant density as a parameter for identifying areas in the process of degradation in the municipality of Lajedo-PE, using geotechnologies as a support for the interpretation of the cover and use of the land through the production of the soil-adjusted vegetation index-SAVI.

METHODOLOGY

The present research was developed in office stages (theoretical-methodological survey and technical application of geoprocessing) and in the field. The first moment consists of collecting bibliographic information concerning remote sensing, Geographical Information System-GIS, Caatinga Biome, degradation of vegetation cover and environmental planning.

In this sense, the considerations of the literature allowed the recognition of applied studies, having the vegetation cover analyzed from the vegetation index. Among the different methods and techniques, the soil-adjusted vegetation index developed by Alfredo Huete in 1988 is of paramount importance when it comes to the vegetation of the Caatinga for mitigating soil interference in the spectral response (RIBEIRO, SILVA and SILVA, 2016).

Therefore, Huete (1988) indicates adjustment values (L) of the index formula that can vary between 0.25 when the vegetation is dense to 1 when the surface has a sparsely distributed vegetation. The value used in the present study is 0.5 being applied to coverage with intermediate density. The SAVI equation is calculated according to the formula (01) described below:

$$SAVI = \frac{(1+L)*\rho iv-\rho v}{L+\rho iv+\rho v} \qquad (01)$$

Where: piv is the infrared band, ρv is the red band and L is the adjustment fator

To achieve the SAVI result, the procedures of i) acquisition, ii) pre-processing and iii) processing of satellite images were adopted.

i) At first, the data referring to the satellite image and Pluviometric data of the municipality were obtained. The satellite used was Sentinel-2 with data from the MSI (Multispectral Imager) sensor available on the United States Geology Service (USGS) website, using a scene on 03/07/2018 (rainy period).

i) The choice of scenes was recommended by collecting monthly rainfall data where the rainy and dry months were distinguished, using the image of the period with the highest precipitation index, with reference to information from the Agência Pernambucana de Águas e Clima -APAC.

ii) After obtaining the sentinel-2 images, pre-processing was performed with Qgis software (version 3.10). Initially, atmospheric correction and conversion to Bottom Of Atmosphere Reflectance (BOA) were applied, using the DOS1 (Dark Object Subtraction) model in spectral bands 4 (red) and 8 (near infrared), both with a spatial resolution of 10 meters.

iii) Then, the digital image processing (PDI) was performed using the QGis Software (version 3.10), performing the vegetation index (formula 01).

Through the result of the index, it was possible to classify the cover with the following classes: Dense vegetation (areas that presented high photosynthetic activity), Semi-dense vegetation (Category with lower canopy density, where there may be spacing of bare soil between the plant extract, as well as areas colonized by grasses and shrubby vegetation), Sparse Vegetation (In this category the vegetation shows low vegetative vigor, in areas with patches of exposed soil distributed in greater proportion) and the last class refers to places with no vegetation. The measurement of the classes occurred through the interpretation of SAVI and false color composition 8(R)-2(G)-3(B), where the pixel values corresponding to different spectral responses were grouped, finally, the field to identify the results obtained in GIS, verifying the categories indicated as lower density of vegetation.

RESULTS AND DISCUSSIONS

The municipality of Lajedo is in the northeast of Brazil, more precisely in the state of Pernambuco, inserted in the mesoregion of Agreste and in the microregion of Garanhuns (Figure 1), being crossed by highways BR-423, PE-180 and PE-170; with a distance of 191.1 km² from Recife, capital of the state. According to IBGE (2019) the population of Lajedo is estimated at 40,589 thousand inhabitants for 2020, with a population density of 193.70 inhab/km².

The physiographic characteristics of the municipality is understood by its insertion in the regional geomorphological compartment of the Borborema plateau, which in turn, constitutes an arched structure that holds altitudes between 500- and 1,000-meters denoting portions with flattened and degraded relief patterns carved in massive structures with ductile (bent) and failed blocks in the crystalline dating from the Precambrian (SILVA, 2008).

Lithology is formed by igneous and metamorphic rocks distributed in different lithological units. Regarding soils, three types are present in the municipality, classified up to the second categorical level (suborder), such as: Regolithic Neosol, Yellow Argisol and Haplic Planosol (EMBRAPA, 2011). Furthermore, Lajedo is mostly under the hydrographic domain of the Rio Una basin, with the Chata, Quatis and Retiro rivers as tributaries; as well as the Bonito, Prata, Serrote, Carnijó and Doce streams with intermittent and ephemeral water regimes with dendritic drainage (CPRM, 2005).

