# Wetland Fires and Its Environmental Conditions

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# Wetland Fires and Its Environmental Conditions

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**ABSTRACT**

Today, many wetlands have been converted into agricultural, industrial, and residential areas. This conversion of land functions creates new problems for the environment and human, one of which is land fires. The results of land fires can also cause other problems that results in losses in various fields, such as human health, the economy, and other fields. The emergence of smog as a result of land fires can cause respiratory problems, disruption of the transportation system, conflicts between neighboring countries, and the others. South Sumatra Province is one of the largest contributors to the haze as a result of land fires, especially its wetlands. Ogan Ilir Regency is one of the areas in South Sumatra Province which has extensive wetlands and fires frequently occur. Fires are caused by triggering factors, one of which is natural factors such as a prolonged dry season, availability of water supply, and intensity of rainfall. This study is an analytic descriptive study that aimed to provide an overview of environmental conditions on land, the majority of which are wetlands which experienced fires in Ogan Ilir Regency in 2019. The environmental conditions studied included soil and vegetation types. The data obtained will be displayed through tables and graphs, then interpreted and analyzed descriptively. The type of data used is secondary data in the form of a report by the Regional Disaster Management Agency Ogan Ilir Regency related to land fires in OI Regency and processed using the Geographic Information System (GIS) application. The results of the analysis show that the area of land fires that mostly occurred in North Indralaya District was 382,7 hectares with a total of 144 hotspots. The burnt area was dominated by peat soil (53%) and scrub vegetation (43%).

***Keywords***: Soil type, Peat soil, Vegetation, Shrubs, Wetland

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## 1. Introduction

According to the Ramsar Convention, wetland is an area in the form of swamps, peatlands, and water that are naturally or artificially formed; is permanent or temporary; water stagnates (landing) or flows; tasteless, brackish, or salty; includes sea water that have a depth of not more than six meters at low tide. Wetlands are a source of life for all living things as well as having ecological functions such as controlling erosion, flooding, and the global climate (Harahap, 2016). Wetlands also have an important role, starting from regulating the hydrological system to carbon sequestration and the sustainability of biodiversity habitats (Margono, Bwangoy, Potapov, & Hansen, 2014).

Wetland ecosystems include swamps, lakes, rivers, mangrove forests, peatlands, coasts, rice fields, and coral reefs. Indonesia has more wetlands with peat swamps types than any other country. There are approximately 21 milion hectares of peat swamps in Indonesia that account for half of the world's tropical peat swamps forests (Murdiyarso, Kauffman, Warren, Pramova, & Hergoualch, 2012). However currently, several wetland areas have been converted into agricultural, industrial and residential land due to the demands and socio-economic conditions of the surrounding community (Dewi dan Rudiarto, 2013). Land conversion has had a negative impact, namely fires due to local logging activities carried out to clear land. This fire incident is also exacerbated by natural factors such as the La Nina and El Nino climate anomalies and the dry season which causes an area to be dry, which can cause fires to spread more easily. In addition, the accumulation of leaves, hot weather, lightning strikes, reduced water supply, and wood and peat vegetation are also the causes of forest and land fires (Irwandi, Jumani, & B, 2016).

The dry season is one of the natural factors that cause forest and land fires. The dry season usually occurs from August to October. Fire events can occur due to the fulfillment of three factors as a condition for the formation of a chemical reaction to form a fire, namely fuel, heat, and oxygen. According to the Intergovernmental Panel on Climate Change (IPCC) in 2010, the hot conditions of the dry season have caused an increase in temperature from 0,8 to 3,5$^0$C which resulted in the drying up of the fuel to approach the point of ignition, making it easier for fire to occur (Yulianti, 2018).

