Forest fires and management efforts in Indonesia (a review)

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Abstract. The area of Indonesia's forests has continues to shrink from year to year. The causes of this reduction have been mainly forest fires and the clearing of forest land into plantations and other nonagricultural uses. The area of Indonesia's forest consumed by fires in 2018 alone was about three times that of the previous year, 2017. These rising concern has pushed the Government into putting up divers efforts to control forest fires. This paper makes a general review of the forest fires in Indonesia, its impacts on humans and the natural resources with a special focus on water. The paper also discusses and brings out some possible loopholes in the system that might have contributed to the persistence of the forest fires. The major source of data for this review is secondary data from the ministry of environment and forestry, Indonesia, other sources were also considered for supporting data. This paper consists of 1. Introduction, 2. Causes of Forest and Land Fires in Indonesia, 3. Effects and impacts of Forest and Land Fires, 4. Water Footprint on Forest and Land Fires, 5. Fire Management Systems in Indonesia.

1. Introduction

Indonesia has been on the records for having consistent annual forest fires. History of forest fires according to data from the Ministry of Environment and Forestry dated back to the early 1980s. The forest fires have since been occurring on an average of 46,882.25 hectares (ha) every year [1]. The scope of the recorded fires includes natural forests, reforested land, afforestation forests, industrial plantations, and individual plantations. In the last five years (2014-2018) the average annual fires covered an area of 757,787.31 ha per year [2].
Based on Figure 1, it can be seen that 2015 experienced the largest fire incident in the 2014-2018 period. The event invited a lot of internal pressure and external calls on the Indonesian government and this led to an increase in the formulation of multifaceted strategies in dealing with subsequent forest fires. The effort yielded fruits to some extent and this was evident in the statistics of 2016 and 2017. In addition to the effort of government, rainfall data also showed a fairly high amount in these 2 (two) years, hence the forests had less dried leaves and wood which normally serve as potential fuel for fires. Figure 2 shows the rainfall in 2015, 2016, 2017 in 6 provinces which are prone to forest fires, namely Riau, Jambi, South Sumatra, West Kalimantan, Central Kalimantan, and South Kalimantan. The average annual rainfall in 2015, 2016, 2017 is 574.2 mm / yr, 968.9 mm / yr, 944.3 mm / yr. It can be seen from figure 2 that the annual average rainfall in 2015 was the lowest compared to 2016 and 2017. This has left a debate as to whether the decrease in forest fires should be attributed to government efforts or the rains.

Figure 2 again shows low rainfall in June-October and its peak in September. This depicts to some extent the dry season experienced during this period. The local people also prefer to do their agricultural land preparations around this time in anticipation of the new rains. The most common and cheap land preparation

Figure 1. Area of Forest and Land Fires in 2014-17 November 2019 [2]

Figure 2. Annual average rainfall in 6 provinces prone to forest fires in 2015-2017 [2]
method usually adopted is the burning method. While some do slash and burn others simply set fire to the weeds on their piece of land. These fires sometimes get out of hand and spread over large unintended areas. This trend is supported by the data in Figure 3 showing more hotspot points in June-October and the peak is in September. It is in light of the rising concerns about the increasing nature of forest fires despite heavy investments in management options that led to the production of this review paper. The paper consists of parts, part 1: Introduction, 2; Causes of Forest and Land Fires in Indonesia, 3; Effects and Impact of Forest and Land Fires, 4. Water Footprint of Forest and Land Fires, 5. Monitoring and management systems in Indonesia.

2. Causes of Forest and Land Fires in Indonesia
The causes of forest fires can be attributed to humans and nature. From these two major causes arises several activities that cause forest fires. These include lightning from nature, negligence, arson, the explosion of ammunition and bombs in military training areas, and in some rare cases the causes are unknown. But generally, in Southeast Asia including Indonesia, forest fires are mainly caused by human activities such as converting natural forest land into plantations or other uses [3]. In addition, forest fires have been increased due to the variability of climate factors ENSO (El Nino Southern Oscillation) and IOD (Indian Ocean Dipole) which mainly impact rainfall in Indonesia. El Nino plays an important role in fire cases in Indonesia [4]. In 2015 there was a long dry season due to Strong El Nino and positive IOD [5]. These two events occurring together escalated the impact on weather thereby reducing rainfall significantly [6]. This event was later confirmed by NASA in 2015 that forest and land fires in 2015 were indeed heightened by the presence of El Nino.

