13 The Forest Margins of Sumatra, Indonesia

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Indonesia still has large forest areas, but they are rapidly being converted to other land uses. Transformation from primary to secondary forest is caused largely by timber extraction, and traditional shifting cultivation systems play a smaller role. Subsequent transformation of secondary and logged-over forest types generally is based on slash-and-burn practices by large-scale farmers and smallholders for a variety of reasons. Migrants convert part of the forest to temporary cropland either in government-sponsored schemes or spontaneously. Such land can evolve into alang-alang (*Imperata cylindrica* [L.]) grasslands or into permanent tree-based production systems (agroforests).

Slash-and-burn is both a land-clearing technique and a land use system. It is inaccurate to equate slash-and-burn agriculture only with permanent forest conversion and unsustainable land use. The technique is attractive because fire is the cheapest, most effective way to clear land (Ketterings et al. 1999). The Alternatives to Slash and Burn (ASB) characterization data (van Noordwijk et al. 1995, 1998; Tomich et al. 1998) suggest that in Jambi (Sumatra), most slash-and-burn is used for replacing old jungle rubber, rather than for conversion of primary forest. Traditional shifting cultivation of food crops, practiced for generations by local people in Sumatra, was sustainable as long as population densities were low enough to allow long fallow rotations. Traditional shifting cultivation has been disappearing as rural population densities increase, but slash-and-burn is used for land clearing by almost all those (public and private, large- and small-scale) who contribute to forest conversion, sometimes in systems that are unsustainable but often in systems that apparently are sustainable for the foreseeable future.

Agroforests begin with slash-and-burn clearing and intercropping of upland food crops, but the primary objective is the establishment of tree crops such as rubber and various fruit and timber species. This system accommodates natural regeneration. As a result, agroforests replicate some elements of natural forest structure and ecology (Michon and de Foresta 1995). In the ASB global project, the island of Sumatra was chosen to represent the lowland humid tropical forest zone in Southeast Asia.

In this chapter we give an overview of the results in phase 1 and 2 of the ASB Project in Indonesia, with a brief historical background of the forest conversion process, discussing the categorization of forest lands in Indonesia and describing the benchmark areas in Jambi and Lampung, before we discuss the main ASB hypothesis on the relationships between intensification of land use and the developmental and environmental consequences this may have.

HISTORICAL BACKGROUND

Since the beginning of the twentieth century, population density in Sumatra has increased by migration from Java, both spontaneous and government sponsored. A clear gradient in population density occurs from the south (Lampung province) to the middle (Jambi, Riau provinces) of the island. Although most land in Sumatra is considered to be government "forest land," a substantial part of this land is no longer under forest cover, and the amount of "forest damage" is correlated with population density at the provincial level, with Riau and Jambi provinces at the lower end of the spectrum and Lampung at the higher end. Because many smallholder farmers practicing slash-and-burn appear to do so because they lack feasible livelihood options, the development of sustainable, labor-intensive land use practices that are viable alternatives to slash-and-burn could discourage deforestation.

The major part of the island of Sumatra was still under forest cover in 1932 (Van Steenis 1935). Forest conversion by that time had taken place mainly in coastal zones (especially in Aceh, West Sumatra, Bengkulu and Lampung provinces), close to the major rivers in the eastern peneplain (especially the Musi River in south Sumatra and the Batanghari River in Jambi), and areas involved in the tobacco (*Nicotiana tabacum* L.) and rubber (*Hevea brasiliensis* [Willd. Ex A. Juss.] Muell.-Arg.) plantation booms in the late nineteenth and early twentieth centuries in north Sumatra. Forest conversion by 1982 had affected most of the remaining forest in Lampung and south Sumatra but not in Jambi (MacKinnon 1982).

This changed with the completion of the Trans-Sumatra highway and associated transmigration projects in the early 1980s. The ASB benchmark areas in Jambi are thus located in an area where forest conversion along the major rivers took place before the 1930s but that otherwise remained mostly under forest cover at least until the early 1980s. The north Lampung benchmark area abuts one of the few forest patches left in the Lampung–south Sumatra part of the eastern peneplain.

