

IV. Local and national concerns: criteria and indicators

Alternative systems and technologies must be profitable and socially acceptable for smallholders; if not they have little prospect for adoption (hence impact). Part IV reports the empirical results of application in Indonesia of the methodological innovations of the ASB global working group on socioeconomic and policy issues (documented in Vosti *et al.* 1998). The GEF project did not provide funds for empirical research on these essential topics, which affect adoptability of land use alternatives by smallholders and also are the basis for assessing tradeoffs (if any) between national policy objectives and global environmental benefits. Thus, funding had to be sought from other sources – and was secured from the Asian Development Bank (ADB) and the Ford Foundation supplemented by additional funds from DANIDA, the Government of Japan, and others. The process of seeking additional funding delayed work on this key component of the research, which could not begin until funding was secured in mid-1997.

Assessment Criteria. Empirical results for Indonesia for four sets of indicators – profitability, labor requirements, cash flow constraints, and household food security – will be presented in this part of the report. From among these, a sub-set of indicators will be selected for two of the sets of assessment criteria presented in Part I:

- Criteria for **smallholders’ socioeconomic concerns**: production incentives, labor constraints, and household food security.
- Criteria for **policymakers’ objectives**: growth and aspects of equity and stability

This part of the report will conclude with sections on tradeoffs and complementarities among smallholders’ concerns and policymakers’ objectives and on ‘scaling up’ the assessment from plots to landscapes and watersheds. Criteria for **institutional barriers to adoption**, which are concerns to both smallholders and policymakers, will be considered in Part V.

IV.1 Profitability indicators

Since many of the land use alternatives in Sumatra involve perennials, the appropriate measure of **profitability** is the **net present value** (NPV, present discounted value) of revenues less costs of tradable inputs (fertilizer, fuel, etc) and of domestic factors of production (land, labor, management) over the full 25 year period considered in the analysis. Because it can account for input and factor costs as well as outputs and can handle time by discounting future values, this measure of total factor productivity is superior to partial measures of productivity (e.g., yield or output per unit labor).

The **policy analysis matrix** (PAM) technique provided the framework for estimating profitability indicators as well as the indicators of labor requirements and cash flow constraints discussed below. The ‘PAM’ is a matrix of information about agricultural and natural resource

policies and factor market imperfections that is created by comparing multi-year land use system budgets calculated at private and social prices (Monke and Pearson 1989 is the basic reference). **Private prices** are the prices that households and firms actually face, so private profitability – the NPV at private prices -- is a measure of *production incentives*. **Social profitability**, calculated at economic (shadow) prices, removes the impact of policy distortions and market imperfections on incentives for adoption and investment. Thus **social profitability** —the NPV at social prices -- is an indicator of *potential profitability* (or comparative advantage). **Divergences**, the difference between private profitability and social profitability, are indicators of distortions, arising either from policy or from market imperfections and failures. The structure of the PAM is described in Table IV.1, which is taken from Monke and Pearson (1989, p. 19).

As pointed out by our colleague, Arild Angelsen, the list of potential corrections to arrive at social prices is quite long. The adjustments to derive social prices in these analyses focus mainly on policy distortions arising from trade restrictions. As discussed below, we also used a lower real discount rate (15% instead of 20%) to capture a rough approximation of the impact of capital market imperfections on the private cost of capital. We have used the same wage rate in both sets of calculations, implicitly assuming that there are no imperfections in the market for unskilled labor. While this is not completely true, it also seems that these imperfections do not have a significant effect in the unskilled labor market (see discussion of labor markets in Section V.4 below). The main omission here is that prices are not adjusted to reflect costs and benefits of environmental externalities arising from these production activities, such as smoke, ecological changes, and loss of watershed functions. These adjustments, which probably would be significant and which are necessary for the complete analysis, are not possible at this time because of lack of data. Filling this gap is a priority for future research, as discussed below in Section IV.5.

