Newsletter

Toward the Regeneration of Tropical Peatland Societies

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Regeneration of Tropical Peatlands

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2019 Peatland and Forest Fires in Central Kalimantan, Indonesia

Forest fires are emerging as an urgent and globally significant environmental problem. Forest fires have tragic and horrifying impacts on both human and non-human beings. Although it did not receive as much international media attention, there was also a massive forest fire in Central Kalimantan, Indonesia, in 2019. In this article, we cover this forest fire and explain our work with the Centre for International Cooperation in Sustainable Management of Tropical Peatland (CIMTROP), Palangka Raya University, toward mitigating the impacts of future forest fires in the region.

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In 2019, Indonesia experienced a weak El Niño event, which increased the severity of forest and peatland fires in both Kalimantan and Sumatra. Some provinces – such as Central Kalimantan, South Kalimantan, Riau, South Sumatra, and Jambi – have been covered in thick smoke and haze for several months. The rapid development of tropical peat swamp forests has increased Indonesian CO_2 emissions dramatically in recent years because the forests' peat layer is burned as part of this development (Hooijer et al, 2006).

At present, peatland-forest fires pose an incredibly serious problem. Figure 1 graphs the total number of incidences of fire in Indonesia in 2019 and shows that most incidences of fire occurred in Palangka Raya city. In August 2019, there were more than 300 incidences of fire in Palangka Raya – about three times more than in Pulang Pisau regency. This past year, fires in Palangka Raya began to increase in May – two months earlier than in Pulang Pisau. This pattern is borne out by the research of Yulianti and Hayasaka (2013) and Yulianti et al. (2019a), who demonstrated that fires are usually concentrated in Pulang Pisau regency during very strong and strong El Niño years such as 2006 and 2015. The total burned area seems to reflect the general pattern of incidences of fire – i.e., Palangka Raya was the most heavily burned area in 2019 (Yulianti et al,

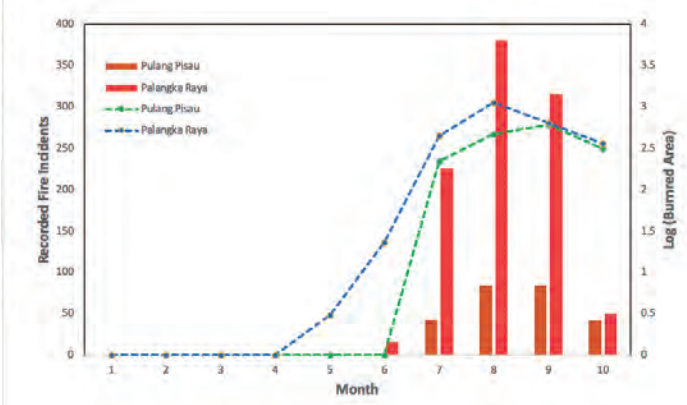

Figure 1. Monthly incidences of fire and total burned area.

Figure 2. Actual fire in Tumbang Nusa, Pulang Pisau – 7 August, 2019.

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2019c). Figure 2 shows photographs of the forest fires. Other research has indicated that the majority of these fires take place on degraded land or shrubs.

Measurements taken at the Meteorology Climatology and Geophysics Agency (BMKG) station in the vicinity of Tjilik Riwut Airport in Palangka Raya, indicated that that whole area was covered by a thick haze in August and September 2019. On 29 September, visibility was reduced to 1,300 metres at the airport. Since 2018, as a collaborative project among Indonesian research institutions, RIHN, Kyoto University and CIFOR, we have installed sensors to monitor carbon monoxide (CO) and particulate matter (PM2.5) levels in Palangka Raya, Pulang Pisau (Tumbang Nusa, Taruna Jaya) and Buntoi. The background level of CO in Palangka Raya was 0.4 parts per million (ppm) during the non-fire season; during August-September 2019, it rose to 3 ppm. By our measurements, concentrations of CO and PM2.5 in Palangka Raya peaked in the second week of August and the third week of September 2019. In fact, CO increased up to 14 ppm and PM2.5 up to 800 $\mu g/m^3$ in a single day (Kawasaki et al, 2019; Figure 3). For some context on how unhealthy these levels of pollution are, the United States' eight-hour Acute Exposure Guideline Level (AEGL) for CO is 27 ppm, and the World Health Organisation's 24-hour Air Quality Guideline for PM2.5 is 25 $\mu g/m^3$. Under these polluted conditions, Indonesia's air quality was unhealthy for humans and other living things.

Examining the impact of forest fires

In order to understand the social impacts of forest fires in Palangka Raya, we conducted a field survey to collect village- and household-level data through interviews with key informants and households by Focus Group Discussion (FGD) from March to April 2019. Local communities' responses to the fires and the rehabilitation activities they undertake differ from

