TEMPORAL DETECTION OF FIRE OUTBREAKS IN THE SEMIARID REGION OF NORTHEAST BRAZIL

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ABSTRACT

Forest fires, in addition to causing extensive damage to forest ecosystems, have fundamental ecological importance due to their impact on atmospheric pollution, climate change, and direct and indirect effects on habitats and ecosystems. This study aimed to conduct a quantitative temporal assessment of fire outbreaks in the Médio Jaguaribe Basin – CE from 2000 to 2023. The study was structured based on a literature review of major journal websites (e.g., Google Scholar, ResearchGate, SciELO, ScienceDirect), seeking relevant studies on the subject. Data preprocessing was carried out using the Google Earth Engine (GEE) platform. Additionally, advanced geoprocessing tools, such as QGIS 3.30 software, were used along with data from the Moderate Resolution Imaging Spectroradiometer. The analysis identified 2003 as the year with the highest number of fire outbreaks, totaling 7,049 occurrences in the region. In contrast, 2014 recorded the lowest number of fire outbreaks, with 1.783 occurrences. The comparison between 2023 and 2006 reveals a considerable similarity, with 5.797 and 4.302 fires, respectively, which may suggest a cyclical pattern or the influence of recurring factors that keep the number of fires relatively stable over these years. Annual climatic conditions, such as precipitation and wind incidence, can influence the occurrence and severity of fires. Furthermore, the study revealed that the primary fire outbreaks occurred predominantly in areas of native and dense vegetation. This finding underscores the urgent need for increased environmental awareness and the development of effective public policies. Such policies should focus on reducing deforestation, promoting sustainable land management practices, and improving fire prevention strategies.

Keywords: Monitoring; Distribution; Wildfires; Vulnerable Areas; Jaguaribe Hydrographic Region,

1 INTRODUCTION

The fire is a determining factor in global environmental changes, causing material losses, destroying natural resources, and altering ecological dynamics at both local and regional levels, whether through accidental or intentional use. In this context, the increasing recurrence and severity of wildfires present a significant challenge to the natural regeneration of ecosystems, as noted by Fidalgo and Fernandes (2023). Despite Brazil's long-standing "Zero Fire" policy and the sanctions established by law, nearly 20% of the country's territory was affected by fires between 1985 and 2020 (Faria, 2023).

Considered a global problem, pose a serious threat to the environment, biodiversity, and human communities, especially in semi-arid regions. In this context, it is crucial to conduct studies that enable rapid and accurate identification of fire outbreaks, contributing to the mitigation of their impacts. Remote sensing emerges as a powerful tool in this scenario, allowing for continuous observation and monitoring of large areas with high temporal and spatial resolution.

In this context, using satellites equipped with thermal and optical sensors allows for the identification of temperature anomalies that indicate the presence of fire outbreaks, even in

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hard-to-reach areas. This technology enables a rapid response to emergencies, facilitating firefighting efforts and contributing to the mitigation of environmental impacts. Additionally, the tool aids in analyzing fire occurrence patterns, providing valuable data for developing prevention strategies.

