

## Policy analysis and environmental problems at different scales: asking the right questions

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### Abstract

In this volume, we seek a common understanding of three environmental problems linked to land use change in Southeast Asia: smoke pollution, degradation of biodiversity functions, and degradation of watershed functions. The objectives of this special issue are to identify usable data and methods for quantifying the impact of land use change on these environmental problems, to identify gaps in either data or methods and, where gaps exist, to set priorities for filling them. That assessment will be done in greater detail in the concluding chapter (Tomich et al., this issue). In this paper, we begin the process by raising policy analysts' basic questions for each environmental problem in turn and making a preliminary assessment of where each of these three problems lies in the 'environmental issue cycle'.

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### 1. Introduction

Plausible (albeit dire) scenarios for the future in Southeast Asia include increasing conflict over land and water resources and degradation of hydrological, ecological, and other environmental services, which

could undermine the stability of national economies, urban centers, and national food security. But do we really know enough about these complex relationships to build a consensus for action? What scientific evidence is available to answer environmental policy questions? Are scientists even asking the right questions? From a policy perspective, Tomich et al. (1999) identified at least three types of questions as crucial:

- *Question Type 1:* Who cares? How are people affected? Are the effects big?

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- *Question Type 2*: So what? Is it a policy problem? Would action serve one or more public policy objectives?
- *Question Type 3*: What can be done? Will it work? What are the risks? What will it cost?

These three basic types of policy questions are elaborated below and applied to each of three ‘meso-level’ environmental concerns: smoke, biodiversity loss, and degradation of watershed functions. A seven-stage ‘environmental issue cycle’ is presented as a framework for analysis of how the data needs and uses may change with evolution of understanding of a policy problem.

### 1.1. Environmental insecurity in Southeast Asia

The summary report of the World Commission on Forests and Sustainable Development (WCFSD) speculates that deforestation ‘... could change the very character of the planet and of the human enterprise within a few years ...’ (Krishnaswamy and Hanson, 1999, p. 6). The press release announcing the WCFSD report included the following statement from George Woodwell of the Woods Hole Research Center: ‘... Forests have a role in supplying the world with timber and fiber. ... But while those products can be partly substituted, the forests’ ecological services for a functioning world cannot’ (Lalley and Magnino, 1999). These statements reflect relatively recent concern with global environmental issues (climate change, mass extinctions), but they also build on a longstanding literature tying the condition of soil, water, and forest resources to social and economic stability at the regional and national scale (e.g., Carter and Dale, 1974). Such concerns have had particular force in Southeast Asia since the monetary and financial crisis of the late 1990s. Actual effects have been mixed, however. Currency collapses boosted incentives for forest conversion and intensification of natural resource exploitation for exports, possibly contributing to long-term natural resource management problems. But local effects varied, in part because of the parallel contraction in infrastructure investment.

The possibility that land use change and natural resource degradation could disrupt the economic and social basis of Southeast Asian nations seems plausible enough. For many countries in the region, irrigated

rice production in the lowlands is the foundation of national food security. High population densities in rural areas and (until the interruption in the late 1990s) rapid growth in urban industry and services each contributed environmental pressures. But how much do we really know about relationships between land use change and the environmental services on which national economies and local livelihoods depend? ‘Natural capital’ is economists’ jargon for the stocks of natural resources (including soil, water, air, vegetation, wildlife, and other organisms) and for the interactions among these that supply environmental services (Costanza et al., 1997; Izac, 1997). Table 1 lists some examples of the wide range of environmental services at different scales that may be affected by land use change. Many of these cut across scales, such as the supply of raw materials (e.g., food, fodder, fiber, medicines, resins, timber) and the moral value of preventing extinctions. Although ‘environmental services’ often have been treated as synonymous with ‘forest functions,’ we prefer the former term because even if forest-derived land uses are not perfect substitutes for natural forests, they still provide some level of these services.

Table 1 also could include a large number of environmental services (and disservices) directly affecting human health, which of course are crucial to human welfare. Land use change per se (see Roulet et al., 1998) and all of the major themes explored in the balance of this paper—smoke, biodiversity, watersheds—have major public health implications. The literature on pesticide runoff alone is substantial (e.g. Rola and Pingali, 1993). Many of these concerns are the topic of a recent review of environmental change and human health (WRI et al., 1998). Moreover, it is possible to treat human health as a separate dimension of overall sustainability—as long as human health is reintegrated into the analysis of tradeoffs with production and other environmental effects at some point (Crissman et al., 1998). Although we will mention them briefly below, human public health concerns are omitted from most of this paper.

