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IDENTIFYING ECOTOURISM ATTRACTIONS IN UBAJARA NATIONAL PARK (CEARÁ STATE) THROUGH REMOTE SENSING

Irene Suelen de Araujo Gomes[1], Anderson Guzzi[2]

[1]*Mestra pela Universidade Federal do Piauí, Teresina/PI. E-mail: irene_suelen@yahoo.com.br; https://orcid.org/0000-0002-8843-6882.*
[2]*Doutor em Zoologia; Professor da Universidade Federal do Delta do Parnaíba (UFDPar), Parnaíba/PI. E-mail: guzzi@ufpi.edu.br; https://orcid.org/0000-0001-7206-7683.*

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ABSTRACT

Tourism is among activities growing faster worldwide. Although it is a major global economic driver, it also largely contributes to environmental impacts. Therefore, ecotourism arose as an alternative to enjoy natural beauty without severely damaging nature. The aim of the present study was to identify the ecotourism attractions of Ubajara National Park (Ceará State) through Remote Sensing. This method involved land cover mapping and land-surface temperature measuring in order to detect both ongoing and potential activities. Ecotourism allows tourists to be closer to nature and widen their perspective on it. Such benefits can be seized by Ubajara National Park visitors through ecological trails and visits to the local cave, so they can come to understand the importance of conservation for maintaining the natural beauty of the Park. Flora and temperature in the Park's highland areas are different from those of its neighborhood; this difference creates a landscape different from that of most Ceará State regions, and it makes this park a suitable place for the development of birdwatching tourism.

Keywords: Ecotourism; Highlands; Birdwatching.

IDENTIFICAÇÃO DOS ATRATIVOS ECOTURÍSTICOS DO PARQUE NACIONAL DE UBAJARA – CEARÁ COM O USO DO SENSORIAMENTO REMOTO

RESUMO

O turismo é uma das atividades que mais cresce no mundo, mas apesar de ser um grande impulsionador global da economia, é um dos grandes responsáveis por impactos ambientais. Nesse cenário surge o ecoturismo como uma possibilidade de usufruir de belezas naturais sem causar severos danos à natureza. O objetivo deste trabalho foi identificar os atrativos ecoturísticos do Parque Nacional de Ubajara/CE através do Sensoriamento Remoto com elaboração de mapas de cobertura e uso do solo e de temperatura da superfície terrestre, informando sobre as atividades já realizadas e as de possível inserção. A influência das atividades do

ecoturismo proporcionam ao turista uma maior percepção e proximidade com a natureza através de trilhas com a possibilidade e conhecimento da importância da conservação como mantenedora das belezas do Parque. Conclui-se que o Parque possui fisionomias de vegetação e temperatura nas regiões de serra diferentes das regiões em seus arredores, produzindo um cenário com atributos diferentes dos observados na maioria das regiões do Estado do Ceará, sendo um local propício para o desenvolvimento do turismo de observação de aves (birdwatching).

Palavras-chave: Ecoturismo. Serra. Observação de aves.

INTRODUÇÃO

Ecotourism is the natural path of the global tourist activity. Brazil is among the main ecotourism destinations due to its diverse natural environment, which is ready for appreciation, although with responsibility and sustainability (PROCHNOW; VASCONCELOS, 2008). Ecotourism can benefit several social sectors, such as tourist trade (agencies, travel guides, among others), governmental areas, non-governmental organizations, populations, tourists and the academia (PIRES, 1998). This tourist category comprises the following principles: environmental responsibility; sustainability; nature conservation; environmental education measures; biodiversity and natural wealth awareness (BRASIL, 2010a).

There are several ecotourism destinations in Ceará State given its coastline, highland and hinterland landscapes, all of which offer several ecotourism activity options suited for different tastes. According to PRODETUR (Tourism Development Program) (BRASIL, 2011), Ubajara City was rated as the best ecotourism destination in Chapada da Ibiapaba region for housing the Ubajara National Park (UNP) — the most important sightseeing attraction in Chapada da Ibiapaba region, which attracts both Brazilian and foreign tourists — along with the cities of Tianguá and Frecheirinha. Therefore, the aim of the present study was to identify the sightseeing attractions of Ubajara National Park (Ceará State) based on Remote Sensing methods, such as land cover mapping and Land-Surface Temperature (LST), in order to assess ongoing ecotourism activities and to envision potential ones.

