TEMPORAL DYNAMICS OF SOIL EXPOSURE IN THE RECLAIMED AREAS OF THE BRUM PROJECT

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ABSTRACT

The Brum Project, located in the semi-arid region of Médio Jaguaribe, Ceará, Brazil, addresses severe land degradation and desertification through experimental recovery efforts. This study aims to evaluate the effectiveness of these recovery practices by analyzing vegetation and soil exposure dynamics between 2012 and 2024. The methodology involves comparing satellite and aerial images from 2012 and 2024 using drone-captured aerial photographs with a MATRICE 300 RTK drone and QUICKBIRD satellite images. The analysis utilizes Python's OpenCV and essential libraries (rasterio, cv2, numpy, and matplotlib.pyplot) to detect non-vegetated areas through image classification.The image processing code defines two main functions: one for displaying images by converting BGR to RGB format and another for reducing image resolution by grouping pixels into blocks and calculating the maximum color value for each block. A color range for green, representing vegetation, was used to create a binary mask, which was then inverted to identify non-vegetated areas. The results were overlaid to highlight non-vegetated zones in red, allowing for a clear analysis of vegetation cover changes. In relation to the evolution of the area between the mentioned years, an analysis of the image pixels revealed that the area changed from 55% exposed area (45% vegetation) to 28% exposed area (72% vegetation). The increase in vegetation provides critical benefits, including enhanced soil quality, improved biodiversity, and better regulation of the local water cycle. These improvements contribute to ecological balance and offer economic and social advantages, such as disaster protection and opportunities for ecotourism and sustainable agriculture. The results underscore the importance of continuing and expanding conservation efforts to ensure the long-term sustainability and maximize the benefits of vegetation recovery in the Brum Project area.

Keywords: Semiarid Region; Soil Degradation; Environmental Changes; Vegetation Restoration; Desertification.

1 INTRODUCTION

Land degradation and desertification are the most severe environmental problems in the semi-arid region of Northeast Brazil. The conjunction of environmental factors, conditioned by the prevailing semi-arid climate and periodic drought events, is associated with socioeconomic and cultural aspects of the inadequate use of natural resources, which has led to the instability of environmental systems (Silva; Oliveira, 2017).

Desertification can be defined as land degradation in arid, semi-arid, and dry sub-humid areas, resulting from various factors, including human activities and climate variations (UNCCD, 1994). In this sense, it is admitted that the desertification process reflects the result of a combination of natural, climatic, and socioeconomic conditions, as well as anthropogenic activities, particularly those involving the use of natural resources, especially for agricultural and livestock production.

In the context of recovering degraded areas in the State of Ceará, the Brum Project stands out as an inspiring experience of cooperation and resilience due to its effective results. The goal of the Brum Project is to experimentally recover a degraded area of five hectares undergoing desertification, aiming for the conservation and sustainable use of natural resources, as well as providing a tool for replicating the techniques used in other areas of the semi-arid region. To this end, various conservation practices for recovering degraded areas have been implemented, such as area isolation, terraces, sediment dams, soil decompaction, and the use of litter and cattle manure.

It is worth noting that the project is the result of the collaborative work of researchers from the Ceará Foundation for Meteorology and Water Resources, with investments from the Ministry of the Environment through a formalized agreement, with funding from the Climate Fund and intervention from the Government of the State of Ceará.

The implementation of the practices began in 2014 as a result of a collaborative effort between the local community and specialist researchers. After the completion of the implementation of the techniques, continuous monitoring and evaluation of parameters began. This made it possible to analyze the long-term impacts of the interventions by observing frequent results concerning meteorological and hydrological variables, as well as the chemical and physical characteristics of the soils. Additionally, the effectiveness of the practices in restoring vegetation cover is assessed through photographic records.

In 2014, the project was awarded the Dryland Champions Award by the United Nations Convention to Combat Desertification (UNCCD). This award aims to recognize actions, initiatives, and projects that facilitate, promote, and implement sustainable management practices to combat land degradation, seeking to improve the living conditions of populations and ecosystems affected by desertification and drought.

The aim of this study was to evaluate, through drone image classification and OpenCV in Python, the evolving dynamics of vegetation and exposed soils in the Brum Project area by comparing two periods: in the year 2012, before the implementation of the recovery practices, and in the year 2024, after the implementation of the practices. From this, the study aims to assess the long-term viability of the recovery methodologies used for the restoration of native vegetation and soil protection.