The global ASB research programme already has made contributions to clarification of tradeoffs between welfare of poor rural households and global environmental services (for Indonesia, see Tomich et al., 1998a, 2001). However, the hydrological, ecological and other environmental services at the local

Table 1  
Examples of environmental goods and services at different scales

Scale	Macro	Meso			Micro
	Global	Regional transboundary <sup>a</sup>	National <sup>b</sup>	Local type II: inter-community <sup>c</sup>	Local type I: intra-community <sup>d</sup>
Commodities	Supply of raw materials Scientific and educational materials Options for new and improved raw materials		Supply of raw materials Livelihoods and employment opportunities Cultural, scientific and educational materials Options for new/improved raw materials		Supply of raw materials Livelihoods and employment opportunities Cultural and educational materials
Amenities and protective functions	Climate stability Evolutionary potential for adaptation Cultural, scientific and educational opportunities	Biodiversity functions: pollination, seed sources, seed dispersal, biological pest control, production stability Evolutionary potential for adaptation Water quantity: buffering flooding and base flow Water quality: filtering sediments, decomposing wastes, and diluting other pollutants Aesthetics: values for residents and as basis for tourism.	Air quality (smoke)		Nutrient cycling Filtering sediments and water pollutants Microclimate effect of trees Aesthetics: values for residents and as basis for tourism
Moral values	Existence of species Cultural survival/support for livelihoods of indigenous cultures Bequest values of climate stability, biodiversity, and other natural amenities for future generations		Existence of species Cultural survival/support for livelihoods of indigenous cultures Bequest values of biodiversity and other natural amenities for future generations		Existence of species Bequest values of biodiversity and other natural amenities for future generations

Sources: typology of goods and services is adapted from Norton (1988). Other references: Barbier (1995), Brenner (1996), Costanza et al. (1997), Daily (1997), Gowdy (1997), Menz et al. (1997), Pimentel and Wightman (1999), Randall (1988).

<sup>a</sup> Regional transboundary scale environmental effects cross the borders of neighboring countries within a region, such as Southeast Asia.

<sup>b</sup> National scale environmental effects loom large within national borders.

<sup>c</sup> Local Type II: Inter-community environmental effects are landscape or watershed scale effects that span more than one settlement or village, such as the effects of land cover change upstream on hydrology downstream.

<sup>d</sup> Local Type I: Intra-community environmental effects are confined to a single settlement or village.

and national level are a significant gap in this analysis in terms of their impact on local people but also regarding potential complementarity with global environmental objectives. For Southeast Asia, smoke pollution ('transboundary haze'), the functional roles of biodiversity, and watershed functions all fall in this 'missing middle', the gap between local interests and global environmental concerns. The focus here is on meso-level environmental externalities that involve groups and spatial or time scales that are too big for individuals to resolve but that fall within the jurisdiction of a single (or a few) government entities. This underlies the distinction in Table 1 between 'Local Type I' (*intra*-community effects) and 'Local Type II' (*inter*-community effects) and is why the latter are classed as meso- rather than micro-issues. Individuals and small groups may be able to deal effectively with *intra*-community opportunities and problems on their own, but (like global, transboundary, and national issues), some intervention by a higher authority may be necessary to address *inter*-community environmental conflicts or to seize opportunities that span multiple communities.

There are several areas of potential conflict between the welfare of households in Southeast Asia's uplands—particularly their pursuit of profitable land use options—and their neighbors downstream (or downwind). Among these perhaps the most pertinent question for the people of Southeast Asia is whether pursuit of profitable land uses undermines key environmental services—translating, for example, into more frequent and more damaging floods, water shortages, and pest outbreaks. The recurrent transboundary smoke problem in Southeast Asia is linked to El Niño, but also is driven by land use change promoted as part of development strategy and resulting conflicts over land. Without interventions to strengthen or create mechanisms for conflict management, the future may bring intensification of social conflicts over natural resources—particularly land and water.

While some have argued that 'artificial' distinctions between global environmental interests and regional, national, and local concerns impede action (UNDP et al., 1994, p. 5), the tradeoffs among objectives spanning these scales should not be ignored. Pursuing global interests in conservation of endangered species and unique ecosystems involves

a high-opportunity cost for local people because of land scarcity in much of Southeast Asia. Under these circumstances, it is clear that the feasibility of key conservation objectives rests on the ability to stabilize the boundaries of the so-called 'protected' areas through some combination of incentives and enforcement. Again, this requires capacities for conflict management, including a mechanism for compensating local people for foregone opportunities. Here, some of the successful examples of bioprospecting in Central America and wildlife management for ecotourism in Eastern and Southern Africa may hold useful insights for Southeast Asia. If it is not feasible to realign incentives for local communities through such means, it is inevitable that conservation areas will continue to shrink—ultimately to the point that they no longer function. There also may be scope for finding common ground to couple local development initiatives with global interests in carbon sequestration since, if the possibility of global climate change is realized, its local manifestation may accentuate the frequency and scale of floods, droughts, fires, and pest outbreaks (Jepma and Munasinghe, 1998, p. 49).