These studies focus on primary production in agriculture and forestry. To get the complete economic picture, especially regarding comparative advantage and growth potential, it would be necessary to extend these analyses ‘downstream’ to include the private and social profitability of processing activities, especially for timber, rubber, cassava, and palm oil. Each of these studies of processing activities (described in Appendix E) would be a major undertaking in its own right and was not feasible during Phase II work in Indonesia.

Table IV.1 Policy Analysis Matrix

	Revenues	Costs		Profits
		Tradable inputs	Domestic factors	
Private prices	A	B	C	D ¹
Social prices	E	F	G	H ²
Effects of divergences and efficient policy	I ³	J ⁴	K ⁵	L ⁶

¹ Private profits, D, equal A minus B minus C.

² Social profits, H, equal E minus F minus G.

³ Output transfers, I, equal A minus E.

⁴ Input transfers, J, equal B minus F.

⁵ Factor transfers, K, equal C minus G.

⁶ Net transfers, L, equal D minus H; they also equal I minus J minus K.

Ratio Indicators for Comparison of Unlike Outputs

Private cost ratio (PCR): $C/(A - B)$

Domestic resource cost ratio (DRC): $G/(E - F)$

Nominal protection coefficient (NPC)

on tradable outputs (NPCO): A/E

on tradable inputs (NPCI): B/F

Effective protection coefficient (EPC): $(A - B)/(E - F)$

Profitability coefficient (PC): $(A - B - C)/(E - F - G)$ or D/H

Subsidy ratio to producers (SRP): L/E or $(D - H)/E$

Source: Taken from Monke and Pearson 1989, Table II.1, page 19.

To assure comparability across land use systems (and across ASB sites in Indonesia and Thailand), a regional short course on application of the PAM approach to natural resource management and policy analysis was held in Chiang Mai, Thailand, 1-13 June 1997. Through participation in lectures and computer-based exercises, teams developed a common methodology for analysis of land use systems. The course, which was funded by ADB, involved eleven participants from Indonesia (see Annex D) plus eight from Thailand. The Indonesian teams trained in the course then undertook studies of six Sumatran land use systems selected for study in ASB Phase II. Five of these six studies were sub-contracted to Indonesian national partners listed in Table IV.2. The sixth, on transmigration systems, was completed by an ICRAF researcher (see Budidarsono 1998). Fortunately, except for the study of industrial timber, preliminary results of these ongoing socioeconomic assessments are available to be included in this report.

Table IV.2 ADB-Funded Grants for Socioeconomic Research in Indonesia

Research Topic	Researchers	Institution
1. Does shifting cultivation really cause deforestation? Economic analysis of shifting cultivation and five-year bush fallow in Lampung Province	- Bustanul Arifin - Agus Hudoyo	Department of Agricultural Economics and Rural Sociology, University of Lampung
2. Economic analysis of land use system for large scale plantations of oil palm and industrial timber estates	- Retno Maryani - Setiasih Irawanti	Forest Products and Forestry Socio-Economics Research and Development Centre, Ministry of Forestry
3. Economic analysis of large scale logging	- Machfudh - Wesman Endom	Forest Products and Forestry Socio-Economics Research and Development Centre, Ministry of Forestry
4. Analysis of the economic efficiency and comparative advantage of the Sumatran small-holder rubber using 'PAM' method	- Prajogo U. Hadi - Gelar Setya Budhi	Center for Agro Socio-Economic Research, Agency for Agricultural Research and Development, Department of Agriculture
5. Economic analysis of NTFP extraction in Rantau-pandan, Province of Jambi	- Arif Aliadi - Wibowo A. Djatmiko	The Indonesian Tropical Institute (LATIN)

Operational definitions for the six land use types were given at the end of Chapter I.

1. Community-based forest management,
2. Large-scale commercial logging
3. Smallholder rubber, including both rubber agroforests and rubber monoculture.
4. Large-scale plantations of oil palm and industrial timber estates
5. Upland rice with bush fallow
6. Transmigration systems, focusing on cassava and *Imperata cylindrica* (*alang-alang*)

See Tables I.2, I.3, and I.4 for additional specifications of these systems. Annex E contains the PAMs for the various scenarios and more information on each of the studies.