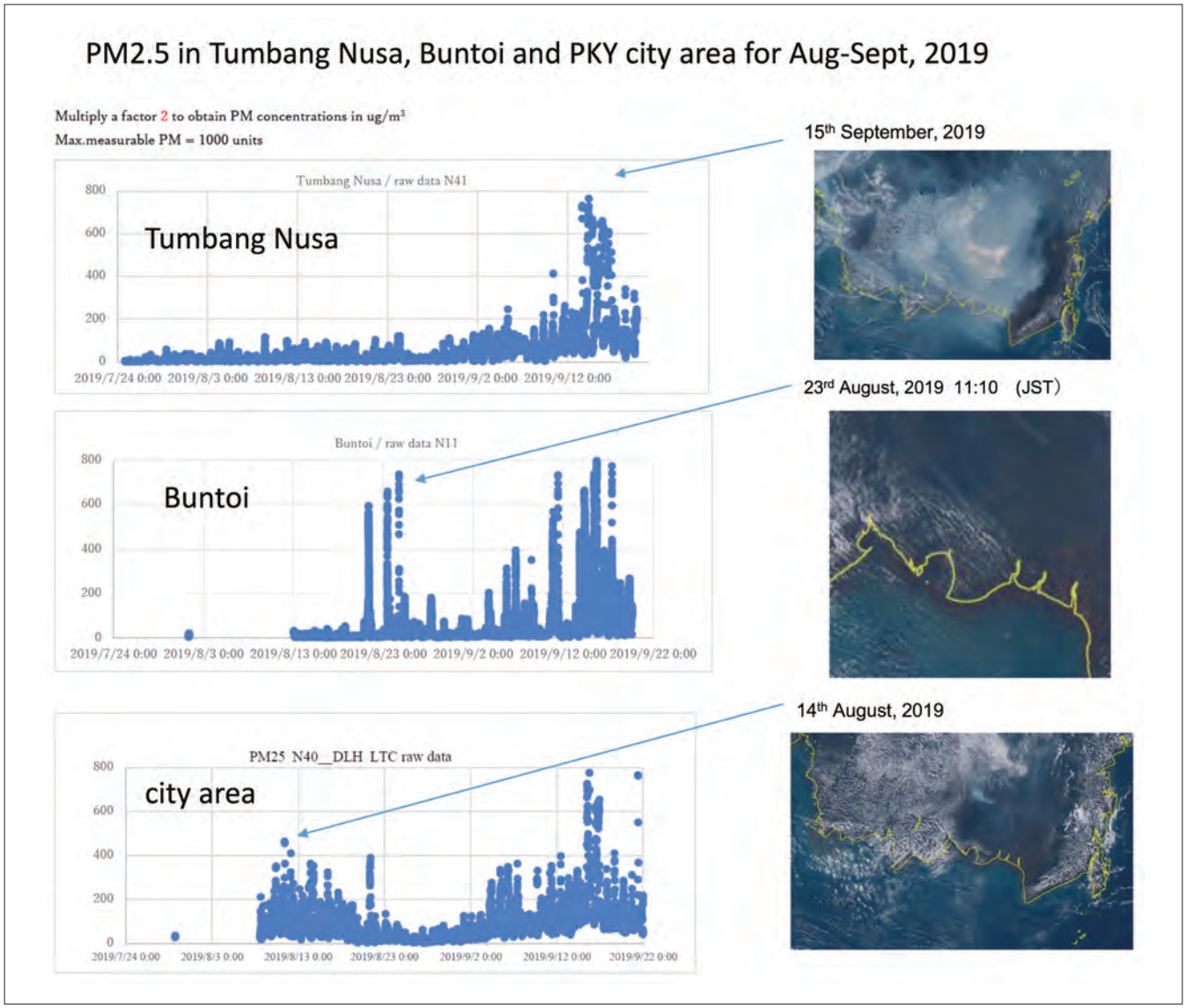

Figure 3. Left: time series of PM2.5 concentrations in Tumbang Nusa, Buntoi and Palangka Raya City for August and September 2019. Right: satellite images of high PM2.5 levels at each location (Kawasaki, 2019).

community to community. To clarify these differences, we collected data on how local people responded to and recovered from the fire disaster. Research sites included the neighbouring villages of Kalampangan, Kereng Bangkirai and Tanjung Taruna. Both sites are located 22 kilometres south of Palangka Raya. Kalampangan is populated primarily by Javanese immigrants while Tanjung Taruna is populated primarily by Dayak and Banjar people.

The FGD interview surveys in Tanjung Taruna, Kalampangan, and Kereng Bangkirai were attended by key informants, including the customary chief/mantir, religious leaders, police, firefighters, and individuals representing the interests of local farmers, fishermen, women, youth, and students. These villages managed their land by swidden agriculture, which requires the large-scale burning and clearing of vegetation, because this was the fastest and cheapest way for them to clear their land. This practice continued up until it was banned in 2015. The human-induced fire is one of the causes of the forest and peatland fires of 2019 (Table 1). Our observations indicated that the 2019 forest fires started mainly in the region's roads and rivers – i.e., points of easy human access. To counteract the spread of fires, the CIMTROP firefighting team taught local firefighters how to better monitor and patrol their land and how to wet the area surrounding a forest fire by injecting well water into the peat layer.

Preparation for future forest fires

To prevent future forest and peatland fires, we together with our aforementioned institutional partners are developing a manual for extinguishing, preventing, and mitigating peatland fires, taking into account both the relevant scientific research and the experiences of the local communities. Our proposed approaches to fighting

Table 1. Analysis of the main causes of forest and land fires in Indonesia in 2015 (Yulianti et al, 2019b).

Natural causes of fire	Human cause of fire	Factors affecting policy
El Niño phenomenon (every 2-15 years)	Clearing land for economic activity	Lack of regulations prohibiting burning at the village / *kelurahan* level
	Fishing	Lack of village-level regulations regarding burning peatland as a land management practice
Thick peat	Throwing away cigarette butts	Lack of village-level regulations on this front
Land damaged / unsuitable for planting	Burning trash	National conservation efforts, relocation of the capital, expansion of rice fields, and transmigration
Land left abandoned or bare	Accident / failure	The policy regarding to the national and regional election schedule, for example the severest fire in 2015 coincided with the election of the Governor of Central Kalimantan or the fires of 2019 coincided with the presidential election.

