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ANALYSIS OF MANDALLA PRODUCTIVITY IN THE BRAZILIAN SEMIARID REGION: AN NDVI-BASED APPROACH

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ABSTRACT

This study analyzed the phenological variation in Mandallas in the semiarid region of Ceará, using the NDVI (*Normalized Difference Vegetation Index*) to analyze the productive performance of Mandallas over an eleven year period. Seven Mandallas located in the cities of Quiterianópolis, Piquet Carneiro, Antonina do Norte and Araripe were evaluated. Data were obtained from the OLI (Operational Land Imager) and TIRS (Thermal Infrared Sensor) sensors on Landsat 8 and Landsat 9 satellites, resulting in a collection of 1,220 image sets processed using the Google Earth Engine platform. The results indicated that Mandallas 309, 311, 314, 334, and 346 showed a statistically significant increase in NDVI, reflecting improvements in both productivity and vegetation health. This increase suggests that the management practices or environmental conditions associated with these Mandallas are positively influencing productive performance. The improvement in NDVI may signify enhanced green cover, greater plant vigor or more favorable conditions for vegetation development. These findings highlight the potential to replicate successful strategies in other regions to optimize vegetation health and productivity. In contrast, Mandalla number 307 did not exhibit a significant difference in NDVI trends, indicating that its productive performance and vegetation health remained relatively stable without clear improvements or declines. This suggests a need to reassess the management practices or environmental conditions in this area, as well as to consider additional technical assistance. The study underscores the importance of targeted management practices and continuous monitoring to enhance vegetation health and productivity. The results provide a basis for further research and practical applications aimed at improving agricultural sustainability and resilience in semiarid regions.

Keywords: Brazilian Semiarid Region; Remote Sensing; Vegetation Analysis; Crop Performance; Agricultural Monitoring.

1 INTRODUCTION

The semi-arid region is characterized, in terms of the socioeconomic context, by profound social inequalities. In addition to this scenario, there are environmental peculiarities and the occurrence of seasonal and periodic droughts. Another important aspect is that public policies for this region are primarily focused on the construction of large reservoirs and water containment, most of which are on private properties.

The Mandalla system is an example of agroecological agriculture aimed at achieving productive and environmental self-sustainability (Nunes et al., 2020). Essentially, it involves a production system that integrates various productive activities, including fish farming, poultry farming, and the cultivation of vegetables, grains, and fruit trees. The technique also emphasizes the importance of rational water use, as it is based on the intelligent use of water. Specifically, irrigation contributes to increased plant production because the water source is the fish-raising reservoir. Consequently, the water is organically enriched by fish waste, feed, and green algae,

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which enhances soil fertility.

The design of the productive mandala is represented by a polyculture system involving nine circles. Originally, the project describes the first three circles with products used by families for their own consumption, the next four circles for products that generate income, and the final circles for addressing environmental concerns. Additionally, the conical shape of the container suggests better water utilization, as this shape reduces water evaporation caused by the sun (Bevenuto; Correa; Alencar, 2023).

The NDVI (Normalized Difference Vegetation Index) is one of the most widely used vegetation indices for analyzing vegetation across various fields of study, but especially in agricultural sciences. NDVI allows for monitoring green biomass in production areas by using the ratio of reflectance in the red and near-infrared bands in its equation, which correlates with biomass accumulation and crop productivity performance (Fontana *et al*., 2019).

2. MATERIAL AND METHODS

2.1 Study Area

A total of seven Mandallas were evaluated across four cities in the state of Ceará: Quiterianópolis, Piquet Carneiro, Antonina do Norte and Araripe (Table 1).

Table 1. Location of the Mandallas evaluated in the study.

City	ID Mandalla	X	Y
Quiterianópolis	346	306757	9342368
Piquet Carneiro	311	461222	9361580
Piquet Carneiro	309	454794	9357340
Piquet Carneiro	307	444624	9356794
Antonina do Norte	318	398364	9257802
Antonina do Norte	314	397631	9256860
Araripe	334	375593	9206088

2.2 Processes and Geospatial Tools Used

To analyze the phenological variation in the Mandallas, the NDVI (*Normalized Difference Vegetation Index*) was calculated for the study area using orbital data from the OLI (Operational Land Imager) and TIRS (Thermal Infrared Sensor) sensors on Landsat 8 and Landsat 9 satellites. Both satellites are characterized by their heliosynchronous orbits, operating at an altitude of 705 kilometers with a 16-day temporal cycle. They are equipped with passive multispectral sensors that capture images in visible and infrared bands, with spatial resolutions ranging from 15 to 100 meters.