## 2. Overarching questions

The WCFSD report and the statement by Woodwell mentioned above are but two examples of myriad well-intentioned messages aimed at policymakers and the public regarding land use change and environmental services. But do we really know enough to build a consensus for action at the local and national level and the scales in between? How big are the effects of land use change (for better or worse) on stability of production systems at these scales? Although it appears that there are no perfect substitutes for natural forests regarding global environmental issues, some derived land uses may provide some of these services (Tomich et al., 2001). How well do these forest-derived land uses substitute for forests from the perspective of local people and national objectives? To what extent does expansion of shifting cultivation and other smallholder land use systems pose a threat to the 'natural capital' of Southeast Asia?

Three types of overarching questions are the focus of this paper.

### 2.1. Question Type 1: Who cares?

How are *people* affected? How *big* are the effects? Who loses? Does anybody win? Are the negative (or positive) effects big enough to capture the attention of local people or of policymakers? What is ‘big’? US\$ 30 billion is big by virtually any standard. According to the *Economist* (3 April 1999, p. 93) that was the cost of flooding in China in 1998, which was the biggest economic loss caused by a single event that year. That figure was roughly 4% of China’s GDP in the mid-1990s, which accounted for about a third of a year’s (very rapid) economic growth for the country. (Economic statistics are from World Bank, 1997.)

The main point is that ‘big’ is *relative*. What is big in Brunei may not attract attention in China; what is big in a Chinese village may not be noticed in Beijing. Do we have the methods and data to answer this question for environmental services in a way that is comparable to peoples’ and policymakers’ other concerns? Measurement is useful—particularly when setting priorities among disparate, competing objectives—but something can be widely considered to be important even if it is not yet quantified (or is not quantifiable). For example, smoke pollution was recognized as a crisis before EEPSEA (1993–1998) figures were available—indeed work to produce those estimates was a response to the importance of the problem. Some have argued (Norton, 1988; Ehrenfeld, 1988) that there are important values of biodiversity that are unquantifiable. If so, how can these be incorporated in the debate?

### 2.2. Question Type 2: So what? Is it a policy problem?

Policy research aims to sharpen identification of policy problems and to bring analysis to bear in order to enhance options for meeting fundamental policy objectives, including growth with poverty alleviation, food security, and environmental stability. Tree planting, reforestation, and soil conservation are means to ends; they are not policy objectives themselves. Unfortunately, government agencies often do set targets in these terms, which is part of the problem. For example, the Vietnamese Government has announced a goal to reforest 5 million ha of ‘degraded’ or ‘barren’ land by 2010. Setting the target in those terms risks

diverting line agencies and local authorities from paying adequate attention to impacts of these projects on local livelihoods, sedimentation and flooding downstream, and other fundamental concerns.

### 2.3. Question Type 3: What can be done?

This question may come in tandem with other questions, such as *Do we really know enough to act?* And, if a particular action is to be taken, *how do we know it will work?* and *what are the risks?* will be asked. A hallmark of policy research is the practical assessment of specific policy instruments, the means of affecting policy objectives in the ‘real world’. Examples of policy instruments relevant to land use change include exchange rates and interest rates; price, trade, and marketing policies; laws and regulations affecting access to and transfer of land and other assets; and public expenditures for infrastructure, research, and extension.

To grapple effectively with these three sets of questions, it is necessary to understand the political, administrative, and legal processes of a particular setting and the ways that various interest groups affect these processes.

## 3. Externalities, institutions, and scale

Many of the amenities and protective functions listed in Table 1 are externalities (see Box 1 for related definitions), including physical phenomena at the meso-scale ranging from smoke produced by land clearing, to biodiversity functions such as pollination, and watershed functions such as buffering base flows and filtering sediments. Understanding these biological and physical consequences—referred to as ‘lateral flows’ in the next paper in this collection (van Noordwijk et al.)—is essential to formulating sound policy responses or even knowing whether intervention is needed. When these lateral flows affect other peoples’ consumption or production opportunities, economists refer to them as externalities.