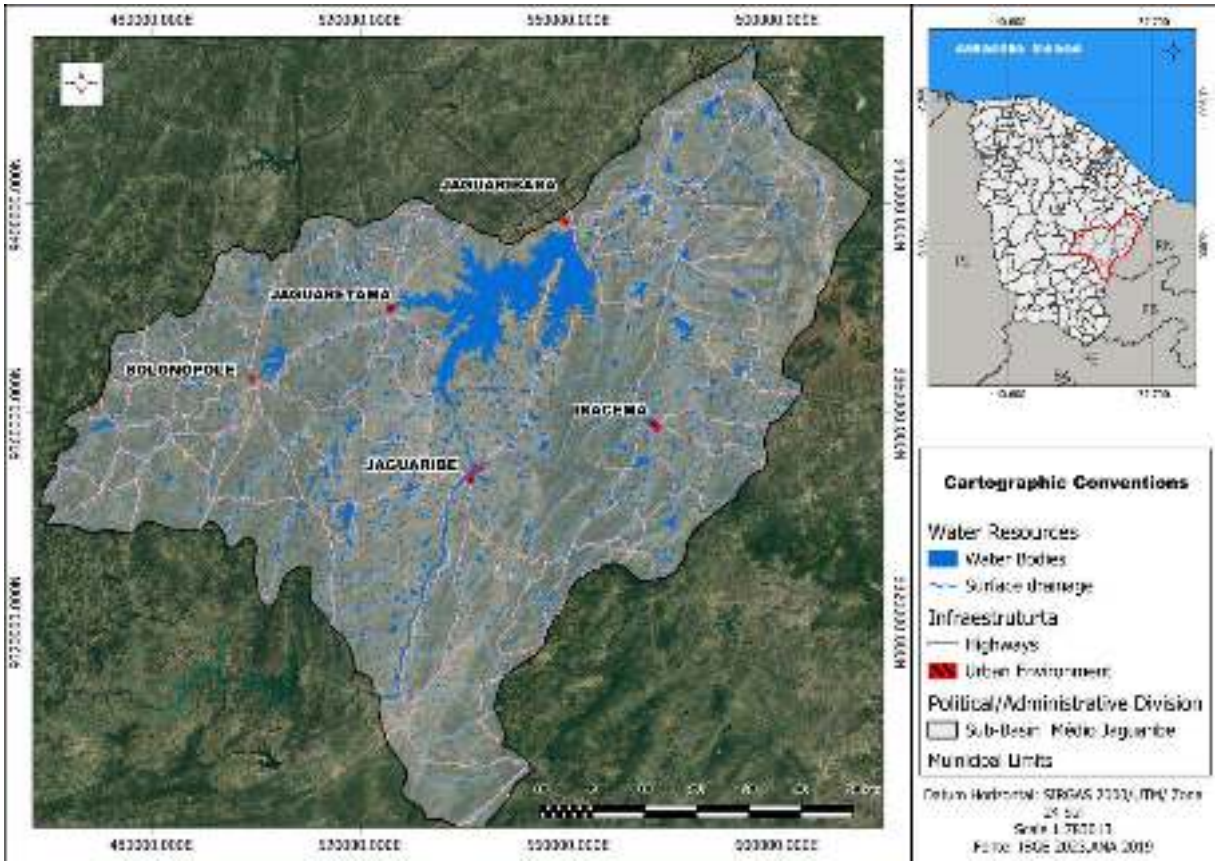
This article aims to analyze the temporal distribution of fire outbreaks in the Médio Jaguaribe Hydrographic Region, Ceará, Brazil, using remote sensing data from 2000 to 2023. It seeks to provide a detailed assessment of the most affected areas and correlate the number of fire outbreaks over the years, identifying trends and variations. This analysis will enhance the understanding of fire dynamics in the region, enabling the development of strategies and identification of vulnerable areas, as well as contributing to the understanding of current challenges and sustainable management of natural resources

2. MATERIALS AND METHODS

2.1 Study Area

The Jaguaribe Hydrographic Region covers an area of 74.621 km², approximately 48% of the territory of Ceará (divided into five sub-basins: Salgado, Alto Jaguaribe, Médio Jaguaribe, Baixo Jaguaribe, and Banabuiú) (Gondim *et al*., 2004). The study was conducted in the Médio Jaguaribe region, which holds significant economic and environmental importance for the state of Ceará (Figure 1).

Figure 1. Location of the study area. Source: Authors**.**



The socioeconomic dynamics developed in the region (the cattle-cotton binomial), within the historical context of Brazil up to the present day, have resulted in environmental degradation, destruction of native vegetation, erosive processes, and loss of the land's productive capacity, as well as desertification. As a result, the region is characterized by a

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complex environment typical of the semi-arid climate, with defined environmental vulnerabilities (Guerra; Souza; Lustosa, 2012).

This scenario is exacerbated by the climatic variability of the semi-arid region, where prolonged periods of drought intensify the effects of environmental degradation. As a result, the land's productive capacity has been significantly reduced, compromising the sustainability of agricultural systems and the resilience of local communities (Figure 2).

Figure 2. Degraded Area in the Desertification Process in the Médio Jaguaribe Sub-Basin. Source: Funceme (2012).

2.2 Processes and Geospatial Tools Used in Detection

The study was structured based on a literature review of major journal websites (e.g., Google Scholar, ResearchGate, SciELO, ScienceDirect), seeking relevant studies on the subject. Data preprocessing was carried out using the Google Earth Engine (GEE) platform. A script was created in JavaScript to define, organize, and download the dataset from the Fire Information for Resource Management System (FIRMS), which provides fire detection information in raster format. This process covered the period from 2000 to 2023, allowing for spatial and temporal visualization of the areas where fires occurred.

The fire locations were identified using the Moderate Resolution Imaging Spectroradiometer (MODIS). Each active fire location is represented by the centroid of a 1 km pixel. This pixel is flagged by the algorithm as containing one or more fires. Subsequently, using Google Earth Engine (GEE), a supervised classification was performed for the study area to identify which areas have the highest incidence of fire outbreaks. The mapping was then created using QGIS 3.30 softwares.

