

Fires in tropical forests – what is really the problem? Lessons from Indonesia

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Abstract Fires have attracted interest and generated alarm since the early 1980s. This concern has been particularly evident in tropical forests of Southeast Asia and the Amazon, but disastrous fires in recent summers in Australia, Europe, and the United States have drawn worldwide attention.

Concern about forest fires, and related air pollution and biodiversity impacts, led international organisations and northern countries – such as the Asian Development Bank, the European Union, the Food and Agriculture Organisation, the United Nations Environment Programme, the World Bank, and the government of Germany – to undertake fire assessments and provide technical assistance. Nongovernmental organisations, such as the International Union for Conservation of Nature and Natural Resources and World Wide Fund for Nature, have also devoted increased attention to fires. Aiming at prevention of future fires, 40 fire projects and missions costing well over US\$30 million have worked in Indonesia over the last 20 years. Despite the money and effort spent on them, fires continue to burn every year. It may appear to some that efforts to address the ‘fire problem’ have not been effective as fires still occur.

There remains a lack of clarity about ‘fire problems’, which has, at times, led to the adoption of policies that may have negative impacts on livelihoods, the environment, and the economy. Two ‘simple’ changes in the way fires are considered would significantly improve fire-related policies and initiatives.

- Fires should be seen as a component of land management processes, rather than as a ‘problem’ to be prevented, suppressed, or mitigated.
- Not all fires are the same.

These two points are discussed in the context of Southeast Asia, and particularly Indonesia, as an example of the problems and questions faced by tropical countries. We argue that efforts

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on fires so far have generated increased knowledge of the ‘fire problem’; now, we need to capitalize on that knowledge to avoid wasting money in the future.

Keywords Causes of fires · Deforestation · Economics · El Niño · Governance · Haze · Peat

1. Introduction

In recent decades, the spectre of fires has loomed large and created surges of concern, interest, and alarm. These concerns have been particularly evident in parts of Southeast Asia and the Amazon, but fires in recent summers in Australia, Europe, and the United States have drawn worldwide attention.

In the tropics, concern about forest fires, and related air pollution and biodiversity impacts, has led international organisations and northern countries – such as the Asian Development Bank, the European Union, the Food and Agriculture Organisation, the United Nations Environment Programme, the World Bank, and Germany – to prepare global, regional, and national fire assessments (e.g., FAO 2000; Qadri 2001; Cochrane 2002) and to provide technical assistance. Nongovernmental organisations, such as the International Union for Conservation of Nature and Natural Resources and World Wide Fund for Nature, have also been devoting increased attention to fires.

This increased interest in, and funding for, fire-related initiatives has generated improved knowledge about fires. However, there is still a lack of understanding of ‘fire problems’ and what should be done to address them. The impacts of fires and their profile have stimulated these activities and fuelled concern but have not clarified the ‘problems’ that underlie these obvious symptoms. This lack of clarity and the ‘heat and hype’ (Sierra Club 2002) generated by large-scale fire events have at times led to the adoption of policies – such as legal bans on all fires in some Asian and African countries – that could have negative impacts on livelihoods, the environment, and the economy (e.g., Laris 2002).

Two ‘simple’ changes in the way fires are considered would significantly improve fire-related policies and initiatives.

- Fires should be seen as a component of land management processes – and at times as part of land use changes – that can have positive and/or negative impacts, rather than just as a ‘problem’ to be prevented, suppressed, or mitigated.
- Not all fires are the same. Fires in El Niño Southern Oscillation (ENSO) years often have different causes and impacts than fires in non-ENSO years; forest fires have different impacts than peat fires and may also have different causes than peat fires.

We discuss these two points in the context of Southeast Asia, and particularly Indonesia, as a practical example of the problems and questions faced by tropical countries. We do not imply that the situation in other countries is the same as that discussed below. The analysis of the situation in Indonesia is presented as an example of the work that needs to be done in other countries to understand their own specific conditions and problems.