INDONESIAN FOREST LANDS

In the 1980s, "Agreed Forest Use Categories" were established on all state forest land in Indonesia. Under this system, forest land is categorized as follows:

- National parks and conservation forests: These are areas in which nature conservation gets priority.
- Protection forests: This class is defined mainly on the basis of slope and protects water supplies for downstream sites.
- Limited production forests: Only collection of nontimber forest products is allowed in this category, which is intended to provide a buffer zone around conservation or protection forests.
- Production forests: Here the Indonesian Selective Logging System is supposed to be followed. Under this system, only a few large-diameter trees are harvested per hectare, followed by a 30-year regrowth period before the next logging operation, to secure sustained harvest with little loss of biodiversity. In practice few (if any) logging concessions have met this target. Forest damage in the concessions is much larger than anticipated because of a combination of logging of more trees than allowed (using inefficient techniques that unnecessarily damage the remaining forest) and the use of forest land for other purposes by large-scale forest squatters following the logging roads. Production forest can be divided into limited production forests with stricter regulation on timber use and nonconvertible production forests.
- Convertible production forests: These are forests officially targeted for conversion to other land use, including industrial timber estates (*hutan tanaman industri,* HTI), transmigration projects, and plantations of oil palm (*Elaeis guineensis* Jacq.), sugar cane (*Saccharum officinarum* L.), and other crops. The total areas in the different categories are shown in table 13.1.

Because any conversion of primary forest entails a significant decline in biodiversity, conservation reserves always have an important potential role in biodiversity conservation. In Sumatra, efforts to conserve large national parks tend to concentrate on mountain areas (such as Kerinci Seblat National Park and the Gunung Leuser Park), while little of the rich lowland forests has been protected effectively. Allowing some use of highland park areas while protecting more of the lowlands probably would increase conservation efficiency while allowing the same number of people to achieve a similar level of livelihood (van Noordwijk et al. 1995). For Sumatra as a whole, 6.6 percent of the original forest is protected in reserves; this equates to 16 percent of the forest that remained in 1982 (MacKinnon 1982). The montane or submontane forests have a better protection status than average, and the mangrove and swamp forest are most endangered.

Table 13.1 Areas in the Different Categories of Forest Land[a] in Indonesia, April 1999

Category	**Area (million ha)**	**Percentage**
Park and reservation forests	20.62	17.02
Protection forests	33.92	28.01
Limited production forests	23.17	19.13
Nonconvertible production forests	35.32	29.16
Convertible production forests	8.08	6.67
Total	121.11	100

[a]This refers to state forest land rather than to the actual vegetation.
Source: Santoso (1999).

Forest classification may have little bearing on the situation on the ground because there is often confusion over the exact location of boundaries. Both protection and production forest categories show the same relationship between forest damage and population density in Sumatra (van Noordwijk et al. 1995). Only the national parks are well protected.

LAND USE IN THE ASB BENCHMARK SITES

The ASB Indonesia consortium has focused on benchmark areas in the forest margins of Jambi in the central part of Sumatra and the deforested and degraded lands with higher population densities found in the southern part of the island, close to Java, with its high population densities. Figure 13.1 shows the main ecological zones of Sumatra and the benchmark areas.

Jambi

Two sites in Jambi province were chosen for detailed characterization by the ASB Project. The Bungo Tebo site is a dissected peneplain of acid tuffaceous sediments, and the elevation is generally less than 100 m above sea level. The Rantau Pandan site is 100 to 500 m above sea level and represents the piedmont zone, which was formed mainly by granite and andesitic lava. Soils in Bungo Tebo are predominantly ultisols, deep, well drained, very acid, and of low fertility. Soils in Rantau Pandan are more varied and complex—ranging from shallow to very deep, moderate to fine texture, and well to moderately excessive drained—but they are also very acid and have low soil fertility. Both Jambi sites average seven to nine wet months (more than 200 mm rainfall) and less than 2 dry months (100 mm rainfall) per year, with annual rainfall of 2100 to 3000 mm. Forestry and the rubber-processing industry (crumb rubber) contributed 99 percent of the exports from the province in 1993. In the rubber industry, small-

