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Local to global perspectives on forest and land fires in Southeast Asia

Daniel Murdiyarso · Louis Lebel

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Abstract Forest and land fires are not new to the landscapes of Southeast Asia. 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. Our synthesis of papers in this special issue suggests both trade-offs and complementarities in various policy responses with differing objectives. There are, however, at least three domains with high potential of meeting multiple objectives. First, is through identification, and improved management, of ecosystems vulnerable to fire under current and future climate. Agriculture, forestry and human settlements on peat land areas in Indonesia are candidates for such a focus. Second, is through building adaptive capacities to manage fire and related land and water resources. 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 building awareness that fire management does not universally equate to fire suppression. Severe smoke haze episodes, for example, are also a result of timing of fires, and some fire-adapted ecosystems may depend on fire to persist. Finally, we emphasize that effective fire management is unlikely to be realized without greater engagement by research and policy with stakeholders in thoroughly exploring the full range of land and fire management options. Negotiation, compensation and trade-offs are probably inevitable.

Keywords Policy responses · Fire and emission mitigation · Vulnerability assessment · Climate change · Adaptation strategies · Governance

1 Perspectives

Forest and land fires are not new to the landscapes of Southeast Asia. There is a significant history of both natural and human-lit wildfires in carbon dated charcoal fragments in forest

D. Murdiyarso (✉)
Center for International Forestry Research, Jl. CIFOR, Situgede, Bogor, 16680, Indonesia
e-mail: d.murdiyarso@cgiar.org

L. Lebel
Unit for Social and Environmental Research, Chiang Mai University, Thailand

Table 1 Perspectives on fires at different geographic levels

Level	Negative perspectives	Neutral or positive perspectives
Local	Fires damage property and degrade forests	Fire is convenient tool to convert and prepare land for agricultural activities
National	Fires are a national embarrassment and diplomatic challenge. International media portrays country as unable to manage own environment properly	Fires are a tool and smoke is a necessary by-product of land and economic development
Regional (SE Asia)	Fires cause deforestation and biodiversity loss. Smoke costs tourism and transport income	Fires are a tool and smoke is a necessary by-product of investments in plantations
Global	Fires contribute to climate change through large fluxes of greenhouse gas emissions and reducing carbon stocks	Fires are an inevitable and partly natural (cyclic) phenomenon in terrestrial ecosystems. They renew and destroy

soils (Goldammer, this volume) (Goldammer and Siebert 1989; Maxwell 2004; Stott 1988). Today fires in Southeast Asia are largely an expression of interactions between humans, 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; Murdiyarso and Lebel 2005; Stolle and Lambin 2003). Climate variability and changes are also very important. Ecosystems and people respond and adapt to these interactive changes. Some landscapes and livelihoods are more resilient than others to changes in fire regimes.

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 (Table 1). These range from viewing fires as a "problem" through to calls to distinguish different kinds of fires, to viewing fires as an epiphenomenon of development. Many of these differences in perspective relate to the spatial and temporal scales in which they are framed. Studies concerned with global carbon cycles, for example, emphasise the large fluxes of carbon to the atmosphere during episodes of intense fire activity such as the 97–98 dry phase El-Nino Southern Oscillation (ENSO). Other studies are more concerned with local livelihoods, place greater emphasis on soil management, property damage and health implications. In between there is substantial interest in conflict and cooperation between countries over trans-boundary haze originating from forest and land fires.

There is an element of truth in each of these perspectives that forms a constructive basis for policy and action. In this paper we draw together some of the main insights from other papers in the special issue about the biophysical and social implications of these different perspectives for public policy. We also contrast findings from Indonesia that are the focus of most papers in this issue with other parts of the Southeast Asia region. Our policy focus is on domains where knowledge can be mobilized and actions are plausible.