Aiming at the prevention of future fires, 40 fire projects and missions costing well over US\$ 30 million have worked in Indonesia over the last 20 years. Despite the money and effort spent on them, fires continue to burn every year. Therefore it may appear to some that efforts to address the ‘fire problem’ have not been effective. Those efforts, however, have improved the knowledge basis about ‘fire problems’. Now we need to capitalize on that knowledge to avoid wasting money in the future.

The scene is set by providing an overview of recent investments in fire activities in Indonesia. Then, the 1000-year-old cycle of forest-fire exploitation and its relevance to Southeast Asia are recalled. Within this cycle, communities, states, and companies have used forests in the process of development, sometimes changing their ecological structure, other times clearing them. We then discuss what are (and are not) fire-related problems. The focus in addressing them should be on the impacts caused by fires and land use changes. The question whether fires should and could be tackled is illuminated by clarifying fire causes and improved understanding of fire impacts. Despite any clarification of what fire problems really are, there will remain a need for further information and data gathering as well as research. This aspect is discussed before concluding with the identification of several initiatives to address fire-related issues on the basis of existing knowledge.

2. Investment patterns in fire management

The so-called Great Fire of Borneo in 1982–1983, and those in 1987, 1991, 1994, and then 1997–1998, sometime referred to as ‘mega-fire events’, stimulated a wide range of responses. Assistance to Indonesia consisted of assessment and investigation missions, emergency support, technical aid, equipment and training as well as expertise and management assistance (Dennis 1999). These efforts reflect the focus and understanding of forest fires of those undertaking them.

Dennis (1999) identifies that projects on fires generally come about in response to significant fire events. Transboundary smoke, widespread fires, and large economic costs combined with local- and regional-scale impacts ‘strongly suggest a problem’. Before 1994 there was a sense that the fires were a one-time event and related to weather and climate conditions. Following 1994 came the recognition that fire-related issues were more complex than shifting agriculture and weather and involved commercial companies, land use changes, and perhaps climate. Consequently projects began to include these wider issues as well as the basic needs of fire fighting. This change reflects a shift from a mainly fire fighting response to one especially focused on determining the underlying causes of fires and their impacts. Of the 35 projects listed, 19 focussed on fire fighting capacity, reflecting the initial thinking that inadequate technical knowledge and resources were the problem, while 6 focused on improved understanding of underlying causes only. Ten of 35 projects sought to improve understanding as well as deal with the practicality of fire fighting. This range of projects covered the full spectrum of fire management.

Despite international efforts, little of the analysis undertaken resulted in governments taking clear steps to manage future fires (Byron and Shepherd 1998). A series of apparently sound recommendations generated by some of these efforts have remained largely unimplemented. We suggest this situation is similar to the circumstances in other tropical parts of the world. A discussion of ‘fire problems’, their impacts and causes follows, shedding light on this apparent lack of action and providing guidance for future activities.

3. The forest-fire exploitation cycle

For some ecosystems fire is critically important. In the wet tropics, however, fire is almost always an ecological disaster. Tropical rain forests in their undisturbed state are nearly ‘fire proof’. The vegetation layers keep moisture in and wind and heat out. Conditions for destructive fires do not develop. When the canopy is opened up, however, for example because of logging or road construction, then sun and heat enter the forest, moisture escapes, and the

forest dries out. As tropical forests are opened up through logging and road construction, they not only lose their natural defence against fire, but logging residues and dead wood are left behind in the forest, providing fuel for future fires. After a forest is burnt, more light and space are available for grasses and other vegetation to grow on the forest floor. This vegetation dries out more quickly and burns easily, creating a cycle that renders the forest ever more inflammable. If this cycle is not interrupted, the forest may completely disappear and grasslands or other vegetation replace it (Byron and Shepherd 1998; Nepstad et al. 1999).

