

# **Vegetation and land fire hazards: Framing the problems to reduce the risks and disasters<sup>1</sup>**

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## **Abstract**

Vegetation and land fires are not new to the Southeast Asian landscapes. Nevertheless, strikingly different perspectives persist about the significance of fires in the tropics to environmental changes and human well-being and consequently how they should be managed to reduce the risks and disasters. In order to frame the fire problems, there are at least three domains with high potential of meeting multiple objectives. **First**, is through understanding natural ecosystem, their functions and consequences for biogeochemical cycles. Assessing their vulnerability to fire under current and future climate is summarized in line with the human systems. **Second**, is through understanding human systems, their adaptive capacity to manage fires and their risks. Investments in capacity at multiple levels are needed, but particularly at fairly local levels where stakeholders have strong incentives to manage fires appropriate to local contexts. **Third**, is through better understanding of fire disturbance regimes for effective mitigation measures. Finally, it is imperative to engage policy-relevant research and greatly involve stakeholders in exploring the full range of land and fire management options.

*Keywords:* fire and emission mitigation, climate change, adaptation strategies, vulnerability assessment, peatlands, policy-relevant research

## **1 Introduction**

There is a significant history of both natural and human-lit wildfires in carbon dated charcoal fragments in forest soils (Stott, 1988; Goldammer and Siebert, 1989; Maxwell, 2004; Goldammer, 2006). Today fires in Southeast Asia are largely an expression of interactions between human, climate and ecosystems. Fires are a commonly used tool in converting forests permanently to agriculture and may continue to be used in subsequent land management. Fire disturbance regimes in forests have also been changed as a result of logging and swidden cultivation practices, landscape fragmentation, roads and fire suppression or other land management and development policies (Applegate *et al.* 2001; Stolle and Lambin 2003; Murdiyarso and Lebel 2005). Climate variability and changes become increasingly important element in fire ecology. Ecosystems and people respond and adapt to the interplay between human and natural phenomena and changes. Some landscapes and livelihoods are more resilient than others to changes in fire regimes.

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There are several competing perspectives about the significance of fires in the tropics to environmental changes and human well-being and consequently how they should be managed (Murdiyarso and Lebel, 2006). These range from viewing fires as a “problem” through to calls to distinguish different kinds of fires, to viewing fires as phenomena of development (Murdiyarso *et al.*, 2004a). Many of these differences in perspective relate to the spatial and temporal scales in which they should be framed as proposed in Figure 1. Studies concerned with global carbon cycles, for example, emphasize the large fluxes of carbon to the atmosphere during episodes of intense fire activity such as the 1997/1998 dry phase of *El-Nino* Southern Oscillation (ENSO). Other studies are more concerned with the dynamics of land-use and local livelihoods, place greater emphasis on ecosystem goods and services. Knowing the geographic scale of the issue there is substantial interests in conflict and cooperation between countries over trans-boundary haze originating from vegetation and land fires.