Figure 4. Focus group discussions in Palangka Raya and Pulang Pisau.

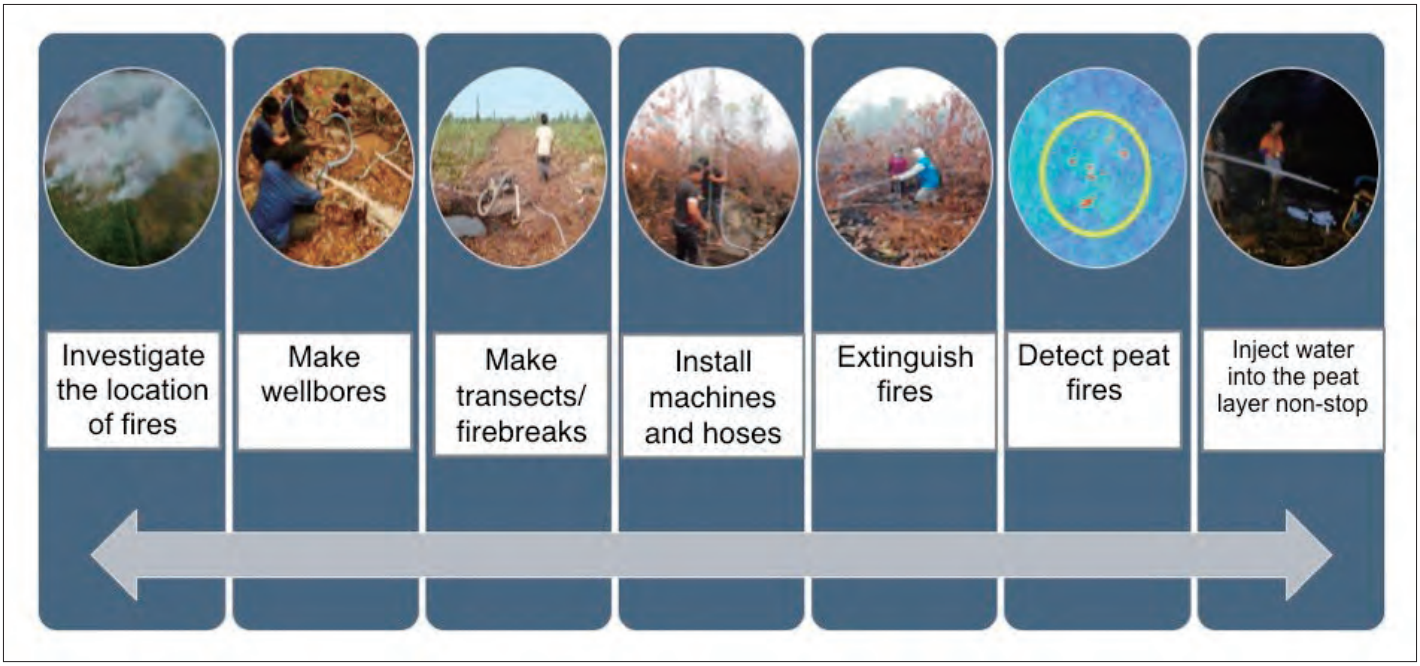

Figure 5. Steps for local firefighters to follow.

peatland fires are shown in Figure 5. These proposals are based on the experiences of CIMTROP volunteer firefighters (*Tim Serbu Api* or TSA), who have been working in this region since 1997. The methods and approaches in Figure 5 is modified from what carried out by the TSA team in Limin et al (2007). This manual is proposed for volunteer firefighters at the village or *kelurahan* level, especially in Palangka Raya city and Pulang Pisau regency. Candidate of TSA members must be trained by senior TSA members in CIMTROP.

We envision local firefighters being split up into four sub-teams of five to seven people each. These sub-teams will have individual responsibilities to make the firefighting efforts more effective. These divided responsibilities include responsibility for accommodation and equipment, providing water sources, making wells and installing pumping machines, providing and analyzing hotspots and making transects / firebreaks, and operating pumps and other equipment as mentioned by Yulianti et al (2019c). We will continue testing this manual and will conduct consultation workshops to check the efficacy and consistency of this plan. We are hoping to make this manual publicly available before next fire season.

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Detecting underground fires with drones

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Even during rainy season, peatland fires may continue to burn underground. Controlling these fires is difficult, as they are invisible to the naked eye from the surface. However, an approach to detecting underground forest fires which combines thermal cameras and drones may prove to be an effective means of identifying and hopefully preventing peatland fires.

Figure 1 shows a regular image and one overlaid with thermal data (Multi-Spectral Dynamic Imaging or MSX) of a burning point taken by a Mavic 2 Enterprise Dual camera. Whereas the regular image only shows smoke spreading out over the ground's surface, the overlaid image on the right precisely identifies the location of underground fires and their hotspots. Although this camera can detect thermal gradients, another thermal infrared camera (Zenmuse XT) can take images which show the Digital Number (DN) value. This camera can both register fire temperatures and produce thermal maps by converting DN values to temperature readings (see Figure 2). The red parts of this image represent hotspots hotter than 70 ℃. Both original images were taken at an altitude of 100 metres.