All of these studies use the macroeconomic parameters tabulated below because the data were collected in July 1997, when the exchange rate was about Rp 2400 / US dollar. By most assessments of economic fundamentals (e.g., purchasing power parity), the Indonesian Rupiah was not greatly overvalued at that time. The consensus was that the overvaluation of the Rupiah relative to the dollar

may have been 10-15% in June 1997. Some expert analysts even expected the Rupiah to appreciate if it were floated in 1997 (McLeod 1997). To almost everyone's surprise, the collapse of the Thai Baht in July 1997 spread to the Rupiah (among others). By January 1998, the Rupiah had fallen to over Rp 17,000 per US dollar. After a recovery below Rp 10,000, it had fallen again to over Rp 14,000 per dollar in June 1998. The reasons why Indonesia's currency fell the furthest and has stayed down the longest rest with profound problems in its banks and other financial institutions compounded by the worst social instability and political uncertainty in 30 years.

The impact on land use incentives resulting from this monetary, social, and political crisis will be examined in Part VI. Although the causes of the regional financial crisis are not yet fully understood, they do not reflect fundamentals of the productive sectors of Indonesia's economy. **By any economic measure, the Indonesian Rupiah was extremely undervalued in mid-1998 as a result of the financial, social and political turmoil.** (Under these conditions, people demand a huge premium to hold Indonesian currency.) **To assess land use alternatives over the longer term, the macroeconomic parameters of July 1997 are a better guide than those that have prevailed during the crisis.**

Macroeconomic parameters for PAMs	July 1997
Exchange rate	Rp 2400 / US\$ 1
Wage rate in Sumatra	Rp 4000 / day
<i>Real</i> interest rates (net of inflation):	
Private:	20 % per year
Social:	15 % per year

Real interest rates – that is interest rates net of inflation -- are the discount factors used to value future cash flows in current terms. As in most developing countries, capital markets in Indonesia are fraught with imperfections – some of which have been manifested in the financial crisis. Private interest rates (at least for smallholders, if not for large corporations that could secure subsidized credit) have been very high in real terms. In July 1997, *formal* sector lending rates were almost 30% pa and inflation was under 10% pa. Thus the private interest rate of 20% used in these analyses is a lower bound for the actual cost of capital for smallholders. The real social interest rate is less than the private rate and 10% is probably too low. So, somewhat arbitrarily, a rate of 15% has been used for the real social cost of capital, which is both the interest rate and the discount rate for calculating NPV at social prices. This difference between private and social interest rates is the main cause of divergences between calculations at private and social prices for many of the land use alternatives. The analyses are quite sensitive to the choice of discount rates, which unfortunately involves considerable uncertainty. Particularly for the private cost of capital, the subjective discount rate may be much higher (or lower) than the 20% real rate used here. Interest rates in the informal sector often exceed 100% per year. Stein Holden estimated that the average subjective discount rate

(rate of time preference) among transmigrants in Riau exceeded 90% (Arild Angelsen *pers comm*). On the other hand, as Angelsen has pointed out, ‘desire to claim or secure land rights may modify the effect of high discount rates.’

An activity with NPV less than zero is ‘unprofitable’ by definition. This does not necessarily mean that there are no positive cash flows. Instead, it means that it would be more profitable to do other things with the land, labor and capital than to devote them to this activity. **If land is scarce, the NPV estimates measure returns to land** because they are the ‘surplus’ remaining after accounting for costs of labor (including imputed value of family labor), capital (through discounting), and purchased inputs.¹ (To the extent that management is a scarce factor, it also would be included in the residual.) We also present a measure of **returns to labor, the wage rate that sets the NPV equal to zero**. This calculation converts the ‘surplus’ to a wage after accounting for purchased inputs and discounting for the cost of capital; no surplus is attributed to land. This measure of returns to labor is valid when land is abundant and labor is scarce. Returns that exceed the wage, Rp 4000 per day, mean the activity will be attractive to family members compared to off-farm work or would justify hiring labor.