Existence of externalities is not a sufficient justification for policy intervention, however, since individuals may be able to negotiate a solution even if markets fail to provide one (Coase, 1960; Zilberman and Marra, 1993). Whether or not such solutions are implemented depends on the value of the externality compared to

**Box 1.** Social costs and scaling in space and time

Why do not individuals take care of environmental problems themselves? Most economists' answers to this question can be subsumed under three broad categories: policy distortions, market imperfections, and market failures. In each case, market incentives that influence people's land use decisions fail to include the full *social costs* (or benefits) of their choices. *Policy distortions* are government mistakes—at least from the point of view of the public interest, if not from the perspective of the private interests of policymakers and bureaucrats. But even if there were no misguided policies, there still would be plenty of work for policy analysts because markets for many (but not all) environmental services either are imperfect or fail completely. *Market imperfections* include the combined effects of uncertainty and irreversibility; regional growth linkages and spillovers; and economies of scale. They also include high transactions costs, which are discussed further below, and factor market imperfections, such as insecure tenure and lack of access to banking services. These classes of market imperfections operating together can create situations where, once an unforeseen threshold is passed, for all practical purposes, there is no going back. *Market failures*, which include *externalities* and *public goods*, are cases where no market price exists. Effects of externalities and public goods may be felt locally, regionally, or globally; in fact they correspond to many of the environmental services listed in Table 1. The term 'externality' refers to the effects of activities by one economic agent on another that are not reflected in market prices. Externalities may have positive or negative effects (or both). 'Public goods' are a specific form of externality. The defining characteristics of public goods are: (1) their use by one person does not prevent full benefits being enjoyed by others and (2) it often is difficult to exclude users, hence it may be excessively costly to charge them. The global environmental services in Table 1—climatic stability and avoidance of extinctions—are global public goods.

the transaction costs—costs of organizing, negotiating, monitoring, and enforcing agreements—involved in a negotiated solution and on the distribution of power among the interested parties. Generally, transaction costs increase with the number of people involved, their dispersion in space, and differences in timing due to lags between causes and effects. The further removed the impacts are in space and time, the more difficult the organizational challenge.

So local environmental externalities concentrated in a small area and involving a few people (who probably know each other and may even be relatives) and for which there are clear and immediate cause and effect relationships, often will not be a policy problem. For example, long-established communities in Indonesia's Outer Islands often have their own well-developed techniques for managing burning and timber felling in order to avoid accidental damage to neighbors' property and widely recognized compensation rules already exist when accidents do happen (H. de Foresta, pers. commun.).

Conversely, transactions costs are likely to be high for global public goods, including climatic stability and avoiding extinctions, since effects are complex and dispersed globally and in which six billion humans share an interest. But, since landscapes provide mixes of multiple services affecting multiple scales simultaneously, what is the scope for better incentives for local resource management also to contribute to solving the larger-scale problems as a byproduct?

**4. Stages of the 'environmental issue cycle'**

Unless there is some channel to aggregate feedback from those affected through an incentive system or other method of social control, externalities will be ignored by the land user causing them. This applies whether the externalities are positive (environmental services) or negative (pollution). And while better information about causes and effects may be necessary to identify solutions, information alone typically is not sufficient because there often are conflicting interests between producers of externalities and those who experience the external effects.

In the case of degradation of environmental services (a negative externality) resulting from land use change, direct conflict, sometimes violence, among the

‘stakeholders’ (i.e., the people concerned on all sides) may result unless some form of authority intervenes. These authorities may be officials or policymakers at various levels of the government bureaucracy—where formal responsibilities are established—but they might also be local leaders, elites or other individuals whose influence derives from positions in clan and other customary institutions, social, religious or civil organizations, or non-governmental organizations. These authorities have at least four strategies to choose among in responding to pressure from the various stakeholders:

- do nothing (ignore the issue for as long as possible),
- compensate the suffering groups,
- mitigate degradation by, for example, increasing the filter functions intercepting lateral flows, as discussed by van Noordwijk et al., this issue, or
- prevent (or reduce) degradation by modifying the behavior of land users (the producers of negative externalities) through regulations, market-based instruments (taxes and/or subsidies), other means of social control, such as negative publicity, or some combination of these approaches.

Even with overt conflicts between land users and the injured stakeholders, considerable pressure may be required before authorities shift into action. Moreover, if no clear (formal or informal) authority yet exists—as often is the case regarding environmental externalities in the ‘missing middle’ scale in developing countries—the threshold for action is even higher since it requires institutional innovation. On the other hand, those who wield power and authority also have their own interests in resource exploitation. Indeed, those elite interests often drive non-sustainable resource use.

The data that will be most effective in eliciting constructive responses from stakeholders and the authorities—hence the most appropriate research methods—depend on where a particular externality is on the seven stages in the ‘environmental policy issue life cycle’ (Fig. 1, adapted from Winsemius, 1986):

- *Stage 1*: Perception by ‘pioneers’ (if they are ultimately judged by society to be correct) or ‘crackpots’ (if they are shown to be wrong) of a particular environmental issue, but no broader awareness either by society at large or by the authorities.