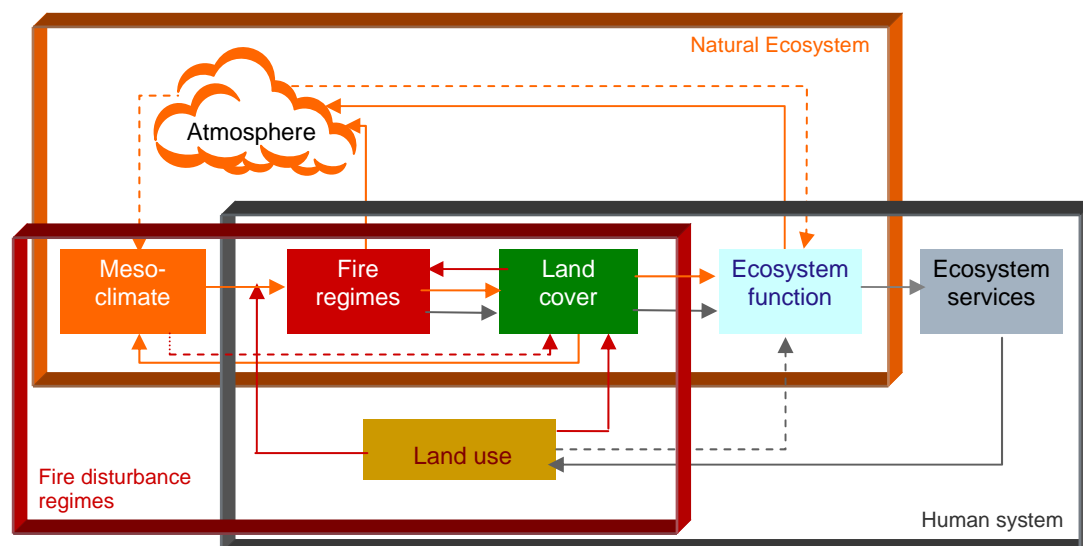


Figure 1. Conceptual framework to understand the vulnerability of peatland ecosystems to climate change and fire regimes (Modified from: Lavorel *et al.*, 2006)

Research has contributed a lot to understanding of how fires in Southeast Asia affect ecosystems, atmosphere and the global carbon cycle. Most of the understanding comes from research carried out in Indonesia. However, there are still several outstanding questions about vegetation and land fires in the landscapes of Southeast Asia.

This paper attempts to examine how a better understanding of these kinds of questions should be addressed. It is argued that without comprehensive understanding it will be hard for societies in the region to manage the risks and avoid the damaging disasters. Knowledge should be further developed at different levels and mobilized for plausible actions.

## 2 Ecosystem and human vulnerability to fire and climate variability

The “big” fires of 1997/1998 in Indonesia resulted from a combination of fires lit for land clearing and preparation by smallholders and larger firms as well as uncontrolled accidental fires in forest and peatlands. The spread of fires was accelerated by dry weather generated *El-Nino* events with substantial direct and indirect damage costs as shown in Table 1. Impacts on timber and estate crops were relatively modest underlining the role of asset management and investment in producing vulnerabilities in different forest types. Logged over forests suitable for conversion to oil palm plantations were extremely vulnerable.

Table 1. Direct and indirect economic losses caused by 1997/98 fires in Indonesia

Sector	Assumptions	Loss (million \$)
Forests and timber	Based on the log market price	2,100
Timber plantation	Foregone profit was also included	94
Non-timber forest products	Based on the household survey	586
Estate crops	Based on area burned	319
Agriculture	Based on decreased rice production	2,400
Erosion and siltation	Foregone value of forest cover	1,600
Health	Health care costs and lost productivity	145
Tourism	The difference between predicted and actual tourist arrivals	111
Transmigration area damage	Fire fighting costs in the areas	50
Carbon emissions	Conservative emission estimate of 0.8 Gt CO <sub>2</sub> . Market price of \$ 7/tCO <sub>2</sub>	1,400
Total		8,855

Source: BAPPENAS (1999); Barber and Schweithelm (2000)

In the context of Indonesia there is increasing risks of low frequency, high impact fires in peatlands (Murdiyarto *et al.*, 2004b). Peatlands cover more than 10% of Indonesia’s land area including many agricultural locations critical to sustaining livelihoods of the poor. Practical policies will need to prioritize the most vulnerable areas of peatlands. In the seasonally dry tropics of montane mainland Southeast Asia this means focusing on managing high frequency modest impact fires in mixed deciduous forests (Schmidt-Vogt, 1998; Maxwell, 2004).

In both cases the issue is avoiding additional wildfires rather than suppressing all use of fires in land management critical to farming and livelihood security. In addition to their roles in conserving biodiversity, regional hydrology, flooding buffer, and carbon storage, peatlands are also important for local livelihoods through fishing and hunting. Repeated peat burning, however, contribute to declining nutrient resources and reduce livelihood options (Saharjo, 2006, Chokkalingam *et al.*, 2006)

In Sumatra, Indonesia, land tenure conflicts between firms and communities frequently lie behind the use of fire as a weapon (Stolle *et al.*, 2003). Here and elsewhere in Southeast Asia the pursuit of fire suppression and forest conservation

policies increases vulnerability of ethnic minority upland farmers dependent on use of fire to prepare their fields for cultivation ( Schmidt-Vogt, 1998; Fox *et al.*, 2000). Fines, arrests and “fire-fighting” actions essentially prevent them from growing a crop to feed their families. Lack of secure land tenure, and in some cases, also of citizenship, compounds vulnerabilities (Tomich *et al.*, 1998; Luangaramsri, 2002; Vandergeest, 2003). Fire management policies need to be adjusted to local ecological and social contexts.