2 Vulnerable ecosystems and people

One way forward is to focus on vulnerable ecosystems and people and to do so in places that contain important stocks of carbon susceptible to fire. In the context of Indonesia this

Table 2 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_2. Market price of \$7/tCO_2	1,400
Total		8,855

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

means managing risks of low frequency, high impact fires in peat lands. In the seasonally dry tropics of montane mainland Southeast Asia this means focussing on managing high frequency modest impact fires in mixed deciduous forests. 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.

Peat lands are important for hydrology of a region, buffering flooding, but when excessively drained upper layers dry up and become prone to fire. Peat lands are also important for conservation of biodiversity, fishing and hunting, and carbon storage. 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 accidental fires in forest and peat swamps. The spread of fires was accelerated by dry weather generated by El Niño Southern Oscillation (ENSO). The direct and indirect damage costs were substantial (Table 2). 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".

Peat fires in Kalimantan and Sumatra make a huge contribution to trans-boundary smoke haze. Heil et al. (this volume) modelled 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. Fire suppression in ENSO dry phase years and re-generation of degraded peat lands, for example by restoring hydrology, would reduce smoke haze but also entail significant costs (Tacconi et al. this volume). Peat lands overall 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 peat land.

Saharjo's (this volume) study may be helpful here as it documented variable impacts of fires of peat depending on level of decomposition in different swidden sites in Riau Province, Indonesia. Repeated burning reduces the depth of peat. Likewise, Chokkalingham et al. (this volume) conclude from their studies in south Sumatra and Lampang province that repeated fires in sonor or swamp rice cultivation contribute to declining resources and reduced livelihood options. They suggest restricting fires to cultivation strips and along key waterways.

In Sumatra, Indonesia, land tenure conflicts between firms and communities frequently lie behind the use of fire as a weapon (Stolle et al. 2003) (Suyanto, this volume). 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 (Fox et al. 2000; Schmidt-Vogt 1998). 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 (Luangaramsri 2002; Vandergeest 2003). Fire management policies need to be adjusted to local ecological and social contexts.

Goldammer's (this volume) study of recovery of forests after major fires is important to policy in several ways. First it underlines the need from, especially a biodiversity conservation perspective, to go beyond peat lands and look carefully at vulnerable dipterocarp forest ecosystems. Excessive use of fire is altering the tree family-level composition of wet tropical forests. Second, it draws attention to the very different fire relations of the vegetation in seasonally dry tropical forests and pine forests. Here outright fire suppression policies would be misplaced and likely to be detrimental to vulnerable deciduous and pine ecosystems.

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 then 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 peat lands 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 Adaptive capacities

A societies' capacity to manage fires is often closely related to capacities to manage land and water resources. Consider the example of peat lands. Projects that involve draining wetland areas to make them more suitable for agriculture can alter risks of fires greatly. For human-environment systems the capacity to adapt is critical because of the complex interactions between land use, ecosystems structures and functions and fire. Climate change confounds these relationships further excerbating uncertainties and increasing prospects of future contexts being different from current or historical experiences.

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. this volume).

With greater understanding the possibilities of moving from fire management as fire suppression to guided use of fire is becoming a real possibility.

By 1998 national level adaptive capacities in Indonesia were low with a huge drain on resources from currency devaluations and pressure from structural adjustment packages of the IMF and World Bank. The fire episodes coincided with the Asian financial crisis and the unfolding of the fall of the Suharto regime. Political resilience was at an all time low and these various events combined resulted in a social movement ("reformasi") that produced a major shift towards more decentralized administration.

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. Contests over land and water resources is a likely consequence of market development, but fair systems of governance prevent these situations from leading to violent conflict that undermines adaptive capacities of society.

Cottle (this volume) explores the potential of insurance against fire in commercial plantations in Sumatra, Indonesia and concludes that the better assessment of risks this involves would be helpful to firms and regional forestry authorities better manage what are by world standards high losses.

Climate is an integral part of dynamics of fire disturbance regimes (Lavorel et al. this volume). Fires are an important link between atmospheric processes and terrestrial ecosystems in the earth system, links that are affected by land-use activities of people. To understand the impacts of climate change on fire regimes, therefore, requires an integrated perspective.