The worst incidence of forest and land fires worldwide occurred in 1997, covering an area of 25 million hectares (Rowell dan Moore, 2001). After the worst fire incident in 1997, the phenomenon of forest and land fires has become an annual phenomenon, especially in Indonesia. The largest forest and land fires in Indonesia also occurred in 2015 with affected area of 2.089.911 hectares and the largest area of fire was in Riau Province covering an area of 2.643 hectares which caused as many as 12 districts/cities affected by haze (Nurkholis et al., 2016). Based on the results of mapping from various studies, it shows that about 80% of fire incidents in Indonesia occur in Kalimantan and Sumatera with an average number of hotspots reaching 60.000 per year caused by two factors, namely natural factors such as weather conditions and seasons, as well as human factors such as conversion of forest and tropical peatlands (Yulianti & Hayasaka, 2013; Yulianti, Hayasaka, & Sepriando, 2013). South Sumatera Province is one of the areas on the island of Sumatera which is the second largest contributor to the haze due to forest and land fires. Ogan Ilir Regency is the area with the most frequent fires. Based on data from the South Sumatera Forest Service, fires occurred in 2014 covering an area of 17.728 hectares, in 2015 covering an area of 12.297 hectares, in 2017 covering an area of 2.614 hectares, and in 2018 covering 3.925 hectares.

Land fires, especially wetlands, are still a problem, both nationally and internationally, because the impact is not only experienced by the local communities of a country but also the world community, especially neighboring countries. In addition, fires do not only affect the environment, but also have an impact on social, economic, and public health conditions (Syaufina, Siwi, & Nurhayati, 2014). One of the effects of fires is the formation of smog. Haze can cause upper respiratory infections and other diseases due to the high index of air pollution due to fire. Based on data obtained from the health office of South Sumatera Province, there were more than 25,000 cases of respiratory infections experienced by the community, especially when forest and land fires occurred. This is proof that the haze caused by fires is very detrimental to the community. Therefore, it is necessary to take precautions to minimize other losses.

Effective control measures in minimizing the occurrence of losses are to know the root cause of a problem and after that take preventive measures and control the root of the problem. In the case of land fires, it has been explained previously that one of the causes of land fires is natural factors, where this natural factor can be in the form of environmental conditions that exist around the land, Therefore, this study was conducted with the aim of providing an overview of the environmental conditions on land, the majority of which were wetlands, which experienced fire in Ogan Ilir Regency in 2019. From the results of this study, it is hoped that it can become the basis for futher studies in resolving the problem of wetland fires in Ogan Ilir Regency in particular and in Indonesia in general based on environmental conditions.

## 2. Research Method

### 2.1. Time and Location of Research

Analysis of wetland fires incidence was carried out in Ogan ilir Regency, South Sumatera Province (Figure 1). Ogan Ilir Regency has an area of 2.666,07 km2. Geographically, Ogan Ilir Regency is located between 2055' to 3015' south latitude and 104020' to 104048' east longtitude.

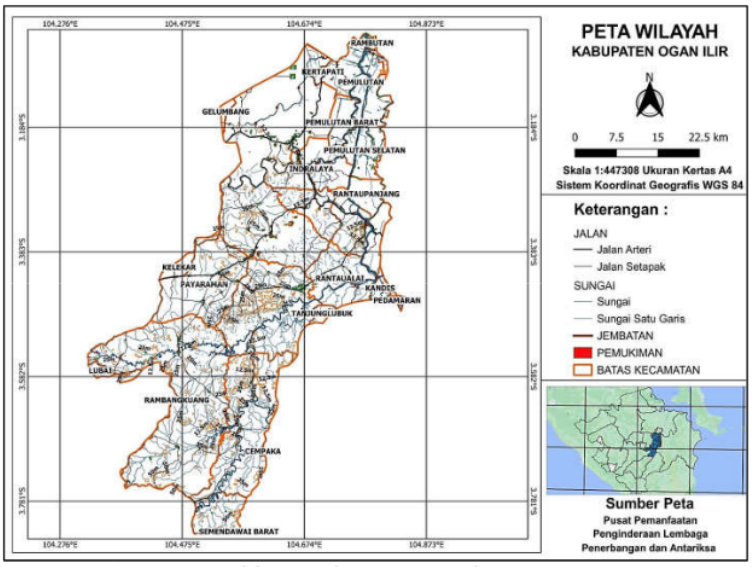


**Figure 1.** Map of the Ogan Ilir Regency, South Sumatera Province

### 2.2. Data Collective and Analysis Methods

This study is a descriptive analytic study which aimed to provide an overview of the environmental conditions on burned land in Ogan Ilir Regency through tables and graphs. The environmental conditions studies included soil and vegetation types. The type of data used in this study is secondary data which comes from reviewing the documents of land fires that originate from the Regional Disaster Management Agency of Ogan Ilir Regency. The components studied were the distribution of hotspots based on the incidence of land fires, the estimated area of land burned by the district, the type of soil, and the type of vegetation. The mapping of fire areas was processed using the Quantum GIS (QGIS) application to find out areas where fires had occurred in Ogan Ilir Regency throughout 2019.