The areas annually affected by fires across mainland Southeast Asia are large. Upland farmers in this region use fire extensively to prepare swidden fields for planting. Lowland farmers also use fires, for example, to burn off crop residues. In urban areas fires are used to reduce leaf litter and control woody vegetation invading land under speculation by real estate developers. Although the seasonal smoke haze problems in this region have received far less attention than those nearer the equator they also pose important health and airline navigation risks. Streets *et al.* (2003) estimated that, for all of Asia, forest burning comprises 45% and crop residues in field 34% of openly burnt biomass. The contexts in which fires are used and need to be managed vary greatly.

In summary there is already enough known about fires in Indonesia to place a high priority on improving land, water and fire management in peatlands areas as they are vulnerable ecosystems upon which many poor farmers depend. There are undoubtedly also other vulnerable human-environment combinations deserving special attention especially from the perspective of biodiversity conservation and these deserve additional assessment and exploration of policy response options.

### **3 Mitigation and adaptive capacity**

Fire mitigation has been largely conducted in conjunction with capacity building on fire fighting and early warning systems. Prior to the huge fires of 1982 in Borneo forest fire fighting strategies and infrastructure were not in place in many areas of Southeast Asia. During the past 20 years, some 40 fire international projects and missions costing well over US\$ 30 million have been implemented, primarily in Indonesia (Dennis 1999). National governments have also invested significantly in fire management and building necessary capacities at local levels which nevertheless often remain low.

Science has made an important contribution to the understanding of the causes and impacts of fires, and in turn has informed operations. Early warning systems such as the Fire Danger Rating System (FDRS) for Indonesia and Malaysia, for example, were developed jointly by scientists and government agencies (de Groot *et al.*, 2006). All this is useful background understanding to strengthen institutional capacity. So far, however, this cumulative understanding has not had anywhere near enough impact. In the last few years, the transfers of responsibilities by central governments to local communities and local governments have risen but they have usually not being accompanied by the resources required to build the capacity to understand and manage new fire regime. While the barriers are not insurmountable the challenges

are large and will require investments. These should be the focus of regional cooperation and broader technical assistance.

Research and policy communities are posed to outstanding research questions:

- What kinds of fires (including when and where) produce the largest irreversible (or at least long time to recover) reductions to carbon stocks in soils and biomass?
- How much impact would restricting burning on certain high risk days for accidental spread or haze formation have on smoke problems even without reducing overall use of fire?
- What happens to forested areas affected by fire which are not converted to agriculture or otherwise settled? How do carbon stocks change over time? Does subsequent fire management make any difference?
- What are the links between the vulnerability of an ecosystem to fire and the people which are found near it? What is the role of adaptation and local policies?
- Are the last twenty years of apparently increased use of fire in some areas like Indonesia for land development indicative of future trends or will use of fire decline without explicit intervention as a result of changing incentives resulting from economic development?

Ultimately adaptation to fire regime changes resulting from climate change would benefit from an explicitly multi-level approach that recognizes some capacities are more appropriately developed at particular levels (*e.g.* Adger *et al.*, 2005). In the case of fires, for example, there are a lot of reasons to expect cooperation at the regional level to be useful for smoke-haze monitoring and risk management.

The law on Local Government enacted in 1999 in Indonesia gives more authority to the local governments at district level (Silver 2003; Wollenberg and Kartodihardjo 2002). Similar series of reforms in Thailand starting in 1995 have progressively empowered the sub-district level (Rajchagool 2002). The consequences of decentralization of responsibilities to more local authorities raises questions about coordination and capacities at lower administrative levels, but also increases opportunities for meaningful public participation in the design of management strategies that might better fit local contexts.

Several institutional challenges remain at local to national levels. Enforcing burning restrictions on farms in particular seasons or places has also proven difficult, in part, because of lack of independent and effective judicial systems throughout the region. Improvements are also needed to the governance processes that allocate land and forest use property rights, especially in forest margin areas where many conflicts over fires take place. Community-based management that includes controlling spread of fires from farmers fields is possible (Kitjewachakul *et al.*, 2004). Finally, interventions in fire management cannot ignore social justice issues arising from some current, extractive, forms of development that leave some people highly vulnerable.

