Analysis of the distribution of hotspot and burn area in Muaro Jambi district, Jambi Province

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Abstract. Jambi Province is one of the fire-prone provinces in Indonesia. One of the districts in Jambi Province that experiences forest and land fires in Muaro Jambi. The objective of this study was to analyze hotspots and burned areas in the Muaro Jambi District in 2015 and 2019. The data used in this study were hotspots and spatial information on burned areas from MODIS Terra/Aqua satellite imagery and rainfall data from BMKG. The results showed that the number of hotspots in 2015 was 2731, with 2,558 hotspots located on peatland. In 2019, hotspot numbers increased by 3321 hotspots, with 3225 hotspots located on peatland. The sub-district that has the highest hotspot number is Kumpeh with 5191 hotspots. The lowest rainfall in 2015 and 2019 was in September. The rainfall in September 2015 was 15.2 mm/month and in September 2019 it was 39.3 mm/month.

1. Introduction
Forest plays an important role in life both in the economic, social, cultural and environmental fields. However, forests in Indonesia have many disturbances, one of which is forest fires [1]. Forest and land fires are becoming worse and uncontrollable which are supported by weather such as the dry season that occurred in 2015 and 2019 [2]. Land burning or land clearing is often the main reason for forest and land fires. One of the provinces in Indonesia that is prone to forest fires in Jambi Province. For the last decade, Jambi Province has experienced two forest fires on a fairly large scale and caught the attention of the government [3]. The area burned in Jambi Province during the period 2015 - 2021 was 67580 17 ha [4]. The conversion of land functions into settlements or oil palm plantations is mostly the cause of forest fires in Jambi Province. Environmental changes result in a high risk of disasters, especially floods and smoke from forest and land fires [5]. Forest fires in Jambi Province often occur in Muaro Jambi District. According to Rustan and Handayani [2] Muaro Jambi District was the district with the worst forest and land fires in Jambi Province in 2019.

Facts from several land fires show that fire management is more focused on the extinguishing aspect than the prevention aspect [6]. This can cause forest and land fires to occur continuously without a proper prevention plan. Early detection of forest and land fires is an important activity in the context of controlling forest and land fires. Fire control with hotspot detection can facilitate efforts to prevent and extinguish forest and land fires. Forest and land fires can be detected through hotspots, which can be used as an indication of forest and land fires [7]. Rainfall can also be one of the supporting parameters for the emergence of hotspots [8]. Based on the largest fire incidence in Indonesia over the last decade, the distribution of hotspots in 2015 and 2019 needs to be analyzed. The
aim of an analysis of the distribution of these hotspots and burned areas can be used as an effort to prevent further forest and land fires.

1. Data

The data required in the processing of this technical module based on updates to the forest and land forest susceptible map in Jambi Province of the year 2015 – 2019 included:

- Hotspots in 2015 -2019 (from NASA MODIS Terra-Aqua)
- Data Administration of Indonesia (from Indonesia)
- Map of peatland distribution (From R&D)
- Rainfall (From BMKG)

2. Method

2.1. Data processing

Data processing was carried out by making a map of the distribution of hotspots in Jambi Province. The mapping was carried out using ArcMap 10.3 software and NASA MODIS Terra-Aqua hotspot data with a hotspot confidence level of 30%. The mapping was made by overlaying the necessary data such as hotspot data, district administration data, peatland data, and burned area map using the clip function in ArcMap software.

2.2. Data analysis

The data analysis used in this research was descriptive. The resulted data was then analyzed using descriptive analysis, an analysis that is useful for providing an overview of a piece of data. In other words, descriptive analysis can describe the conclusions on the data that have been presented.