While pristine rainforests may be almost fire proof, 'it is increasingly difficult to think that any forests, from the tundra margins to the tropics, were ever pristine and untouched' (Williams 2003). For millennia until today humans have used, burnt, and cleared forests for subsistence and commercial activities. Williams (2003) notes that fire was the force that allowed humans to accomplish the first great ecological transformation of the Earth; only the development of agriculture and animal husbandry 10,000 years ago and the industrial revolution 200 years ago caused ecological changes of a similar magnitude. Globally, the area of forest cleared before 1950 still exceeds the area cleared since then (Williams 2003). This circumstance applies particularly to areas such as Europe and North America, but in areas experiencing recent and rapid economic growth, such as Southeast Asia, the pace of forest clearance has picked up since 1950. In Indonesia, forests covered some 162.3 million ha, or 84% of the land, in 1950. That figure had decreased to about 95.6 million ha, or 50% of the land, by 1997 (FWI et al. 2002). Other countries, such as the Philippines and Malaysia, went through a rapid deforestation phase with associated smoke and haze emissions earlier than Indonesia. Historical records show that peninsular Malaysia saw wide-scale forest burning in the two rubber plantation booms of 1905–1906 and 1909–1910 (Potter 2001).

Fire in tropical countries such as Indonesia is best seen as a component of land management processes – and at times as part of land use changes – rather than as a problem to be prevented, suppressed, or mitigated. The obvious implication is that when fires are used intentionally to change the land use, fire fighting is irrelevant unless there are unwanted fires, e.g., unintentionally escaped fires. Of course, as discussed below, drought conditions contribute at times to unwanted fires.

4. Fire problems in Indonesia

It is misleading to think about 'fires' as a policy problem. The impacts of fires are the problem. Not recognizing this has two significant implications.

1. There is a risk that all fires are perceived as problematic rather than considering in what circumstances fire may be an appropriate land management tool.
2. We may lose sight of the fact that fires can have differentiated impacts (e.g., according to the location and impacted areas) that require different policies to be addressed.

In Indonesia there are two major fire-related policy problems:

- smoke haze pollution, including carbon emissions, and related impacts;
- forest degradation and deforestation, including the loss of products and services, including timber, non-timber forest products, biodiversity, soil erosion, and flood control.

4.1. Smoke haze pollution

Smoke haze pollution from fires has affected Indonesia and Southeast Asia since at least the late 1800s (Potter 2001). In recent years peatland fires have been identified as the major source of smoke haze pollution. In Indonesia, peatland fires may have contributed between 60% and 90% of the emissions resulting in smoke haze in 1997–1998 and were also the major source of carbon emissions (BAPPENAS-ADB 1999). In 1997, the main contributors to smoke haze pollution were fires in the peatland areas of the degraded South Sumatran wetlands and the peatlands of the One Million Hectare Rice Project, Central Kalimantan, initiated by the government in 1996 (see Figure 1). Fires in the peatlands of Jambi, Riau, and West Kalimantan (linked to plantation and small-holder activities) also contributed to the smoke haze, but to a lesser degree. The total area of peat and swamp forest burnt amounted at least to 624,000 ha in Sumatra, 1,100,000 ha in Kalimantan, and 400,000 ha in West Papua (Table 1).

Peatland fires in plantations of oil palm and timber occurred in 1997, but they also recur regularly in non-ENSO years, when they are probably the main source of smoke haze in Riau and Jambi provinces. Unfortunately, no data are yet available on the average area burnt annually for plantation purposes and those fires potential impacts.

Other problematic peatland fires are found in peri-urban areas. They are lit on an annual basis for agricultural purposes on shallow peatland that has already been converted to agriculture. These fires cause local smoke haze problems that can negatively affect health and

Table 1 Fire-affected areas in 1997–1998 (ha)

Vegetation type	Sumatra	Java	Kalimantan	Sulawesi	West Papua	Total
Montane forest			213,194		100,000	313,194
Lowland forest	383,000	25,000	2,690,880	200,000	300,000	3,598,880
Peat and swamp forest	624,000		1,100,000		400,000	2,124,000
Dry scrub and grass	263,000	25,000	375,000		100,000	763,000
Timber plantation	72,000		883,988			955,988
Estate crops	60,000		382,509	1,000	3,000	446,509
Agriculture	669,000	50,000	2,481,808	199,000	97,000	3,496,808
Total	2,071,000	100,000	8,127,379	400,000	1,000,000	11,698,379

Source: Tacconi 2003



Fig. 1 Indonesian provinces significantly affected by fires

disrupt transportation, business, and schooling. Fires typical of this group are the annual fires around Pontianak and other towns in Kalimantan and Sumatra. In this case as well there are no data on their extent and impact.