METHODOLOGY

Study Site

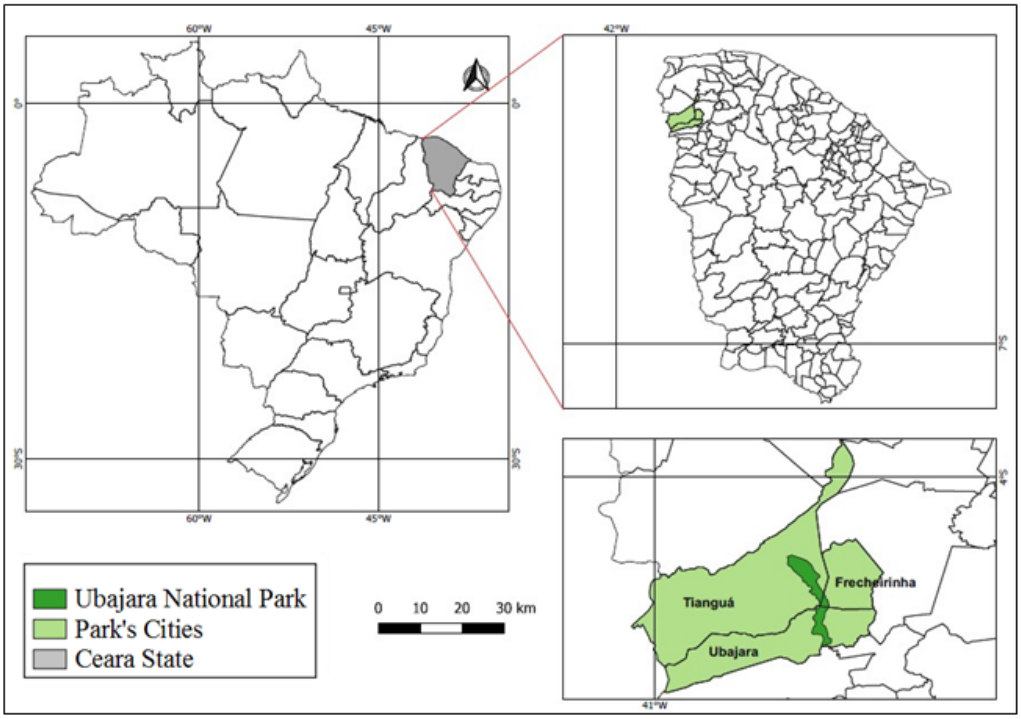
Ubajara National Park is located in Northwestern Ceará State, at latitude of 3° 46' S and Longitude of 40° 54' W (Figure 1). Its territory spreads through the cities of Ubajara, Tianguá and Frecheirinha. According to the last census (2010) of the Brazilian Institute of Geography and Statistics

(IBGE), Ubajara, Tianguá and Frecheirinha's populations account for 31.787, 68.892 and 12.991 inhabitants, respectively (BRASIL, 2010b).

Most cities in Ceará State, mainly the Park's neighboring ones, are located in the semi-arid Northeastern region. Thus, their climate is dry, with high temperatures (ZANELLA, 2005). However, Silva and Cavalcante (2004) claim that such a climate makes the occurrence of humid and sub-humid regions easier. This profile creates contrasting landscapes in the local flora due to geographical, geological and landform features — such as altitude — in Serra da Ibiapaba.

Climate in the region was classified as of tropical monsoon, according to Köppen's classification (1948): rainy season from January to May, and dry season from July to November, with mean annual temperature of 28 ºC.

Figure 1: Localization of Ubajara National Park



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Methodology

Images were obtained in the Landsat 8 (OLI) satellite database (2018) of the United States Geological Survey (USGS) website. They were converted into polygonal vectors in order to find the polygonal area of each class. Data were gathered to generate thematic maps for the entire UNP area. Tables included quantitative data and the polygon area percentage of each class.

Colors were combined for better image visualization and analysis. Bands 5, 4 and 3 were associated with color channels R, G and B — initials of the colors Red, Green and Blue, according to Moreira Filho (2012) —, respectively.

