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Temporal analysis of fire outbreaks in the municipality of Bom Jesus, Piauí

Análise temporal dos focos de queimadas no município de Bom Jesus, Piauí

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A B S T R A C T

In recent years, the number of fires and forest fires in all regions of Brazil has been growing. This study aimed to evaluate the occurrence of fire outbreaks in the municipality of Bom Jesus, state of Piauí, Brazil, between 2016 and 2021. For the methodological procedures, records of the foci of occurrence of fires obtained from the Burning Database (BDQueimadas - INPE) were used. Spatial interpolations were made of the points of occurrence of fires and forest fires. Data from outbreaks for the years 2016, 2017, 2018, 2019, 2020 and 2021 were analyzed, later processed in the QGIS software. In the six years, most of the outbreaks occurred in the months of September and October, the driest months. Practically the entire area of the municipality was affected by the fires and fires, but the highest densities and intensities of the outbreaks were observed in the western region of the municipality. The outbreaks of fires and fires recorded in the last six years are concentrated in the west, northwest and center regions of the municipality, causing serious environmental impacts for biodiversity and the population in general.

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R E S U M O

Nos últimos anos, vem crescendo o número de ocorrências de queimadas e dos incêndios florestais em todas as regiões do Brasil. Objetivou-se avaliar a ocorrência dos focos de queimadas no município de Bom Jesus, estado do Piauí, entre os anos de 2016 a 2021. Para os procedimentos metodológicos utilizou-se registros dos focos de ocorrência de queimadas obtidos no Banco de Dados de Queimadas (BDQueimadas – INPE). Foram feitas interpolações espaciais dos pontos de ocorrência das queimadas e dos incêndios florestais. Foram analisados dados de focos referentes aos anos de 2016, 2017, 2018, 2019, 2020 e 2021, posteriormente processadas no *software* QGIS. Nos seis anos, a maioria dos focos ocorreram nos meses de setembro e outubro, os meses mais secos. Praticamente toda a área do município foi atingida pelas queimadas e incêndios, porém as maiores densidades e intensidades dos focos foram observadas na região oeste do município. Os focos de queimadas e incêndios registrados nos últimos seis anos se concentram nas regiões oeste, noroeste e centro do município, provocando sérios impactos ambientais para a biodiversidade e a população em geral.

Palavras-Chave:
Fogo, impactos ambientais, flora e densidade de Kernel.

Introduction

Fires and forest fires are recurrent events and have triggered a series of impacts on biodiversity (Pereira *et al.*, 2022). They cause partial devastation in the different biomes, as well as their ecosystems, and have the potential to cause economic damage and directly affect the well-being of human society (Pivello *et al.*, 2021).

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Since the beginning, the fires are used for various purposes: cleaning pastures, preparing areas for planting and burning bagasse. In the Cerrado, as well as in other Brazilian biomes, fires have a close relationship with agricultural activities and deforestation (Daldegan *et al.*, 2019; Rock and Birth, 2021). Possibly, the fires are related to the expansion and displacement of agricultural borders, fire is used as a management tool in various agricultural practices (Rocha and Nascimento, 2021). Another common factor is the burning of household waste in urban areas (Lopes *et al.*, 2018).

Burns and fires produce and emit into the atmosphere a number of harmful gases such as carbon monoxide (CO), carbon dioxide (CO^2), nitrous oxides (NO^3), hydrocarbons and aerosol particles (Pereira *et al.*, 2016).

These environmental impacts generated by the different forms of exploitation have been compromising the sustainability of ecosystems, such as the loss of biodiversity, invasion of species, degradation of water and soil ecosystems and regional climate changes (Sala *et al.*, 2000; Oliveira, 2018).

Changes in natural areas reduce the permeability of water in the soil (Brito *et al.*, 2019). The impacts of fires and environmental changes in urban spaces have the potential to alter the climate at a higher intensity than that promoted by global climate change (Silva *et al.*, 2019). The smoke generated by fires and fires causes a series of problems for public health such as: Respiratory, cardiovascular and neurological diseases, especially among children and the elderly who are the most susceptible group (INPE, 2020).

The monitoring of fire outbreaks is one of the measures that aims to reduce the negative environmental impacts generated by carbon emissions, important for the adoption of public policies to prevent and combat this impacting agent for the conservation of biodiversity and soil (ALVEZ; PÉREZ-CABELLO, 2017; JESUS *et al.*, 2020).