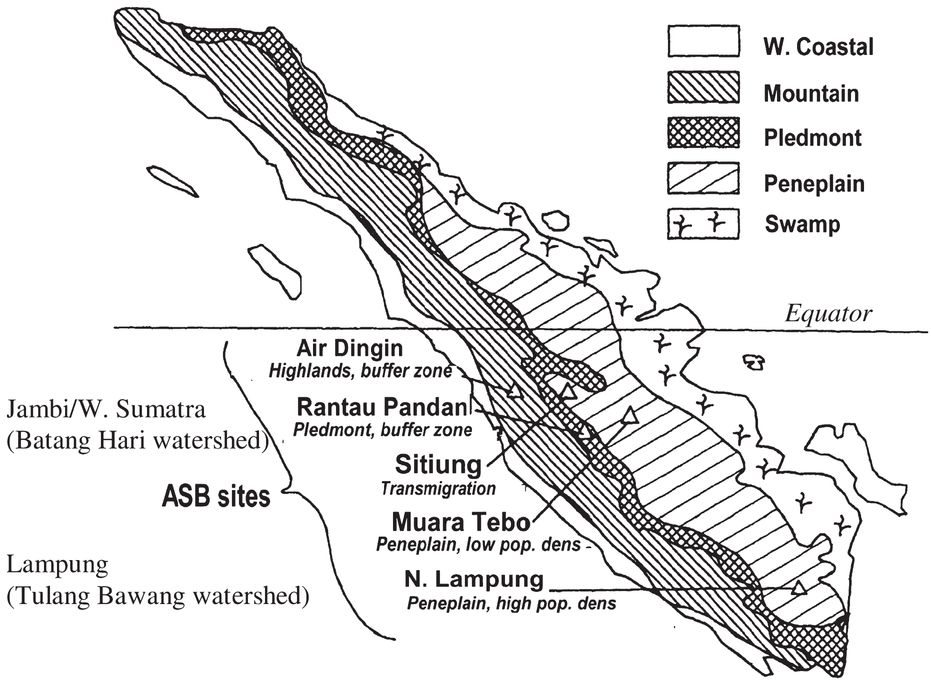

Figure 13.1 Agroecological zones of Sumatra and with ASB benchmark sites indicated (van Noordwijk et al. 1995).

holder rubber plays a crucial role. The total area of rubber cultivation in Jambi in 1993 was 502,642 ha, of which only 3447 ha was planted with high-yielding varieties under intensive management; the rest was jungle rubber (rubber agroforests). About 64 percent of the land in Jambi is categorized as state forest land. However, forest status often was declared long after local communities had settled there. In practice, a large part of the forest land is used for rubber agroforests and other forms of agriculture.

After the completion of the Trans-Sumatra highway in the 1980s, Jambi became a popular migrant destination. The ASB studies indicate that more than 25 percent of spontaneous migrants came between 5 and 15 years ago, and almost 40 percent came less than 5 years ago; more than 80 percent of spontaneous migrants came from Java, and less than 20 percent came from other parts of Sumatra.

Almost every smallholder household interviewed in the ASB surveys in Jambi is engaged in agriculture. Less than 10 percent of households and spontaneous migrants engage in nonagricultural activities. This is in strong contrast to transmigrants. Although agricultural activities are the main occupation of transmigrants, 75 percent of these households reported nonagricultural work (in trading, services, and paid labor). Most household heads did not complete primary school; the figure exceeded 70 percent for each site and was as high as 95 percent for the sample of local people in Bungo Tebo.

Lampung

The peneplain of northern Lampung, Sumatra, was chosen to represent the landscape degradation that can follow forest conversion if intensive food crop production is pursued on these soils. Of the benchmark sites, only the Pakuan Ratu subdistrict in north Lampung has no forest left, except for an industrial timber plantation or HTI (production forest). All other forest remnants have been converted into agricultural areas or are too small to be included in the statistics.