## 3. Result and Discussion

An overview of Ogan Ilir Regency based on the 2016-2021 Ogan Ilir Regency Mid-Term Development Plan, Ogan Ilir Regency has an area of 2.666,07 Km$^2$, consisting of 16 districts, 227 villages, and 14 sub-districts, where the largest districts with an area of 528,82 Km$^2$ is Rambang Kuang Districts and the smallest districts with an area of 40,85 km$^2$ is Rantau Panjang Districts. The largest number of villages with a total of 25 villages are in Pemulutas Districts. Topographically, Ogan Ilir Regency has 65% of its area dominated by wetlands in the form of wet swamps, tidal swamps, peaty (bergambut) and peat soils (Peraturan Daerah Kabupaten Ogan Ilir, 2016).

### 3.1. Distribution of Hotspots in Ogan Ilir Regency

The distribution of hotspots is mapped based on the records of land fires in Ogan Ilir Regency that have occurred throughout 2019 (Figure 2). In addition, to determine the area of land that was burned due to the land fire incidents, it is displayed in a table based on the district (Table 1). Based on the result of the Regional Disaster Management Agency of Ogan Ilir Regency data recapitulation, it is known that there was burned land covering several district so that the recapitulation of the amount of burned land was accumulated for all district areas where the land was burned (Table 2).

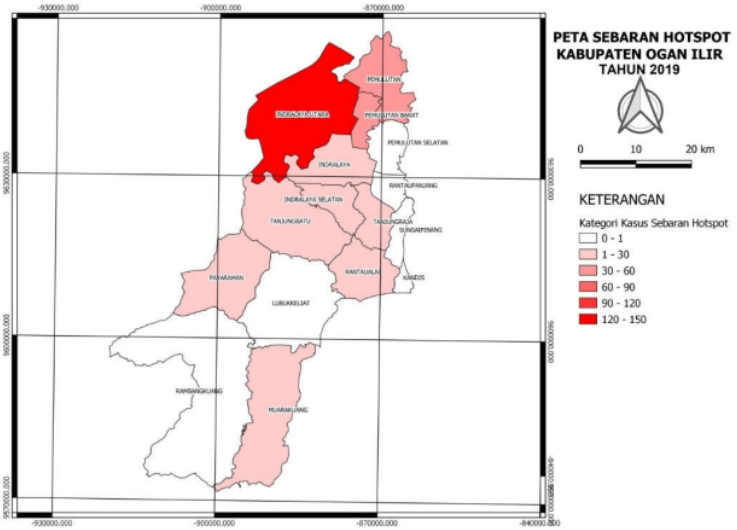


**Figure 2.** Wetland Fire Incident in Ogan Ilir Regency, South Sumatera Province in 2019

The map above shows that throughout 2019, Indralaya Utara was the district that experienced the most land fires with 144 hotspots and Payaraman District which experienced the least land fires with 1 hotspot. Meanwhile, Pemulutan Selatan, Rambang Kuang, Lubuk Keliat, Kandis, Rantau Panjang, and Sungai Pinang Districts did not experience land fires throughout 2019.

Based on the topoghraphy, Payaraman District has relatively small swamp size with only 20% of the total area, which is 180,5 Km$^2$, and is quite evenly distributed from Tebedak Village to Tanjung Lalang (Badan Pusat Statistik Kabupaten Ogan Ilir, 2020a, 2020b). Based on the Regional Disaster Management Agency of Ogan Ilir Regency data, it is known that the fire incident recorded in Payaraman District occurred in Talang Seleman Village, where the village is located between Tebedak and Tanjung Lalang Villages. Some of these things could be the cause of Payaraman District experiencing land fires but in a small number of hotspots because it is not an area prone to land fires. It is necessary to have futher study to find out in real terms and to do more in-depth examination regarding this matter.