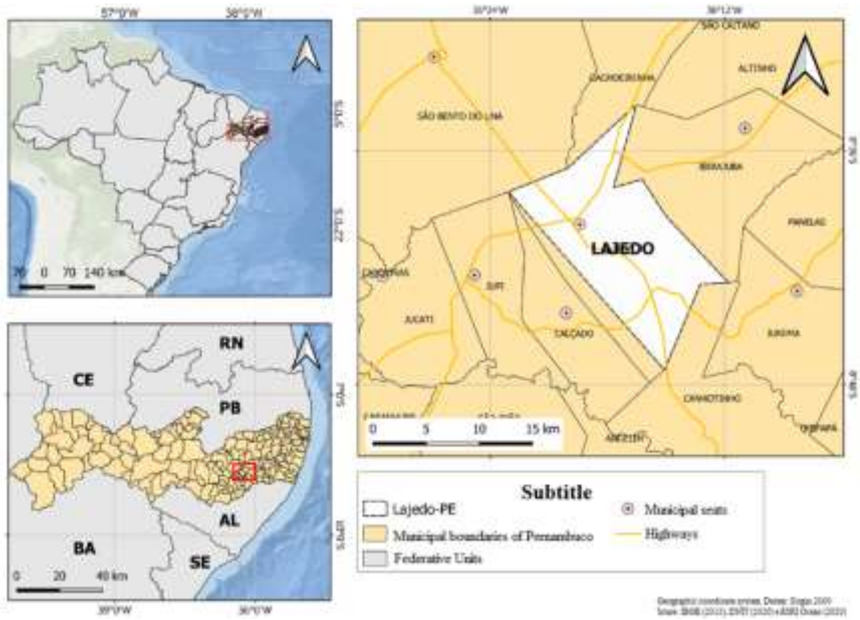

Figure 1: Location map
Source: Authors (2020).

From the vegetation index adjusted to the soil-SAVI, it was possible to classify the image through the density of the vegetation cover, taking the following classes: dense vegetation, semi-dense vegetation, sparse vegetation, and absence of vegetation, applying the index in the rainy season, as shown Figure 2.

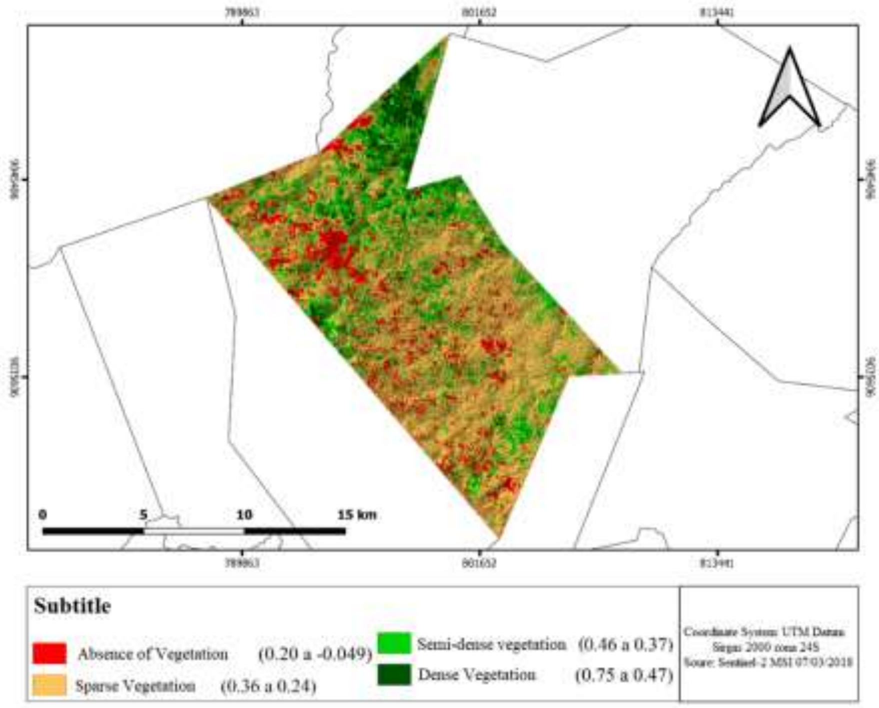

Figure 2: Soil-adjusted vegetation index-SAVI
Source: Authors (2020).

In view of the recognized categories, it is possible to quantitatively infer the dimension and land cover, therefore, an area with no vegetation is available for about 22,450 km² that includes different uses, that is, built area (anthropic use), water reservoirs (dams), bare soil with mining and temporary cultivation areas.