Although local land abundance with household labor scarcity has prevailed historically and certainly continues in the ASB sites in Brazil and Cameroon, this fundamental relationship seems to be shifting in Sumatra. Nevertheless, it still is reasonable to believe that local land abundance and household labor scarcity continue in the forest margins, at least from the point of view of smallholder households in central Sumatra. This is supported by the result that returns to labor for rubber agroforests, the predominant smallholder land use, are almost identical to the wage rate (Table IV.3). This implies that no ‘rent’ accrues to land under the dominant system and is consistent with land abundance (since the ‘rent,’ its opportunity cost, is near zero).

- For these reasons, and to facilitate cross-site comparisons, **returns to labor valued at private prices was selected as the indicator of profitability for smallholders’ production incentives**. Private prices are used in this indicator to reflect actual incentives smallholders faced under policies in effect in mid-1997.

At the same time, local and national policymakers increasingly are making public policy decisions under conditions of land scarcity and labor abundance. Land certainly is a constraint that should be considered by policymakers in choices regarding development of large-scale estates versus smallholders and there are other reasons to believe these development strategies are mutually exclusive (Tomich *et al* 1995).

- **Returns to land valued at social prices will be used as the indicator for potential profitability from policymakers’ perspective**. Social prices are used to indicate potential value added from this alternative if policy distortions and market imperfections were removed. This impact on value added is directly linked to policymakers’ growth objectives.

¹ In some figures, we will use an alternative measure called the **internal rate of return (IRR)**, which is the discount rate that brings the NPV to zero. The IRR is technically inferior to NPV for assessment of mutually-exclusive alternatives (Gittinger 1982), but using it makes the same point with greater clarity.

Table IV.3 Profitability Matrix, July 1997

Land Use System	RETURNS TO LAND			RETURNS TO LABOR	
	NPV Private Prices	NPV Social Prices	Divergences	Wage to set NPV to Zero	
				Private Prices	Social Prices
	Rupiah 000 / ha	Rupiah 000 / ha	Rupiah 000 / ha	Rp / person-day	Rp / person-day
Community - based forest management	8.0 to 16	9.4 to 18	(1.5) to (2.5)	11,000 to 12,000	11,000
Commercial Logging	(804) to (131)	(32) to 2,102	(2,233) to (773)	(17,349) to 2,008	7,917 to 31,400
Rubber agroforest (seedlings)	1.6	73	71	4,000	4,100
<i>Rubber agroforest (clones)</i>	(95) to 2,202	234 to 3,623	(330 to (1,420)	3,900 to 6,900	4,200 to 7,700
<i>Rubber monoculture</i>	(167)	(993)	(826)	3,683	2,600
Oil palm monoculture	275	1,480	(1,204)	5,797	9,981
Upland rice/bush fallow rotation	(220) to (76)	(180) to 53	(37) to (130)	2,700 to 3,300	3,000 to 4,500
Monoculture cassava/ <i>Imperata cylindrica</i>	(71) to 360	(315) to 389	135 to 243	3,895 to 4,515	4,085 to 4,455

Estimates of returns to land and returns to labor, each evaluated at private and at social prices, are presented in Table IV.3. The upland rice / bush fallow rotation stands out as being unprofitable, either in terms of potential profitability (returns to land at social prices) or smallholder production incentives (returns to labor at private prices). For the upland rice / bush fallow system, the higher (less negative) returns are for the fallow of ten years or more, which is no longer feasible. The lower (or more negative) numbers in the range correspond to short fallow shifting cultivation. These results are consistent with the disappearance of shifting cultivation in most of Sumatra's peneplains and piedmont. Sustainable forms of continuous foodcrop production may be *technically* feasible in Sumatra's peneplains, but often are not financially attractive because they require too much labor and too many purchased inputs. For this report, we have focused on cassava, which may be among the most profitable of the continuous foodcrop alternatives for the peneplains. The most profitable cassava system studied was an extensive fallow system without any fertilizer applications. Profitability at private prices was estimated at over Rp 545,000 per ha (see Appendix E). However, this example is not included in Table IV.3 because, as noted in Part III, these systems mine nutrients, exhausting the soil and reducing the range of future land use options. Two cassava systems that use fertilizer are included in Table IV.3, one with fertilizer applications from the first year and one with fertilizer beginning in the seventh year after forest clearing. Application of fertilizer from the first year after clearing (30 kg N; 60 kg P; and 60 kg K per year) is not profitable privately (negative Rp 71,000 per ha) or socially (negative Rp 315,000 per ha). These treatments and the agronomic results

