Fuelling the fires: practical steps towards wildfires in Indonesia

Delima Hasri Azahari Darmawan
Senior Researcher of Center for Agro Socio Economic and Policy Research

*E-mail: delimahasridarmawan@yahoo.com

Abstracts. Forest and land fires occur in numerous countries, including Indonesia. Even countries with the best technology and equipment, such as the US, Australia and European countries - have strong management and government as well as the funds to better prevent their forest and land fires. This paper argues that forests and land fires can occur in different places, regardless of its plantation. Thus, it shows that palm oil plantations do not necessarily cause such fires, as many have argued for the case of Indonesia. Russia, the US, Australia, Portugal and Italy for example do not have oil palm plantations, but forest and land fires have taken place, even more severe than in Indonesia. This paper will look at the distribution of the fires based on sector and land use. At the same time, by using the case of Indonesia, it will also provide update information on forest and land fires in Indonesia and efforts by stakeholders in palm oil governance.

Keywords: palm oil; forest and land fires; wildfires; governance

1. Introduction
1.1. Initial Development of Oil Palm in Indonesia
In 1911, a Belgian company opened the first commercial oil palm plantations in Pulau Raja (Asahan) and Sei Liput (Aceh), and a German company also opened an oil palm plantation in Tanah Itam Ulu. The year is considered as the beginning of oil palm plantations in Indonesia. The Belgian and German investor ventures into oil palm plantations were later followed by other foreign investors, including some from the Netherlands and Britain. In 1916, there were 19 oil palm plantation companies in Indonesia and the number increased to 34 companies in 1920. The first palm oil mill (PKS) in Indonesia was built in the Sei Liput in 1918 and the second in Tanah Itam Ulu in 1922 [1].

Indonesia palm oil industry began its rapid growth after the successful establishment of large national private plantations (PBSN I, II, III) and the introduction of cooperation between oil palm farmers and corporations known as the Nucleus Estate and Smallholders (PIR) program. After the successful trial of the World Bank-financed PIR program (PIR I-IV), it was further developed into various other PIR models. Special PIR and Local PIR were introduced from 1980 to 1985 in order to develop the local economies; PIR Transmigration was develop from 1986 to 1995 in line with the opening of new territory and PIR Primary Credit Cooperative for Members were started in 1996, associated with the development of rural co-operatives. Through these PIR schemes, oil palm plantations expanded rapidly from North Sumatra and Aceh to Riau, Kalimantan and other parts of Indonesia. The total area of oil palm plantations in Indonesia increased from 300,000 hectares in 1980 to about 11.6 million hectares in 2016 and 14.33 million hectares in 2018. Meanwhile, CPO
production increased from about 700,000 tons in 1980 to 33.5 million tons in 2016 and 40.57 million tons in 2018. Smallholders plantations covered 40.59% of the oil palm plantations’ land bank and private firms covered 54.43%, while state owned enterprises decreased 4.98% (Figure 1).

![Graph showing percentage of growth in land development in the last 20 years.](image)

*Source: Directorate General of Plantation Statistics 2018*

**Figure 1.** Indonesia Palm Oil Growth 1978 - 2018

### 1.2. Oil Palm Growing Development

The rapid growth in Indonesia’s CPO production has changed the country’s position in the world’s palm oil market. In 2006, Indonesia succeeded in replacing Malaysia as the world’s largest CPO producer and by 2016 Indonesia’s share reached 54 percent in the world’s CPO production, while Malaysia was in second position with a 32 percent share. Indonesia mostly produces palm oil for export and only about 20 to 25 percent is for domestic consumption in, for example, the oleo food industry and for oleo chemicals, detergents, soaps, and biodiesel. Indonesia’s palm oil exports have generated a significant amount of foreign exchange for the national economy. CPO and derivative products have made a significant contribution to the country’s non-oil exports and the country’s economy as a whole as shown in Figure 2.
With its high export volume, palm oil has become the main largest export commodity for the country. From the standpoint of economic development, the foreign exchange generated from palm oil exports is more sustainable and beneficial for the economy because (1) it is produced from oil palm plantations in 190 districts in Indonesia, (2) about 41 percent is produced by smallholder oil palm plantations, (3) there is an increase in processed products from the domestic downstream industry and (4) it is produced through plantation owners’ own efforts as they do not receive subsidies from the government.