The sparse vegetation class comprises 109,160 km², which corresponds to areas without vegetation density that contain open plots with exposed soil between vegetation to a lesser extent, and areas with extensive pastoral activity with medium and large animals raised dispersed between the shrub extract and grass, as well as cultivated areas where the newly planted genus is in the growth period (phenological zonation).

The semi-dense vegetation covers 39,188 km² and presents a greater density than the previous class, however it contains smaller open spaces between the vegetation. In addition, it is located mainly on the banks and on river channels and water reservoirs colonized with shrubs and grasses, spatially arranged in a heterogeneous way, not following a pattern in the landscape, constituting, also, portions referring to agricultural spaces. Finally, the dense vegetation dominates 18,298 km² distributed in some points on the riverbanks, agricultural areas with high photosynthetic activity and located in areas with soil completely covered by shrub vegetation.

In view of the grouped and previously mentioned categories, it is worth mentioning that SAVI presents results that vary between -1 and 1, with negative values indicating little or no plant activity, whereas values close to zero indicate vegetation open to soil with vegetation of low size and estimates close to 1 correspond to less sparse vegetation with more homogeneous and dense coverage.

Analyzing the rainfall data to obtain the results, the importance of understanding the period of data acquisition was evidenced, as Perez *et al* (2004) indicate the conditions of high photosynthetic activity of the caatinga after precipitation events. Thus, precipitation conditions the distribution of vegetation cover and biomass in dry lands, with the rainfall parameter as a fundamental input in understanding the changes in areas covered by caatinga (CUNHA *et al* 2012; LIMA and ALMEIDA, 2017).

For the research, the period with the highest concentration of rainfall was considered, which began in the month of January to May 2018, with an average of 75.54 mm for the wettest months, therefore, the production of SAVI took the image in the month of March (75.3mm), which exceeds the annual average (40mm), as shown in Figure 3.

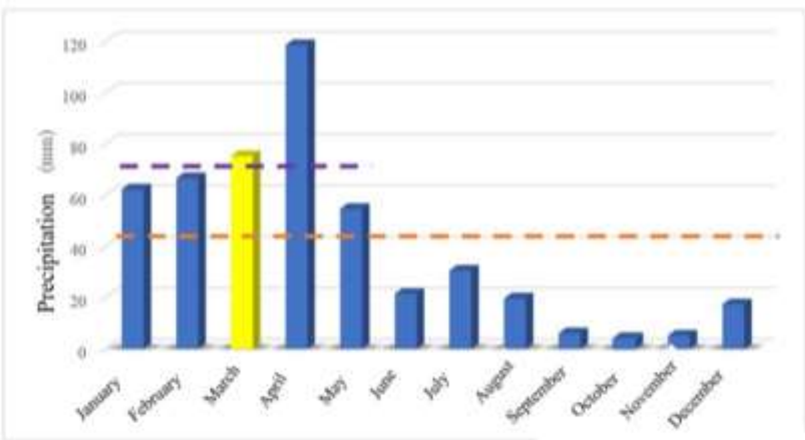

Figure 03. Monthly rainfall data for 2018, average purple dashed line of the rainiest months of the year analyzed, annual average orange dashed line. Yellow column represents the month of the acquired image (March). Source: APAC (2018) adapted by the authors (2020).

Completing the considerations of the importance of pluviometric data in diagnosing the vegetation behavior of the caatinga, the period of higher precipitation index has repercussions on greater availability of water in the pedological system, characterizing the moment of leaf maturation in the phenological cycle. In this context, Lajedo presents a plant physiognomy with deciduous and subdeciduous characteristics, with the loss of leaves partially or completely during water scarcity, however, the leaf composition resumes after rainfall events (CPRM, 2005).

Through this aspect, it is possible to affirm that the period of acquisition of the scene represents the favorable moment for the water availability in the soil, where it can be understood that the areas that have low photosynthetic activity (with the exception of the urban area) consist of potential or already degraded spaces, however, other aspects must be considered, such as the type of cultivation and the moment of acquisition of the image, since temporary agriculture activities predominate in the municipality.

Furthermore, it is necessary to indicate the suppression of vegetation resulting from the productive activities developed in the municipality, with agricultural practices being one of the main productive activities. In line with this, the planted and harvested areas intended for temporary agriculture in 2018 represent 1730 hectares, with regard to permanent cultivation, this is available according to the agricultural census for 315 hectares with production. In 2018, livestock has a total of 1,000,456 small, medium and large animals (IBGE, 2017; 2018).