Smoke haze pollution has significant impacts on human health and the environment. During the 1997–1998 ENSO event, an estimated 35 million people were affected by higher than normal pollution levels (Glover and Jessup 1999), with hospitalization estimates ranging from 19,000 patients (BAPPENAS-ADB 1999) to 267,000 cases (Glover and Jessup 1999). Carbon emissions from peat fires have been estimated in the range of 442 million tonnes (Tacconi 2003) to 810 million tonnes (Page et al. 2002). The lower bound estimate is equivalent to about 27% of the average annual global emissions from land use change over the period 1989–1995. Health costs for the region were estimated at US\$ 147–289 million, and carbon emission costs at US\$2.8 billion for the lower end estimate (Tacconi 2003). These impacts occurred during one of the most significant ENSO events of the twentieth century. The impacts of smoke haze in non-ENSO years have yet to be assessed.

4.2. Forest degradation and deforestation

The Indonesian fires of 1997–1998 generated considerable international attention, not only because of the smoke haze generated but also because of the perception that the fires caused the economic and ecological losses associated with degradation or deforestation of the areas affected. Little attention was paid to the fact that fires were mainly affecting secondary logged-over forest rather than ‘pristine’ forest. Land clearing fires in plantation areas were also criticized as perceived to be contributing to forest loss.

In relation to problematic wildfires, those of East Kalimantan in 1997–1998 are the most glaring example. The over 2 million ha of forest burnt in East Kalimantan (about 60% of the total lowland fire-affected forest in Indonesia) were all categorized as degraded lowland forest.¹ East Kalimantan was also the area most severely affected by the ENSO-related drought at the national level, and indeed one of the most affected on a global scale.²

Arson fires are obviously considered a problem. While they are at times described also as ‘conflict fires’, they should perhaps be considered as ‘livelihood induced fires’, as these deliberately lit fires are an attempt to reacquire, or access for the first time, land resources needed for livelihood purposes. While they may be problematic from the perspective of the party controlling the resources affected, they are beneficial to those who ignite them. In 1997–1998, fires from arson affected established plantation areas and national parks. The data available are scarce and it is unclear if fires lit for livelihood reasons affect more than a few thousand hectares as recorded for plantations (Gouyon 1999) and national parks (Suyanto et al. 2000) in Sumatra.

There are also fires that should not be regarded as problematic. Land clearing fires to establish plantations are in this category, unless they generate significant smoke haze, i.e., are on peatland. Plantation fires represent the most obvious example of the need to consider fire issues in the context of land use processes. These fires are used to clear land allocated to a land use alternative to natural forest. Therefore, the fires themselves are not the cause of deforestation. The 1997–1998 fires in Sumatra, Sulawesi, West and Central Kalimantan, and West Papua appear to have been largely in land clearing areas (Tacconi 2003).

¹ Spatial data from the Integrated Forest Fire Management Project (GTZ).

² Let us note that in this paper wildfire means anthropogenic fires, possibly started for a specific purpose or accidentally, that burn out of control, hence are unwanted on that scale. Accidental ignition, hence accidental fire, refers to ignitions that are not deliberate acts.

The net impacts from wildfires that occur in ENSO years are difficult to assess, because statistics of areas of fire-affected forest in non-ENSO years are unavailable. It is possible, however, to make a rough assessment by considering the annual deforestation rate as a benchmark. This rate is estimated in the range of 1.7–2 million ha (FWI et al. 2002). Given that about 6 million ha of forest were burnt in 1997–1998 (Table 1), some 4 million ha of forest above the annual average were burnt during that ENSO event. The economic losses relating to burnt timber, loss of future timber growth, and non-timber forest products have been estimated in the range of US\$1.25–1.93 billion, and the losses relating to flood protection, soil erosion and siltation, and biodiversity in the range of US\$0–340 million (Tacconi 2003).