The volume of Indonesian palm oil exports has increased sharply in the past several years in line with the increased in production. Indonesia’s palm oil exports, which totalled 15 million tons in 2008, increased sharply to 25 million tons (CPO equivalent) in 2016. The sharp increase in the volume on Indonesia’s palm oil exports has also changed the composition of export products.

The policy to promote the domestic downstream palm oil industry has successfully improved the composition of Indonesia’s palm oil exports from mostly CPO to mostly processed palm oil products. In 2008, CPO accounted for about 55 percent of Indonesia’s palm oil exports. In 2016, the figure underwent a major change as the share of the processed palm oil products in total palm oil exports increased sharply to 78 percent.

The palm oil export destinations shown in figure 3. India, European Union and China is major palm oil export destination with 6.7 million ton; 4.78 million tons and 4.4 million tons, respectively. While Africa 2.5 million tons; Pakistan 2.4 million tons; Middle East 1.94 million tons; Bangladesh 1.45 million tons and USA 1.2 million tons (Figure 3).

* Volume of export is not include of biodiesel and olechemical

**Source:** BPS dan GAPKI

**Figure 2.** Indonesia Production and Export of CPO
Indonesia’s Trade Balance is shown in Figure 4. In year of 2018 and the beginning of year 2019 Indonesia experienced negative balance of trade because of negative balance in oil and gas. However, the non-oil and gas experienced with positive balance of trade. It is mostly cause by palm oil positive balance of trade of 7 billion USD. This figure shows how important of palm oil in Indonesia economy as source of foreign exchange (devisa) earnings.

2. Land Use Performances
If you read ingredient labels, you'll see palm and palm kernel oil everywhere: in bread, chocolate, frozen pizza even in soap, toothpaste and cosmetics. No wonder the oil palm tree, whose fruit and seeds are used to produce these oils, is in tremendous demand as a crop in West and Central Africa.
and Southeast Asia. But while the trees are considered a highly productive source of vegetable oil, farming them can carry a heavy environmental impact. As large farms clear land to make room for oil palms, deforestation and forest fires can occur, threatening biodiversity.

Various forms of unfair competition through negative and even black campaigns such as deforestation, the effect on climate change, and losing biodiversity have been carried out against palm oil since the early 1980s. This is mostly due to the revolution in the development of Indonesia’s palm oil that has attracted the attention of the global community. The change in the position of palm oil to become the world’s main vegetable oil replacing soybean oil, which had dominated the world’s vegetable oil market for more than 100 years, has triggered a new dynamic in global vegetable oil competition. As shown in figure 3, palm oil, soybean oil, and rapeseed oil contributed to 35%, 29%, and 15% respectively to the vegetable oil production in the world. The share of palm oil increased from 22 percent (1965) to 40 percent (2016), while the share of soybean oil fell from 59 percent to 33 percent in the same period. Thus, it is quite clear that the largest share palm oil in the world’s vegetable oil production is not due to the large size of oil palm plantation but due to higher palm oil productivity than other vegetable oil-producing plants. The oil palm is grown in 43 countries and accounts for 10 percent of the world’s permanent crop land producing 70 million tons of palm oil each year.

The global palm oil market is staggeringly large, with the industry valued at $62 billion in 2016, according to the United Nations Environment Programme. Palm oil is found in roughly half of all supermarket products, says the UN, as well as in biofuels.

The development of palm oil plantations around the world, which has been said to have undergone revolutionary growth in recent years, has actually been exaggerated, the data show that the expansion of the oil palm plantations is far lower than that of other vegetable oil crops such as soybean, sunflower, and rapeseed. The area of the world’s four largest vegetable oil producing plants (palm oil, soybean, sunflower, and rapeseed) reached about 200.5 million hectares in 2016 of this area, 61 percent (121 million hectares) comprises soybean plantation. While the area of oil palm plantations is only 10 percent (20 million hectares) [2].