Each thermal infrared camera has strong and weak points respectively. The adequate application of these cameras and drones helps us gather detailed information on underground fires and dramatically improves the efficiency of firefighting efforts in peatlands.

Figure 1. Regular image (left) and one overlaid with thermal data (right) taken by a Mavic 2 Enterprise Dual camera (November 2019 in Palangka Raya).

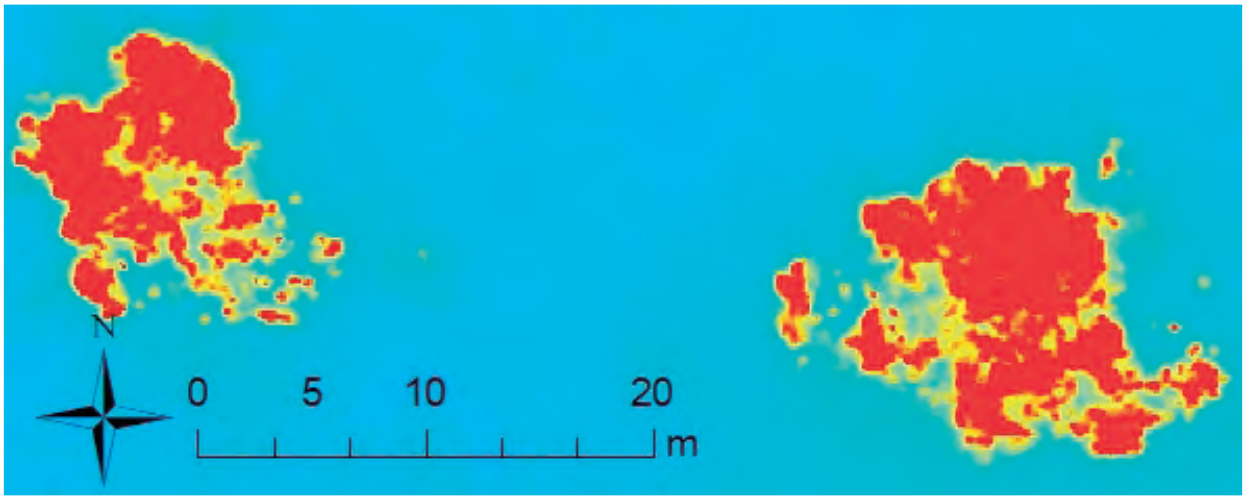

Figure 2. Temperature map rendered by Zenmuse XT (November 2019 in Palangka Raya).

Global and Indonesian Climate in 2019

Associated with a moderate El Niño-like global climate situation, less rain fell in Indonesia in months around September 2019, causing rather serious forest fires probably due to man-made causes.

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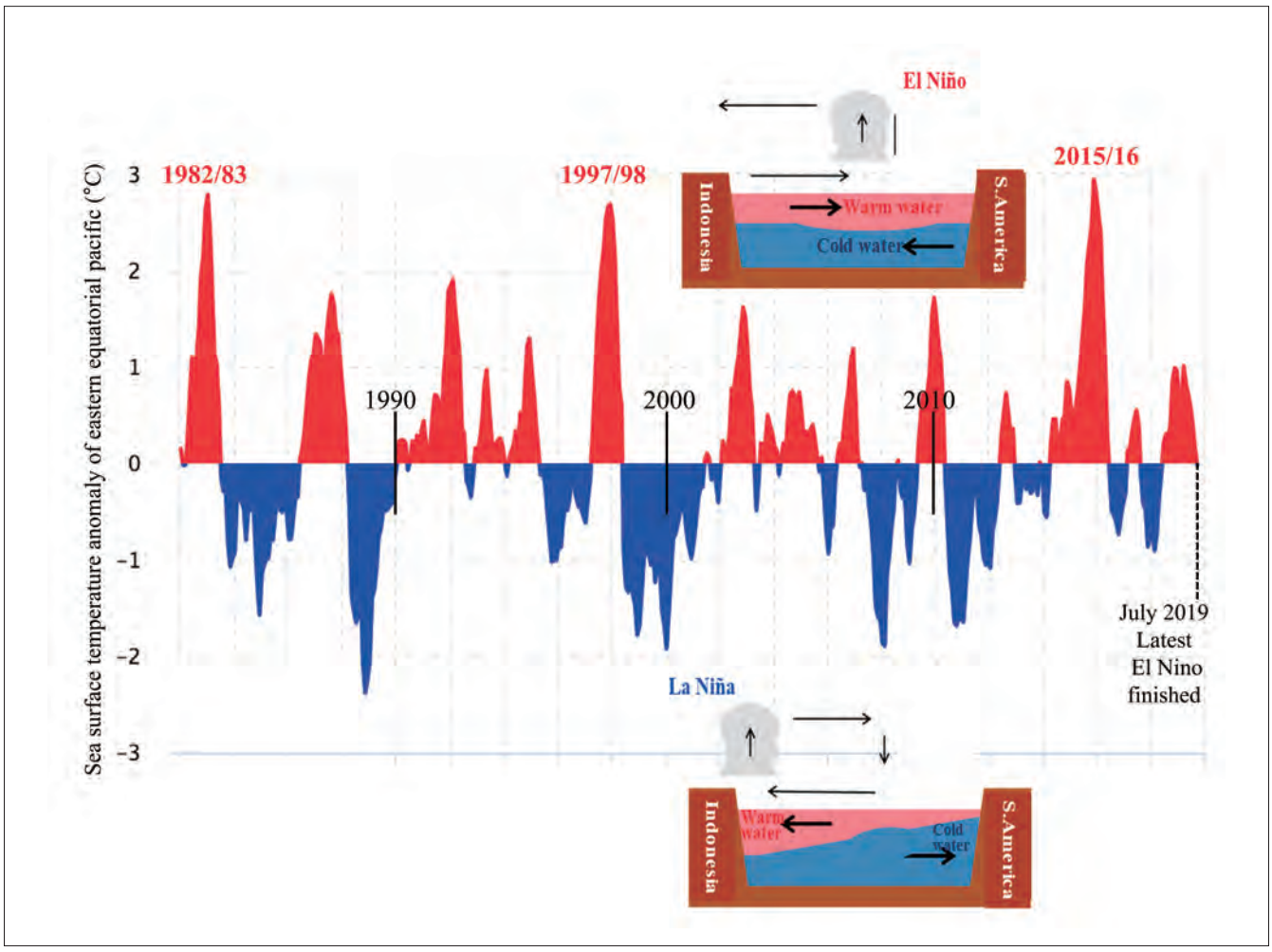
Clouds associated with warm Pacific Ocean surface water oscillate eastward and westward every few years. This is called the El Niño-southern oscillation (ENSO), and consists of El Niño and La Niña events with eastward and westward shifts, respectively. A similar oscillation, the Indian-Ocean dipole mode (IOD), appears on the western side of Indonesia, and a westward shift is called the positive IOD event. Thus, during El Niño and/or positive IOD events, Indonesia receives less rainfall than average, and this correlation is quite clear in the dry season (June-August in Jawa). In major El Niño and positive IOD events, Indonesia receives often less rainfall even in the rainy season, leading to serious droughts and smog. Since 1950s, eight relatively strong El Niño events (in 1957/58, 1965/66, 1972/73, 1982/83, 1986–88, 1991/92, 1997/98, and 2014–16) occurred (see Fig.1). Of these, the events of 1982/83, 1997/98 and 2014/16 were 'super-El Niño' events.