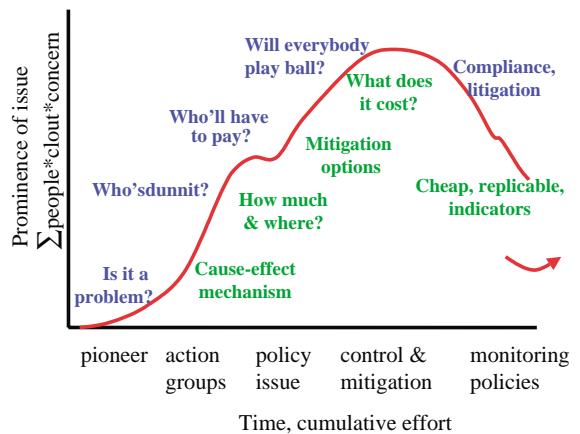


Fig. 1. Schematic ‘issue cycle’ of an environmental externality in a democracy showing how public perceptions evolve over time through social interaction and scientific enquiry (adapted from Winsemius, 1986, p. 17).

- *Stage 2*: Lobbying by ‘action groups’, denial of effects by some groups of stakeholders, and incipient awareness but no action by authorities.
- *Stage 3*: Widening acceptance of existence of (potential or actual) environmental impacts, with mounting awareness and pressure for action by authorities.
- *Stage 4*: Debate on evidence of ‘cause and effect’ and attribution of ‘blame’.
- *Stage 5*: Inventory and assessment of prevention and mitigation options and their environmental, economic, and administrative costs and benefits.
- *Stage 6*: Negotiations on prevention or mitigation of impacts.
- *Stage 7*: Implementation, monitoring, and enforcement of prevention or mitigation actions.

The course of these events obviously depends on the particulars of culture, society, polity, and economy. While the concentration of power and decision-making under a centralized, authoritarian regime might appear to accelerate Stages 3–7, there is a greater risk that the process may be ‘nipped in the bud’ at Stage 2. Broad accountability of the authorities to the public seems to be a decisive element; here the political participation and public debate epitomized by democracy has distinct advantages, at least in the discovery of problems if not necessarily in the identification and implementation of efficient solutions.

Whereas details differ between various environmental issues, the course of events in regional issues such as ‘acid rain’ in NW Europe and global issues such as ‘climate change’ could follow similar paths, at least if actions somehow respond to both the numbers of people concerned and the intensity of their concern (as in Fig. 1). In Stages 2 and 3 of this cycle, research would be needed primarily to test the validity of Stage 1 ‘suspicions’ about a link between an undesirable environmental impact and a change in land use. Establishing a probable cause-and-effect chain as opposed to ‘mere coincidence’ or ‘spurious correlation’ is important at this point as a basis for sound policy intervention. This information also could help to build broader support for action and to undermine resistance from vested interests. In these stages there also is a need to estimate the likely magnitude of impacts—are the effects big or small?—since initial uncertainty may range over several orders of magnitude.

Once awareness and support is formed for action on a particular environmental issue, the debate may shift focus to specification of cause and effect chains, especially where they are important for attribution of blame. Perceived gaps in the quantification of impacts or in causal explanation of the phenomena are major obstacles in Stage 4. This stage also is where positions are staked out for subsequent negotiations among stakeholders. Various stakeholders may agree (Stage 5) on the need for an inventory of prevention and mitigation options; or the process may be more adversarial, with each group applying evidence selectively and advocating a position serving its own interests. If the latter, the negotiation process in Stage 6 and implementation in Stage 7 may require formal mechanisms for dispute resolution and conflict management, either through courts or some other mechanism for arbitration and enforcement. Either way, the outcomes of Stage 6 could be enhanced (from a broad social perspective) from inventory of the impacts and the role of various actors in causing the problem as well as assessment of the various options for action (Stage 5). In Stage 6, simplified parameters (‘rules of thumb’) often are more persuasive than full quantification of webs of cause-and-effect and spillovers in complex models.

If agreement can be reached on some mix of prevention and mitigation, research needs will shift again to those for monitoring either environmental impacts or changes in behavior (or both) and, as necessary,

enforcement of pre-agreed sanctions. Standardization of measurement methods is particularly important at this stage. When lack of compliance leads to legal conflicts, the methods for monitoring impacts also are likely to be scrutinized, which could establish a premium on replicability and reliability (low measurement error) and a discount on speculative inquiries into complex causality.