The spontaneous movement of people between Java and Lampung, and additional efforts by the government during various periods in the twentieth century, are key to understanding its landscape dynamics. Government-sponsored transmigrants generally have found the lowland peneplain soils unsuitable for their crop-based systems. Only in depression and valleys, where paddy fields could be created, has agriculture become a major source of their livelihood. Otherwise off-farm labor has had to provide the income that the remaining population of the area had; a substantial number of transmigrants left the area in the first few years. This exodus may have accelerated as conditions worsened because of drought and the national financial crisis; eleven out of thirty households interviewed in 1993 had left the village when a repeat survey was done in 1998 (Elmhirst et al. 1998).

Some migrants settled of their own accord, despite the hardships in the area, including the second generation of the government-sponsored transmigrants, for whom there is no land in the village. Spontaneous migrants tend to use agricultural systems intermediate between the local system and the Javanese food crop–based system, with a greater emphasis on tree crops.

The indigenous Lampung people, who live along the rivers, still have their semipermanent food crop production on flooded riverbanks, but two decades ago they stopped the extensive shifting cultivation of the lowland peneplain. Along the rivers, they still have old jungle rubber gardens on the margin of Sumatra's rubber domain. Recently there has been renewed interest in rubber production, but as a whole the indigenous Lampungese now aim to secure their livelihoods outside agriculture (Elmhirst 1997; Elmhirst et al. 1998).

The research site of Krui is on the west coast of Lampung province (across the mountainous Bukit Barisan range), where a narrow coastal strip has had a long history of settlement but little immigration over the last century. Here an extraordinary form of agroforestry was developed by local farmers about a century ago, the *Shorea javanica*–based damar agroforests (De Foresta et al. 2000). International organizations and national partners led by ASB formed the Krui team' that helped in obtaining government recognition for the value of this land use system as property rights (Fay et al. 1998). This work culminated in 1998 in the signing by the minister of forestry of a decree creating a special class within state forest land, Kawasan Dengan Tijuana Istimewa ("Zone with Distinct Purpose") granting the local community tree tenure in perpetuity and the right to fully manage state forest land, preventing outsiders from gaining access to that land.

ASB Hypotheses for Indonesia

The key hypothesis underlying phases I and II of the ASB project in Indonesia is that intensifying land use as an alternative to slash-and-burn can simultaneously reduce deforestation and poverty (van Noordwijk et al. 2001). In phase I, the research program was designed to characterize selected benchmark sites and identify and prioritize research following the ASB global guidelines. In phase II, the research program was designed to better understand how the Indonesian government and donor agencies could balance global environmental objectives with economic development and poverty reduction. Although conversion of primary forest has the major effect on biodiversity and carbon stocks, the resulting land uses also matter a great deal for the supply of these global public goods. Measurements of differences in environmental consequences of the various land uses provide the basis for quantifying major tradeoffs involved in land use change.

The ASB surveyed the five main agricultural land uses in the Jambi benchmark areas:

- Wet rice fields (*sawah*). Except for local farmers in Bungo Tebo (who reported none), households typically have one wet rice (*Oryza sativa* L.) or paddy field. The average size of wet rice plots is 0.31 ha for the sample of transmigrants and 0.68 ha for spontaneous migrants in Bungo Tebo, compared with 0.84 ha for the sample of local people in Rantau Pandan.
- Upland fields (*ladang*). This category includes both the shifting cultivation rotation of food crops followed by fallow, and upland fields that will be—or already have been—planted with perennials such as rubber. Local people and transmigrants both average about one plot per household. Spontaneous migrants have more upland plots (1.6 per household), and their upland fields are bigger (1.6 ha on average, compared to less than 1 ha for other groups).
- Perennial plots including agroforests (*kebun*). As just noted, perennial plots also begin with intercropping of upland food crops, but the primary objective is establishment of tree crops such as rubber agroforests (the main land use for these sites), various fruit species, and (recently, in Rantau Pandan) cinnamon (*Cinnamomum burmanii* [Nees] Bl.). Local people in Bungo Tebo typically have two perennial plots (mainly rubber) per household, with plots averaging 3.6 ha each. Spontaneous migrants at this site have somewhat fewer plots (1.8 per household), but their plots are bigger on average (4.3 ha per plot). Transmigrants reported an average of 1.4 plots per household and an average size of only 1.8 ha per plot. Surprisingly, data from the sample of local people in Rantau Pandan yielded averages similar to those of the transmigrants

in Bungo Tebo. This probably reflects underreporting of plots located on state forest land.