The orbital imaging of both platforms follows a grid pattern based on orbits and path points. The study area is fully covered by orbits 217 and 218, and path points 64 and 65. Images with L2SP (Scientific Product) correction level were acquired and processed using the Google Earth Engine platform, covering the time period from December 1, 2013, to August 31, 2024, resulting in a collection of 1.220 image sets for the analyzed period.

Each set of images was subjected to data filtering to eliminate all cloud pixels, Cirrus clouds, and cloud shadow pixels, preserving only the pixels unaffected by these variables. After filtering and calculating the index, the georeferencing of each Mandalla guided the extraction of NDVI values for each pixel in the image series. The graphical and statistical analysis of the extracted data was conducted using Python, using the *Pandas* and *Seaborn libraries.*

The Mandallas were identified by their distinctive features, primarily the circular shape of the reservoir and the cultivation areas. Their structure often incorporates symmetry and

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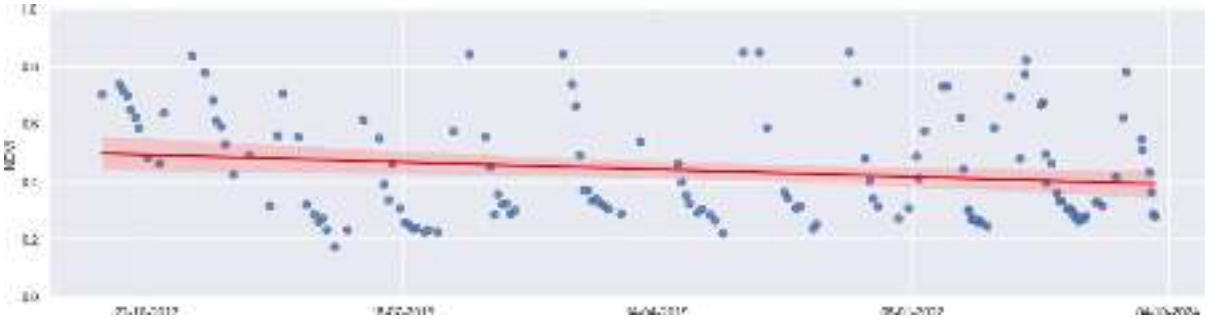
complex geometric patterns, reflecting a harmonious organization (Figura 1).

Figure 1. Features of the Mandalla as seen in satellite imagery. Source: Google Earth, 2024.

3 RESULTS AND DISCUSSION

The Mandalla identified as number 318 showed a significant decrease in NDVI trends over the eleven years evaluated in this study, indicating that the reduction in NDVI suggests that the vegetation in this area is less vigorous or more sparse compared to other analyzed areas. This information can be crucial for adjusting agricultural practices, identifying areas in need of intervention, improving the sustainable management of natural resources, and assisting in technical support activities. It helps in areas that require site visits and periodic monitoring (Figure 2).

Figure 2. Phenological Variation of Mandalla 318.



The Mandallas identified as numbers 309 (Figure 3), 311 (Figure 4), 314 (Figure 5), 334 (Figure 6), and 346 (Figure 7) showed an increasing trend in NDVI, statistically significant difference, suggesting that the management practices or environmental conditions associated with these Mandallas are supporting productive performance. The improvement in NDVI may reflect an increase in green cover, greater plant vigor, or more favorable conditions for vegetation development. This result may indicate effective management strategies or successful interventions in these areas and could serve as a basis for replicating these practices in other regions to enhance vegetation health and productivity.

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Figure 3. Phenological Variation of Mandalla 309.

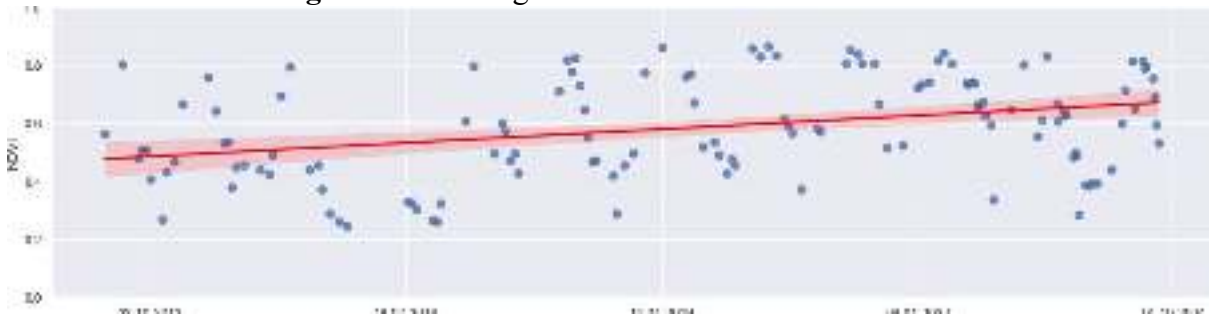


Figure 4. Phenological Variation of Mandalla 311.