To understand this dynamic, it´s important to identify, map and monitor the sites with the highest occurrences of fires, quantify and observe their changes in spatial and temporal patterns and their impacts (intensity, seasonality, size and time of return) (ALVARADO *et al.*, 2017; JESUS *et al.*, 2020).

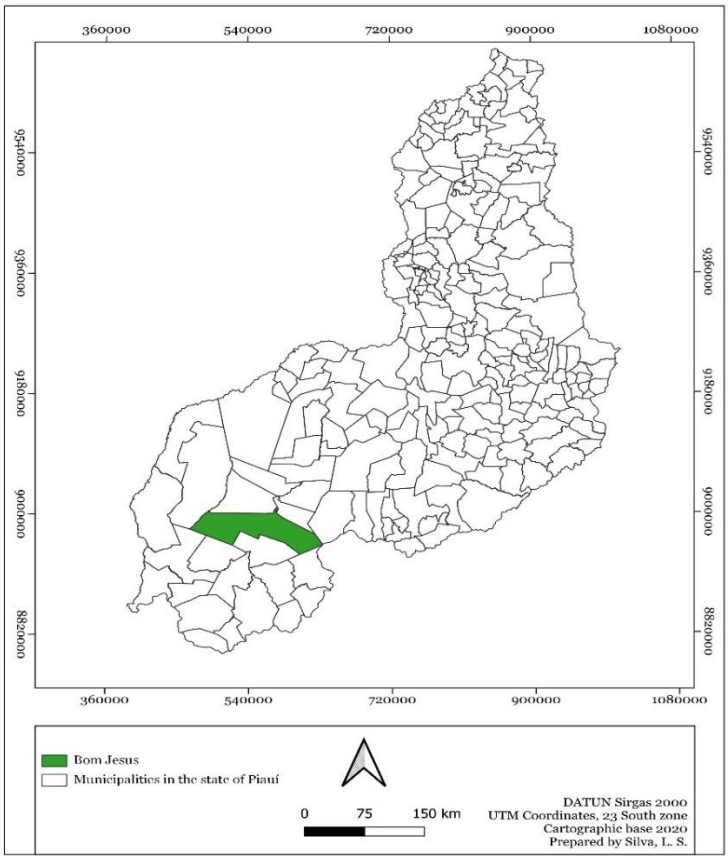
The objective of this study was to analyze the temporal distribution of fire outbreaks over a period of six years in the municipality of Bom Jesus, located in the south of Piauí.

Methodological Procedure

The study was carried out in the city of Bom Jesus, in the extreme south of Piauí, which is located in the southwestern mesoregion of Piauí, at the coordinates 9º05'20,4"S; 44º20'55,1"W; 277 m (Figure 1). It has a territorial area of 5.471,024km² (IBGE, 2021), whose municipality is covered by vegetation of Caatinga, Cerrado and areas of ecotones. This city stands out for its records in grain production (soybeans and corn).

Figure 1.

State of Piauí and location of the municipality of Bom Jesus.



The climate of the region is of the Aw type (tropical climate with dry winter period), average annual rainfall varies from 900 to 1200 mm per year and average temperature of 26.2 ºC (INMET, 2021). It has two well-defined periods, being a dry period that comprises the months of May to October and another rainy period that occurs between November and April (Alvares *et al.*, 2013).

Data analysis

Data on fire outbreaks in Brazil were obtained from the Queimadas Program (*Programa Queimadas*) database on the site: http://queimadas.dgi.inpe.br/queimadas/bdqueima das, para o período de 2016 a 2022, developed by the National Institute for Space Research (*Instituto Nacional de Pesquisas Espaciais*) (INPE, 2018). The AQUA_M-T reference satellite was used, which according to INPE (2018) is indicated for the analysis of time series of fire events, specifically analyzing the number of outbreaks.