But in terms of oil productions, with 121 million hectares, soybean plantations produce only 53 million tons of oil or only 33 percent of the world’s top four vegetable oil production. On the contrary, oil palm plantations with an area of 20 million hectares, can produce 65 million tons of oil or 40 percent of the world’s top four vegetable oils [2]. This is due to the high productivity of oil palm plantation, which is far higher than the productivity of other vegetable oil producing plants. The productivity of palm oil per hectare of land is much higher (8-10 times) than the productivity of other vegetable oils. Thus, with less land, oil palm plantation can produce more vegetable oil. The vegetable oil productivity data also reveal that oil palm plantations are the most efficient crops in converting solar energy into vegetable oil.

The data is internationally recognized and shows the largest land use change including deforestation (Land Use, Land Use Change and Forestry, LULUCF) occurred on soybean plantations, followed by rapeseed plantations and sunflower. From 1990 to 2008, 3.83 million ha of global pet land was converted into agricultural land or for other uses [3]. Of that, about 37 percent happened in Russian and 33 percent in European peat land areas. About 13 percent of Indonesia’s peat land was also converted in that period.

Based on the data of Wetland International (2008), most global peat land (80 percent) is utilized for agricultural activities and only 20 percent is utilized for peat land forest. The use of peat land for agriculture in various regions is as follows: Africa (65 percent), the Americas (75 percent), Europe (67 percent), and Asia (89 percent).

Of the peat land used for agriculture, most of the 296.3 million ha is in the Asian region, followed by the American region. Russia, which has about 137 million hectares of peat land, uses 130 million hectares, about 94 percent, for agriculture. The US, which has about 22 million ha of peat land, uses approximately 12.4 million ha (55 percent) for agriculture. Meanwhile, Indonesia (Agricultural Research and Development Agency, 2008), which has about 18.3 million ha of peat land, uses about
6.05 million ha for agriculture. Therefore, it is not true that the most global peatland is used for peatland forest and it is not true that Indonesia is the country to use the most peat land for agriculture.

3. Fuelling the Fires on Forest an Land Toward the Wildfires

Forest and peatland fires in Indonesia are a cause of major international concern because of the large GHG emissions associated with these fires [4], and the negative impact of resulting aerosol emissions for human health, transport, tourism, economic activity in the Southeast Asian region [5, 6, 7, 8].

Fires are typically lit for agricultural purposes during the regular dry season [9], but their impacts are heightened during years of anomalously low rainfall [10]. Drought years in Indonesia occur when anomalously cold sea surface temperatures surround Indonesia and warm waters develop in the eastern Pacific Ocean (El Niño Southern Oscillation, ENSO) and in the western Indian Ocean (Positive Indian Ocean Dipole, IOD) [11].

ENSO conditions typically occur every three to seven years and result from weakened easterly trade winds in the western equatorial Pacific, allowing warm surface water to shift towards the coast of Peru in the eastern Pacific [12]. The positive phase of the Indian Ocean Dipole (IOD) is a related phenomenon that occurs when warm waters off the coast of Sumatra shift towards East Africa [13].

All major Southeast Asian haze events from 1960 to 2006 have occurred during years of anomalously low rainfall induced by ENSO and/or IOD conditions [7]. The fires of 1997-98, the year that saw the strongest recorded ENSO and IOD in the 20th century, burned 9.7–11.7 million ha on Borneo and Sumatra and destroyed 4.5–6 million ha of species rich Dipterocarp forest (including 1.5–2.1 million on peat soils) [14, 15].

The study by Gaveau et al. (2014) found that 52% of the total burned area (84,717 ha) was within concessions, i.e. land allocated to companies for plantation development [16]. However, 60% of burned areas in concessions (50,248 ha, or 31% of total burned area) was also occupied by communities. This presence makes attribution of fires problematic. The remaining 48% of the total burned land (79,012 ha) was owned by Indonesia's Ministry of Forestry (under central government). These areas were deforested prior to fires and their ownership is often contested by the local government.

The interesting thing to learn is the distribution of fires based sector and land use. About 70 percent of fires in Europe and North Africa hits forest, timber estates and natural land and about 29 percent of fires take place on agricultural land [17].

