Spatial model of control of fire prone peatlands based on rainfall data (case study: Kepulauaan Meranti Regency, Riau Province)

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Abstract: Peatland fires in Indonesia occur every year, and the impacts are also known to cause many costs. Fires in Indonesia are 99% caused by humans. Fires can occur when the components of the fire are available, namely fuel, oxygen and heat sources. Triangel fire components are in optimal conditions when the land is dry. Dry conditions are mainly caused by weather, and are reinforced by human activities. The main influence of weather is in the form of rainfall, while the human influence is in the form of canalization. Low rainfall causes dry land and plants. Canalization has the potential to cause the surrounding land to become dry. The canalization is made so that the plant roots are in the aerobic zone, so that the plants can grow well. The purpose of this study is to find out how much rainfall there are still fires and their distribution. By knowing this information, it is hoped that efforts to control forest and land fires can be carried out more effectively. The method used is spatial analysis. Materials used: 2005-2016 rainfall data, 2005-2016 hotspots data, 1: 50,000 scale RBI map. The results of this study indicate that the chance of occurrence of fires on the low rainfall class (0 – 100 mm) has 70.5% higher than chance of occurrence of fires than medium rainfall class (100 – 300 mm) of 24.5%.

1. Introduction
Forest and land fires in Indonesia occur every year, until what year the forest and land fires have stopped, no one knows. The impact of forest and land fires has also been known to cause many losses. Studies from Cifor for Indonesia taken from ISAS and ADB show that the calculation of fire costs from the ISAS (Institute of Southern Asian Studies) is tangible: US $ 652 million, and the intangible is US $ 1,812 million. Meanwhile, the tangible cost of fog reached 88 million US dollars; and intangible ones reached 289 million US dollars. Meanwhile, calculations from the ADB (Asian Development Bank) show that the cost of the tangible fires: 2171 million US dollars and the intangible reached 2,398 million US dollars. Meanwhile, the tangible cost of fog reaches 144 million US dollars; and intangibles amounted to US $ 148 million [1]. These losses cover various sectors: environment, social, economic, health, sea, air and land transportation, education. Forest and land fires are worse when they occur on peatlands. Fires can occur both above the plant (crown fire), on the ground (surface fire), and below the ground (ground fire) [2], [3] and [4].

Peatlands in Indonesia are the largest tropical peatlands in the world (± 14.9 million ha) distributed in Sumatra, Kalimantan, and Papua. [5]. About 30% of it has the potential for agricultural land [6]. As land with potential for agriculture, peatlands are used for agriculture and plantations.
Periodically or permanently, natural peatlands are always saturated with water (anaerob). These conditions are not suitable for certain agriculture and plantations whose roots require aerob conditions to obtain oxygen. In utilizing peatlands for agriculture and plantations, canalization is carried out. This canalization is carried out to lower the water table, so that the plant root zone is in aerob conditions. The impact of canalization is that the peatlands are dry, and they are prone to fires.

The key to fire control is rewetting the peatlands. Rewetting naturally is by the rainfall that falls on that location. Rewetting through human intervention is by making canal blocking and back filling (http://indonesiabaik.id/infografis/strategi-3r-untuk-restorasi-lahan-gambut), so that the surface water level of the canals can rise. As the water level in the canal rises, it will inhibit the runoff of water from the surrounding peatlands. In this study, the emphasis is on natural rewetting which relies on rainfall.

In Indonesia 99% of forest and land fires are caused by deliberate factors [7]. On the other hand, the resulting impact is the occurrence of uncontrolled fires in the form of smoke that cause losses of up to trillions of rupiah [1]. The research question is starting with how much rainfall can cause land fires. The aim of this study is to find out in how much rainfall there are still cause fires and their distribution. By knowing this information, it is hoped that efforts to control forest and land fires can be carried out more effectively.

2. Methods

2.1. Study Area and Data
The study area is in the Meranti Islands Regency Riau Province. (Fig 1.). Geographically Meranti islands Regency is located at coordinates between 0 ° 42 '30 "- 1 ° 28 '0" N and 102 ° 12 '0" - 103 ° 10 '0" E and is located on the east coast of Sumatra Island, with its boundaries as follows. In the north it is bordered by the Malacca Strait and Bengkalis Regency; in the south, it is bordered by Siak Regency and Pelalawan Regency; in the west bordering Bengkalis Regency; to the east it is bordered by Karimun Regency and Riau Islands Province.