3 RESULTS AND DISCUSSION

The analysis of Figure 3 reveals a significant variation in the number of fire outbreaks over the years in the study area. The year 2003 stands out as the period with the highest number of occurrences, totaling 7.049 fire outbreaks, which may indicate climatic conditions or human activities more prone to fires during that period. In contrast, 2014 shows the lowest number of fire outbreaks, with 1.783, suggesting a possible decrease in the intensity of fires or greater effectiveness in preventive measures. The comparison between 2023 and 2006 reveals a considerable similarity, with 5.797 and 4.302 fire outbreaks, respectively, which may suggest a cyclical pattern or the influence of recurring factors that keep the number of fires relatively stable over these years.

During dry periods, vegetation becomes drier and more susceptible to ignition, as the lack of moisture reduces soil and plant humidity, increasing flammability. Additionally, the absence of rainfall contributes to the accumulation of dry matter, such as leaves and branches,

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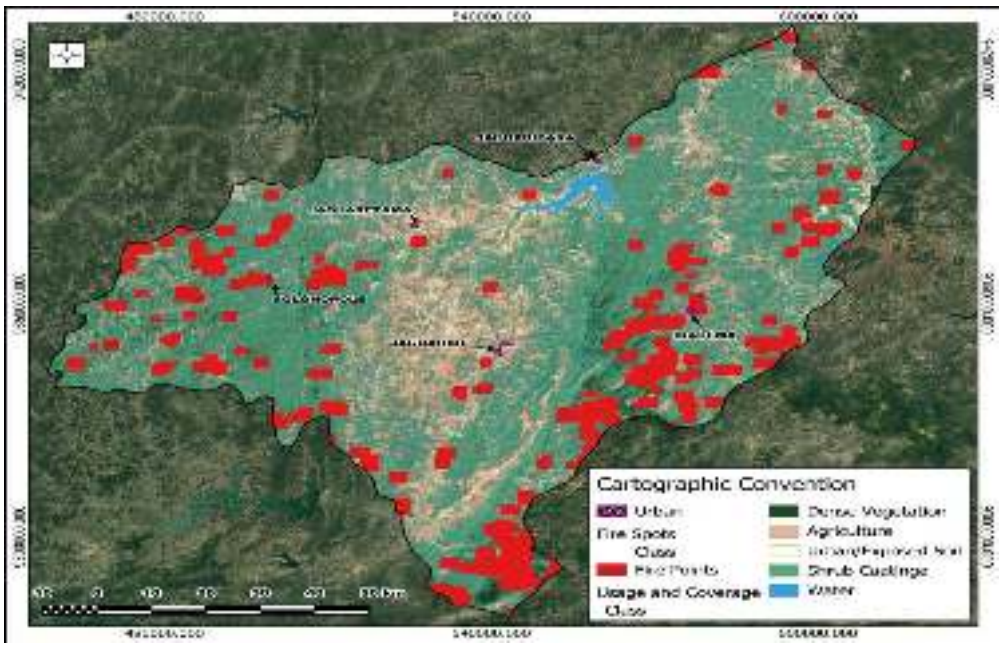
which serves as fuel for fires. In contrast, wetter years generally favor the robust growth of vegetation, which, although it may initially increase the amount of available fuel, tends to be less flammable due to its higher moisture content.

The figure 4 illustrates the distribution of fire outbreaks in the study area, providing a detailed view of the intensity and location of these events over time. The visualization fire outbreaks can reveal important spatial and temporal patterns, allowing for the identification of areas more susceptible to fires and a better understanding of the factors contributing to their occurrence.

Figure 3. Variation in the number of fire outbreaks over the years. Source: Authors**.**

Figure 4. Spatial distribution of fire outbreaks in the study area. Source: Authors.



In this study, it is observed that native vegetation areas experienced the highest concentration of fire points. The conversion of natural areas into agricultural lands often results in practices that increase vulnerability to fire, such as the removal of native vegetation and soil exposure (Ebright *et al*., 2023). Additionally, deforestation can create conditions conducive to fires by removing the vegetative cover that acts as a natural buffer against the spread of flames. Therefore, deforestation and the opening of new areas for cultivation may be the primary explanations for the higher incidence of fires in native forest areas.

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4 CONCLUSION

This study revealed that the main fire outbreaks in the area were found in native and dense vegetation. The conversion of natural areas into agricultural lands and deforestation significantly contributes to the increased incidence of fire outbreaks by removing the vegetative cover that acts as a natural buffer against the spread of flames and exposing the soil. These factors underscore the urgent need for integrated environmental management strategies and protective policies aimed at reducing the impact of deforestation and promoting sustainable practices. Implementing preventive measures and raising awareness about the importance of preserving native vegetation areas are crucial for mitigating the frequency and severity of fire, ensuring the protection of natural ecosystems and long-term sustainability.

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