As per September 2019 the coverage of Land and Forest Fires in Indonesia was 328,724 hectares with 2,583 hot spots. To overcome the fires, the Government of Indonesia already provided 42 helicopters with 163 million liters of water, 164,016 kg of salt and 9.072 personel (Figure 5).
Figure 5. Land and Forest Fires Distribution in Indonesia

Location of the fires by concession vary in some provinces with average on pulpwood concession of 15%, Oil Palm 11%; Logging % and others 69%. In Riau and South Sumatera, the fires in pulpwood concession were higher than in the oil palm concession, while in Jambi, West and Central Kalimantan, the fires in Oil Palm concession were higher than in Pulp wood concession. However, the highest fires in Logging concession was happen in Jambi province.

Table 1. Percentage of fires based on concessions and Provinces, 2019

| Concession | Riau | South Sumatera | Jambi | West Kalimantan | Central Kalimantan | Indonesia |
|------------|------|----------------|-------|-----------------|-------------------|-----------|
| Pulpwood   | 29   | 25             | 17    | 20              | 2                 | 15        |
| Oil Palm   | 19   | 2              | 19    | 26              | 15                | 11        |
| Logging    | 2    | 2              | 10    | 1               | 2                 | 5         |
| Others     | 50   | 71             | 54    | 53              | 81                | 69        |

Source: Global Forest Watch, 2019

From 2010 to 2015, for example, the average extent of forest and land fires in various countries remained high. In some countries they are even more extensive than in Indonesia. The area of forest and land fires in Russia reaches about 2.3 million ha each year; in the US it reaches 2.2 million hectares; about 236,000 ha burn in Australia, about 107,000 in Spain and about 84,000 hectares in Portugal. The area of forest and land fires in those countries is larger than in Indonesia, where it is about 64,000 hectares per annum [18].

The data shows that global forest and land fires are not country specific, not ecosystem specific and not industry/commodity specific either, but a global phenomenon that happens in nearly every country every year. Countries that have the best technology and equipment, have management, government and a large amount of funds and a reliable community ethos, such as the US, Australia and European countries, are also unable to prevent forest and land fires. Forest and land fires are not related to whether there is peat land and whether there are oil palm plantation. Russia, the US, Australia,
Portugal and Italy do not have oil palm plantations, but forest and land fires also take place, even more than in Indonesia.

This shows that forest areas are the most being gutted by fire in each country. A great many fires also hit agricultural land in nearly each country in Europe and North Africa. This raises interesting question: Do farmers in advanced countries like Europe have habits like Indonesian farmers? Or is agriculture the victim of a spill-over of forest fires?

Forest and land fires that happen in various countries also happen in Indonesia. Based on data from the Forestry and Environment Ministry of the Republic of Indonesia (2016), forest and land fires happen in a majority of provinces throughout Indonesia. In several provinces with high concentrations of oil palm plantations such as Central Kalimantan, South Sumatra, East Kalimantan and Riau, forest and land fires have taken place in relatively large areas. However, forest and land fires covering relatively large areas also take place in provinces having no oil palm plantations, such as Lampung, North Sulawesi, Gorontalo, Maluku, East Java, Central Java, and West Java. Meanwhile, oil palm plantation-expansion provinces such as North Kalimantan and Bengkulu record relatively fewer forest fires compared with fires in Central Java and East Nusa Tenggara provinces, where there is no oil palm development [18].

Therefore, just as in other countries, forest and land fires in Indonesia are not systematically or specifically related to oil palm development. In fact forest and land fires can happen in provinces with or without oil palm development. Also, forest and land fires do not specially hit peat land areas. East Java, West Nusa Tenggara and West Java, which do not have any peat land, also suffer from forest fires in relatively large areas. The spread of hotspots in November 2015 based on land use shows a similar pattern of hotspots in other countries suffering from forest fires. About 56 percent of hotspots turned out to be outside oil palm concessions, namely primary forest managed by government. This is followed by production forest (HTI) concessions, at 33 percent, while the hotspots in oil palm plantation concessions accounted for only 7 percent.