• Bush fallow (*belukar*). Bush fallow comprises two categories. *Semak*—land covered by grasses, shrubs, and small trees—is the first fallow stage. The second stage, *belukar tua,* often resembles secondary forest; land is covered by larger trees and may even include old rubber trees that no longer are productive. In Rantau Pandan, sample households reported an average of 1.7 bush fallow plots with an average size of 1.5 ha, whereas in Bungo Tebo the number of plots per household is somewhat lower (1.2–1.3 plots) but the average plot size is larger (1.6–2.8 ha).

• Home gardens (*pekarangan*). Home gardens, comprising a variety of annuals and perennials used for many purposes, are cultivated intensively by transmigrants and spontaneous migrants but are less used by local people.

The ASB study of land use change in the 1982 to 1996 period showed that jungle rubber is the predominant farming system in the Jambi area. In a 1982 vegetation map, large areas were indicated as "mosaics of rubber and shrub" or "mosaics of rubber and forest." On 1992 and 1994 satellite maps, however, the major part of the rubber complex is indicated as "old secondary forest." Whether this change is a true maturation of the jungle rubber system or a result of the coarser scale of the 1986 map is not clear. Farmers said that jungle rubber is inherited from generation to generation and seldom rejuvenated because of limited access to better planting material, loss of potential income while waiting for the new plantation to become productive, and wild pigs disturbing plants (Hadi et al. 1997). Farmers replace jungle rubber only after production has become very low and when they need land for their food crops. Plots of rubber, cinnamon (traded as *cassiavera*), or both range from 0.5 to 4 ha per household.

Since 1999, a pilot project from the Department of Forestry, Hutan Rakyat ("community forest"), has been carried out in the community's bush fallow. About 50 ha of this *belukar* was given to families to be cultivated with durian (*Durio zibethinus* Murr.), cinnamon, surian (*Toona sinensis* [A. Juss.] Roem), and sengon (*Paraserianthes falcataria* [L.] I. Nielsen) as agroforests. Planting material also came from the project, which recommended a slash-and-mulch system without burning. It is a first step in the government's recognition of the role of local people in managing the forest. If this project succeeds, it may be a good basis for future programs.

No agricultural land use consistently harvests products without putting management efforts into maintenance of the system, so all judgments of sustainability depend on a specified management regime and on farmers' efforts to overcome obstacles. Land-clearing techniques play an important role. The effects of improper land-clearing methods are observed even 8 to 10 years after the land has been cleared, and especially when the overall soil fertility has drastically declined. Improved understanding of people's interactions with forests is fundamental to development of effective options for sustainable management for forested lands. The ASB's research project in Indonesia has assessed which land use options are agronomically sustainable (Weise 1998a, 1998b; chapter 6, this volume).

A set of field-level criteria and indicators was used to evaluate the sustainability of a range of land use systems that can follow forest conversion (van Noordwijk et al. 2001). Natural forest can be used as a starting point for all land use types. Synthesis of sustainability indicators showed that most land use systems considered have one or more aspects that need attention, but most of these stay within the range of solvable problems at the farm level. The various tree crop systems appear to be freely convertible to each other, but extensive rubber agroforests will change in character once the seedbank of original natural vegetation is depleted and the site is out of reach of seed dispersal. The cassava–*Imperata* cycle has a number of associated issues, such as maintaining a nutrient balance, which are so serious that they probably cannot be resolved at the farm level within the current constraints (Weise 1998a, 1998b; chapter 6, this volume).