A moderate El Niño event occurred from late 2018 until July 2019. After that, El Niño-like features still continued, but only in the western Pacific – this is called El Niño *modoki* – a Japanese word meaning similar but different. A positive IOD event began



▲ **Figure 1.** ENSO events over the past 40 years. (Sea surface temperature data : IRI/Columbia U).

around May 2019 and peaked around October 2019. (see the left column of Fig. 2). This sequence and the seasonal march, combined with local cultivation practices, produced forest fires in Amazonia and the Congo Basin in the first half of 2019, in Sumatera and Kalimantan in September 2019, and in Australia from October 2019 (see the right column of Fig. 2). As of January 2020 the climate situation in Indonesia has become more normal. Although the El Niño *modoki* has not yet ended, the positive IOD is concluding, the rainy season has come to Jawa, and floods occur in Jakarta under attack by an intense Asian monsoon (called cold surges) and/or an Indian-Ocean super cloud cluster (called Madden-Julian oscillation) .

2019's decrease of rainfall did not have as much of an effect on the global climate as super El Niño events might. However, 2019's forest fires produced massive green-house gases to accelerate global warming, and demonstrated that the climate is changing due to excessive and intrusive methods of economic development (e.g., burning natural tropical forests for cultivating plantations, etc.). These changes may be irreversible and have serious consequences for future human societies. We need to promote the collection and analysis of long-term climate data, and obtain conclusions as to how to sustainably develop tropical peatlands.

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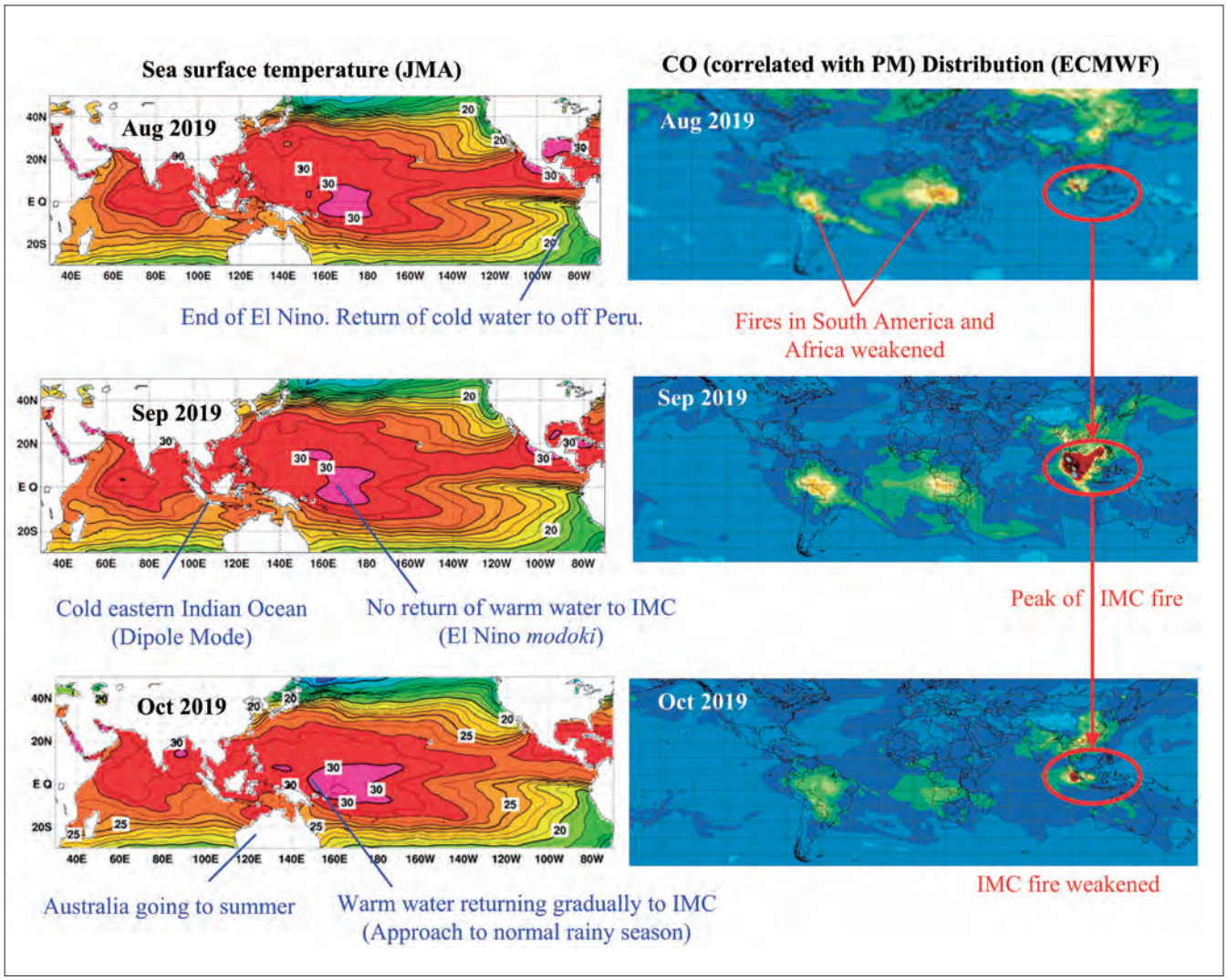