Government and community officials need to be clear about this fire problem that fires can also occur anywhere with extreme hot weather conditions. This means that fire may not only caused by human activity, but also due to other factors such as the environment and natural conditions. Nevertheless, human activity is the main factor, not only unintentionally, but also intentionally such as caused by political competition as stated by the Coordinating Minister of Politic, Law and Human Right [17].
Source: GAPKI, 2019

Figure 6. Source of Indonesian Forest and Land Fires

The National Police Chief General Tito Karnavian wonders about the fire patterns that rarely entered oil palm and other industrial plantations.

In line with the fire data in some areas according to Global Forest Watch (Figure 6) the largest is outside the concession and in accordance with the statement of the Chief of Police. According to the National Police Chief, it showed that the forest and land fires were carried out by certain individuals to open new land [20]: "What we have seen from the helicopter with the TNI Commander and the Head of BNPB, the land that has become plantations, both oil palm and other industrial plants, how come none has been burned. For example, there are but a few and at the boundaries.

4. Policy Actions

Since 2011 the Government has issued Presidential Instruction No. 10 Concerning Postponement of new licenses for oil palm from Primary forests and peatlands. Every 2 years the Inpres is extended and in 2018 the Inpres No. re-issued. 8 Moratorium on new licenses and management of oil palms, and most recently through Presidential Instruction No. 5 of 2019 prohibiting the issuance of new licenses for (permanent) oil palm from primary forests and peatlands.

That means, since 2011 there have been no new licenses from forest areas. Area clearing is only done on land that already has a permit, but has not yet finished planting.

However, such policies did not prevent the June 2013 fires. The study by Gaveau et.al, 2014 shows that these fires occurred mostly in already-cleared peatlands. Burn locations suggest ignition by both communities and companies. Most fires are lit in order to prepare land for cultivation but some are likely accidental, while others may be arson: we still know too little concerning these specific events and the intentions and safeguards used.

Efforts to avoid major haze events require that all land users control fire use during any dry periods. Given land use practices in the region and the frequent conflicts among land users, this will be challenging. We advocate active protection of remaining peatland areas and cessation of further drainage. Financial incentives for forest protection are not competitive with commercial land values and future payments for reducing emissions from deforestation and forest degradation (REDD) are unlikely to change this. Unless strong action is taken Indonesia's peatlands are likely to remain a major source of GHG and aerosol emissions.

If one looks at the threat of heavy punishment for those setting forest fires, common sense says it is unlikely corporations would do this. Indonesian laws and regulation impose heavy sanctions on
companies found to have deliberately set forest and land fires. The sanctions include imprisonment and heavy fines. Article 78 paragraph 3 and 4 of the 2009 Forestry Law stipulates sentences of five to 15 years or a fine of Rp 5 billion at the maximum for perpetrators of forest fires; while article 187 of Criminal Code threatens a sentence of 12 years. Article 48 paragraph 1 of 2004 Plantations Law, Article 108 of the 2009 Environmental Protection and Management Law stipulates sentences of up to 10 years and fines of up to Rp 10 billion.

Then there is Government Regulation no 15 of the 2000 on the control of land damage for biomass production with sanctions against perpetrators, and referring to the 1997 Environment Management Law, which stipulates that perpetrators of environmental crimes are subject to (1) confiscation of benefits obtained from criminal acts; and/or (2) closure of whole or part of the company; and/or (3) reparation due to the criminal acts; and/or (4) obligation to work on what has been neglected without any rights; and/or (5) nullifying what has been neglected without any rights; and/or (6) putting the company under supervision for three years at a maximum.

An examination of the weight of the sanctions and punishment imposed on perpetrators of land fires in corporations, shows it is hard to believe that plantation owners would risk their investments worth trillions of rupiah by setting forest and land fires to clear land to save a few billion rupiah. It would seem that only irrational entrepreneurs would carry out land clearance by burning.

Besides the heavy punishment, losses resulting from forest and land fires also cause declines in productivity of oil palm plantations. Results of a study by the Oil Palm Research Center disclose that impacts of drought alone can reduce productivity by 28-41 percent and yields by 0.6-2.5, meanwhile haze affects the process of formulation and growth of oil palm, fruit, thereby reducing productivity by about 0.2-5.5 percent. This means the potential loss per hectare due to declining productivity caused by forest and land fires in the surrounding areas could reach up to Rp 12-15 million per hectare.