Color combination is essential for image management, since the human eye can easier distinguish between hot and cold colors than among shades of gray. Therefore, the herein performed analysis and image differentiation can help discriminating the colors shown in the results (ROSA, 1992).

Landsat-8 thermal band 10 was converted into surface temperature (in degrees Celsius). Temperature variables were calculated in QGIS raster calculator through the following formula: LC8 -> LST = (1321.08 / Ln (774.89 / (3.3420E-04 * "band10.tif" + 0.10000) +1)) - 273.15. Next, a layer of 23 (min) to 42 (max) color gradient was added to the histogram. False color bands were rendered and classified into five types to make result analysis easier.

This methodology included pixel-to-pixel classification: Pixel value calculation and pixel classification were based on the maximum likelihood (MAXVER) algorithm, whose maximum and minimum values were shown in histograms. MAXVER increases the likelihood of finding pixels belonging to the same class, since distance between pixels is statistically calculated (BARBOSA; VERCCHIA, 2009).

RESULTS AND DISCUSSION

Land use/cover classification

Thematic maps were generated in QGIS software after land-cover data collection. Figure 2 (map) shows Ubajara National Park's land use and cover in 2018, where Caatinga prevails over other biomes. However, typical tropical dry forest features can be observed, as indicated in the map legend.

Table 1 shows a Total Vegetation Coverage map. The Semi-deciduous Tropical Rainforest (Dry Forest) is the largest biome (3.191.490 hectares) in the map, and it was followed by the Deciduous Thorn Forest - Caatinga Woodland (1.899.270 hectares) and by the Semi-deciduous Tropical Montane RainForest - Rainforest (1.180.440 hectares). This classification was based on studies by Moro et al. (2015), which described Ceará State's vegetation features: high and lowland areas indicate the species diversity of each biome, according to features such as climate and geomorphology.

Table 1: Total Vegetation Coverage map

Land use/cover classification	**Hectares**
Semi-deciduous Tropical Rainforest (Dry Forest)	3.191,490
Deciduous Thorn Forest - Caatinga Woodland	1.899,270
Semi-deciduous Tropical Montane RainForest – Rainforest	1.180,440

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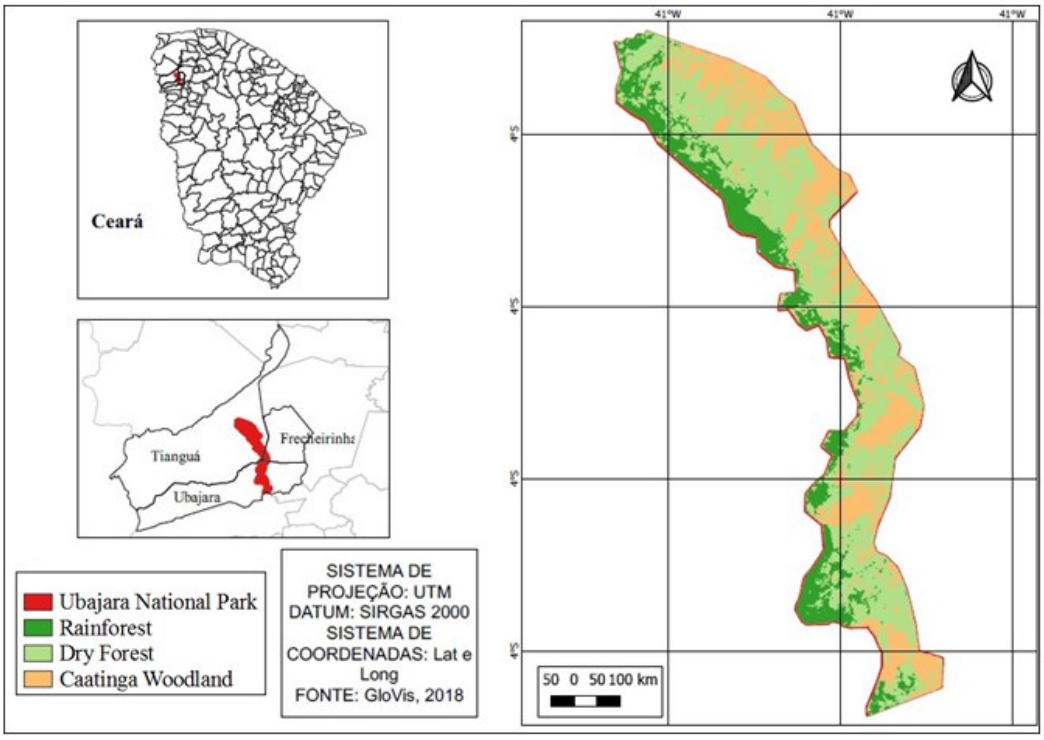
Figure 2: Land use/cover classification