2. MATERIAL AND METHODS

2.1 Study Area

The study area is located in a Susceptible Desertification Area (SDA) - Desertification Nucleus III/Médio Jaguaribe. Nucleus III covers a total area of approximately 8,436.5 km², which represents 5.3% of the state of Ceará. This region includes five municipalities: Jaguaribe, Jaguaribara, Jaguaretama, Alto Santo, and Morada Nova. Nucleus III is situated in a semi-arid region, with average temperatures ranging between 26°C and 28°C, a rainy season from January to April, and an annual rainfall index of approximately 769.54 mm (Funceme, 2023).

The experimental area covers 5 hectares and is located in Sítio do Brum, in the municipality of Jaguaribe, 345 km from the city of Fortaleza. Its central geographical position is at latitude 06° 11' 08" south and longitude 38° 39' 36" west of Greenwich, and it is part of the Médio Jaguaribe River Basin, upstream of the Castanhão Reservoir.

To characterize the soils of the Project area, trenches were dug for the morphological description of soil profiles. Subsequently, soil samples from each horizon were collected and sent to the Soil Laboratory at the Federal University as per Santos et al. (2018). The predominant soil class identified in the Project area was Luvisol.

In the entire region of the municipality of Jaguaribe, the primary vegetation is hyperxerophytic caatinga, which has the capacity to withstand and/or tolerate physiological drought, typical of semi-arid climate conditions. Currently, due to severe degradation, only

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fragments of this vegetation remain, many of which are in secondary succession. Before the implementation of the recovery practices, there was a noticeable predominance of xique-xique (*Pilocereus gounellei*) and capim panasco (*Aristida adscensionis*), partially covering the exposed soil (Figure 1).

Figure 1. Area of the Brum Project before the implementation of conservation practices. Source: Funceme, 2012.

2.2 Processes and Geospatial Tools Used in Detection

Evaluations of soil exposure dynamics were carried out by comparing images from the years May 2012 and May 2024. For this purpose, aerial photographs captured in 2024 using a MATRICE 300 RTK drone with an attached Zenmuse P1 camera were utilized. For the year 2012, QUICKBIRD satellite images with a spatial resolution of 60 centimeters were used.
A code was employed for detecting non-vegetated areas using OpenCV in Python. Essential libraries such as rasterio, cv2 (OpenCV), numpy, and matplotlib.pyplot were imported. These libraries play crucial roles in reading TIFF files, performing image processing operations, conducting mathematical calculations, and displaying images, respectively.

The code defined two main functions: The first function was an image display function, which converted the colors of an image from BGR (format used by OpenCV) to RGB (format used by Matplotlib) and displayed it with a specific title. The second function was responsible for reducing the image resolution. It grouped pixels into square blocks of a predetermined size, and for each block, the maximum color value among the pixels was calculated. This value was then used to represent the entire block, helping to reduce the image size while preserving the most prominent color features.

The code defined a color range for green, representing vegetation, and created a binary mask to identify these areas. The mask was then inverted to detect non-vegetated areas. These non-vegetated areas were colored red in a copy of the image. The mask was resized to match the dimensions of the original image, and the original image was overlaid with the colored version, highlighting the non-vegetated areas in red. Finally, the code displayed the results, showing both the detected non-vegetated areas and the original image overlaid with non-vegetated zones in red. This clear and detailed visualization allowed for an efficient analysis of the regions of interest, easily distinguishing between vegetated and non-vegetated areas, which is crucial for environmental and agricultural monitoring applications.

3 RESULTS AND DISCUSSION

Figure 2 shows the result of the vegetation and exposed soil conditions in the Brum Project area after processing the images. There is an increase in vegetation and a reduction in soil exposure in the 2024 image compared to the 2012 image, indicating a significant recovery