Large land fires occurred in 2015 then decreased in 2016 to 2018. Based on data released by Global Forest Watch, the rate of deforestation in Indonesia decreased significantly in 2017 and 2018 (Haniy, Hamzah, & Hanifah, 2019). This is because the La Niña weather pattern that hit Indonesia causes the land to

be wet, making it difficult for fires to spread such as when the land is dry and there is a role for peat restoration and forest moratorium as one of the national policies in efforts to prevent and control forest and land fires. However, in 2019, land fires occurred again because that year was one of the years with the highest average temperature (World Meteorological Organization, 2020).

**Table 1.** Recapitulation of Land Fire Incidents in Ogan Ilir Regency in 2019 by District

| No. | Districts | Area Burned (ha) | Number of Hotspots |
|---|---|---|---|
| 1. | Pemulutan Barat | 86.5 | 31 |
| 2. | Pemulutan | 126.55 | 46 |
| 3. | Indralaya | 50.85 | 19 |
| 4. | Indralaya Selatan | 39.3 | 20 |
| 5. | Tanjung Batu | 47 | 13 |
| 6. | Rantau Alai | 70 | 24 |
| 7. | Muara Kuang | 27.2 | 9 |
| 8. | Indralaya Utara | 382.7 | 144 |
| 9. | Tanjung Raja | 15.3 | 10 |
| 10. | Payaraman | 1 | 1 |

**Table 2.** Recapitulation of Burned Land Covering Several Districts

| No. | Districts | Villages | Area Burned (ha) |
|---|---|---|---|
| 1. | 1. Indralaya Utara<br>2. Pemulutan<br>3. Pemulutan<br>4. Pemulutan Barat | 1. Sungai Rambutan<br>2. Muara Baru<br>3. Teluk Kecapi<br>4. Arisan Jaya | 49 |
| 2. | 1. Indralaya Utara<br>2. Indralaya Utara<br>3. Indralaya Utara<br>4. Pemulutan Barat<br>5. Pemulutan Barat | 1. Pulau Semambu<br>2. Lalem Raya<br>3. Sungai Rambutan<br>4. Arisan Jaya<br>5. Talang Pangeran Ulu | 139 |
| 3. | 1. Indralaya Utara<br>2. Pemulutan Barat<br>3. Pemulutan Barat<br>4. Pemulutan | 1. Sungai Rambutan<br>2. Arisan Jaya<br>3. Talang Pangeran Ulu<br>4. Ibul Besar I | 20 |

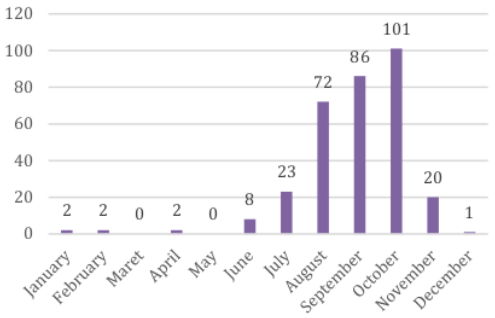


**Figure 3.** Numbers of Hotspots per Month in Ogan ILir Regency in 2019

The graph in Figure 3 shows that in Ogan Ilir Regency, the highest number of hotspots in 2019 occurred in October. In line with the study by Hero, et al, which stated that there was a decrease in the amount of monthly rainfall during the range of July to October so that this had an impact on the number of hotspots that increased dramatically, especially in October (Hero, Alfa, Selatan, & Barat, 2018). Similar to the explanation in Hero and Alfa's study, the highest incidence of land fires in Ogan Ilir Regency occurs from July to October.