3. Results and Discussion

3.1. Number of Hotspots in 2015 and 2019 in Muaro Jambi District

Muaro Jambi District has a climate suitable for farming activities such as agriculture, plantations, livestock, or other economic activities including planting oil palm. Muaro Jambi District is a district located in a lowland area and has a flat slope of 67.50%. Land use as a plantation and agricultural sector in Muaro Jambi District is the largest land-use area [9]. Figure 1 shows that Muaro Jambi District has the highest number of hotspots in 2015 - 2019 compared to other districts in Jambi Province, which is 6132. The number of hotspots in 2015 in Muaro Jambi District was 2731 and 3321 in 2019.

![Figure 1. Number of hotspots per district in Jambi Province.](image-url)
developments, especially in agriculture. A large number of farmers are converting land to oil palm [10]. Of course, the transfer of land use using the burning technique because is considered more efficient and cheaper. The burning continues to become uncontrolled forest and land fires. In addition, the El-Nino phenomenon that occurred in 2015 and 2019 exacerbated forest and land fires. According to Rustan and Handayani [2] the dry season that occurred throughout 2015 and 2019 caused a lot of hotspots to appear in various regions, including Jambi Province. This can be caused by changes in the weather annually, and the ineffectiveness of fire control, especially in Muaro Jambi District. Muaro Jambi District is included in the district that has the highest level of the forest and land fire vulnerability in 2011-2015 [11]. The results of Istima [12] state that forest and land fires in Muaro Jambi District predominantly occur on peatlands. Figure 2 also shows the same thing where the highest number of hotspots is in peat areas.

Figure 2. Number of the hotspot year 2015 and 2019 in Muaro Jambi District.

There are more hotspots on peatlands than on mineral lands. In 2015 the number of hotspots on peatlands was 2558 and 3225 hotspots in 2019. The number of hotspots on land in 2015 was 173 and 96 hotspots in 2019. This can happen because the area of Muaro Jambi has a fairly large area of peat. According to Thoha et al. [13], the spread of fire in peatlands is influenced by rainfall, and with the increasing rainfall, the availability of water in peatlands increases which will make it difficult for the land to burn. Forest and land fires are often caused by peat loss of soil moisture and water content, fires on peatlands often occur during land clearing [14]. Which can cause direct sunlight to fall on the peat soil causing the peat soil to lose its moisture and water content.

3.2. Distribution of Hotspots per District in Muaro Jambi District

The distribution of hotspots in 2015 and 2019 was seen to be dense in peat locations in the area around Kumpeh District. Figure 3 shows the density of hotspots in the Kumpeh area and its surroundings. The greater the hotspot density, it will provide the higher the level of vulnerability compared to areas that show little hotspot density. On average, fires that occur in the Jambi Province are caused by the clearing of new land for Industrial Plantation Forests (HTI) and plantations. According to [15] the plantation sector is a very important part in supporting the direction of development in the Jambi Province Region. This shows that the use of peatlands for plantation areas is very high.
Figure 3. Map of hotspot distribution in Muaro Jambi District (a) 2015, (b) 2019.

The number of hotspots in 2015 and 2019 in Kumpeh District was 5197. The District had a total of 2329 hotspots in 2015 and 2868 in 2019 (Figure 4). The high number of hotspots in the Kumpeh District indicates that this area is prone to forest and land fires. The peat area in Kumpeh sub-district is included in the Berbak National Park area, where jelutung and wood collectors are the main suspects in causing the fires [16]. In Muaro Jambi District only 1 hotspot was found in Sungai Bahar and the southern part of Bahar Districts. This occurrence might happen because the areas of Sungai Bahar and South Bahar sub-districts have been converted into well-maintained oil palm plantations so that land clearing activities by burning are not carried out. Following Siringoringo [17] statement, Sungai Bahar District is the sub-district that has the largest area of oil palm land in Muaro Jambi District with a land area of 32312 Ha.
Sungai Gelam, Kumpeh Ulu, and Taman Rajo sub-districts are located around the Kumpeh sub-district which has a lot of hotspots and this can happen because the sub-district is in a peat area. On the other hand, areas that do not have peat areas, such as North Bahar, South Bahar, and Sungai Bahar, have few or even no hotspots. Other areas, such as the Jambi Outer City District, have become residential areas [18]. Based on the description above, it can be seen that the peat area has a fairly large distribution of hotspots. The area of peatland in Jambi Province is 4043602 ha (45% of the total area of Jambi Province) [15]. Most of the peat areas in Muaro Jambi District are located in the Kumpeh Subdistrict and its surroundings, which have more hotspots than areas without peat. In 2019, the burned area in Jambi Province reached 56593 ha and almost 90% of the burning occurred on peatlands [2].