During this progression of stages, social and political processes *ideally* would shift research priorities and methods through a sequence from intensive (process-oriented, cause-and-effect relations, explanatory models) to extensive (spatial databases, long-term monitoring) approaches, with a gradual standardization of measurements and data collection protocols from a (possibly haphazard) pioneering phase. Standardization of methods and general agreement on cause-and-effect chains obviously brings advantages, but it also can become a liability if it prevents critical examination of discordant information and refinement of process-based understanding. At the end of a cycle (Stage 7), or even as early as Stage 4, perceptions of environmental issues may ‘fossilize’ and require either significant time or some disillusioning shock before they are rejuvenated and another round of the cycle ensues. Problems that apparently had been ‘understood’ and ‘solved’ or at least brought under control, may re-emerge in a new cycle if situations change or if the initial diagnosis proves to be incorrect or the interventions ineffective. Once broad support for specific interventions has been built, however, the pioneers for the new cycle may have to come from a different group of stakeholders.

## 5. Managing smoke

Slashing and burning is the preferred method of land clearing in the tropics—for smallholders and large companies alike—because it is cheap, at least from a private perspective, and relatively easy. In addition, fire eliminates field debris, reduces problems with weeds and other pests and diseases, makes nutrients available in the form of ash (also meaning less reliance on purchased fertilizers) and loosens the soil to make planting easier. In some ways it is preferable environmentally compared to some other land-clearing methods. For example, bulldozers and



other heavy machinery cause soil compaction and erosion. But the smoke from these fires also provides a textbook case of divergence between private benefits (cheap, effective land clearing) and social costs (lost opportunities for commerce and tourism from disruption of transport and obliteration of beautiful views, damage to human health (especially asthma and bronchitis), increased absenteeism and reduced worker productivity). In fact, smoke features prominently in Coase's (1960) seminal treatment of externalities.

### 5.1. Who cares about burning and smoke?

Who benefits most from free use of burning for land clearing, large-scale plantations or smallholders? Which of—or under what circumstances do—these groups contribute the most to smoke problems? How do these costs compare with the direct benefits of burning for land clearing? What are the consequences of land clearing without the use of fire? And who bears the greatest costs of smoke from burning for land clearing? Local people in the neighborhood? ... people in the province or state? ... the nation as a whole? ... people in other countries?

In addition to use of fire as a tool for land clearing, fire also can be a weapon in social conflict (Tomich et al., 1998b). But does arson play a significant role in the smoke problem? Vayda (1998) argues that the incidence of accidental fires may be much higher than is conventionally believed. For a complex situation where firm conclusions are difficult even with detailed case studies (Potter and Lee, 1998), is there any hope of being able to attribute shares of smoke between purposive burning (for land clearing or arson) and accidents? (In addition to the social costs of smoke, simulations by Menz et al. (1997) indicate that risk of fire spreading from neighbors' plots could be a significant disincentive to smallholder tree planting on *Imperata cylindrica* grasslands.)

### 5.2. What can be done to reduce the smoke problem?

The answers to the 'who cares' questions matter a great deal for the design of interventions—training programmes may be appropriate if most smoke comes from accidental fires, but would be irrelevant or even counterproductive if most fires are set deliberately—but is it feasible to measure these

phenomena at a scale relevant for policy formulation? What policy options and policy instruments exist to manage the recurring regional problem of smoke from land clearing? Are there opportunities for action to improve management of smoke through policy reform, institutional strengthening, or public awareness? What are the main lessons from the experience of different countries in designing and implementing strategies to manage smoke? Are there any win-win opportunities? If there are conflicting interests, should/will the victims of smoke compensate people who give up burning? Or should the polluters pay? Is either approach feasible administratively or politically?

### 5.3. Is burning the problem? Or is it the smoke?

With the return of smoke to the skylines of Singapore and Kuala Lumpur in mid-1999, and with fresh memories of the smoke problems of 1997/1998, ASEAN environmental ministers once again called for immediate implementation of a 'zero-burning' policy (*The Star*, 17 April 1999). Is it possible to go beyond rhetoric and apparently futile past efforts to ban burning to identify more workable options for managing burning to reduce smoke problems? If options exist, who would implement them? Who (or which institution) has the greatest influence over smoke and/or burning for land clearing? How could they influence it? What is a workable unit for management of smoke? ASEAN or other international organizations? The nation? Whole islands? Regions? Specific landscapes? Fields? What role do local ('informal') institutions play in managing burning and smoke?