Seasonal changes are not the only cause of forest and land fires, but climate conditions that are getting drier and then exacerbated by the El Nino phenomenon result in an increasing potential for fires (Hero et al., 2018). The El Nino phenomenon causes reduced rainfall intensity in Indonesia, especially from June to November (Ropelewski & Halpert, 1987). Irwandi's study also explains that the incidence of land fires due to high drought on fuel is influenced by the El Nino phenomenon (Irwandi et al., 2016). Peatlands that have experienced dryness have caused the water level to drop to 20 cm below the surface of the peat which can trigger fires on the surface of the peatlands (Putra et al., 2008).

### 3.2. Soil Type

Based on the analysis of the Regional Disaster Management Agency of Ogan Ilir Regency data, Bakung Village is the village with the most extensive fires with a total burned area of 114 hectares. This is related to the type of soil in Bakung Village that experienced fire, which was peaty soil (bergambut). The results showed that most of burned land was peaty soil (bergambut) (53%).

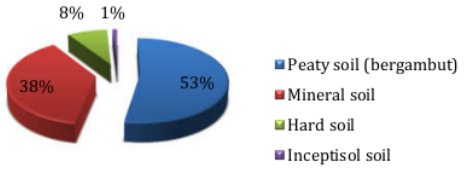


**Figure 4.** Types of Soil in the Burned Area

Peaty soil (bergambut) is mineral soil that has a peat layer on the surface of 20 to 50 cm (Antonius, 2016). The difference with peat soil can be seen from the thickness of the peat. Soil or peaty land (bergambut) is land that has a peat thickness of less than 50 cm, while soil or peat land has a peat thickness of more than 50 cm (Subekti & Wahyuni, 2015; Syaufina & Hafni, 2018). Peat and peaty soil (bergambut) are both formed from organic matter (litter) but peat soil contains >65% organic matter while peaty soil (bergambut) contains organic matter between 5 and 65% (Darmawijaya, 1997).

The organic matter content is an indicator of soil fertility and identifies the level of maturity of the peat and acts as a spur for microorganisms in the soil decomposition process. Due to the presence of organic matter in peaty soil (bergambut), such as peat soils, peaty soil (bergambut) can also have the potential for

fire when the soil is dry. The constituents of peaty soil (bergambut) are mostly from the remains of organic matter that have been buried for a long time. The remaining organic material becomes highly flammable. Fires that occur on soil or peaty land (bergambut) are not only in the form of flaming combustion but also burn deeper layers (20-50 cm) (Usup, 2015).

Apart from peaty soil (bergambut), fires in Ogan Ilir Regency also occurred on mineral soils, hard soils dan inceptisol soils. Study data shows that 38% of the burned land in Ogan Ilir Regency is of mineral soil. Mineral soils are soil formed from mineral materials through a weathering process that is influenced by climate and causes rock to disintegrate into loose parent material through a pedogenic process until it develops into soils (Hardjowigeno, 1986). According to Faturrahma's study and the topographical condition of Ogan Ilir Regency, it is known that most of the land types in Ogan Ilir Regency are swamps (65%) which are classified as mineral (Badan Pusat Statistik Kabupaten Ogan Ilir, 2020b; Faturrahma, 2019) so that many fires in Ogan Ilir Regency alco occur on this soil types.

In addition, mineral soils have low C-Organic (organic matter) content, which is less than 20% (Cahyono, 2014). The results of the analysis according to Mintari, et al. that the C-Organic content in the range of 16,21-54,76% is high (Mintari, Astiani, & Fernando, 2019). So that id it id related to the C-Organic content in mineral soils which is less than 20%, the mineral soil is classified as having C-Organis contents which tends to be low. Soils that has a low C-Organis content will inhibit the decomposition process so that fuels such as litter, twigs, and dead plants become less completely decomposed and eventually become potential fuel for fires (Saharjo et al., 2018). The availability of C-Organic material in the soil depends on the intensity of the fire, i.e. when the temperature of the fire increases, the more C-Organic material is burned, thereby accelerating the decrease in the amount of C-Organic in the soil (Mintari et al., 2019).