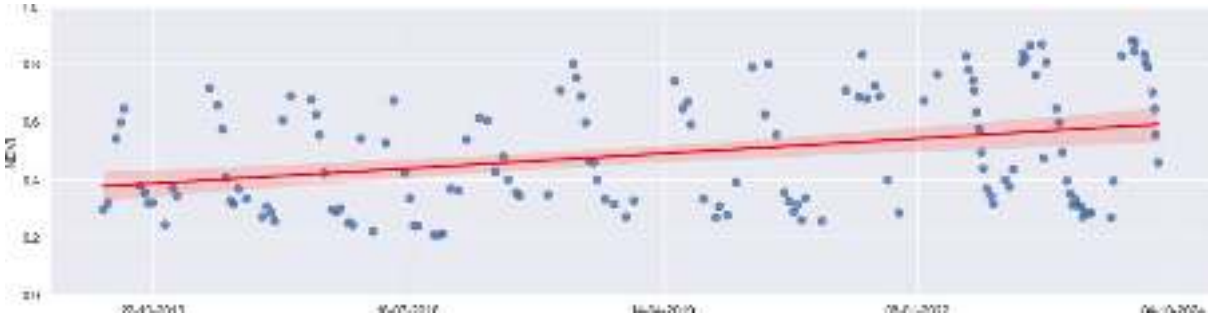


Figure 5. Phenological Variation of Mandalla 314.

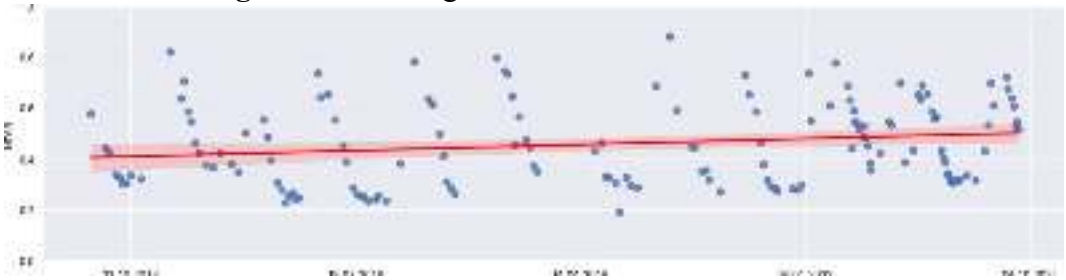


Figure 6. Phenological Variation of Mandalla 334.

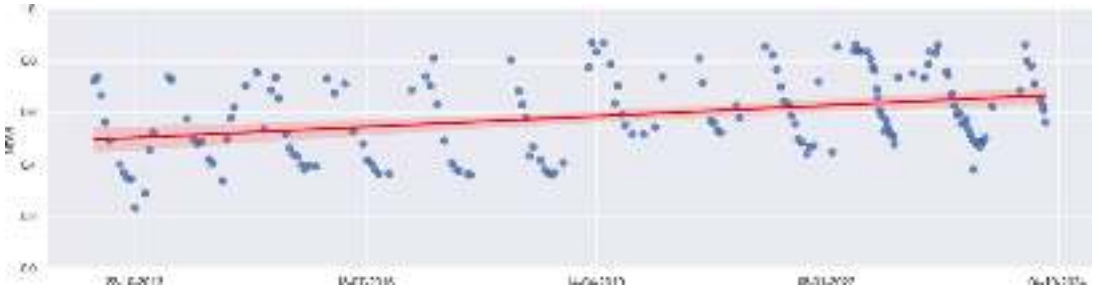
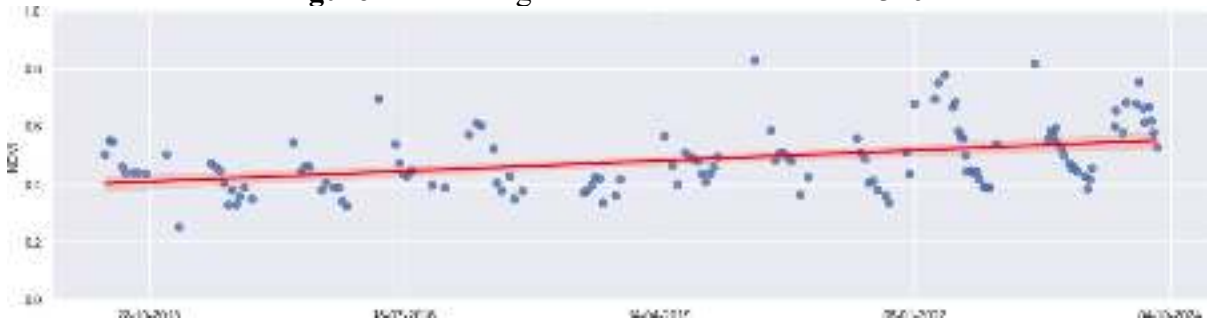


