Forest Fires and climate change in Indonesia

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Forest fires in Indonesia cause significant social and environmental impacts. Some fires occur naturally and even play an ecological role. However, a substantial number are human-induced, either directly for land clearance or indirectly by opening the canopy of closed forests. In combination with human causes, climate change and climate variability are likely to increase the extent and intensity of forest fires.

Introduction

Forest fires in Indonesia have dragged the attention of the international community because of their environmental, social and economic consequences. They have large negative impacts on local and national development as they directly affect biodiversity, the livelihood and health of local people, and can also negatively affect infrastructure, transport and the forest industry. They also emit a large amount of green house gases: fires in 1997-1998 made Indonesia one of the largest emitters of greenhouse gases in that year, as they released more than 700 million metric tonnes of CO_2 into the atmosphere (Reiley 1999 in Applegate 2002).

Forest fires are not new to Indonesia. They are said to be as old as the history of human kind. Written records show that forest fires have been occurring in Kalimantan since the 17th Century. However, since 1980, Indonesia has witnessed an increase in the extent of the area, intensity and frequency of fires. Major events occurred in 1982-83, 1987, 1991, 1994, 1997-98 and 2002 (Bowen *et al*. 2001 and Tacconi 2003). The most severe fires in the last twenty years occurred in 1997, affecting approximately 11.7 million hectares, mostly lowland peat and swamp forests, timber plantations and agricultural areas (Tacconi 2003).

What causes forest fires?

Forest fires do not only derive from human activities; in fact, a large number are linked to natural causes. Some forests have evolved under, and are adapted to, fire conditions, and even need fire for reproduction and the cycling of nutrients. Natural forest fires are cyclical and obey to specific conditions of climate, soil, topography and vegetation: low humidity or dry climate, sufficient accumulation of biomass and an ignition factor (usually a thunder). Strong winds could contribute to spread fire.

However, human induced fires are increasingly contributing to the occurrence of fires. These causes can be classified as follows:

- ***Direct causes*** are those linked to the act of setting up fire. Fire is usually seen as a cheap way to clear land for agriculture and cattle grazing activities. Oil palm and forest plantation companies previously used fire for such purpose. Likewise, local communities use fire as it is the cheapest way for clearing land, or because they believe that it could improve soil properties. Fire is also used to provide easier access for harvesting timber, fish and other products, to generate grass new sprouts or to ward off insects. Finally, a large amount of forest fires are also initiated by careless camping.

- ***Indirect causes*** favour the occurrence and increase the risk of forest fires. They include activities like road development, resettlement projects and logging activities. Road development through closed forest areas may increase risk of forest fires by opening access to settlers or gatherers to collect forest products or to clear forests. Logging activities can also contribute to increasing the risk of forest fires as they open the canopy (leading to low microclimate humidity) and because they leave debris behind. In addition, human-induced changes in climate could be seen as indirect causes whenever they lead to an increase in dry conditions and biomass in an area.

The impact of forest fires on development

Forest fires have significant socio-economic consequences. It is estimated that the total lost caused by the fires of 1997 -1998 was between US$ 8.7 billion to 9.6 billion (Applegate *et al.* 2002). Following is a general description of the major impacts from forest fires:

- Health. Forest fires release toxic gases like carbon monoxide (CO), ozone (O_3), nitrogen dioxide (NO_2), hydrocarbons, aldehydes, particles and polycyclic aromatic hydrocarbons (PAHs) (Ostermann and Brauer 2001). It is known that exposure to these gases can cause acute respiratory infections.

- Livelihoods. Many communities are still benefiting from forest goods and services. They harvest timber and non timber forest products and use water whose quantity and quality is linked to the presence of forests. As a result of forest fires, there will be less (in term of quantity, quality and diversity) timber and non timber products and services available for the communities.