5. The causes of fire-related problems in Indonesia

The causes of problematic fires are often complex and interlinked. They can be summarized in five main categories:

- (i) environmental conditions;
- (ii) livelihood, financial, and economic interests;
- (iii) bad governance;
- (iv) lack of knowledge; and
- (v) accidental ignitions.

The fire events of 1972, 1982–1983, 1987, 1991, 1994, and 1997–1998 occurred in ENSO years. The contribution of environmental conditions to wildfires is therefore obvious. Of course, this link does not imply that just environmental conditions in themselves caused the fires. Rather they represent a necessary but not sufficient cause of large-scale fire events.

Livelihood activities in swamp and peat areas, such as agriculture, fishing, and turtle hunting, appear to be responsible for deforestation and smoke haze in 1997–1998 in the Mahakam area in East Kalimantan (Chokkalingam et al. 2001) and in the Danau Sentarum area in West Kalimantan (Dennis et al. 2000). Smoke haze in the Mahakam area is also reported in the historical records dealing with the droughts of the late 1800s (Potter 2001), which show how ENSO and livelihood combined to generate smoke haze pollution well before the establishment of modern commercial activities in Kalimantan.

A combination of lack of knowledge, financial and economic interests, and more recently livelihood activities created the worst peat and swamp fires of South Sumatra in 1997–1998. They were responsible for a significant share of the smoke haze pollution over Sumatra and peninsular Malaysia. Logging concessions were first allocated starting in the 1970s. Concessionaires exploited the forest, and people started moving in. Most of them moved voluntarily, but some also arrived under the transmigration program. To ensure the long-term prevention of fires would, at that time, have required the capacity to foresee that logging operations were not going to operate sustainably, although this should have been a straightforward conclusion given the standards of logging operations in Indonesia. It would have also required the recognition that once people had moved in after logging, they were going to adopt livelihood practices that in drought years may result in escaped fires in peatlands.

Bad governance and environmental and livelihood causes were at the root of the worst case of peatland fires in Indonesia and probably globally, the One Million Hectare Rice Project in Central Kalimantan. The Indonesian government had environmental impact assessments

showing that the scheme was unfeasible. However, former president Suharto personally supported it. The decision to implement the project was deeply rooted in the political economy of the forest sector rather than based on rational-technical reasons. Bad governance dominated this land use decision, which led to the unsustainable development of a peatland area that made it prone to fires. In more recent years, the area has come under increasing settlement pressure and smallholder land clearing fires. There are also fires apparently associated with illegal logging. All these generate smoke haze on an annual basis, which becomes particularly critical during ENSO years.

Financial interests drive peatland fires for land clearing in plantations of oil palm and timber that reoccur on an annual basis, even in non-ENSO years, when they probably are the main source of smoke haze in Riau and Jambi provinces, often drifting to Singapore and peninsular Malaysia. In ENSO years, the smoke haze problem is aggravated by the increased dryness of the peat. In Indonesia, forest clearing to establish timber plantations on peat soil is estimated to cost US\$180/ha with burning, whereas 'zero-burning' methods (i.e., mechanical clearing) may cost up to US\$817/ha (Gouyon and Simorangkir 2002). Bad governance, i.e., lack of law enforcement, could also be said to cause clearing fires on peat land. Indonesian legislation bans all land clearing fires, but it is not enforced even in regard to peat areas that clearly generate significant pollution.

The economic interests possibly driving the actions of the government of Indonesia can be discussed in the context of the estimated costs of the 1997–1998 fires. If preventing the fires in East Kalimantan implied maintenance of the forest in its 'pristine' state, this course of action would have required forgoing decades of log production. Official log production in East Kalimantan over the period 1969–1997 was about 172.7 million m³ (data from Hinrichs and Solichin 1999). The net present value of those logs in 1997 was roughly US\$25.4 billion.³ To err on the conservative side, it may be assumed that the value of the timber produced in the area burnt is equivalent to one quarter (i.e., about US\$6.3 billion) of total production, which is the ratio of the area burnt to total forest in logging concessions. Comparing the net value of log production with the costs of the fires in East Kalimantan, estimated at a maximum of about US\$1.7 billion (Tacconi 2003), shows that it may be undesirable from a national economic point of view to maintain 'pristine' forests in order to avoid the costs of fires.⁴