![Figure 1. Kepulauan Meranti Regency Riau Province](Image)

2.2. Hotspot and Rainfall
Re-wetting is wetting with the construction of canal blocking, drilling wells and other efforts that encourage the wetting of peatlands. Rewetting is the key to controlling and suppressing land fires.[8]. Naturally, fires will be extinguished when wet with rain. Natural rewetting is closely related to the amount of rainfall in a location. In Kepulauan Meranti Regency, the highest rainfall in 2005 reached 138.83 mm, and in 2016 it reached 108.32 mm. (see Table 1).
Table 1. Max Rainfall in Rainfall Station Point Year 2005 and 2016

| No | Rainfall Station Point | Max Rainfall (mm) Year 2005 | Max Rainfall (mm) Year 2016 |
|----|------------------------|-----------------------------|----------------------------|
| 1  | Merbau                | 98.60                       | 79.47                      |
| 2  | P_Merbau              | 130.31                      | 71.31                      |
| 3  | Putri_puyu            | 85.98                       | 89.54                      |
| 4  | Rangsang              | 71.98                       | 108.32                     |
| 5  | Rangsang_Barat        | 72.98                       | 71.31                      |
| 6  | Rangsang_Pesisir      | 95.66                       | 73.38                      |
| 7  | Tebing Tinggi         | 130.31                      | 71.31                      |
| 8  | Tebing Tinggi Barat   | 68.39                       | 56.24                      |
| 9  | Tebing Tinggi Timur   | 138.83                      | 68.12                      |

Source: processing data from LAPAN

The amount of rainfall is classified into 4 classes (see Table 2). Based on the rain class, the Kepulauan Meranti Archipelago Regency consists of two classes: low rainfall and medium rainfall.

Table 2. Rainfall Classification

| No | Rainfall Class (mm) | Range of Rainfall |
|----|---------------------|-------------------|
| 1  | Low                 | 0 - 100           |
| 2  | Medium              | 100 - 300         |
| 3  | High                | 300 - 500         |
| 4  | Very High           | > 500             |

Source: https://www.bmkg.go.id/iklim/informasi-hujan-bulanan.bmkg?p=analisis-curah-hujan-dan-sifat-hujan-oktober-2020&tag=&lang=ID

The study was conducted with the stages of such activities on the flowchart as spatial model (figure 2). The model is an approach to make it easier to study complex systems in nature, so that the model is a simplification of natural realities that are so complex. The model is expected to represent the reality of the object. Modeling (modeling) is the process of representing the real world in the form of a model. [9] (Terlien 1996), [10] (Berge et al. 2001), [11] (Eriyatno and Larasati 2013), and [12] (Marfai 2017). Meanwhile, spatial is a representation of an object that has a geographical position, namely the location of an object at latitude and longitude. [13] (BIG. 2011), so that spatial modeling is a process of real-world representation that is geographically referenced in the form of a Spatial model. Several stages are described in section below.
Figure 2. Flowchart Stage of Research Activities

- Hotspots data with level of confident > 80% for year 2005 and 2016 were plotted on Rupa Bumi Indonesia (RBI) map scale 1:50,000. The hotspot data were obtained from LAPAN which is sourced from the MODIS image with 250 m spatial resolution. Thus each pixel represents an area of 250 m² which means each hotspot point represents a total area of 250 meters².
- Rainfall data is sourced from the Center for Atmospheric Science and Technology LAPAN. This data has a spatial grid resolution of 0.25 x 0.25 deg (~ 25 sq km), meaning that 1 grid represents a spatial area of ~ 25 km². Rainfall data contained at each rainfall measurement station are grouped into rainfall classes into an isohyet map. Grouping refers to the BMKG's rainfall classification. The Isohyet map consists of 2005 and 2016 isohyet maps as shown in Figure 3 and Figure 4.

Figure 3. (a) Isohyet Max Rainfall 2005 Map; (b) Isohyet Min Rainfall 2005 Map

Figure 4. (a) Isohyet Max Rainfall 2016 Map; (b) Isohyet Min Rainfall 2016 Map
Spatial analysis is done by overlaying the Isohyet map and hotspot to be able to produce the class of rainfall the distribution of hotspots.