- Biodiversity loss. Forest fires destroy large forest areas that serve as habitat for biodiversity. They directly eliminate plants and animals and also result in forest degradation that leads to a decrease in the survival rate of the species. For example, the fires in 1997-1998 resulted in 33 % population decline of the Orangutan (*Pongo pygmaeus*) in Borneo (Rijksen and Meijaard 1999 in Secretariat of the Convention on Biological Diversity 2001). Moreover, fires in 1982-1983 in Kutai National Parks (East Kalimantan) resulted in widespread mortality of reptiles and amphibians (MacKinnon *et al.* 1996 in Secretariat of the Convention on Biological Diversity 2001) and lost of fruit trees that caused the population of fruit-eating birds such hornbills declined dramatically (Nasi *et al.* 2002).

- Forestry and agriculture. These sectors have experienced great economic loss due to forest fires. Wild fires and man made fires have destroyed large areas of natural commercial forests as well as agricultural crops, such as pulp wood and oil palm plantations.

- Tourism. Some argue that the forest fires in 1997 – 1998 led to a decrease in tourism. Visitors may be concerned about the effects of smoke haze to their health as well as transportation safety (see below). On the other hand, forest fires can destroy forests with the potential to be tourism sites.

- Greenhouse gas emissions. Estimates suggest that in 1998, more than 12 million ha of closed natural humid tropical forests were burnt in Borneo, Sumatra, the Brazilian Amazon and Mexico. Murdiyarso and Adiningsih (2006) estimated that Indonesia alone had contributed 1.45 Gt C to the atmosphere in that year.

- Transportation. Haze from fires has affected visibility in some parts of Sumatra and Kalimantan. It has particularly affected the city traffic, sea transportation and flights to the extent that accidents such as an airplane crash and boat collisions at Malacca strait may be linked to problems of low visibility caused by forest fires.

As an example to the economic loses caused by forest fires, Table 1 includes some figures compiled by Applegate *et al.* (2002) on the events that took place between 1997-1998 in Indonesia.

Climate variability and climate change in relation to forest fires

As mentioned above, fires require three conditions to occur: fuel (biomass), dryness and an ignition factor. The linkage between forest fires and climate change is twofold: first, changes in climate have significant implications on the humidity of a region (e.g. they can lead to drier conditions) and, second, they could increase the production of biomass, resulting from more rain, higher temperatures and a higher concentration of CO_2 in the atmosphere.

Future climate change scenarios indicate that most of Indonesia will become warmer and wetter, except its southern part (including Java and Bali) which will become drier (Hulme and Sheard 1999). Predictions also point to an increase in seasonal variability, which means that the country will experience more intense dryness during the dry season. Extreme events as part of the interannual variability mechanism such as El Niño-Southern Oscillation (ENSO) or Indian Ocean Dipole Mode (IODM) are increasing in intensity and frequency (Lal *et al.* 2001).

Table 1. *Summary of mean economic costs of the 1997-1998 drought and fires.*

Sector	Mean estimated economic losses (in million US$)
Agriculture	
Farm crops	2,431
Plantation crops	319
Forestry	
Timber from natural forest (logged & unlogged	1,813
Lost of growth in natural forest	355
Timber from plantations	91
Non timber forest products	631
Flood protection	413
Erosion and siltation	1,354
Carbon sink	1,446
Health	148
Building and property	1
Transportation	33
Tourism	111
Fire fighting costs	12
Total	**9,158**

Source: Applegate et al. (2002)

These projections indicate a higher risk of fires resulting from higher dry conditions. This risk is not limited to the South of Indonesia (e.g. Java and Bali), as dry conditions over the whole region are exacerbated during the dry season due to interannual climate variability. In other words, the risk of fire during the dry season may increase as a consequence of internannual variability.

The second factor affecting the occurrence of forest fires is biomass. Warmer and wetter climate, together with a higher concentration of CO_2, can increase variables such as tree growth rate, final radial stem size (Hattenschwiller *et al.* 1997) litter-fall and fine root increment (IPCC 2001). An increased amount of biomass is a direct increase of the available fuel, thus conducing to a potential increase in the extent and intensity of forest fires.

