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ANÁLISE TEMPORAL DOS ÍNDICES NDVI E SAVI NA BACIA DO RIO BANABUIÚ-CE

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RESUMO: A Caatinga é um bioma brasileiro de 734.000 km², que é constantemente ameaçado pela ação antrópica. Neste cenário, o presente estudo avaliou a eficácia dos índices espectrais NDVI e SAVI na análise de cobertura vegetal na bacia hidrográfica do rio Banabuiú, localizada na região central do estado do Ceará. Os índices NDVI e SAVI foram calculados e comparados para determinar sua assertividade em determinar áreas de vegetação. Os resultados mostram que é possível utilizar os índices para mensurar os danos causados pelo desmatamento nessas áreas

Palavras-chaves: Caatinga, vegetação, desmatamento.

TEMPORAL ANALYSIS OF THE NDVI AND SAVI INDICES IN THE BANABUIÚ-CE RIVER BASIN

ABSTRACT: The Caatinga is a Brazilian biome of 734,000 km² that is constantly threatened by anthropogenic action. Against this backdrop, this study evaluated the effectiveness of the NDVI and SAVI spectral indices in analyzing vegetation cover in the Banabuiú River basin, which is located in the central region of the state of Ceará. The NDVI and SAVI indices were calculated and compared to determine their assertiveness in determining areas of vegetation. The results show that it is possible to use indices to measure the damage caused by deforestation in these areas.

Keywords: Caatinga, vegetation, deforestation.

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1 INTRODUCTION

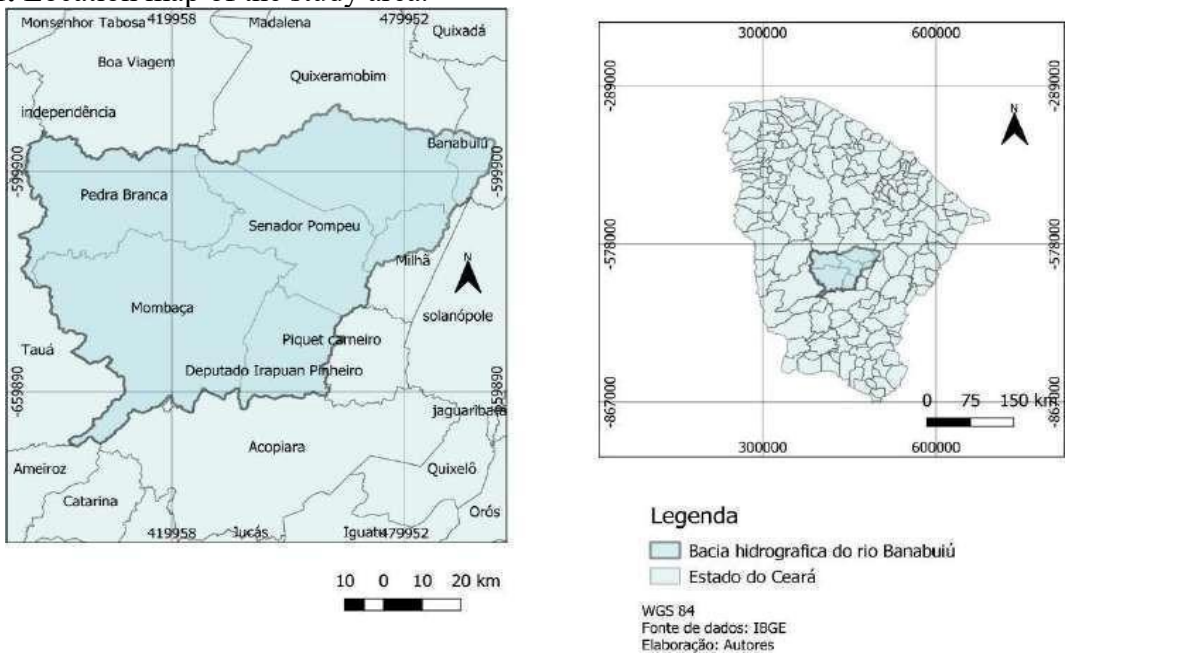
Located in the semiarid region, the Caatinga biome is located entirely in Brazil and covers an area of 734,000 km² (Souza; Artigas; Lima, 2015). This biome has long been exploited in an unsustainable way by humans, which has led to losses of floristic and faunal diversity, acceleration of the soil erosion process and a reduction in the quality of water in reservoirs (Beuchle). *et al.*, 2015). According to Bandeira *et al.* (2017), studying river basins in a semiarid context is important for a natural balance of the environment, especially because of their multiple uses, such as urban occupation, tourism and leisure, the use of water resources, agriculture and livestock.