3.3. Rainfall and Number of Hotspots in Muaro Jambi District

Every year, hotspots data have a pattern wherein September the hotspot distribution data increases (Figure 5). This can occur due to low rainfall, so the distribution of hotspots can increase before the increase in rainfall. Hotspot data can be combined with rainfall data so that a model of the relationship between the amount of rainfall and the number of hotspot detections in the area can be identified [19]. In 2015 the highest number of hotspots was in September with 995 hotspots and had the lowest rainfall amounting to 15.2 mm/year.

January and February have a similar amount that is 130 mm and 130.9 mm with the number of hotspots of 1 and 3 respectively. Rainfall begin to show a downward graph from June, July to August
and decreased sharply in September with rainfall respectively 103.3, 53.9mm, 26mm, 15.2mm. The numbers of hotspots in June, July, August and September respectively 36255 mm, 642 mm, 995 mm, 755 mm respectively. The decrease in rainfall was followed by an increase in the number of hotspots from June to September. According to Saharjo and Velicia [20], in 2015 hotspots began to be found in large numbers from July to November because these months had a dry climate (dry season). In November and December, there was a significant increase in rainfall, thereof 238.7 mm of rain and 257 mm of rain.

Low rainfall can trigger an increase in hotspots, and vice versa if the amount of rainfall is high and the increase in hotspots will be below. Under normal circumstances where rainfall is sufficient and regular, the humidity of litter, soil or forest floor is very high so that fires will not occur easily [21]. Forest fires cannot occur easily when there is high rainfall, on the contrary, low rainfall can trigger litter or burning material to dry out more easily. Dry litter and low rainfall can facilitate the burning process for land clearing or land-use changes.

Figure 6. Graphic of hotspot distribution and monthly rainfall in 2019 in Muaro Jambi District

From The beginning of 2019 starting from January to June. It had quite high rainfall. The steep decline occurred in September with 39.3 mm of rainfall and it had several hotspots as many as 2556 higher than that in September 2015. A significant increase is expected to occur due to the long dry season in most parts of Indonesia [22]. From October to December, rainfall started to increase and the number of hotspots started to decrease. The rainfall in October was 158.9 mm with a total of 567 hotspots, and in November and December, it had rainfalls of 160.9 mm and 185.5 mm with several hotspots 1 and 2 respectively.

The two years had something in common they had the highest hotspot and the lowest amount of rainfall in September. This shows that September is the peak of the dry season in the Muaro Jambi Region. According to Thoha [23] the tendency for hotspots to occur shows that rainfall influences hotspots, although in terms of the number of hotspots monitored, there is no fixed trend. This can be seen from the increase in hotspots accompanied by a decrease in rainfall and vice versa, and if the rainfall increases, the hotspot decreases. According to Abdi et al. [24] the existence of a hotspot will be found in an area, if the rainfall decreases; on the contrary, if the rainfall begins to increase in an area, the hotspot will decrease even if there is no hotspot.

3.4. Identification of Burned Areas in Muaro Jambi District

The area burned in 2019 increased sharply compared to that in 2015. Figure 7 shows that the area burned in 2019 was greater in peat areas. In 2015 the burned area reached 1585.8 ha and the burned area in 2019 reached 43534.6 ha. Peatland fires are a serious problem because catastrophic fires on peatlands occur almost every year. The limitation of productive land makes peatland selected as
suitable land to be developed in agriculture [6]. It isn’t mean that peatland is good for agricultural land, but has to be used as agricultural land because of the lack of productive land.