The Association of Southeast Asian Nations (ASEAN) has been at the forefront of mostly rhetorical attempts to promote regional cooperation on trans-boundary pollution issues, including those arising from vegetation fires. In 1999, after several years of discussions a Regional Haze Action Plan was developed by a Haze Technical Task Force with support from the Asian Development Bank. The widely accepted ASEAN response was expected to be revisited annually (Qadri 2001). The emphasis in implementation, as for example laid out in the Operationalized Regional Action Plan, remains firmly on fire suppression and mitigation. The underlying causes of fires are not addressed (Murdiyarso et al. 2004a). The ASEAN Agreement on Transboundary Haze Pollution (ATHP) entered into force on 25 November 2003 following the ratification by seven countries. Indonesia, notably, has not yet ratified the agreement which in any case is not legally binding. Not surprisingly significant transboundary haze events from fires continue to occur.

#### **4 Fire disturbance regimes**

Zero burning is not always effective, especially when new plantations were introduced to replace secondary vegetation or heavily logged-over forests. Fires were used and most of the time with little precaution such as preparing fire crews which would only have cost around US\$ 2.69/ha. However, companies seem to be more willing to pay a fine of \$ 3.30/ha in the off-chance they were sentenced and found guilty of doing wrong (Simorangkir, 2006).

Peatland fires in Kalimantan and Sumatra make a huge contribution to trans-boundary smoke haze. Heil *et al.* (2006) modeled dispersion of fire pollutants and found that if peat fires are excluded then ambient air quality standards are only exceeded close to the main fires, whereas if they are included such standards are exceeded along way from the source as observed.

At the regional level much of the haze problem could be eliminated by avoiding synchronous burning at times when prevailing winds and atmospheric conditions will lead to high concentrations where people live or transport systems are seriously affected (Tomich *et al.*, 1998). Modeling studies of regional haze pollution dispersal and deposition (Heil *et al.*, 2006) could certainly inform such efforts.

At the global level rewarding preservation of carbon stocks in natural forests, including measures to protect them from fires, might be possible through markets and trading in carbon. The economic loss due to possible carbon credits if they were sold in the carbon markets of \$1.4 billion (Table 2) is largely conservative. More than 2 Mha of peat lands were burned during the 1997/98 fires (Tacconi *et al.*, 2006). In addition, when these vulnerable ecosystems were accounted for, Murdiyarso and Adiningsih (2006) estimate that the total carbon emissions during 1997/98 fires was 5.3 Gt CO<sub>2</sub>. The current rules under the Kyoto Protocol, however, allow only afforestation and reforestation activities to be credited. Therefore, there is no incentive to conserve the existing carbon stored in the vegetation biomass and emission reduction by avoiding deforestation. Apart from emissions of greenhouse

gases, forest and land fires also release aerosols to the atmosphere and modify surface properties which also interact with climate ( Page *et al.*, 2002; Guido *et al.*, 2003; Murdiyarso and Adiningsih, 2006; Lavorel *et al.*,2006).

## 5 Conclusions

There are three major ways that multiple objectives including mitigation and adaptation to climate change could be constructively pursued in public policy. First, more attention needs to be paid to vulnerable ecosystems and people, both under current and future climate. There appear to be clear benefits at multiple-level of better protection of the more vulnerable peatlands ecosystem which are biologically diverse and particularly carbon-rich ecosystems.

Second, policy needs to look more closely at the institutions guiding the management of fires and their relationship to land and water resources development. There is a need to build capacity that is flexible enough to cope with cyclic risks of destructive fires, for example, due to phase shifts in ENSO. Adaptation is also critical because of the complex interactions between land use, ecosystems structures and functions and fire that exist even under current climate, but which when confounded by climate change are even more uncertain.

Third, there are alternative ways to manage land which would result in less fire-related emissions being released synchronously to the atmosphere. These might involve delays in time of burning and use of zero-burning methods for disposing of waste vegetation. Incentives and regulations, however, are needed and may be justified because of benefits to human health at local and regional levels this should be pursued. Where aggregate long-term emissions of greenhouse gases from such efforts are also feasible they should be supported.

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