Remote sensing, in this context, proves to be a valuable tool for assessing these levels of deforestation. Vegetation indices have the ability to minimize topographic effects by producing a linear scale of measurement that ranges from -1 to 1: "values close to 1 indicate dense vegetation cover," values close to 0 represent approximate values for the absence of vegetation, whereas negative values represent surfaces with water or flooded areas (Rego *et al.*, 2012). Therefore, this work aims to use *the normalized difference* vegetation index (NDVI)-normalized difference vegetation index and the soil-adjusted vegetation index (SAVI)-soil-adjusted vegetation index (SAVI) in plant analysis of the Banabuiú River basin-Ce.

2 MATERIALS AND METHODS

The research was carried out in the Banabuiú River basin in the central region of the state of Ceará, Brazil. This basin extends across eight municipalities in Ceará: Banabuiú, Quixeramobim, Milhã, Senador Pompeu, Pedra Branca, Mombaça, and Piquet Carneiro, as shown in Figure 1.

Figure 1. Location map of the study area.



To carry out this study, two images from the Landsat-8 satellite, the *Operational Land Imager (OLI) sensor, were used* through the database of the United States Geological Survey *(USGS). Survey - USGS).* On July 23, 2021, and August 14, 2023.

The two spectral indices, the NDVI and SAVI (equations 1 and 2, respectively), were calculated. The mapping of vegetation areas via the NDVI was developed on the basis of the behavior of the spectral response of bare areas in the near-infrared and red regions.

$$NDVI = (NIR - RED)/(NIR + RED) \quad (1)$$

where: NIR - band 5, near infrared *band infrared;* RED- band 4, red band (*red).*

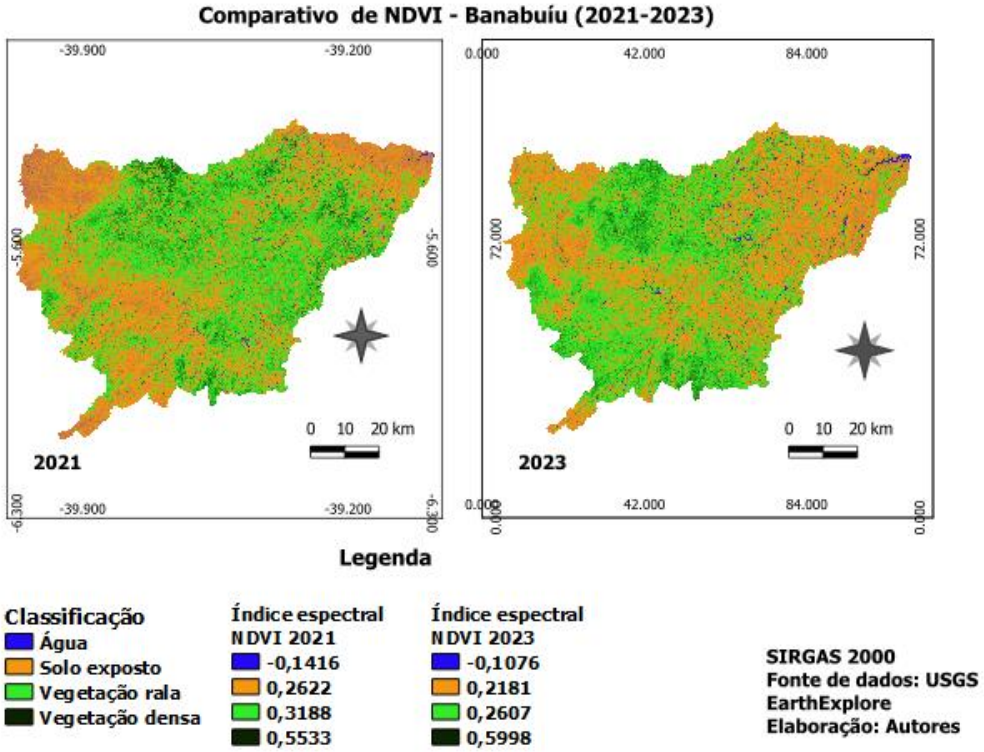
$$SAVI = ((NIR - RED)/(NIR + RED + L)) \text{ x } (1 + L) \quad (2)$$

where NIR is band 5, near *infrared band infrared; RED is band 4, red band*; and L is the constant for adjusting the effect of the ground on the canopy reflectance (0.5 for coverage areas with intermediate vegetation density).

3 RESULTS AND DISCUSSION

Figures 2A and 2B show the maps generated from the NDVI, referring to the dates of July 23, 2021, and August 14, 2023.

Figure 2. NDVI calculated for the Banabuiú basin with images from the Landsat 8 OLI sensor: (A) images from July 23, 2021; (B) images from August 14, 2023.