Accidental causes are said to contribute to fires particularly during ENSO years, but their potential contribution is difficult to assess because of lack of data. Only BAPPENAS-ADB (1999) reports data showing that community members in Riau (46% of respondents) and East Kalimantan (15%) thought that dry peat areas were vulnerable to discarded cigarette butts during the long drought. Byron and Shepherd (1998) dismiss accidental sources of ignitions, but Vayda (1998) cautions against that view, at least until more information is available.

The preceding analysis has considered the situation in Indonesia to clarify some of the perceived problems, impacts, and causes, thus exemplifying the analysis needed to understand 'fire problems'.

³ The net present value in 1997 was calculated by multiplying the volume of logs produced in year 't' by the net value of logs (US\$28, the minimum net value used in the estimates of timber loss by ADB study) and compounded at a rate of 10%.

⁴ It has been noted above that bad governance has affected forest management during the Suharto period. This example does not imply that forest management decisions were made on a rational economic basis. It shows what the incentive structure would be, if a rational economic approach were adopted.

6. Improving knowledge about fire problems

6.1. Country studies

Country level studies are required to improve the understanding of fire issues in most tropical countries. Global and regional reviews (e.g., FAO 2000; Cochrane 2002) have improved existing information about individual countries, but more in-depth studies are needed to understand whether fires are problematic and what should be done in each country. These studies would seek answers to questions such as the following:

- Is people's health negatively affected?
- Is biodiversity threatened, protected, or even stimulated?
- Do fires save or cost money, at the individual, company, and national levels?
- Who benefits and who loses? And who has the power to affect change?

6.2. Fire data

Consistently collected data over time will help in improving comprehension of 'fire problems'. Nepstad (2002) notes that the first need is to quantify and systematize field observations to understand why fires are lit and which fires are fought. With some exceptions this critical effort has yet to be undertaken. Reliable data on the number of fires, area burnt, and the averages across the years are infrequently available for most countries in the tropical forested regions of the world.

The data needed include information such as: When did the fire start? Where did it start? When did it finish? How large is the area burnt? What ignited the fire? Well-collected data can identify the geographic focus, the major land uses, the key fire users, and the timing of fires. Supported by these basic data, a stronger delineation can be made between fires that are wanted and those that are not. Importantly, these data must be collected by land management institutions and agencies, both government and private.

6.3. Ecological, economic, and social research

To develop policies aimed at reducing future risks and negative impacts of fires during ENSO events, it is necessary to assess both the ecological and socio-economic factors contributing to increased fire risk in the relevant forest ecosystems, particularly in areas that are identified as protected or production forests. There need to be systematic assessments of the characteristics of fuels, weather, ignition sources, and the fire behaviour they generate. Researchers, institutions, and organisations with land management responsibilities should collect the data necessary, analyse them, and work through the implications for fire fighting structures and arrangements from the local level to national and perhaps transboundary scales.

7. What should be done to address fire problems?

It is always desirable to have as much information and knowledge as possible. Perfect information and knowledge, however, are never available. Therefore, after having indicated above areas for further research, we discuss some practical initiatives aimed at addressing 'fire problems'.

7.1. The role of fire fighting

The visible symptoms of fires readily reported are flames and smoke. External actors, and often local and national actors, assume that the extensive and persistent nature of fires arises from the lack of equipment, training, infrastructure, and organisation for fire suppression. The response by donors and national governments, consistent with this understanding, is then to supply, suggest, or seek additional fire fighting capacity. In many cases this approach suits donors, organisations, and the private sector. The response is simple, demonstrable, and involves supply of highly visible support, for which there is often a domestic source of willing expertise readily available.