### 5.4. What are the priorities for research and for action on burning and smoke?

Given the lack of effective action to date, under what circumstances would more or better data be used? Depending on the weather, the transboundary smoke problem in SE Asia oscillates between Stages 1 and 4 (or even Stage 5) of the 'issue cycle'. Although authorities can ignore the problem between 'crises' there has been mounting public awareness in adversely affected countries and (primarily external) pressure for action by Indonesia, the main source. It remains to be seen whether regional attempts to ignore the problem or to affect the appearance of doing something about

it will be accepted in the future, but it is clear that Indonesia's capacity to act was reduced by monetary and political crises in the late 1990s (Makarim, 1999).

At this stage, what data would be most useful in designing and implementing a strategy to manage burning in order to address the smoke problem? Can remote sensing be used reliably and precisely enough to apportion blame? Aside from remote sensing and better understanding of institutional functions at various levels, what other types of data or research would be useful in forging a consensus and identifying viable options for action? Is more or better information the answer?

## 6. Degradation of biodiversity functions

Much discussion of biodiversity conservation focuses on *global* existence values—in other words, preventing extinctions. Much less attention has been given to *local* functional values of biodiversity (belowground as well as above). Here we seek to put aside, for the moment, legitimate global concerns with extinctions, in order to focus on local, functional roles of biodiversity in landscapes where people seek their livelihoods.

### 6.1. How does reduction of biodiversity affect peoples' livelihoods?

There is ample evidence that forest conversion reduces biodiversity. The winners are those who profit from forest-derived land uses. But who loses from lower biodiversity richness at the local level? How? Are there threshold effects of biodiversity loss on stability of production such that land use change that could be sustainable for a limited number of 'winners' on a limited area would be an ecological catastrophe if everyone did it? What are the functions of biodiversity in the stability of production systems? How important are these stabilizing functions of biodiversity compared to its other ecological goods and services? For example, are the effects of biodiversity on production stability big or small compared with:

- opportunities for direct use and marketing of forest products by local people, either under normal conditions or during difficult times?

- effects of biodiversity conservation on prevalence of human pests (tigers, elephants) and diseases (malaria)?
- aesthetic and spiritual roles of biodiversity for local people, which also may be developed as a basis for new economic activities such as ecotourism?

### 6.2. Does biodiversity loss affect national policy objectives?

Should national policy makers worry about loss of biodiversity in the same way they seem concerned about degradation of watershed functions? From a national perspective, how important are the stabilizing functions of biodiversity compared to other pressing national concerns? How can diverse societies identify these functional roles of biodiversity and assess trade-offs with other public policy objectives?

### 6.3. Do we know enough about functional roles of biodiversity to be able act?

Biodiversity is the most difficult among our three meso-level environmental issues because there is no clear consensus about the basic functional roles of biodiversity in the landscape. On this, Gowdy (1997, p. 26) points to a dilemma for policy analysts:

Although our present socioeconomic system cannot continue to expand indefinitely by destroying biodiversity, it is quite possible that economic growth can continue for decades or perhaps even centuries. . . . If biodiversity loss and all other forms of environmental degradation will not appreciably affect economic activity in the immediate or even medium-term future, why should we bother to protect it?

The reply also is a question: are some ecosystems headed on a path toward collapse, which, on a human time scale, is essentially irreversible?

The functional role of biodiversity at the local level would appear to be at the beginning of the 'issue life cycle' where there is little awareness of a problem—if indeed one exists—and basic questions about cause–effect relationships have not yet even been identified. How much of what types of biodiversity is needed to maintain productivity and stability? Is it possible to produce a short list of key ecological

functions of biodiversity regarding the stability of production systems at the plot or farm level? How about a list encompassing interactions across plots within a landscape? What is the appropriate unit for analysis at the landscape level? What are the appropriate scales—in space and in time—for assessing the effects of biodiversity loss on stability of production systems?

## 7. Degradation of watershed functions

National concern for natural forest conservation and reforestation often focuses on the degradation of upper watershed functions, typically understood as some combination of:

- on-site declines in *land productivity* as a result of soil erosion,
- off-site concerns about *water supply* (quantity) including annual water yield, peak (storm) flow, dry season base flow, and groundwater recharge or depletion,
- off-site concerns about *water quality*, including siltation of reservoirs and environmental damage from runoff of pesticides, fertilizers, or animal wastes.

### 7.1. Who cares about erosion?

When is soil erosion a problem for farmers? Can the *on-site impact of erosion on productivity* be measured at the plot level? Can these on-site effects be estimated for bigger units? . . . for landscapes? . . . for states, provinces, or nations? What is an appropriate time scale for such estimates? Are these effects big? If so, under what circumstances? When is soil transfer a problem (or an opportunity) for people downstream? Can the *off-site impact on productivity of soil transfer* (erosion net of sedimentation) be estimated at the landscape level? . . . for states, provinces, or nations?