Coalition of statistical information on land use allows clarifying indiscriminate issues in remote sensing. Thus, native and cultivated vegetation have temporally distinguishable spectral characteristics considering the phenological stages seasonally changeable during a year (SANO and BORGES, 2019).

In this way, the activities carried out on the ground demand the total or partial removal of the natural vegetation cover, in this perspective it was evidenced in some points of the areas with lower vegetation density (sparse, semi-dense and absence) the result of degradations linked to changes in vegetation cover.

Therefore, at some points soil compaction processes were visualized in mining areas (Figure 4A, coordinates 8°40'3.02"S / 36°20'6.90"W), as well as erosive features related to concentrated surface runoff associated with soil compaction and plant deprivation or areas of natural and cultivated pasture (Figure 4B, coordinates 8°39'50.08"S / 36°18'35.92"W), activities of extractivism and burning of vegetation were also recognized (Figure 4C, coordinates 8° 37.999'S/ 36° 18.304'W) that produces negative impacts responsible for the deterioration of the superficial horizons of the soil and making them more fragile to surface runoff.

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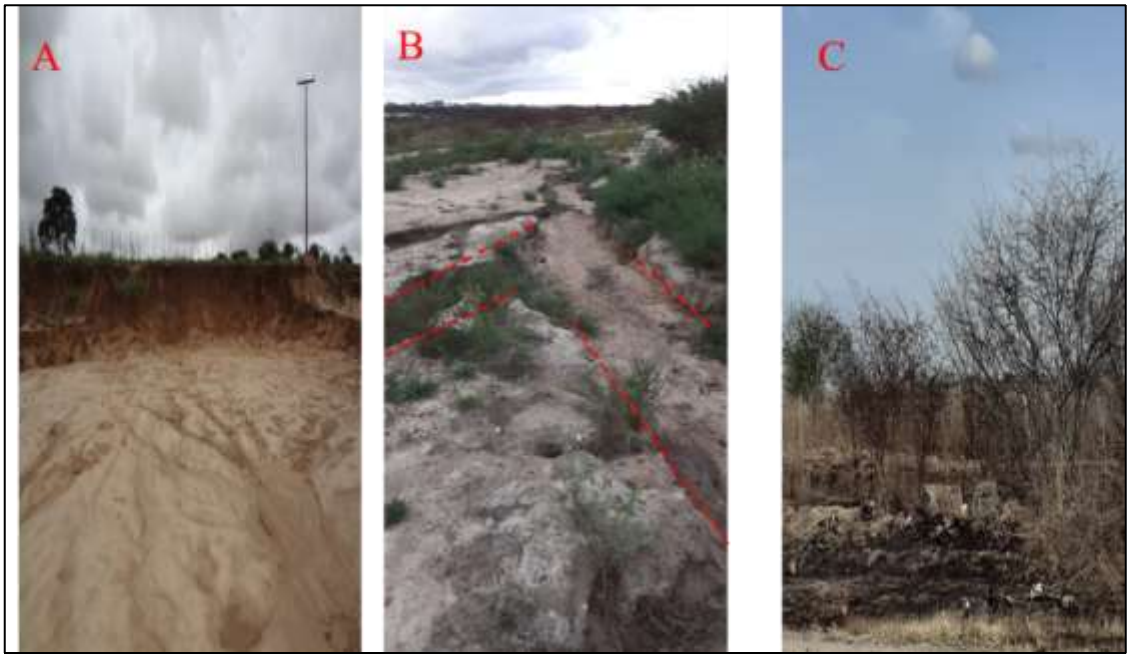

Figure 04: Degraded areas and in the process of degradation
Source: Authors (2020).

FINAL REMARKS

The research carried out made it possible to understand and spatialize land cover in the city of Lajedo/Pernambuco, considering plant density as a criterion, having as a procedural and technical basis based on geoprocessing and remote sensing data, which made it possible to identify areas with lower photosynthetic activity, touching, therefore, the in loco step to validate the information obtained in a GIS environment.

The soil-adjusted vegetation index (SAVI) met the demand of the study, comprising the entire land cover of the municipality. However, greater detailing of the information produced is necessary, incorporating land use and periodic monitoring through remote sensing, in view of the different uses of land in the temporal scale. Finally, the research consists of a pioneering analysis on a municipal scale that can promote actions aimed at the planning and management of degraded areas, especially in rural areas, so agricultural activities are important activities for the municipal economy.

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