Spatial model of peatland fire control strategies through peat maturity level approach: Case Study of the Kepulauan Meranti District

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Abstract. Tropical peatland in Indonesia is the largest in the world. Approximately 30% of the area potentially can be converted into agriculture and plantations. However, it is very susceptible to forest fires due to agricultural land preparation. The practice of burning forests is done because of some reasons namely fast, inexpensive, and produced ash that will fertilize the soil. The impact of land and forest fires is very large both in terms of economic, social, and environmental. Fires on peat lands consist of crown fire, surface fire, and ground fire which have a severe impact on environmental, social and economic impacts. In terms of management, it is also more difficult and longer time compares to fires on mineral land. The main objective of this paper is to use spatial modeling to provide an early warning system for forest fires on peat lands based on peat maturity level approaches. Physical data, which include the level of maturity, peat thickness, land unit, and land cover will be considered as an independent variable. Meranti Islands District, Riau Province is selected as a case area. The spatial analysis was carried out on physical aspects and the distribution of hotspots that had a level of confidence greater than 80%. The results showed that identification of potential fires through peat maturity levels, cannot be used optimally because peat areas that have different levels of maturity are not separate polygons or still in atribut form., The land cover of shrubs should be a major concern in the identification of potential fires.

Keywords: fire, maturity, peatland, spatial model

1. Introduction
The Peat Region in Indonesia is the most extensive tropical peatland in the world (± 14.9 million ha) spread across Sumatra, Kalimantan and Papua and around 30% of it is potential as agricultural land [1]. As land that has the potential for agriculture, peat land is used by various parties for agriculture
and plantations. In its use, users clear peatlands by burning. Forest burning practices are carried out for several reasons, namely fast, cheap, easy and produced ash which is expected to fertilize the soil. [2].

The impact of land and forest fires is enormous both in terms of economic, social, and environment. Forest fires that occurred in 1997-1998 were estimated to cause losses reaching US $ 9.3 billion to US $ 20.1 billion [3]. In Sumatra, peatland fires cause losses of up to 2.8 billion dollars [4]. From a social point of view, forest fires cause health impacts such as acute respiratory tract infections (acute respiratory infections) [5], schools are closed to avoid the effects of smoke. From the environmental side, the impact of forest fires on peatlands is in the form of reduced peat thickness that reaches 3-5 cm per year [6] and its release of carbon in large quantities. From peat burning 2 times per year assuming carbon peat density is around 50 kg m\(^{-3}\) or 0.05 t m\(^{-3}\), carbon emissions are estimated to reach around 110.1 t CO\(_2\)/ha/year [6].

Fires on peatlands consist of canopy fires, surface fires and land fires that have a severe impact on environmental, social and economic impacts. In terms of management, it is also more difficult and longer compared to fires on mineral soil. Thus the impact is getting longer and wider. Funds used for blackouts also become larger [7].

The research aims are to use spatial modeling to provide an early warning system for forest fires on peatlands based on an approach to peat maturity.

2. Material and Methode

2.1. Study Site
Kepulauan Meranti Regency is one of the regions of Riau Province which has an area of 3,707.84 km\(^2\) or 4.26% of the total area of Riau Province. Administratively, the area consists of 9 (nine) subdistricts [8]. In terms of its relation to peat, the Meranti Islands Regency region consists of 3 (three) peat hydrological units (KHG): KHG Padang Island, KHG Tebing Tinggi Island, and KHG Pulau Rangsang (KLHK). Overall, the Meranti Islands Regency area > 75% is the KHG area (figure 1).

![Distribution of KHG](image)

**Figure 1.** Location of Study Area Kepulauan Meranti District

2.2. Hotspot Distribution
Hotspots with level of confident > 80% are used for fire identification. Hotspot distribution is used to indicate the location of any area that is on fire. Fire areas can be grouped according to the administrative area, type of land cover can also be based on peatlands that have a certain level of maturity.
By following with the characteristics of the level of peat maturity that the more raw (younger) maturity, the easier it is to burn. Hotspot data was obtained from LAPAN and USGS, from 2005 to 2016. The distribution of hotspots showed in figure 2.