▲ **Figure 2.** Distributions of sea surface temperature (left) and atmospheric pollutants (right) between August and October 2019.

News of Indonesian Fires in 2019

In 2019, large-scale forest and peatland fires broke out across Indonesia and caused catastrophic deforestations and health hazards across the country. These fires were the worst seen in the country since 2015. This paper gives a broader picture of the 2019 Indonesian fires and the health hazards they pose by surveying news published online up until December 2019.

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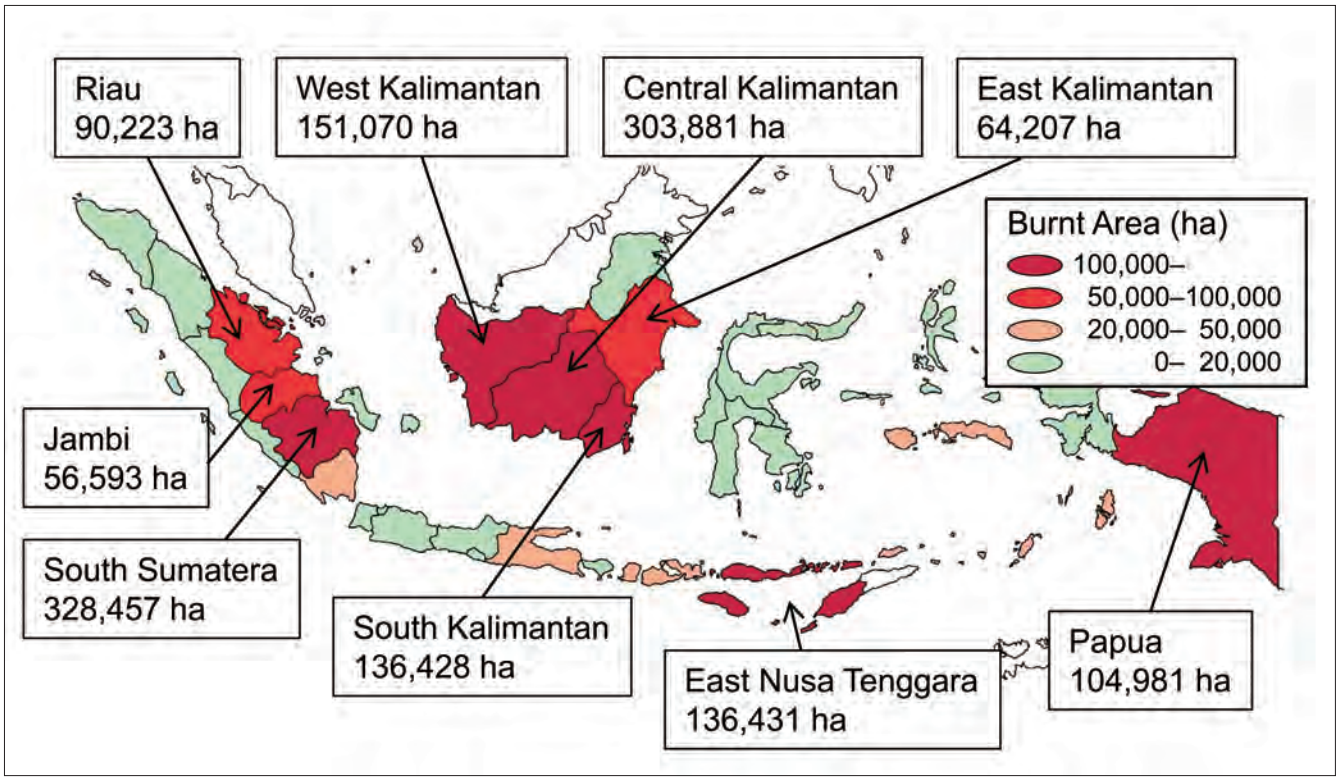


▲**Figure 1.** Total burnt area in Indonesia in 2019. Source: Ministry of Environment and Forestry website (SiPongi–KLHK), http://sipongi.menlhk.go.id/hotspot/luas_kebakaran. Data retrieved on 7 January 2020.