Cross-checks of geographic information from the points of occurrence were performed through spatial interpolations. The spatial interpolation used was by the method of Inverse Distance Weighting (IDW) for the surface of interpolation and generation of the maps. Data

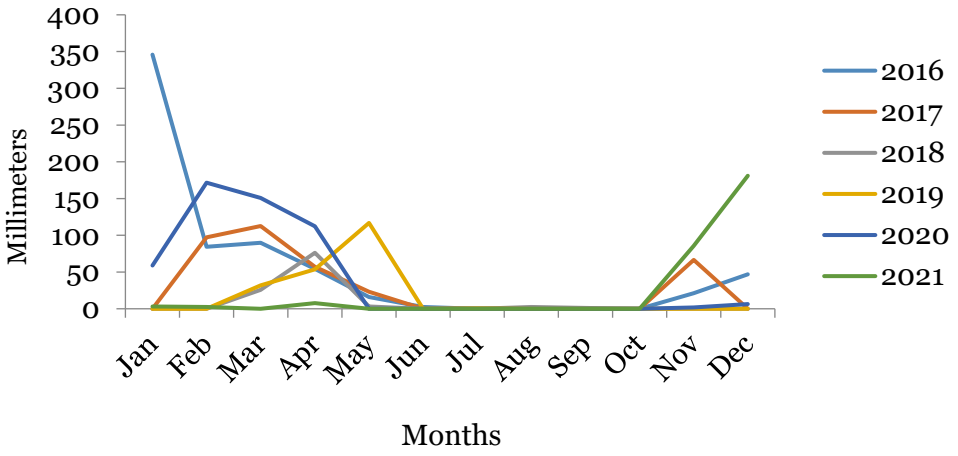
from fire outbreaks for the years 2016, 2017, 2018, 2019, 2020 and 2021 were analyzed, later processed in the software QGIS 3.18.3. The Kernel algorithm was used, which is a statistical method of estimating densities to analyze the spatial distribution, pattern and intensity of fire throughout the municipality. The density of the fire outbreaks was calculated by means of the Kernel estimator with classification of the foci in levels: Unregistered, minimum, low, medium, high and critical.

Results and Discussion

According to Figure 2, between the months of June and October, the events of low / or absence of precipitation, low relative humidity and high temperatures favor the increase of fires and forest fires. These were the months with the highest numbers of records of fires observed by Abreu and Souza (2016), stated that these months are considered drought, are the months with the highest temperatures.

Figure 2.

Cumulative precipitation graph between the years 2016 to 2021.



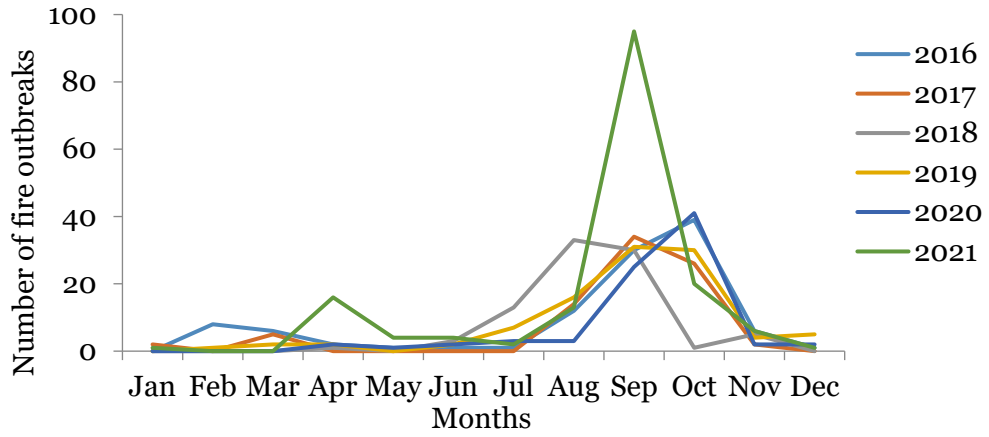
Source: INPE.

In the months with no precipitation, the greatest amount of these disturbances is observed. While the low amount of foci of these disorders is observed in the rainy season between the months of November to May (Figure 3). There are several reasons for the emergence of fires, among them: land clearing, formation and renewal of pastures in rural areas and arson. And in the urban area burning of household solid waste and cleaning of lots.

The municipality of Bom Jesus has areas traditionally exploited by agricultural activities, mostly in family farming regime that still use fire to clean the areas for cultivation, thus registering numerous fires before the rainy season. This was also observed by Costa (2019) in other regions of Brazil.

In the last six years, a high number of fire outbreaks were recorded, in 2016 (107), 2017 (83), 2018 (86), 2019 (100), 2020 (81) and 2021 (162) occurrences. Figure 3 shows that the monthly distribution of fire outbreaks, the months with the highest occurrences were the driest months (August to November), corroborating with Alvarado *et al.* (2017) and Jesus *et al.* (2020), Souza Neto *et al.* (2021). Therefore, the anthropic action is responsible for the main causes of fires in this municipality, because there is a low probability of occurrence of fire by lightning, since the fires and fires occur in the dry period, as observed by Cunha-Neto *et al.* (2021).