Currently, fire management in Southeast Asia, as in other parts of the world, is almost exclusively a government effort and focuses more on fire suppression than on fire management strategies that balance prevention, preparation, fire fighting, and restoration of damage. Much of this emphasis is based on perceptions of fire from outside the tropics. The assumption that fires are uncontrolled wildfires that threaten lives and destroy infrastructure in dramatic circumstances appears generally unfounded. Additionally, fire fighting is strongly limited in its effectiveness, expensive, difficult to implement, and addresses only the symptoms. Further investments in fire fighting should therefore be considered carefully. Such investments are likely to be appropriate in situations and locations where fires are mainly accidental and not linked to the forest-fire exploitation cycle.

7.2. Supporting research capacity

In developing countries, forest fire scientists are few, mainly un-supported, and a relatively recent addition to the research fraternity (Nepstad 2002). Their research is in the early stages of evolution and represents a small proportion of the fire research being published. At the International Wildland Fire Conference, Sydney 2003, scientists and practitioners from 17 developing countries presented 47 papers, while their counterparts from 14 developed nations added 234 reports (International Wildland Fire 2003). Supporting the improvement of fire research capacity in tropical countries should be a priority. This investment would pay itself off handsomely, as increased research capacity would contribute to ongoing identification and monitoring of fire problems, and it would save a great deal of investment in fire management activities focused on the wrong problems.

7.3. Reducing smoke and haze pollution

Smoke haze pollution is a significant problem in Southeast Asia. Indonesia, being the major source of that pollution, deserves special attention. Peatlands cover 11%–16% of Indonesia's landmass (Bellamy 1997), but when on fire contribute about 60%–90% of the overall smoke and haze produced, including carbon emissions. This knowledge suggests focusing efforts on the peatlands, where it will be most effective in reducing or preventing smoke haze pollution.

In ENSO years, degraded peatlands are probably the most significant risk factor for the generation of smoke haze. Their management and eventually their regeneration and restoration may be required to avoid significant events of air pollution. The costs and the viability of this policy need to be ascertained, and compared with the expected benefits (i.e., improved economic production, environmental benefits, and avoided environmental costs). In non-ENSO years, a reduction in peat fires from land clearing in plantations would considerably reduce smoke haze pollution. The decision to introduce policies aimed at effecting that reduction requires an assessment of its health, environmental, and economic implications. It was noted

above that the use of ‘zero-burning’ methods on peatlands may be financially unattractive to companies and that an incentive system would have to be designed if a reduction in smoke haze pollution were deemed desirable.

7.4. Improved logging practices

Ecological studies show positive feedback among logging, forest fires, fuel loading, and future fire susceptibility. Therefore, forest management practices such as reduced-impact logging minimize fire susceptibility in areas prone to droughts. It needs to be understood, however, that improved management practices reduce fire risk to a greater extent in areas completely controlled by concessionaires, i.e., with limited human presence. Also, reduced-impact logging at times results in ‘reduced-income logging’ (Putz et al. 2000); thus financial incentives and enforcement activities would have to be put in place.

7.5. Improving governance

Improving governance may seem an issue far removed from fire management. We have seen that in some cases livelihood, financial, and economic interests may be favouring fires. Bad governance means that fire prevention and suppression may not eventuate even in situations where these interests would favour them. Forest management, including fire management, is above all affected by the governance system. Efforts directed at improving forest governance, and that embrace the whole forest sector and integrated fire management approaches, are the initiatives best placed to have real and lasting impacts on ‘fire problems’.

To summarize, fires are a component of land management processes. In tropical countries, fire is often used to carry out land use changes. There are also situations in which fire affects land use, but not in a planned or rational way. Rather it has impacts distributed over long periods of time, in an unregulated fashion, linked to multiple causes. Fire can have positive and negative impacts, and it is not just a ‘problem’ to be prevented, suppressed, or mitigated. It is obvious that not all fires are the same. Wildfires in ENSO years can be expected to have more significant negative impacts than wildfires in non-ENSO years. Forest fires and peat fires have different impacts, and may also have different causes. There are a series of steps that should be taken to improve knowledge of fire problems. Once available, this information will support the processes that address the question, what really are the fire problems in tropical forests.

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