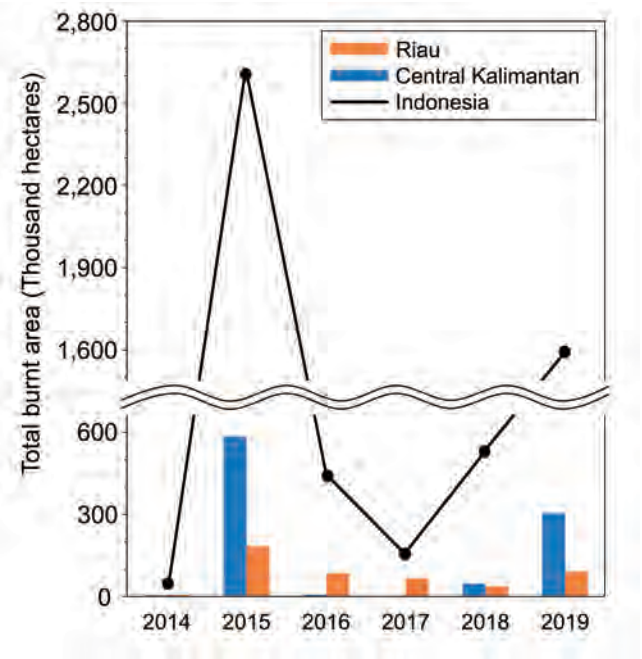
At the beginning of 2019, both Indonesian and international meteorological agencies forecasted that 2019 dry season would bring less rainfall than usual due to the effects of the El Niño *modoki* and the Indian Ocean Dipole (see page 6-7) (*Republika*, 2 Oct.). Indeed, Indonesia received less rainfall between January and October than usual, which sparked frequent fires in August and September.

The main areas affected by the fires were Kalimantan, eastern and southern Sumatra, and Papua – all areas which contain a broad area of peatland. In addition, there were fires in East Nusa Tenggara, which has mineral-rich soil (see Figure 1). After October, Kalimantan and Sumatra entered the rainy season and the number of hotspots began to decrease.

Indonesia's National Disaster Management Agency (BNPB) announced in mid-December that the total area which had been burnt from January to the end of October was 942,000 hectares. Of this area, 270,000 hectares were peatland and 672,000 were mineral land (*Kompas*, 18 Dec.). However, reports published by Indonesia's Ministry of Environment and Forestry (KLHK) show that the total burnt area was 1.592 million hectares (see Figures 1 and 2).

The different figures presented by the BNPB and KLHK show that different agencies estimated the total burnt area differently. In a case, KLHK and BNPB announced that 75,841 hectares of land were burnt in Riau province up until mid-October (BNPB and KLHK's online report). On the other hand, Riau's Regional Disaster Management Agency (BPBD-Riau)

reported that 9,094 hectares had been burnt over the same period (Bisnis.com, 9 Oct). In another case, the Centre for International Forestry Research (CIFOR) reported that more than 1.6 million hectares of land had been burnt from January to October. This online report was published on 2 December, but was criticized by KLHK and taken down on 6 December (*Nature*, 10 Dec.) (Despite criticism, the KLHK's estimation at the end of December presents almost the same figure as the CIFOR's report.). An online report by the scientific journal *Nature* attributed the cause of these fluctuations in reports of burnt areas to these agencies using different satellite data and ground observations.



▲ **Figure 2.** Total burnt area in Riau, Central Kalimantan and Indonesia between 2014–2019. Source: same as Figure 1.

In any case, the total burnt area in 2019 was dramatically larger than it has been over the past three years (see Figure 2). Although the total number of hotspots decreased after October, some areas received seasonally low amounts of rainfall and experienced occasional wildfires (*Mongabay*, 23 Oct.). Continued analysis will discern what the actual, total area was that was burnt by of the Indonesian fires of 2019.

Haze and health hazards

Severe forest fires bring severe air pollution. The air quality index, which shows the pollution of local atmospheres due to particle matter 2.5 (PM2.5) reached unsafe levels of 200-300 parts per million (ppm) in many points of Indonesia in 2019 (The possibilities of contracting respiratory diseases dramatically increase when the value is beyond 100).

Levels of PM2.5 went beyond 300ppm in Riau on 12 September. The resulting haze reduced visibility to 200-400 metres on 13 September (see Photograph 1). The Riau Health Centre encouraged people to refrain from open-air activities (*Tirto*, 13 Sept.) and the governor of Riau province declared a provincial emergency due to the haze on 23 September (Channel News Asia, 24 Sept.). The director of the Riau Health Centre announced that about 34,000 people contracted acute upper respiratory tract infections between 1 and 22 September (*Elshinta*, 23 Sept.).