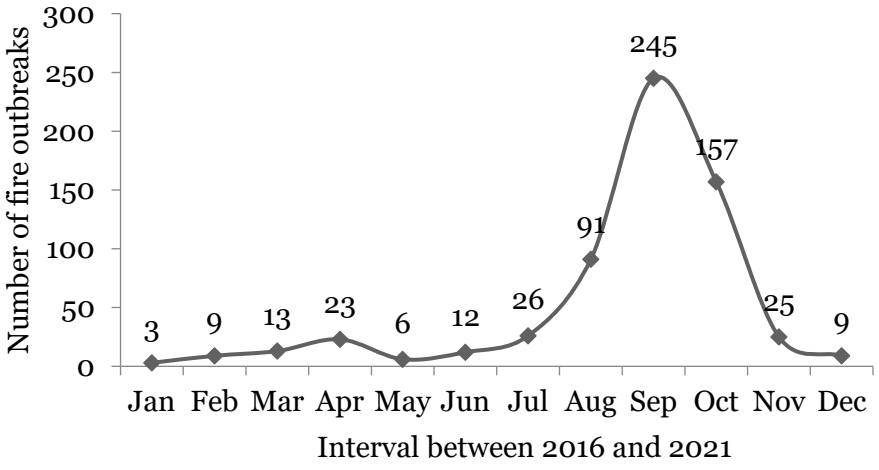
Figure 3.
Temporal record of fires and forest fires between the years 2016 to 2021.



According to Figure 3, 2020 had the lowest number of fires, with 81 cases in total. Already in 2021 there was a significant increase in the number of outbreaks, 162 occurrences. In the six-year period, most of the outbreaks occurred in the months of September and October (Figure 4). That is, the great concentration of the number of foci occurs in the dry season. It was also in this month that Carneiro and Albuquerque (2019) observed the highest number of fire outbreaks. January was the month that recorded the lowest number of fire outbreaks (Figure 4).

Figure 4.

Distribution of fires and fires between the months during six years.



The data show that in the annual temporal context a large number of records of fires occurs in the second half, it´s a pattern that is repeated every year, the favorable atmospheric conditions, as observed by Coelho Junior, Martins and Carvalho (2018).

Historically, in the state of Piauí, the second semester is recognized as the period in which the highest number of fires is recorded, in this period these events also occur at the level of Brazil (INPE, 2020).