ASB's Research Activities and Major Research Findings

Major findings in phases I and II of ASB activities are as follows:

- No surveyed households practiced shifting cultivation in the classic sense (van Noordwijk et al. 1995).
- All households, whether local farmers, government-sponsored transmigrants, or spontaneous migrants, use slash-and-burn methods for land clearing (van Noordwijk et al. 1995).
- The most common land use system in the Jambi benchmark site is clearance of logged-over or secondary forest or old jungle rubber to plant upland rice mixed with rubber trees; in the second year upland rice or other food crops may be grown, but the emphasis is on the tree crops.
- Most of the existing rubber agroforests in Jambi are old and have low productivity. To get sufficient income, a large area is needed. Currently, land for rubber expansion is very limited; most of the forested land that is seen as potential areas for rubber expansion by local people is already distributed by the government to projects and therefore is off limits.
- The most common land use system in the north Lampung benchmark site is clearance of secondary (or logged-over) forest or shrub fallow vegetation to plant food crops or sugar cane. Recently, however, interest is growing in converting the land to better-adapted and more profitable tree crops in the form of rubber, oil palm, or fast-growing timber species. Such tree-based systems can accommodate short-term needs for food production.
- Vertebrate pests (wild pigs and monkeys in the forest margins, rats on the degraded lands) are perceived as major constraints in cultivating food crops. Wild pigs are also a threat to young rubber plants and deter farmers from investing in more expensive higher-yielding rubber planting material.

• Soil fertility constraints are most obvious on the peneplain sites where transmigrant farmers have attempted continuous food crop production. Aluminum toxicity, phosphorus deficiency, and rapid depletion of soil organic matter means that continuous food crop production is not possible without substantial inputs of fertilizers. Many of the current high-yielding crop varieties also need lime.

• North Lampung has more frequent, more pronounced dry seasons than the rest of Sumatra. These are a limitation for several tree crops, including hybrid coconut (*Cocos nucifera* L.) and various fruit trees. These dry periods also entail a fire risk and tend to maintain *Imperata* grasslands.

• Logging concessions in Jambi have affected large areas of primary forest in the piedmont and the peneplain zone; logging roads encourage an inflow of spontaneous migrants who usually plant rubber. Thus, rubber expansion may prevent the regeneration of logged-over forests and speed up permanent forest conversion.

• The transmigration program can have two results: Where villages are successful, they attract a spontaneous influx of people from Java. Where they do not succeed, they became a source of spontaneous migrants, who either search for more fertile land in the forest margins or go to urban areas.

• Land tenure in the transmigration areas is recognized officially, whereas that in the local villages is based mainly on customary law (*adat*); land disputes are common where the two tenure systems overlap.

• Conflict over forest land use occurs when current regulations and policies are declared after settlers have occupied the forest or when new settlers occupy forest land where such regulations are not effectively implemented.

• As much as 59 percent of the above-ground carbon stocks were removed by forest fire, and about 97 percent of unburned trees were removed from the plots. Changes in soil carbon stocks were small (Murdiyarso et al. 1997).

• The methane oxidation capacity of upland soils under trees (which partly offsets methane emissions in other land uses, such as paddy rice fields) declines with soil compaction (Murdiyarso et al. 1997; chapter 3, this volume).

• Nitrous oxide emissions appear to be related to the temporary abundance of soil mineral nitrogen or the amount of nitrogen cycling through the system (Davidson et al. 2000). At certain times during the year and during the land use cycle fluxes from forests are higher than those from other land uses and vice versa. No consistent relationship between land use and net emissions of nitrous oxide over a system's lifespan has yet been found (Tomich et al. 1998; Davidson et al. 2000).

• Alternative land uses at the forest margins differ in their potential for conservation of above-ground biodiversity, with a range of alternatives falling between the extremes of the smallholder's complex agroforests and large-scale plantation monoculture.

• All tree-based alternatives appear to be agronomically sustainable.

• Because of the currency collapse in 1997, profitability of many tree-based systems has increased substantially, which boosts incentives for forest conversion by smallholders and large-scale operators alike.

• There may be tradeoffs between potential profitability and above-ground biodiversity in tree-based production systems, but this must be verified.

• Potential profitability of some tree-based alternatives for smallholders (such as rubber agroforestry with higher-yielding rubber varieties) appears to be comparable to large-scale oil palm estates, but this also must be verified.

• Smallholders must address some important institutional questions to enable widespread adoption of profitable agroforestry alternatives.