![Burn area in peat and mineral areas in 2015 and 2019 in Muaro Jambi District.](image)

**Figure 7.** Burn area in peat and mineral areas in 2015 and 2019 in Muaro Jambi District.

There was an increase in burned areas in 2019 in peat areas. The burned area which increased from 2015 could occur due to the El-Nino that attacked Indonesian territory. Like in 2015, in 2019 the El-Nino disaster occurred which caused the rainy season to be delayed from the time it should have been. This long dry season can lead to the emergence of hotspots and forest and land fires. Figure 8 shows the burned areas in Muaro Jambi District in 2015 and 2019. The map shows that the average fires more frequently occurred in peatlands than in mineral areas. This shows that areas that are prone to fire are peat areas. Besides being supported by climates such as El-Nino, human factors also gave an effect such as land clearing using burning techniques. This shows that human behaviour in using fire is the cause of forest fires. El-Nino can be a good time in the process of land clearing because the climate supports the spread of fire more quickly. In addition, land clearing using burning techniques is also cheaper and easier.

According to the local government of Muaro Jambi District [9], the prevention of forest and land fires in peat areas has not been maximized due to a lack of public awareness to maintain and protect environmental sustainability. In addition, the implementation of forestry programs with the community has not been optimal due to the limited quality and quantity of human resources regarding forestry management. The use of space also does not take into account the aspects of sustainability and nature conservation. According to Syaufina [25] 99% of forest and land fires in Indonesia are caused by humans, both intentional and unintentional, while natural factors are only 1%, for example, fire is used in clearing land for agriculture. Land clearing for plantations has also begun. The development of the oil palm plantation area in Jambi Province is inseparable from the development of the oil palm plantation area in the District. Muaro Jambi District is the centre of the largest palm oil production in Jambi Province, with a production of 338781 tons with an area of 130.9 thousand hectares. Therefore, a lot of land clearing using forest burning techniques for plantations. occurs in Muaro Jambi District for plantations. The 9 thousand hectares of oil palm plantations in Muaro Jambi District are divided into two: large state and private plantations, and people's plantations [10].
Figure 8. Map of burned area in Muaro Jambi District (a) in 2015, (b) in 2019.

According to Regional Medium Term Development Plan of Muaro Jambi Regency [9], Muaro Jambi District is a potential area to maintain environmental balance, especially peat areas, but it is very vulnerable to fires every dry season. Therefore, efforts to reduce the incidence of forest and land fires, especially on peatlands, can be carried out with agricultural production models on peatlands. The non-burning peatland management technique (PLGTB) is an approach to prevent forest and land fires in peat areas. This technique is expected to be an activity that supports sustainable peatland management efforts [26]. Community needs to manage land can be integrated with practices that stimulate peatland to remain wet. According to Gunawan et al. [27] the use of ameliorants such as compost and biological agents can be carried out only in wet peat conditions, this is done to prevent aerobic microbes from actively decomposing and nutrients can be provided. In addition, guidance and supervision of farmers must also continue to be carried out so that the PLGTB will continue to run and avoid land clearing by burning.

4. Conclusion

1. The total number of hotspots in 2015 was 2731, most of which were spread on peatlands, amounting to 2558 hotspots. The total number of hotspots in 2019 was 3321 with the number of hotspots mostly on peatlands of 3225. The highest number of hotspots was in Kumpeh Subdistrict which has the largest peatland.
2. The number of hotspots in 2015 and 2019 started to increase in June and peaked in September, and the rainfall began to decline in May and decreased sharply in September. Decreased rainfall can exacerbate the condition of forest and land fires. The total area burned in 2015 was 19995.3 which was mostly found on peatlands, which was 15855.8 ha. The total area burned in 2019 was 45,636.4 ha, and 43,534.6 ha of which were found on peatlands. Prevention of forest and land fires in peat areas has not been maximized due to a lack of public awareness to maintain and protect environmental sustainability.

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