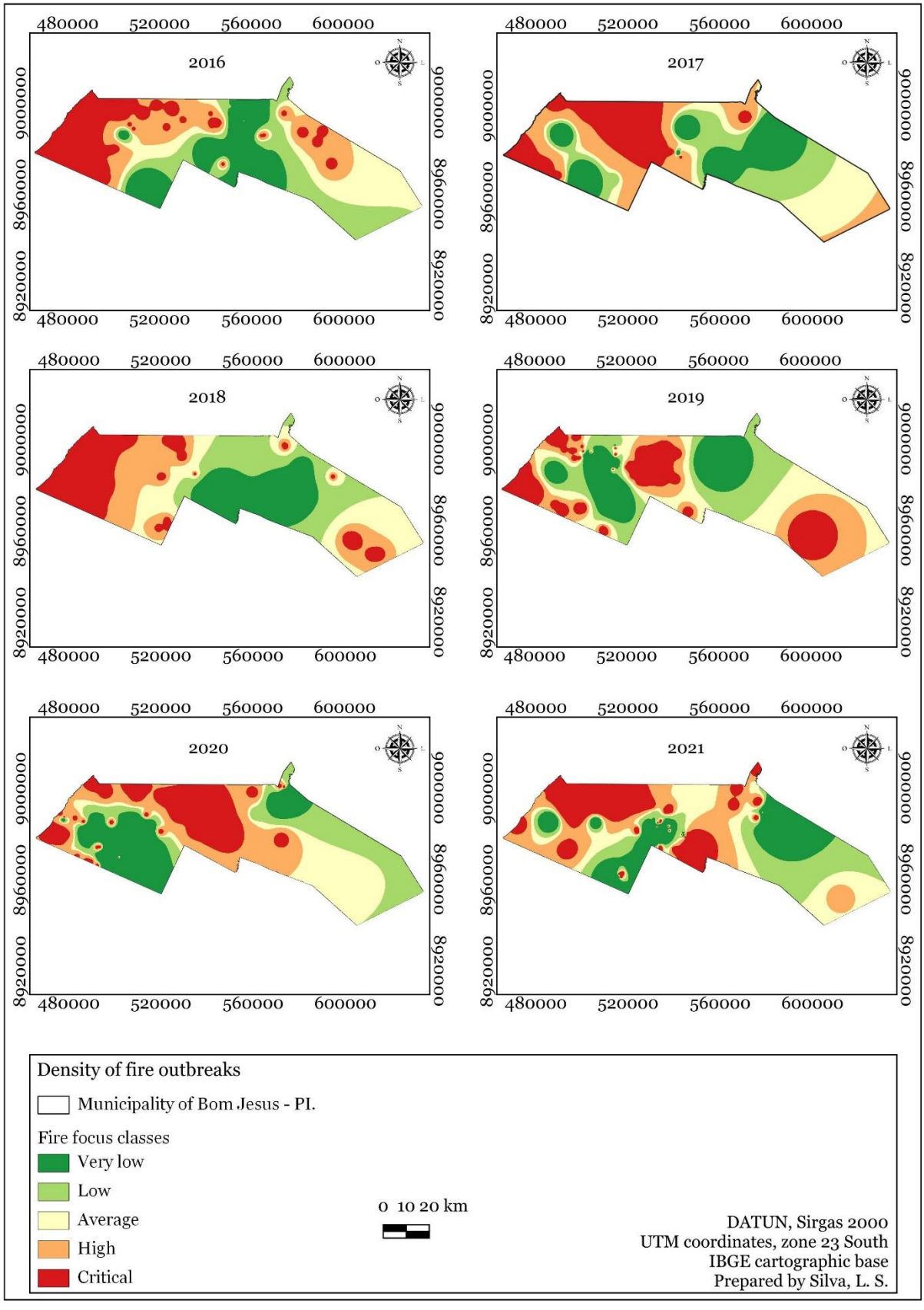
In Figure 5, the Kernel maps resulting from the interpolation of the fires, it´s observed the intensity of these in the municipality of Bom Jesus, the density of the foci is shown in five classes. The entire area of the municipality was practically affected by the fires and fires, but the highest intensities of the outbreaks were observed in the western region of the municipality. The spots of high and critical density were dispersed in the west, northwest and center.

In 2017 the very high and critical class concentrated in the north, south, northwest and west of the municipality of Bom Jesus. In 2018 the very high and critical class concentrated in the west, southwest and northwest region. In relation to the areas with incidence of the very high and critical class represent extensions with significant percentage in the territory of "*Bonjesuense*", indicate a region of alert for the amount of record of detected outbreaks.

In the western region, they noticed larger burned areas where the Cerrado vegetation predominates, in the dry season, especially in the middle of this season as observed by other authors (Araújo and Ferreira, 2015; Alves; Perez-Cabello, 2017; Jesus *et al.*, 2020), due to low humidity is the most favorable period for the spread of fire.

In the eastern region it´s noted that the presented a low density of foci in the high and critical levels in relation to the other regions, it´s the part of the municipality located within the Serra das Confusões National Park. Even though it´s a protected area these disturbances still occur.

Figure 5.
Graphs of the monthly distribution of hot spots detected by the sensors of the AQUA_M_T satellite, between the years 2016 and 2021.



Strong fire pressure at the dry time of the year can contribute to more intense and prolonged fires (Menezes *et al.*, 2019). The increase in fires in the largest classes of outbreaks indicates the urgent need for improvements in protection, as it indicates a deficiency in the actions of mobilization, detection, displacement and firefighting (Machado Neto *et al.*, 2017). Therefore, it´s important that the public power and society become aware and get involved in fighting fires, as their frequency can put species of fauna and flora at risk of extinction and soil impoverishment (Lourenço, 2018).

Conclusions

Given the increase in the number of fires recorded in the last six years, the concentrated in the west, northwest and center of the municipality, causes serious environmental impacts for biodiversity and the population in general, it´s therefore necessary to systematically and periodically monitor, municipal brigade aiming to combat these practices that cause degradation, as well as other measures that can minimize them.

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