LESSONS LEARNED

Forest-derived land uses differ significantly in their ability to substitute for specific functions of natural forests (De Jong et al. 2001). Because of the multiple objectives of production and environmental services of forests, deforestation must be viewed as a multidimensional phenomenon. Sometimes this policy problem can be simplified with tradeoff analysis.

The Sumatra case shows that agroforestry solutions help alleviate poverty but that they may speed up rather than slow down forest conversion as their profitability attracts migrant farmers and thus reduces biodiversity (Tomich et al. 2001).

The rapid spread of rubber as a smallholder crop in Sumatra since the beginning of the twentieth century and of smallholder oil palm in the late 1990s have contributed to large-scale forest conversion, to the point that there is very little lowland primary forest left. The logging concessions, especially those of the 1960s to 1980s, followed by an inflow of spontaneous settlers with rubber-based agriculture, have completed the conversion. Murdiyarso et al. (2002) show that the labor absorption of rubber agroforests can be high (providing a decent living to population densities of the order of sixty people per square kilometer), similar to that of oil palm, indicating that rubber agroforests so far are our best bet for integrating biodiversity and profitability of land use. If possible, however, segregating land into full protection status with more intensive agriculture in the remaining land might be superior (Van Schaik and van Noordwijk 2002). The returns to labor for logging in the presence of roads are so high that labor-intensive agroforestry as such can never compete with forest destruction, and a combination of social or government-based rules for protecting forests and labor-intensive, profitable land use systems is a prerequisite for forest protection (van Noordwijk et al. 1995; Tomich et al. 2001). Efforts to develop land use alternatives and policy options to pursue global environmental objectives (biodiversity conservation and carbon sequestration) are futile without consideration of agronomic sustainability and environmental services at other scales, objectives of farmers and policymakers at various levels, and weaknesses in markets and other institutions that influence the adoptability of land use alternatives by smallholders.

Tenure, institutions, trade policies, and macroeconomic shocks affect a household's livelihood options and thereby either reduce or intensify further deforestation.

This policy and institutional environment also has a powerful effect on the natural resource management decisions made by people at the forest margins.

Ongoing collaboration, contact, and presence of national and international members of the research team are essential for real impact on policy and technology options. Building effective multidisciplinary teams to study complexities of land use change is feasible but involves high costs.

FUTURE RESEARCH NEEDS

Scientists active in the ASB Indonesia team identified future research needs:

- Examine a wider range of tree-based best bets regarding their environmental, agronomic, and economic impacts and feasibility of adoption (Williams et al. 2001).
- Gain a better understanding about the relationships between above-ground and below-ground biodiversity, production sustainability, and potential profitability (Murdiyarso et al. 2002).
- Expand the assessments of sustainability from plot-level agronomic issues to include environmental externalities at the landscape level, including watershed functions.
- Complete the landscape transect by expanding the present focus on the peneplains and piedmont agroecological zones to include the montane zone and coastal swamps.
- Study more intensively the underlying causes of fires, policy issues, and technological alternatives to alleviate such catastrophic fires and smoke problems as happened in 1997 and 1998.
- Analyze how macroeconomic shocks affect land use change, environmental services, poverty, and household food security.
- Verify the potential environmental, social, and economic benefits of a smallholder-based development strategy as an alternative to large-scale plantation monoculture.

CONCLUSION

Indonesia still has large forest areas, and conversion to other land uses is rapid. The transformation from primary to secondary forest is caused largely by timber extraction, with traditional shifting cultivation playing a smaller role.

Although a part of the deforestation resulting from slash-and-burn is linked to the poverty of people living at the forest margins, the conditions necessary for increased productivity of agroforestry and other land use systems to reduce poverty and reduce deforestation are not sufficiently well understood.

The ASB's study of the present land use systems has revealed that all tree-based alternatives to slash-and-burn appear to be agronomically sustainable.

In developing alternative land uses and policy options that address global environmental objectives (biodiversity conservation and carbon sequestration), agronomic sustainability, and other environmental services, we must continue to consider the objectives of farmers and policymakers at various levels and weaknesses in markets and other institutions that influence the adoptability of land use alternatives by smallholders.

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