Efforts to avoid major haze events require that all land users control fire use during any dry periods. Given land use practices in the region and the frequent conflicts among land users, this will be challenging. We advocate active protection of remaining peatland areas and cessation of further drainage.

Financial incentives for forest protection are not competitive with commercial land values and future payments for reducing emissions from deforestation and forest degradation (REDD) are unlikely to change this. Unless strong action is taken, Indonesia's peatlands are likely to remain a major source of GHG and aerosol emissions.

Based on the experience of major fires in 2015, oil palm stakeholders have collaborated with surrounding communities by establishing a fire-care community and a fire-free village that aims to prevent and control fires, especially in villages surrounding the company's concession. It turned out that this effort was not enough because there was still a large area of burning outside the concession.

Timber plantations like APP and APRIL as well as oil palm plantations like Musim Mas and United Plantations enforce standard operating procedures that separate the match from the fuel with relative ease. They educate smallholders on proper slash-and-burn techniques and coordinate fire suppression efforts during their land preparation prior to the rainy season. This approach has resulted in a significant decrease in wildfires within well-managed oil palm plantations.

With over 40% of the oil palm land bank under smallholder ownership [21], the lessons learned from commercial estates can now be carried-over to smallholders. But this requires fundamental changes both by the general public - through addressing the false narrative of “forest fires”/"karhutla” and reintroducing the term ‘wildfires’- and the smallholders - through recognition of being a driver of wildfires rather than a victim.

Based on reports from the GAPKI there were 4 members of the GAPKI who experienced a fire where the burned land had oil palm plantations. This means that it is impossible for the company to burn its own assets or production machines. Based on information, GAPKI can ensure that all GAPKI members have implemented a zero burning policy and even now no longer allow for new land clearing.
The oil palm stakeholders such as GAPKI and GPPI, do not tolerate any members burning intentionally to open new plantations. The GAPKI and GPPI also supports legal action. But the stakeholders asked government officials to see objectively whether the company intentionally set fire or was a victim of a fire. The oil palm stakeholder hope that the government can protect the already large investments that have been invested in the palm oil industry. Do not let us invite investors from outside, but existing investments are not protected.

During this time, the fact is the fire that occurred on the concession, the company was blamed for failing to secure the concession land. This is a question, because it is not easy to protect concessions from large fires amid extreme weather conditions. Article that is often imposed on companies is Article 88 of Law no. 32 of 2009, namely that every person whose actions, businesses and / or activities use B3, produce and / or manage B3 waste, and / or which poses a serious threat to the environment is solely responsible for losses that occur without the need to prove the element of error.

5. Conclusion
The problem of forest and land fires will be repeated continuously (with various causes), if the root of the problem is not resolved. Based on scientific research and data and evidences, the fires can be caused by various reasons and no clear casual relation to oil palm. Government and community officials need to be clear about this fire problem that fires can occur anywhere, mainly in extreme hot weather conditions. This means that there is a possibility that the fire was not only caused by human activity but also due to natural factors. At the same time, efforts to reduce such fires should be taken. This includes the revision of regulations such as those that allows the community to burn for new land clearing, support the cluster system in fire prevention and control such as those implemented in Pelalawan Riau, and land use management must be made open access land by forming a farmer institution that is proven to minimal the fires.

With such potential losses in oil palm plantations caused by haze from fires, it is difficult to believe that oil palm plantations either individually or collectively carry out burning, which would cause losses to themselves. It is also difficult for common sense to accept that oil palm plantations deliberately left land fires in the surrounding areas unattended as that would cause losses in the form of productivity declines. Of course, all have to share the responsibility for extinguishing fires, regardless of who initiates them.