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Caatinga covers approximately 46% of Ceará State. Nevertheless, Ubajara National Park covers forests that quickly change from wet to dry. This profile makes Ubajara National Park the only Brazilian park where two different biomes can be simultaneously seen (BRASIL, 2002; CEARA, 2007).

Weather conditions in dry and wet forests in Serra da Ibiapaba region are milder than those in its surrounding semi-arid regions (GUEDES, 2000). UNP's surrounding regions cover the

following biomes: Rainforest (located in the high plains - plateau) and Caatinga woodland (it extends from the foothills to the most flat hinterland landform, and it is covered by mixed dry forest vegetation) (GUEDES, 2000). Table 2 shows land use/cover categories and biome images followed by the description of their respective vegetation types.

Table 2: shows land use/cover

Classes de Uso e Cobertura	**Descrição**	**Exemplo com fotos**
Caatinga Woodland	Characterized by high light intensity throughout the year, mean temperature ranging from 25 ºC to 30 ºC and physically adapted plants capable of regrowing from tree trunks and roots.	 A
Rainforest	Located in Ceará State's highlands. It is characterized by high precipitation rates and vegetation different from the surrounding Caatinga, since it is covered by large trees and plants, such as epiphytes, ferns and bryophytes	 B

Dry Forest	Caatinga subtype with wider vegetation coverage.	 C

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Moro et al. (2015) explained that highlands' weather conditions enable the growth of typical rainforest flora: wind circulation cools the rain and unevenly distributes it in Caatinga-predominant regions surrounding the study site. In essence, heavy precipitation allows rainforests to grow in the highlands.

Ubajara National Park's ecotourism activities take place in all the three aforementioned biomes. Tourists can walk through eight routes (figure 3 - Main UNP tourist routes) whose mountains, hillsides and hinterlands extend from the Park's entrance onwards. Tours can be scheduled upon arrival. Route one (Ubajara Cave) covers the Ubajara-Araticum trail crossing Cafundó Waterfall. It lasts six to seven hours and is a 14 km round trip. Route two (Ubajara's Cave) crosses Araticum, it is a 4.5 km round trip that lasts 2 to 3 hours. The trail starts in the hinterland (lower end of the Park) and is covered by Caatinga-predominant vegetation.

Route three (Gameleira's Overlook) is a 2.5 km round trip that lasts 1 to 2 hours. Trees can be climbed along the trail. This overlook was named after the several *gameleiras* — trees whose wood is extracted to make troughs (food containers) — growing along the trail's river. The following waterfalls can be found in the Park: Gameleira, Cafundó, Gavião and Murimbeca.

Route four (Cafundó Waterfall) is a 6 km round trip that lasts 3 to 4 hours. The waterfall is approximately 70 meters high and can be visited at any time of the year, as it is perennial. Route five (Gavião Waterfall) is an 8 km round trip that lasts 4 to 5 hours. It is hard to walk through this route, since it is close to the abyss. It is ideal for physically fit tourists who enjoy adventure trips. Route six

(Bicycle Trail) is a 10 km round trip that lasts 3 to 4 hours. Tourists can visit an overlook along the way and appreciate the Cafundó waterfall.

Route seven (night tour) is a 4 km round trip that lasts 2h. One of the greatest advantages of this route is the observation of nocturnal animals such as *agouti, paca* and snakes. Accordingly, this trip is best enjoyed on full moon nights. Route eight (Historical and cultural tour) begins right at the Park's entrance. Tourists get a ride to the Visitors' Center, where they learn about the Park's history and appreciate craftwork. Pendurado Overlook — which is located a few meters away from the Visitors' Center — offers panoramic views of the hills and nearby towns.