Futhermore, there were 8% incidents of land fires in Ogan Ilir Regency with hard soil types. Hard soil or sub soil is a layer of soil with a thickness of between 50-60 cm. Sub soil is soil located at the bottom of the top soil that has experienced weathering. This layer is in the range of 30 cm from the surface soil, the thickness of subsoil is between 50 cm-1 m from the topsoil. This hard soil can also be related to the consistency of the soil which describes the state of the soil that cannot be crushed when squeezed by hand and difficult to press with the thumb (Fiantis, 2015; Hetty, 2019). This hard soil is deep enough and can rarely be penetrated by tree or plant roots so that it does not allow for the accumulation of fuel such as litter, leaves, and dead branches and plants. Based on the Regional Disaster Management Agency of Ogan Ilir Regency report, fires that occurred on hard soils were mostly overgrown with shrubs. Therefore, it can be concluded that the incidence of fire on this soil type id not related. The fire incidents reported on this soil type occurred because of the vegetation that grew on it, and it is also known that most of the fire occurred in shrubs (43%).

In addition, 1% of land fires in Ogan Ilir Regency were inceptisol soil. From the result of the Regional Disaster Management Agency of Ogan Ilir Regency data analysis, it is known that the type of inceptisol soil that has experienced this land fire is sugarcane plantation in Burai Village in Tanjung Batu District and Sejaro Sakti Village in Indralaya District. In two different studies, it was stated that inceptisol soil (young soil) had a low clay content (<8%) and was in a layer between 40 and 50 cm deep from the mineral soil surface (Arabia, Manfarizah, Syakur, & Irawan, 2018; Ketaren, Marbun, & Marpaung, 2014). In addition, inceptisol soil also has sufficient water availability at 0,1-1 atm and has high enough organic matter (10-31%) (Ketaren et al., 2014). For this reason, it can be said that the fire incident in Ogan Ilir Regency on the inceptisol soil is also not related. Fires caused by ignition of sugarcane plantations were recorded as a type of vegetation in this soil type fire.

### 3.3. Vegetation Type

Figure 5 shows that the burned area in Ogan Ilir Regency is dominated by shrubs (43%). Several studies have stated that 99% of forest and land fires are caused by human factors while 1% are caused by natural factors as a driving force as well as exacerbating fires (Balch et al., 2017; Budiningsih, 2017; Chelsea Nagy, Fusco, Bradley, Abatzoglou, & Balch, 2018). Although the percentage is small, there is still a possibility that land and forest fires may occur due to environmental conditions. In addition, environmental conditions can also exacerbate fire incidents, one of which is the type of vegetation. The Jawad and Pualilin study shows that there is a close relationship between forest and land fre and the type of vegetation (Jawad, Nurdjali, & Widiastuti, 2015; Pualilin, Tjoneng, & Abdullah, 2019).

Based on Faturahma's study, it is known that most of the vegetation types in Ogan Ilir Regency are shrubs (Faturrahma, 2019). This shrub grows on idle land which is still widely found in Ogan Ilir Regency. As stated by Siregar in his study, there are still many idle lands or lands that are not managed by the community in the Ogan Ilir Regency area (Siregar, 2019).

Shrubs are woody shrubs with many branches of the same size. This type of vegetation is relatively dry during the dry season, so it is easy to catch fire and spreads during a fire. As stated by Jawad and Pualilin, shrubs are the type of vegetation that is most sensitive to sparks (heat soucers) (Jawad et al., 2015; Pualilin et al., 2019). There is still a lot of land in the area of Ogan Ilir Regency that is overgrown by shrubs, because it is not managed by the owner, so that the Ogan Ilir Regency is prone to land fires, especially in the dry season, because the land loses moisture and becomes dry.