### 7.2. Is erosion a policy problem? What about water supply?

Mountain valleys and the great alluvial plains, which are the foundation of food security in Southeast Asia, are products of erosion. What do available estimates tell us about effects of soil transfer on

productivity for larger spatial units? Are these values big or small? . . . under what circumstances? On net, does erosion from steep slopes and deposition in the lowlands increase or decrease aggregate production? If erosion were to halt completely, what would be the effect on lowland productivity? How do the net effects on aggregate productivity compare with other effects of soil transfer, siltation of reservoirs for example?

Although ‘most analyses of watershed services have focused on soil erosion effects’ (Kramer et al., 1998, p. 2), rapid growth in water demand forecast for domestic and industrial uses may over time emerge as a greater threat to growth in food production (Pinstrup-Andersen and Pandya-Lorch, 1998, p. 6; Rosegrant et al., 1997). For Southeast Asia, Rosegrant et al. (1997, p. 7) predict that ‘. . . a doubling of domestic water withdrawals and a 290% increase in industrial demand will boost the combined share of these sectors in total water demand from 25% in 1995 to 47% in 2020.’

### 7.3. Does land use change really harm watershed functions?

The question may seem absurd, since there already has been a lot of action. Hundreds of millions of dollars have been spent over decades on soil conservation and watershed management projects in Southeast Asia. Big government bureaucracies exist in most countries in the region to classify perceived watershed ‘problems’ and to implement a conventional set of ‘solutions’, typically involving expensive public works, restrictions on land use, and forced eviction of land users. An empirical base has been built to formally justify these actions, including widely accepted and seldom-questioned ‘rules of thumb’ regarding minimum area under natural forest, maximum slope for agricultural uses, and the like.

Degradation of watershed functions is the most mature of our three environmental topics. Indeed it shows signs of being fossilized at Stage 7 of the ‘issue cycle’ by vested interests in the present consensus. It remains to be seen how present approaches, and the supporting mindsets, will adapt to regional trends toward decentralization of decision-making, which *may* lead to greater accountability to upland farmers and other local groups, and a spate of relatively new evidence that questions basic relationships between

land use change, soil movement, and water supply (Bruijnzeel, 1990; Chomitz and Kumari, 1996; Calder, 1998; Kramer et al., 1998; Lal, 1998; Lindert, 1998). Do landscapes—land uses and their combinations in different patterns or ‘landscape mosaics’—matter for soil transfer? How does the sedimentation arising from various landscapes compare with other sources of sedimentation, road construction for example? Do methods exist to quantify erosion from natural processes, agriculture, and other activities (such as road construction) and to assess the impacts (positive as well as negative) of resulting sedimentation at the landscape, provincial, or national scale? Do landscapes differ significantly in their impact on *water supply* downstream? How does land use change affect total water supply (annual yield)? . . . risk and severity of flooding? . . . risk and severity of water shortages? What is an appropriate time scale for such estimates?

### 8. Concluding question: What can be done about land use change?

If there are ‘big’ concerns at various scales, what policies and institutional options really can influence the rate and pattern of land use change? Of course past and ongoing policies already have affected land use in Southeast Asia’s uplands. These include policies on issues as diverse as resettlement, national defense, road construction, foreign investment, logging, land tenure, narcotics eradication, and agricultural prices. In many cases, there have been big, unintended effects on land use change from policies that were not directed at upland land use at all. Perhaps a prior question—how to improve or redirect the influence of existing policies?—is more pertinent.

But even if existing policies can be reformed to better balance development and a host of other objectives with environmental concerns, a need for new policies and institutional innovations to address specific environmental problems is likely to remain. Policy interventions with explicit environment goals so far have had (at best) a weak influence on specific environmental issues, such as transboundary smoke problems, biodiversity conservation, and watershed management. Banning burning for land clearing has not worked, at least in Indonesia. And while the extent of officially designated protection areas have expanded in some

countries—for example, in Cambodia these have multiplied many times in the past decade—the real issue is the effectiveness of protection. In this sense of real outcomes rather than formal designations, effective conservation areas for the protection of biodiversity have continued to shrink in most (perhaps all) countries in the region. And it is difficult to demonstrate results after years of watershed management projects.

Approaches to upland environmental issues so far mainly are variations on land use planning, which seeks to regulate decisions of millions of people dispersed across the landscape, by which we mean combinations of land uses in different patterns or ‘landscape mosaics’. Land use planning risks being limited to nice colors on maps in planners’ offices but little impact on the ground if it does not also involve workable ‘policy levers’ that *really* can influence the rate and pattern of land use change that alters these mosaics.

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