The haze spread beyond Indonesia. In Malaysia, 2,600 schools cancelled classes between 16 and 20 September, stopping 1.7 million students from attending school (CNN (in Indonesian), 18 Sept.). The Malaysian prime minister announced that the government attempted to make artificial rain with drones, and contacted the Indonesian government seeking cooperation in fighting and reducing forest fires (*Kontan*, 20 Sept.). In Singapore, the government introduced air filters in schools as a result of the haze (*Straits Times*, 20 Sept.). A spokesman for the Singaporean Minister of the Environment and Water Resources emphasised the importance of promoting cooperation among ASEAN countries to prevent the worst effects of the forest fires and resultant haze (*Kompas*, 27 Sept.).

Indonesia is not the only country which bears responsibility for the forest fires and resultant haze. Both the KLHK and Indonesian meteorological agency attributed the haze in Malaysia to fires that had happened within that country (BBC [in Indonesian], 12 Sept.). Governments and private enterprises in both Malaysia and Singapore have over-developed forests and peatland in Indonesia and in their own territory, leading to higher incidences of fire and more serious fires. It is necessary to develop a comprehensive, international system to prevent future problems and disasters.

Responses to the problem

The heads of the Indonesian, Malaysian, and Singaporean governments identified the forest fires as an important regional issue during a summit meeting held at the beginning of August (*Jakarta Post*, 7 Aug.). While the Indonesian government received some criticism from the other countries because of their insufficient measures of insufficient environmental regulations, Indonesian President Joko Widodo responded that Indonesia did its best to prevent and fight the fires by dispatching its army to help fight fires, water-bombing fires, and attempting to make artificial rain (*Tempo*, 7 Aug.; 17 Sept.). He directed related institutions such as Peatland Restoration Agency (BRG) and the BPBD to emphasise the importance taking preventative measures, such as keeping groundwater levels high (*Warta Ekonomi*, 8 Aug.).

▲**Photograph 1.** Haze covers the runway of Pekanbaru airport on 22 September 2019.

On the other hand, several non-governmental organisations (NGOs) criticized the government's countermeasures. The NGO Walhi pointed out that the BRG had made no clear progress on peatland restoration over the past four years (CNN [in Indonesian], 12 Sept.). Likewise, Greenpeace Indonesia demanded that the Indonesian government apply sanctions to the companies which had violated relevant laws and regulations and caused environmental damage. They pointed out that the 2019 fires occurred in similar places as the 2015 fires, and that this demonstrated that the companies responsible for the 2015 fires are not to be trusted (BBC [in Indonesian], 24 Sept.). They also demanded that the government fine international companies which had violated relevant laws and regulations. While the government imposed the fines of 3 trillion rupiahs on nine international companies over the past four years, they have collected only 78 billion rupiahs (BBC [in Indonesian], 2 Oct.).

2020 may be a tipping point regarding Indonesian peatland restoration policy and activity for two reasons. First, the 2019 fires demonstrate that the restoration activities of the last three years had only limited preventative power. More drastic and wide-ranging efforts are necessary. Second, changes in central and local governments may help affect change. Widodo was reelected and is reorganising forest policy; Syamsuar (who is regarded as being earnestly interested in environmental problems) was elected governor of Riau; and the BRG will be reorganised at the end of the year. Thus, it is necessary to observe the government movements closely in 2020 to get a better sense of what the future holds.

▲**Photograph 2.** Unwatched fire burning undergrowth in a coconut garden (Bengkalis Island, 14 September 2019)

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Peat Swamps' Importance for Freshwater Fish and Ecosystems

A new member of RIHN's project, Dr. Nofrizal of Riau University, explains his research on freshwater fish in peat swamp ecosystems. His knowledge and experience working with many Japanese researchers will contribute enormously to our understanding of peatland river ecosystems.

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Peat swamps are areas which are directly adjacent to river water. During the rainy season, these areas flood as the river overflows. Among faunal groups, fish exhibit the highest endemicity to peat swamps (Posa et al. 2011). Work in Peninsular Malaysia has shown that the blackwaters of peat swamps are not species-poor or low in biomass, and up to 33% of known freshwater fish species are associated with peat swamps (Ng et al. 1994; Kottelat et al. 2006).

This condition is similar to the mangrove area on the coast, where, during high tide, seawater enters the mangrove forest area. Mangroves form the foundation of a highly productive and biologically rich ecosystem which provides homes and feeding grounds for a wide range of species, many of which are endangered (van Bochove et al. 2014). Therefore, mangrove forests are important to freshwater ecosystems because many aquatic animals choose these forests as spawning and nursery grounds.

Due to the similarity between mangrove forests and peat swamps, I hypothesise that peat swamps are important spawning and nursery grounds of fresh water aquatic animals. My research aims to prove that peat swamp area are important to freshwater ecosystems.

To do this, we conduct a series of surveys, through which we collect adult and juvenile fish in several peat swamps. We then compare some of the adult fish species obtained in the surrounding river areas to determine how similar they are. We then analyse the fishes' oocyte levels to determine their maturity (fish with oocyte levels of 3 or 4 are close to spawning). Next, we gather juveniles living in peat swamps with a plankton net and analyse their DNA. This kind of DNA analysis can help determine precisely which species of juvenile fish live in peat swamps. Data confirming the similarity of juveniles from peat swamp areas to fish which live in the surrounding river will be key to this research.

My research proves that peat swamp areas are key pillars of freshwater ecosystems because several species of freshwater fish use them as spawning grounds. This kind of proof will, hopefully, galvanise campaigns to protect these vibrant, important ecosystems.

▲ **Photograph 1.** Traditional fish trap or *pengilar ikan* in Rantau Baru village

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