Focussing on building adaptive capacity in fire management could be an effective way to address adaptation to climate change because it is through droughts and fires induced by climate change that some of the largest impacts on forest and plantation ecosystems are anticipated. Chokkalingham et al. (this volume) in particular emphasise the importance of stimulating alternative livelihood options during drought years. They also suggest that properly guided private sector could play an important role through estate tree or palm crops and agroforestry systems rather than current emphasis on annual crops. Industry expertise could be a helpful ally in estimating costs of adaptation to climate change in the commercial forestry sector. 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.

4 Mitigation incentives and instruments

Technically feasible options for achieving land management objectives with less fire or by burning at other times often exist that could help mitigate local, regional and global air

pollution problems caused by fire emissions. The problem is that incentives to invest in such technologies or building expertise to apply such knowledge are weak and the regulatory instruments that might reinforce such behaviour are either lacking or ineffective.

One possibility that has been suggested is zero-burning (Murdiyarso et al. 2004). Simorangkir (this volume) calculates that for large-scale operators, zero burning can be cost-effective in the long run when they have to deal with low-volume biomass residues and debris. Clearly, this is not always the case, 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, this volume).

Several institutional challenges remain at local to national levels. Enforcing burning restrictions on firms 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.

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). Modelling studies of regional haze pollution dispersal and deposition (Heil et al. this volume) could certainly inform such efforts. The Association of South East Asian Nations (ASEAN) has responded to recurrent haze episodes from fires through establishment of task forces, creation of action plans and negotiation of agreements (Murdiyarso et al. 2004). For the most part these activities focus on symptoms and general cooperation on issues like fire prevention, fighting and monitoring (Qadri 2001). 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.

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. this volume). In addition, when these vulnerable ecosystems were accounted for, Murdiyarso and Adiningsih (this volume) estimate that the total carbon emissions during 1997/98 fires was 5.3 Gt CO_2. The current rules under the Kyoto Protocol, however, allow only afforestation and reforestation activities to be credited. In other words, there is no market-based mechanism allowing the purchase of carbon credits obtained from cancelling carbon emissions resulting from tropical forest clearing and biomass burning. 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 (Guido et al. 2003; Page et al. 2002) (Murdiyarso and Adiningsih, this volume; Lavorel et al. this volume).

5 Conclusions

Fire can be viewed as either a problem or a solution at various levels (Table 1). Fire has very different meanings and policy implications when viewed as a tool for clearing, as a producer of damaging smoke, or as a source of greenhouse gas emissions.

We identify at least 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 peat lands areas which are particularly carbon-rich ecosystems through improved fire management at district or national levels.

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.

Research has contributed a lot to understanding of how fires in Southeast Asia affect ecosystems, atmosphere and the global carbon cycle (e.g. Articles in this volume). Most of the understanding comes from research carried out in Indonesia with much less known about the seasonally dry tropics and sub-tropics. The reviews and original research in this special issue highlight that there are still several outstanding questions about vegetation fires in the landscapes of Southeast Asia (Box 1). Without a better understanding of these kinds of questions it will be hard for societies in the region to deliberate the benefits and trade-offs associated with alternative options for linking local or national level development policies to regional and international efforts at climate change mitigation and adaptation.

Box 1. Outstanding research questions

1. Would a reduction in fire frequency result in more or less CO_2 emissions per unit area averaged over time over the next decade? What about average over the next century?
2. 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?
3. 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?
4. 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?
5. 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?
6. 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?

To carry out assessments in a way that will lead to actionable policies will require much greater engagement of stakeholders, from those that benefit to those that are adversely affected, by current and proposed changes to fire management regimes. A broad and transparent exploration of land and fire management options is needed. This will help provide public support for land and fire management policy changes that address not only symptoms and impacts but also some of the less desirable underlying drivers and causes of damaging fires.

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