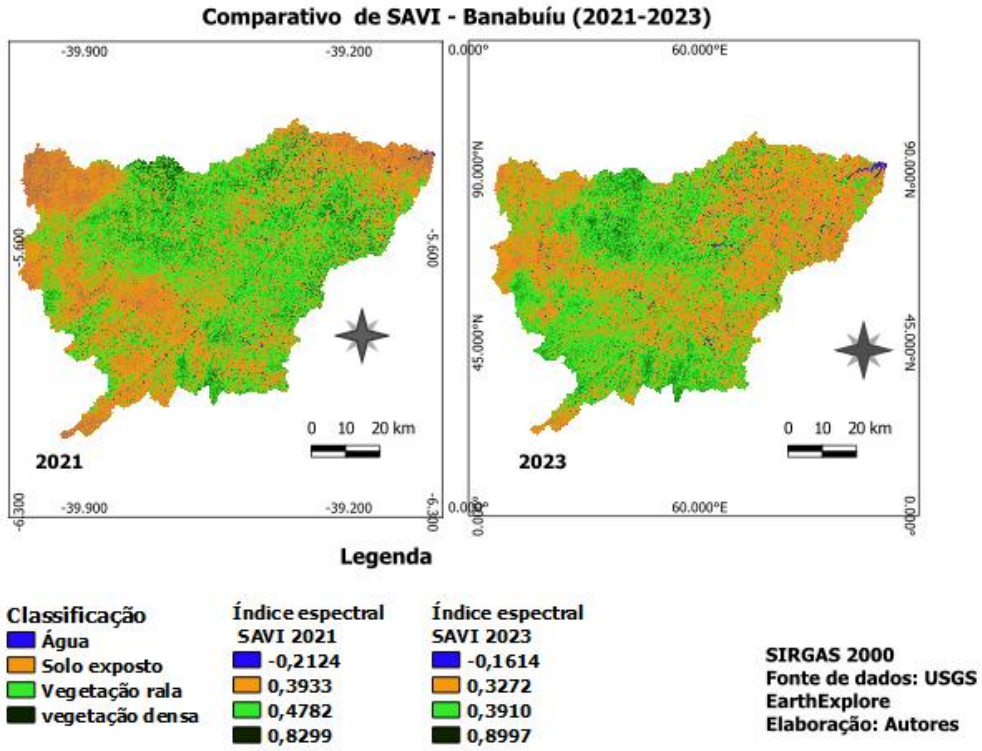


Figures 2A and 2B, corresponding to the years 2021 and 2023, respectively, identify areas with indices on a scale of 1--1. On this scale, values close to 1 suggest the presence of dense vegetation, values of approximately 0 indicate areas with little or no chlorophyll activity, and negative values are characteristic of water bodies. As noted by Sartori *et al.* (2009), areas with water availability may present low NDVI values in situations where exposed soil is predominant.

When the two images are compared, it is noted that in the 2023 image, there is a greater concentration of pixels with values close to zero, which is indicative of exposed soil or sparse vegetation. This fact can be explained in such a way that the greater the vegetation biomass is, the closer the pixels are to 1, and as this value decreases, the lower the biomass present.

Therefore, Figures 3A and 3B show the maps generated from SAVI, illustrating the years 2021 and 2023, respectively.

Figure 3. SAVI calculated for the Banabuiú Basin with images from the Landsat 8 OLI sensor: (A) images from July 23, 2021; (B) images from August 14, 2023.



The SAVI is an adaptation of the NDVI, which was proposed by Huete (1988). The SAVI incorporates an adjustment factor to mitigate the impact of soil presence on vegetation detection, especially in areas with light or dark soils, which helps reduce soil background effects.

Although not visually noticeable, the SAVI and NDVI present differences when the generated indices are analyzed. In SAVI, higher values are generally observed than in NDVI, as shown in Table 1. Positive values of the SAVI index indicate areas with vegetation, whereas negative values represent areas without vegetation or with bodies of water, as highlighted by Alvarenga and Moraes (2014).

Table 1. Linear regression and coefficient of determination of the developed models

Classes	NDVI 2021	NDVI 2023	SAVI 2021	SAVI 2023
Water	-0.1416	-0.1076	-0.2124	-0.1614
Exposed soil	0.2622	0.2181	0.3933	0.3272
Sparse vegetation	0.3188	0.2607	0.4782	0.3910
Dense vegetation	0.5533	0.5998	0.8299	0.8997

Through this difference in indices, it was possible to quantify the vegetation area via both indices, the NDVI and the SAVI, as shown in Table 2.

Table 2. Quantification of the vegetation area for the years 2021 and 2023 calculated via the NDVI and SAVI

Classes	Year 2021 (NDVI Area in hectares)	Year 2021 (SAVI area in hectares)	Year 2023 (NDVI Area in hectares)	Year 2023 (SAVI area in hectares)
Water	7.20	7.11	28.26	28.26
Exposed soil	215,002.89	214,998.21	214,908.94	216,137.45
Sparse vegetation	216,100.71	216,104.31	215,499.87	215,407.71
Dense vegetation	214,105.77	214,106.94	214,779.50	213,643.15
TOTAL	645,216.57			

4 CONCLUSIONS

Using the NDVI and SAVI indices, it was possible to determine, classify, and map the vegetation area of the Banabuiú River basin. The study demonstrated that these indices can be used to measure the damage caused by deforestation, serving as a basis for decision-making by competent authorities.

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