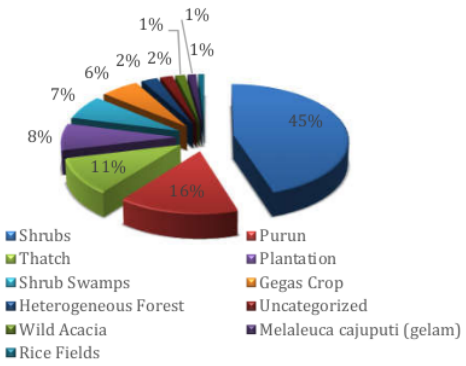


**Figure 5.** Jenis Vegetasi pada Wilayah yang Terbakar

The intensity of a fire is determined by the amount of heat energy and the rate of release. The amount of energy released futher depends on the thermal energy possessed by the fuel, as well as the amount of fuel and heat from the explosion, to be precise the heat of the explosion from a unit mass of the fuel (Trollope, 1984). The types of vegetation that exist in nature can be fuel. However, the vegetation factore cannot cause sparks because there must be other trigger factors, namely heat and oxygen. This is supported by the fire triangle theory which states that fire can be formed if the three elements are met, namely oxygen, fuel and heat. When a fire is ignited, to keep the fire burning continuously another element is needed, namely a chain chemical reaction, so it is called the Fire Tetrahedron. When a fire is burning it takes a very fast effort to put it out, before it gets so big that it gets out of control.

The occurrence of ignition in the land is a process of the fire triangle and completed by the element of a chain chemical reaction, because all the elements are available in nature. The source of heat that can come from the sun's heat and the heat that is generated intentionally through the burning process of garbage or cigarette sticks, oxygen available in the air, as well as fuel in the form fo vegetation. Accumulation of leaves, heat sources, or rock friction is not the main cause of forest fires, but they can affect fire behavior. Therefore, the cause of fire is not only determined by vegetation but also by other factors such as the role of humans and other natural factors in the form of wind and water supply.

In the study by Putra, et al, it was explained that the highest distribution of hotspots was found in dry shrub cover with low humidity (Putra et al., 2018). This type of shrub vegetation has a very high fire hazard level. In addition, the dry season is also affected by geothermal heat, causing plants and shrubs to become drier, withering and burning easily (Pasaribu & Friyanto, 2008; Rahardian, Yudo Prasetyo, & Haniah, 2016). Other study also explains that forest and land fires are affected by extreme climatic conditions such as the dry season which is then exacerbated by the presence of vegetation factors, especially wood and grass that are flammable and lack of water supply avalilability (Haris, Kumalawati, & Arisanty, 2017).

Based on the documents of the Central Bureau of Statistics of Ogan Ilir Regency, it is known that the highest amount of rainfall in Ogan Ilir Regency in 2019 occurred in March, namely 344,25 mm, while the lowest amount of rainfall was in August, which was 35,75 mm (Badan Pusat Statistik Kabupaten Ogan Ilir, 2020b). From these documents, it is also known that the rainfall in Ogan Ilir Regency from July to October tends to be low compared to other months. This is in line with the data on land fire incidents, where there are a large number of hotspots in those months (See Figure 3).

The availability of water supply in Ogan Ilir Regency tends to be dry due to low rainfall and construction of canals. The construction of canals on peatlands causes drought during the dry season due to reduced water reserves in the soil. Study by Adji, et al. states that the contruction of canals can damage the hydrological conditions and characteristics of peatlands (Adji, Damanik, Teguh, & Suastika, 2019). In line with study by Sumarga, et al, the number of hotspots was found in peatlands where canals were constructed (Sumarga, Hein, Hooijer, & Vernimmen, 2016). Although the construction of canals can cause water drainage in peatlands, canals also has water management function. Therefore, canal making must pay attention to the condition of the land contours so that the ecosystem in the peatland environment is maintained.

The factor of wind direction and speed also affected the spread of a fire which can spread to an uncertain place. Based on documents from the Meteorology, Climatology and Geophysics Agency and the Central Bureau of Statistics of Ogan Ilir Regency, the wind direction in Ogan Ilir Regency tends to go east with a speed of 5,66 Knots, where it is known that the east of Ogan Ilir Regency is Ogan Komering Ilir Regency. Based on the document review, Ogan Komering Ilir Regency experienced the most land fires in 2019. This proves that the wind direction affects the occurence of forest and land fires because it can enlarge the flames from the source and affect the speed at which the fire spreads.

## 4. Conclusion

Based on the study results, it can be concluded that: 1) The distribution of hotspots mostly occurred in Indralaya Utara District with 144 hotspots with the largest area covering 382,7 hectares, 2) land fires incidents in Ogan Ilir Regency occurred the most on peaty land (bergambut) (53%), 3) the vegetation type that mostly burned in the area was shrubs (43%).

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