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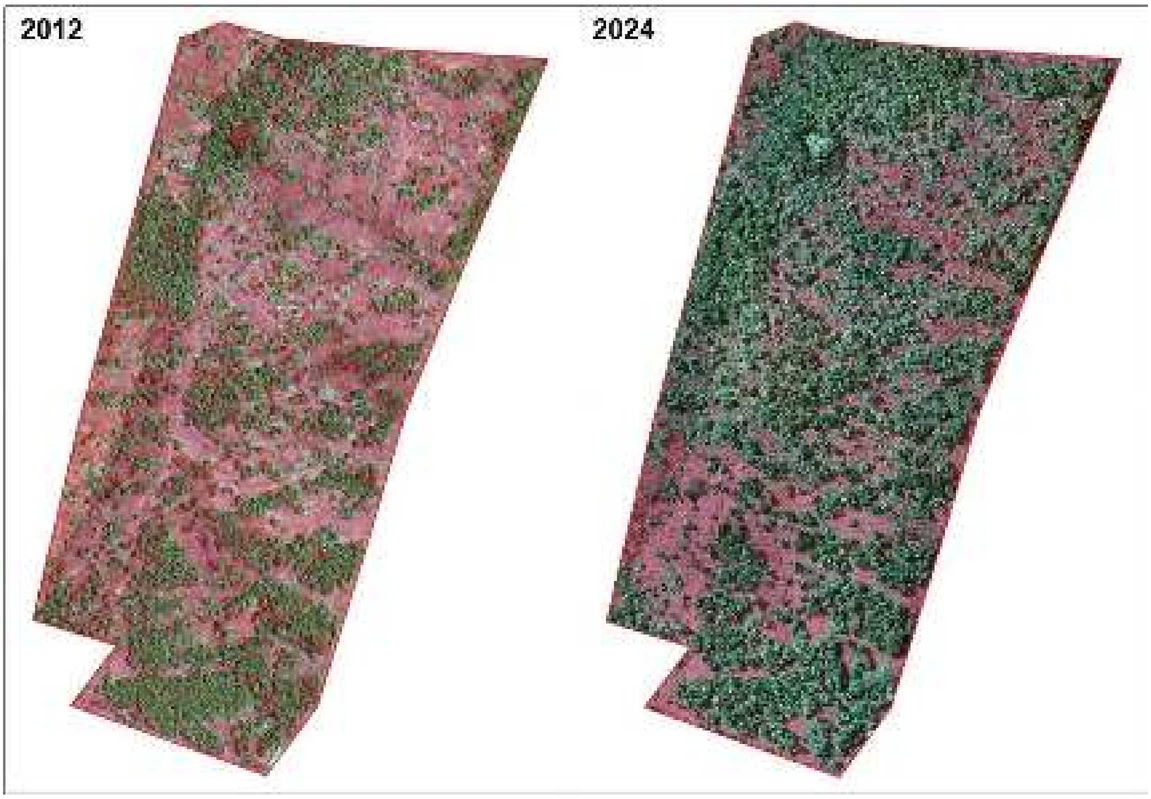
of vegetation cover. This increase in vegetation is evident from the greater presence of green areas in the 2024 image, contrasting with the more deforested or degraded areas seen in the 2012 image. These results are crucial for assessing the success of recovery initiatives, demonstrating the positive impact of interventions over the past 12 years.

Figure 2. Vegetation and exposed soil in the Brum Project area in May 2012 and May 2024, before and after the implementation of conservation practices, respectively, resulting from image processing.



In relation to the evolution of the area between the mentioned years, an analysis of the image pixels revealed that the area changed from 55% exposed area (45% vegetation) to 28% exposed area (72% vegetation). Approximately 50% (28/55) of the exposed area has been recovered in terms of vegetation cover. This indicates that the Brum Project area experienced an increase in vegetation cover and a reduction in exposed soil over this period, demonstrating a significant progress in the environmental recovery of the area.

The increase in vegetation cover brings substantial benefits to the environment, including improved soil quality, increased biodiversity, and regulation of the local water cycle. These improvements not only help restore the ecological balance of the area but also provide economic and social benefits to local communities, such as protection against natural disasters and increased opportunities related to ecotourism and sustainable agriculture (Dias; Francelino; Almeida, 2020).

4 CONCLUSION

The data presented emphasize the importance of continuing and expanding conservation and environmental recovery efforts in the Brum Project. Sustaining these actions will be essential to ensure the long-term sustainability of the area and to maximize the environmental, social, and economic benefits that the restoration of vegetation cover can provide.

REFERENCES

DOI: 10.51189/coninters2024/41732

DIAS, N.; FRANCELINO, D.; ALMEIDA, L. Análise da cobertura vegetal como indicador de qualidade de vida no município de Barbacena - MG. **Enciclopédia biosfera**, v. 17, n. 32, p. 44 – 58, 2020.

FUNCEME. Fundação Cearense de Meteorologia e Recursos Hídricos. Relatórios de Monitoramento. Disponível em: http://www.funceme.br/?page_id=4082/. Acesso em: 26 de Agosto.2024.

SILVA, E. G. B.; OLIVEIRA, V. P. V.; Identificação das áreas susceptíveis à desertificação no estado do Ceará: antecedentes cartográficos. **Revista Brasileira de Geografia Física**, v. 10, n. 4, p. 1296 – 1280, 2017.

UNCCD. United Nations Convention to Combat Desertification. **Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa**; ONU: Paris, France, 1994; 56p.

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