Geographical variation in the predicted climatic response over the Indonesian region will cause the nature of the fire risks also to vary.

Climate change and climate variability are likely to increase the risk of more seasonal and small forest fires in the southern part of Indonesia (south Sumatra, south Kalimantan, south Sulawesi, Java, Bali and Nusatenggara). In these areas, forests are generally drier and, therefore, the risk of fire increases during the normal dry season. In addition, increasing biomass due to increased CO_2 concentration, despite of less water availability (Cao and Woodward 1998), further increases fire risk. Furthermore, with increased seasonal variability, there is a tendency of shifting from rain forest ecology to seasonal rain forest ecology, which provides more open canopy and drier forest floor in the dry season (Whitmore 1998, Condit 1998, Werner 2003).

In the northern part of the country (central and northern Sumatra, most of Kalimantan, northern Sulawesi and Papua), the risk of big fires will be influenced by interannual climate variability. Climate, in general, is likely to become wetter; there will be enough moist to prevent forests from fires during normal years. Peatlands, which are rich with organic content, are normally water-logged and difficult to burn. However, in the events of extreme dryness caused by ENSO and IODM, the biomass is drier and the water table on peatlands drops, thus exposing large quantities of biomass and making them easy to burn. A combination of ENSO and IODM, such as those in 1992/1993 and 1997/1998, have caused severe droughts that correlates with the increased number of hotspots of forest fires over Indonesia. These big fires can directly cause heavy loss in biodiversity, in particular they can eliminate fire sensitive plant species quickly, and can cause the forests to degrade and to be more susceptible to repeated fires.

Science, policy and practice gaps

Indonesia has undertaken various efforts to prevent recurring forest fires. For example, the government has released a new regulation (Government Regulation 4/2001), which forbids all kind of forest and land fires, and has worked with other Southeast Asian Countries on formulating ASEAN national and regional haze action plans and related technical programmes. However, those actions are unlikely to reduce the risk of forest fire because fire is still considered as the cheapest and easiest way to clear the land. Moreover, policies and programmes have not considered in detail underlying causes such as land tenure and land use allocation conflicts and competition issues (Murdiyarso *et al.* 2004). The impact of climate change and how it may alter the forest susceptibility to fires have not been properly addressed.

In an effort to combat global warming, Indonesia has participated in the global climate change forum for some years. It has in place a national strategy and policy on climate change since 1993. In addition, the government adopted a National Action Plan on Climate Change in 1998, it submitted its first National Communication in 1999, it established a National Committee and Technical Team on Climate Change (NCCC) in 2003 and ratified the Kyoto Protocol in 2004.

Unfortunately, some government and research institutions, the private sector, NGOs and people at the local level are generally not aware of the consequences of climate change. The Indonesian National Capacity Self Assessment (NCSA) report, released in January 2006, highlighted the capacity constrains faced by Indonesia to face the challenge of a changing climate. Some of them are:

- Institutional capacity and commitment to address climate change is low;
- Relevant government sectors have not adequately addressed climate change issues, nor have translated them into appropriate legislations. Adaptation to climate change is particularly lacking.
- There is a lack of capacity to assess vulnerability, to develop regional climate models, to design and assess adaptation strategies and to systematically observe and monitor climatic variables and climate change impacts;
- Systems for Integrated data on climate change have not been set up;

Conclusion

The regional and international attention to forest fires in Indonesia has been increasing as a result of the implications for environment and development. Most fires are human-induced, either by direct or indirect causes. In addition, their intensity and extent is, and will increasingly continue to be, partly influenced by climatic conditions. Under a scenario in which drier conditions are expected in the country, vulnerability to climate change becomes significant for fire policy. To support the decision making process, there is a need to understand how and where climatic conditions are likely to increase the frequency and intensity of forest fires. From the adaptation standpoint, such analysis should consider the vulnerability of local communities as determined by foregone goods and services from forests, other direct impacts in health and indirect impacts on transport, tourism and other sectors.

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