Spatial analysis is done by overlaying the distribution hotspot based on rainfall class and distribution hotspot based on administration. The results of this overlay obtained fire prone identification based on rainfall class and its distribution area based on administration.

Fire prone identification can be used parties for more effective in fire hazard mitigation by using rainfall data.

3. Result and Discussion
Spatial analysis was carried out to find out what class of rainfall it was possible to have a hotspot with a level of confident > 80%. To get it, an overlay is done:

**First:** Isohyet data on minimum rainfall conditions in 2005 with hotspots in 2005; and Isohyet data on maximum rainfall conditions in 2005 with hotspots in 2005 (see Figure 5)

**Second:** Isohyet data on minimum rainfall conditions in 2016 with hotspots in 2016; and Isohyet data on maximum rainfall conditions in 2016 with hotspots in 2016 (see figure 6.)

**Figure 5.** (a) Distribution of hotspot based on maximal rainfall Year 2005; 5 (b) Distribution of hotspot based on minimal rainfall Year 2005

**Figure 6.** (a) Distribution of hotspot based on maximal rainfall Year 2016; 6 (b) Distribution of hotspot based on minimal rainfall Year 2016.

Hotspots in 2016 at the maximum rainfall in 2016 shows 2 (two) classes of rainfall: low rainfall and medium rainfall. At low rainfall, there are 82 hotspots; There are 3 hotspots in medium rainfall. Based on the administrative area, the distribution of hotspots in 2016 with the maximum rainfall year 2016 is shown in Table 3.
Table 3. Distribution of hotspots in 2016 with maximum rainfall year 2016 Based on administrative area (Sub Distirc)

| Sub Distric | Total hotspot | Class of Rainfall | Luas Area (ha) |
|-------------|---------------|-------------------|----------------|
| TEBING TINGGI | 34 | Low Rainfall | 1.707.046,16 |
| | 3 | Medium Rainfall | 114.575,30 |
| RANGSANG BARAT | 4 | Low Rainfall | 200.828,96 |
| MERBAU | 44 | Low Rainfall | 4.888.984,60 |
| Total | 85 | | |

Source: spatial analysis

Hotspots in 2005 at the maximum rainfall in 2005 shows 2 (two) classes of rainfall: low rainfall and medium rainfall. At low rainfall, there are 314 hotspots; There are 24 hotspots in medium rainfall. Based on the administrative area, the distribution of hotspots in 2005 with the maximum rainfall year 2005 is shown in Table 4.

Table 4. Distribution of hotspots in 2005 with maximum rainfall year 2005 Based on administrative area (Sub Distirc)

| Sub Distric | Total hotspot | Class of Rainfall | Luas Area (ha) |
|-------------|---------------|-------------------|----------------|
| MERBAU | 72 | Low Rainfall | 7.969.257,05 |
| RANGSANG BARAT | 24 | Low Rainfall | 2.061.683,23 |
| TEBING TINGGI | 257 | Medium Rainfall | 13.923.534,27 |
| TEBING TINGGI BARAT | 218 | Low Rainfall | 2.965.568,55 |
| Total | 571 | | 26.920.043,10 |

Source: spatial analysis

Based on the results of spatial analysis, it shows that in 2005 with a maximum rainfall, it shows that in the low rainfall class there are 314 hotspots (55 %), which are more than at the same time in the medium rainfall class there are 257 hotspots (45%). There is a difference of 57 hotspots. In 2016 with a maximum rainfall, it shows that in the low rainfall class there are 82 hotspots (96 %), which is more than at the same time in the medium rainfall class there are 3 hotspots (4%). There is a difference of 79 hotspots. So the average chance of a fire occurring is 45% up to 96% or 70.5% at low rainfall; and 4% up to 45% or 24.5% in Rainfall medium.

4. Conclusion

Based on this study, it can be concluded that the rain data can be an instrument for controlling forest and land fires; and the chance of occurrence of fires on the low rainfall (0-100 mm) has 70.5% higher than chance of occurrence of fires than medium rainfall (100-300 mm) of 24.5%.

Acknowledgments

We are grateful to Centers for Research, Promotion and Cooperation, Geospasial Information Agency (BIG) for the data and financial support which allows us to write this scientific paper.

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