References
[1] PASPI, Industri Minyak Sawit Indonesia Menuju 100 Tahun NKRI [Indonesia’s palm oil industry towards 100 years of independence], Bogor (2014).
[2] PASPI, The Myths vs Facts of Indonesia’s Palm Oil Industry in Social, Economic and Global Environmental Issues, Third Edition (2017).
[3] Joosten, H., The Global peatland CO2 picture: peat land status and emission in all countries of the world. Wetlands International (ed). Prepared for UNFCCC, Bangkok (Sept/Oct 2009).
[4] Heil, A., Langmann, B. & Aldrian, E. Indonesian peat and vegetation fire emissions: Study on factors influencing large-scale smoke haze pollution using a regional atmospheric chemistry model. Mitig. Adapt. Strat. Glob. Chang. 12, 113–133 (2007).
[5] Page, S. E. et al. The amount of carbon released from peat and forest fires in Indonesia during 1997. Nature 420, 61–65 (2002).
[6] Rein, G. in Fire Phenomena and the Earth System: An Interdisciplinary Guide to Fire Science (ed Belcher, M.) 15–33, John Wiley & Sons, (2013).
[7] Van der Werf, G. et al. Climate regulation of fire emissions and deforestation in equatorial Asia. P Proc. Natl. Acad. Sci. U.S.A. 105, 20350–20355 (2008).
[8] Murdiyarso, D. et al. Policy responses to complex environmental problems: insights from a science–policy activity on transboundary haze from vegetation fires in Southeast Asia. Agric. Ecosyst. Environ. 104, 47–56 (2004).

[9] Hendon, H. H. Indonesian Rainfall Variability: Impacts of ENSO and Local Air–Sea Interaction. J. Climate 16 (2003).

[10] Field, R. D., van der Werf, G. R. & Shen, S. S. Human amplification of drought-induced biomass burning in Indonesia since 1960. Nat. Geosci. 2, 185–188 (2009).

[11] Hendon, H. H. Indonesian Rainfall Variability: Impacts of ENSO and Local Air–Sea Interaction. J. Climate 16 (2003).

[12] Sarachik, E. S. & Cane, M. A. The El Nino-southern oscillation phenomenon. (Cambridge University Press, 2010).

[13] Saji, N., Goswami, B. N., Vinayachandran, P. & Yamagata, T. A dipole mode in the tropical Indian Ocean. Nature 401, 360–363 (1999).

[14] Murdiyarso, D. and Adiningsih, E.S, Climate Anomalies, Indonesian Vegetation Fires and a Terrestrial Carbon Emission, Mitg.Adapt, Strat. Glob.Chang 12.101-112 (2007).

[15] Tacconi, L., Moore, P and Kairnowitz, D., Fires in Tropical Forest: What is really the problem? Lessons from Indonesia, Mitg. Adapt. Strat.Glob. Chang, 12.55-56 (2007).

[16] Gaveau et al David L. A. Gaveau, D.L.A., Sheil, D., Husnayaen, Salim, M.A., Arjasakusuma, S., Ancrenaz, M., Pacheco, P., and Meijaard, E. Rapid conversions and avoided deforestation: examining four decades of industrial plantation expansion in Borneo, Nature Scientific Reports (2016).

[17] European Commission/JRC,215 Europe Economics. The Economic Impact of Palm Oil Imports in the EU. London (2014).

[18] PASPI, The Myths vs Facts of Indonesia’s Palm Oil Industry in Social, Economic and Global Environmental Issues, Third Edition (2017).

[19] Kompas.com September 13. Kabut Asap dan Karhutla Riau, Peristiwa Tahunan yang Selalu Berulang [Internet], (September 13, 2019). Available at: https://www.kompas.com/tren/read/2019/09/13/194927565/kabut-asap-dan-karhutla-riau-peristiwa-tahunan-yang-selalu-berulang.

[20] Pekanbaru Newspaper, Malam Kualitas Udara Pekanbaru Capai Level Berbahaya (September 16, 2019).

[21] Ministry of Agriculture of Indonesia, Statistik Perkebunan Kelapa Sawit Indonesia 2016-2018, Jakarta (2018).

[22] GAPKI, Upaya Pencegahan dan Penanganan Karhutla di Perkebunan Sawit, (September 19, 2019).

[23] Global Forest Watch, A Dynamic Online Forest Monitoring and Alert System that Empowers People Everywhere to Better Manage Forests [internet], Available at: https://www.globalforestwatch.org/.