Hotspots are also related to FRP (fire radiative power). FRP can be used to measure wildfire quantities [9]. FRP distribution based on year of acceptance is shown in figure 3.

2.3. Characteristics of peatlands against fire

Peatland is a land that has a top layer of peat thickness ≥ 50 cm with organic matter content ≥ 20% [10]. Peatlands have irreversible nature if the condition has been damaged. Damaged conditions include peat in dry conditions and burning. In dry conditions, peat will burn easily, and most effectively become fuel, until a fire occurs. Based on the triangle fire concept, peatland and then vegetation above it acts as fuel, such as elements used in triangle fire which include elements of fuel, oxygen, and heat (see figure 4). On a larger and broader scale, as fuel is vegetation, oxygen is climate. Heat on a larger scale played by landform [11]
Based on its level of maturity, peat consists of three types namely fibric peat with raw maturity, hemic peat with half ripe maturity, and peat sapric with mature maturity. The characteristics of peat are based on their level of maturity as in Table 1.

| Nr | Level of Maturity | Characteristic |
|----|-------------------|----------------|
| 1  | Fibric            | The content of organic matter can still be identified visually with a composition of $\geq 75\%$ part of peat. |
| 2  | Hemic             | The content of organic matter can still be identified visually with a composition of $25 - 75\%$ parts of peat. |
| 3  | Sapric            | The content of organic matter can still be identified visually with a composition of $\leq 25\%$ part of peat. |

Source: Noor.M (2010)

Fibric peat is more susceptible to burning compared with hemic and sapric. The distribution of the level of maturity is graphically shown in Figure 5.
2.5. **Spatial analysis**

Spatial analysis is an analysis that uses spatial data to get specific goals with spatial dimensions. Spatial analysis consists of overlay for its polygon data. The data used include 1. Hotspot data for the period 2005 to 2016, 2. Land cover data from 2005 to 2016, 3. Soil data in which there is information on the level of soil maturity. Land maturity level data is a single data. The data processing stages are carried out as shown in Figure 6.

Hotspot data is overlaid with land cover data. This step is to obtain information on the distribution of hotspots distributed in any land cover, and which land cover has the most hotspots. Overlays are performed on hotspot and land cover data.

![Figure 6. Steps of Processing Data](image)

Graphically the distribution of hotspots is illustrated in figure 7

![Figure 7. Distribution of hotspots in land cover on period 2005-2016](image)
3. Result and discussion

The results show that the highest hotspots occurred in the shrubs and bushes. The hotspot pattern followed the distribution of unused land for cultivation which was dominated by shrubs and bushes. In the 12 year time (2005 up to 2016) the highest number of hotspots is always present in the type of land cover shrubs and bushes. This shows that the trend in the pattern of movement of forest fires always follows the lands of the shrubs and bushes. (See figure 8, and table 2).

In terms of level of peat maturity, it showed that many hotspots are found in the land units of the freshwater peat dome and the tidal peat dome. Based on the level of peat maturity, both land units have the same level of peat maturity, sapric and hemic. Dominantly both are dominated by sapric. that the type of level maturity.

| Land Cover Type      | Number of Hotspot per year |
|----------------------|-----------------------------|
|                      | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
| Shrubs and bushes    | 8    | 18   | 4    | 28   | 158  | 16   | 8    | 18   | 29   | 425  | 33   | 71   |
| Open land            | 3    | 1    | 0    | 0    | 31   | 1    | 0    | 1    | 0    | 277  | 13   | 3    |
| Swamp forest         | 5    | 2    | 0    | 2    | 36   | 7    | 5    | 3    | 12   | 114  | 41   | 6    |

Source: Data MODIS YEAR 2005 UP TO 2016

4. Conclusion

Based on the results of spatial analysis, it shows that shrubs have the most hotspots from year to year. So the land cover of shrubs should be a major concern in the identification of potential fires. The land unit which is a mapping unit for the level of peat maturity, is still an attribute data that is data expressed in the form of dominant (D) and few (F) attributes so that identification of potential fires through peat maturity levels, cannot be used optimally, because peat areas that have different levels of maturity are not separate polygons

5. References

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Acknowledgments
We are grateful to Centers for Research, Promotion And Cooperation, Geospasial Information Agency (BIG) for the data and financial support.