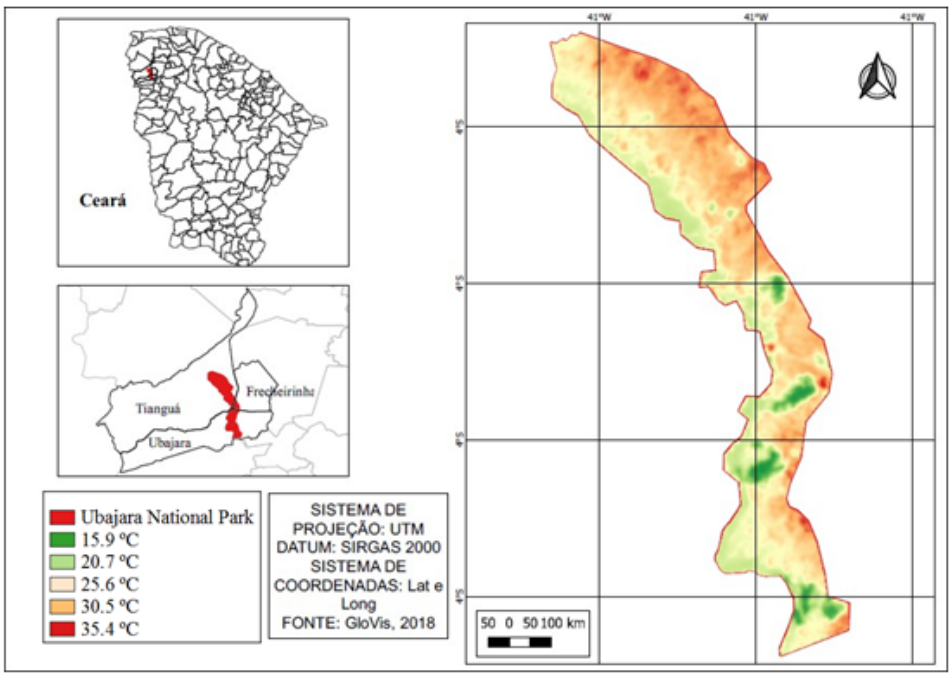
Land-Surface Temperature (LST) classification

Results of supervised classification through Land Surface Temperature (LST) data analysis are described in Figure 4 (Land-Surface Temperature (LST) classification map).

Highlands with temperatures ranging from 15 °C to 20 °C are covered by dense vegetation — typical of rainforests. Caatinga woodland — located on hillsides and on their intersections — is the hottest biome (30 to 35 ºC). Dry forests between highlands and hinterlands reach temperatures of 25 ºC, on average. Temperatures in areas covered by dark green, light green and yellow vegetation tend to be low, as these features are indicative of vegetation richness.

Studies by authors such as Mashiki (2012) help understanding how land surface temperature affects lack and abundance of vegetation. Sunlight reflection by exposed soils increases environmental temperature, whereas abundant vegetation decreases it by contributing to shading and evapotranspiration.

Figure 4: Land-Surface Temperature (LST) classification



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Jabert (2012) evidenced the correlation between the herein discussed variables (temperature and vegetation), due to the ability of plants to absorb sunlight energy. Results have proven the effect of vegetation on land surface temperature, since calculated highland temperatures were lower than that of vegetation directly exposed to sunlight, because of highland altitudes.

Furthermore, the Ubajara National Park's mild-weathered greenery landscapes attract visitors every year and encourage both ongoing and potential ecotourism activities, such as birdwatching — a widespread activity in the United States that has been growing in Brazil due to tourists who enjoy watching and photographing birds in their natural habitat.

CONCLUSIONS

Remote Sensing data collected through Landsat 8 (OLI) satellite image (2018) identification and quantification have shown that changes in land surface temperature are directly related to different forest-covered landscapes, whereas land use is directly related to altitude — high temperatures in foothills and hinterland landforms, and low temperatures in high upland areas (highland ranges), where vegetation is dense and grows in the middle of large dry forest transitions.

The Park's conservation is ensured by Chico Mendes Institute for Biodiversity Conservation (ICMBio). This institute favors and encourages ecotourism activities, such as ecological trails,

cycling and fauna and flora observation in highlands and hinterlands during both dry and wet seasons. Therefore, ICMBio makes these regions the ideal place for the development of birdwatching tourism.

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