Satellite detected images between 2001 to 2017 revealed that most hotspots in plantations and concessions amounted to 47%, while those on community lands were around 22% and in conservation forests around 31% [7]. These revelations show the incidence of fire that can be attributed to human activities. According to information from workers in the ministry of environment and forestry, Indonesia (KLHK) the characteristics of forest fires in Indonesia vary from province to province. For example, in the province of West Kalimantan fires are generally caused by the practice of Gawai, this is the cultural practice of preparing traditional agricultural land in the community by using fire. East Nusa Tenggara Province people have a habit of burning grass in the hills. This is intended to grow young grass to feed animals. Whereas in the Riau province forests are generally burnt for oil palm plantation. In other cases which are quite rare, human-caused forest fires can occur due to carelessness or intentional burning of forest to seek revenge. This latter cause of forest fires raises concern about the alarming rate of unemployment in the country. It is an open secret that unemployed youths in the communities are often hired by selfish rich men to perpetuate these destructive acts. Unemployment can, therefore, be included as a contributor to forest fires.

Between 2012 and 2018, Law enforcement agencies have brought about 12 companies to book for involving the burning of forest unlawfully. They were altogether charged with IDR. 0.697 Trillion as compensation to the state. [2]

3. Impacts of Forest and Land Fires
Forest and land fires have many negative impacts on human life and nature. Based on survey from several journals Table 1 divides the impact of forest fires on the environment, economy, social and health with their respective references.
**Tabel 1.** The historical impact of forest fires

| Authors | Impact of Forest Fire |
|---------|-----------------------|
| Volkova L et al., 2019; Guo M et al., 2017; Martin D, Tomida M, Meacham B, 2016; Goto Y & Suzuki S, 2013; Loures L, et al., 2012; G. R. van der Werf et al., 2010 | Environment [8][9][10][11][12][13] |
| Stephenson C, Handmer J, & Betts R, 2013; Silva FRY, 2012; Appiah M et al., 2010 | Economic [14][15][16] |
| Paveglio TB, et al., 2015 | Social [17] |
| Harrison, Mark E., 2009 in Global Forest Watch, 2019 | Health [18] |

In a recent report from the Director-General of law enforcement Ministry of Environment and Forestry, they lamented on the negative impacts of the forest fires and categorically mentioned some of the effects such as: direct effect on public health, directly negative impacts on the ecosystem, causing a direct burden on the economy, causing transboundary issues such as air pollutions in neighboring countries like Singapore and Malaysia.

Among the many negative impacts caused by these forest fires the emission of \( \text{CO}_2 \) has been one of the serious concerns, not only to Indonesia but the world at large. Peatlands, in particular, have been found to emit more \( \text{CO}_2 \) than normal land during the event of forest fires. This is basically due to the flammable carbon stock that is stored under these soils. Figure 3 shows \( \text{CO}_2 \) emissions from peatland fires and trend of increase in 2010-2015 [2].

![Figure 3. CO\(_2\) emissions from peatland fires in Indonesia [2]](image)

Economically the impact of forest fires in Indonesia has been quite large, in 2013 the average loss was about USD 4.5 million [18] and in 2015 it rose to USD 16.1 million [7]. Some of the indirect economic losses include the thick cover of haze in the atmosphere that has caused some schools, shops, and other businesses to be closed.

4. **Water footprint on forest and land fires**

Forest among its many benefits to humans also serves as a storage of water which the community uses as drinking water, irrigating rice fields and other needs. Forest fires have an impact on the quality and quantity...
of water. Water that is exposed to the dust and ashes produced from forest fires becomes dirty thereby reducing the quality of water. During fire fighting expeditions water is expended in large volumes. Data from a Post Forest Fire survey conducted in 2019 about water bombing showed that the total amount of water that was expended for extinguishing fire between January 2015 to October 2019 was as much as 800,508,429.1 liters of water. Besides these losses, volumes of streams and other water bodies that serve mankind also got dried up during and after these fires. Table 2 derived from the ministry of environment and forestry (KLHK) gives details of the data on volumes of water used for water bombing during fire fighting.