Figure 7. Phenological Variation of Mandalla 346.



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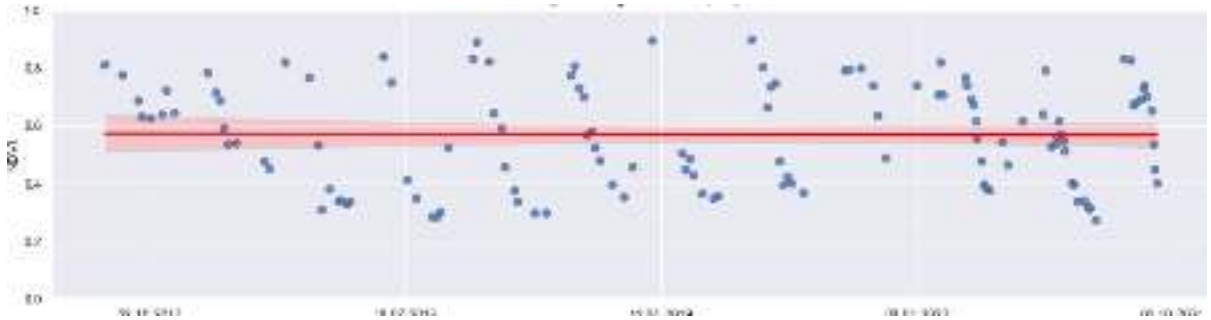
The Mandalla identified as number 307 did not show a significant difference in the NDVI trend over the years. This indicates that, unlike the other Mandallas analyzed, the productive performance and vegetation health in this area did not exhibit a clear or consistent variation throughout the study period (Figure 8).

Figure 8. Phenological Variation of Mandalla 307.



4 CONCLUSION

The analysis of Mandallas in the semi-arid region of Ceará provided valuable insights into variations in NDVI trends and their implications for agricultural practices. Among the evaluated Mandallas, several showed a statistically significant increase in NDVI, suggesting improvements in productivity and vegetation health over the study period.

In contrast, Mandalla number 307 did not show a significant difference in NDVI trends, indicating that its productive performance and vegetation health remained relatively stable, with no clear improvements or declines.

Overall, the study underscores the importance of targeted management practices and continuous monitoring to optimize vegetation health and productivity. The findings serve as a basis for further research and practical applications aimed at enhancing agricultural sustainability and resilience in semiarid regions.

REFERENCES

BEVENUTO, V.; CORREA, M. M.; ALENCAR, A. F.; As Mandalas Produtivas no Brasil: Uma Revisão de Literatura. **Brazilian Journal of Agroecology and Sustainability**. v. 5, n. 1, p. 27–39, 2023.

FONTANA, D. C.; SANTOS, L. N.; DALMAGO, G. A.; SCHIRMBECK, J.; SCHIRMBECK, L.; **NDVI e alguns fatores de variabilidade**. In: Anais do XIX Simpósio Brasileiro de Sensoriamento Remoto, 2019. Anais Eletrônicos. Santos-SP: INPE. Disponível em: chrome-xtension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.alice.cnptia.embrapa.br/alice/bitstream/doc/1109325/1/ID445752019SBSR.pdf. Acesso em: 28 de agosto de 2024.

NUNES, C. A. R.; OLIVEIRA FILHO, P. J.; SILVA, F. A.; SANTOS, A. P.; BARBOSA, J. B.; SANTANA, I. C.; FRANCA, F. S. S.; CARDOSO, E. C.; Acompanhamento de sistema integrado agro aquícola em comunidade carente do Médio São Francisco. **Revista Sertão Sustentável**, v. 2, n.1, p. 41 – 44, 2020.

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