**Table 2.** Amount of water expended for water bombing during forest fires in recent years

| Year               | 2015      | 2016      | 2017      | 2018      | 2019(till October) |
|--------------------|-----------|-----------|-----------|-----------|--------------------|
| water (liter)      | 150,610,2 | 100,122,9 | 97,630,000| 315,959,200| 386,667,896,0      |

5. Indonesian Government's Efforts in Forest Fire management

Forest fires are a national disaster for Indonesia. The government also regards it as a serious matter and gives it the necessary financial support. Minister of Finance Regulation Number 230 / PMK.07 / 2017, Minister of Environment and Forestry Letter Number S.112 / Menlhk / Ppi.4 / 3/2018, and LHK Minister Letter Number S. 214 / Menlhk / PPI / Ren.0 / 4/2019 all related to the financing of forest fire management efforts and other forest resource management. The central fund for this is the Forest Resource Revenue Sharing Fund and Reforestation Fund (DBH-DR).

The support system works to create posts that carry out multilevel operations, namely village posts, operational areas, regional post, and Central Posts (national level). In each region groups are formed from the community and are called fire care communities (Masyarakat Peduli Api, MPA). MPA assists officers in monitoring and handling forest fires. Formation of troops and training in forest and land fire control for local governments and concession holders. The government also conducts technical training and awareness campaigns on forest fires and their prevention to the public. Routine patrols are carried out in the context of socialization and early extinguishing involving posko officers, local governments, communities, the army, companies, and NGOs, etc.

Monitoring efforts have led to early detections of fires by using thermal CCTV cameras at 15 points. The use of wireless systems in monitoring forest fires is done by officers at each post. Several studies on early detection systems are conducted using wireless sensors [19]; [20]; [21]. On the latest about using Sensors for early detection, there are researches underway that seek to fit sensors to the body of animals and release them into the forest. This is referred to as biological sensors [22]. The government has provided fire monitoring tools in regional units in the form of drones in monitoring locations prone to forest fires. In addition, the patrols of Manggala Agni officers have been formed in each region. The findings of each unit are reported to the central post in Jakarta. Monitoring of fire-prone locations can also involve the community such as the collection of mobile data carried out by using the Post Bushfire House Surveyor and Droid Farmer [23]. It is necessary to increase the capacity of human resources in using this tool so the results are effective. For mobile applications, the government provides Sipongi application. This application launched in march 2015 enables the local people in the community to directly monitor forest fires.

Public involvement that has been carried out so far involves using traditional methods, wherein the community reports to the Agni manggala officers at the various post that was formed [24]; [25]. Despite the existence of these monitoring systems, the lack of assessment often renders their works incomplete, especially in preparing reports on forest fires.
Nationally, the government established a central command post for monitoring hotspot points in Indonesia that reaches the western and eastern parts using Terra Aqua Modis, S-NPP and NOAA satellites. Hotspot monitoring is done by monitoring through the Sipongi KLHK Website, LAPAN, BMKG, BNPB. Currently, the rehabilitation and monitoring efforts on peatlands are carried out by KLHK using Simantag 0-4m which monitors peat water levels.

Prevention efforts through legal channels are carried out by the government through an intelligence center. Giving warning and monitoring letters to companies and the provincial governments that are associated with the burning of forests and lands. The Director General (DG) of the Ministry of Environment and Forestry (KLHK) Protection carries out criminal and civil lawsuits against perpetrators of forest fires. Some other achievements of the DG so far include: issuing 1,098 administrative sanctions to corporations, gaining IDR16.9 trillion from civil verdicts, prosecuting and arranging 731 cases to the court and launching 1,180 forest security operations. However in a recent report, the DG lamented that their work in enforcing law is not achieving the expected results because the system lacked prevention instruments, such as public awareness, coaching, and monitoring [26]. The DG is also limited in their quest to dispense justice due to lack of assessment methods.

6. Conclusion

From the foregoing discussions, it can be seen that Indonesia as a country is vulnerable to both natural and man-made forest fires. This event has not only cost the country internally in terms deaths, disease, burdening national budget, loss of biodiversity, etc, but has also got international impacts such the negative contribution to climate change resulting from the tonnes of CO2 emitted, and also straining of diplomatic ties with neighboring countries as a result of transborder pollution. In the meantime, the government has tried to put the situation under control by engaging various options such as early detection, monitoring, law enforcement, etc. But amid all these efforts, there are some gaps that still exist such as insufficient education, inefficient impact assessments methods, weak linkages between the state intuitions and the communities, and this has hampered the work of law enforcement agencies, researchers and other stakeholders.

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