are taken from experiments conducted at the Biological Maintenance of Soil Fertility (BMSF) research project at the ASB benchmark area in Lampung. However, an intermediate approach (also reported in Table IV.3) with fertilizer applications beginning in year seven (50 kg N; 50 kg P) does produce relatively attractive returns at both private prices (Rp 360,000 per ha) and social prices (Rp 224,000 per ha). However, the longer-run sustainability of this system requires further study. Note that, because of chemical fertilizer price subsidies that were still in effect in mid-1997, cassava is one of the few cases where estimated 'divergences' are positive, indicating that policy increases private profitability.

Returns to labor are highest for community-based forest management (extraction of NTFPs), but these high returns are dependent on some mechanism to exclude outsiders. Thus, this system plays an important role for existing communities that can regulate access to forest lands. If, on the other hand, communities could not regulate access to their forests, one would expect the returns to labor from extraction of forest products to decline toward the wage rate. However, even under 'open access' one would still expect returns to labor to exceed the wage rate by some margin equal to a risk premium. The risks involved include possibility of failure to find products to extract and also the risk (and associated costs) of detection by officials, since many of these activities are prohibited.

The relatively low returns to land – only slightly above rubber agroforests – suggest that NTFP extraction is not a feasible alternative for large numbers of people, because there is not enough land for everyone to practice this extensive livelihood strategy. This results must be interpreted with some care, however, for three reasons. First, these extractive activities are highly site-specific. It may be that the study site is not representative. Only additional studies can resolve this. Second, as often is the case, at least part of this community forest is on State Land and it is not clear how this problem of tenure insecurity might bias these results. On one hand, long run profitability may be overstated because of unsustainable harvesting (viz., songbirds and rattan). On the other hand, if the community or individual members had secure property rights, this might induce them to invest and to manage resources to increase productivity over time. Finally, as already noted, it was not possible to put a value on timber extraction, but it is likely that this is significant. We hope to be able to conduct a study of the economics of smallholder timber extraction in the future.

The results for commercial logging appear paradoxical, but this is because of policies that produce the biggest divergences for any of these land uses. First, the sustainable logging regulations – if they really are followed – reduce profitability, mainly by slowing timber extraction. Second, high export taxes (effectively an export ban) for logs and sawn timber depressed the domestic prices of logs from 50-70% below comparable world prices. (Timber export taxes were to be reduced to 30% by the end of 1998.) However, timber companies could get around both of these problems. First, as mentioned above, many companies circumvent regulations on timber extraction. Second, these typically are vertically-integrated firms producing products like plywood for the export market.

Therefore, the best indicator of profitability of these activities for logging companies is the figure of just over Rp 2 million per ha, valued at social prices that reflect world prices of forestry products. When comparable estimates are available for industrial timber plantations, it seems likely that these will be more profitable than logging.

By all accounts, illegal logging is common, which seems inconsistent with these results of negative returns to logging at private prices. However, the major cost item for logging concessions -- establishing and maintaining logging roads -- is not incurred by illegal loggers. If one can get access to timber without having to invest in infrastructure (and at the same time circumventing various fees), logging can be very profitable.

One could argue that the estimated NPV of logging activities of over Rp 2.1 million per ha (about US\$ 875) in mid-1997 should be added to the social profitability for *all* the other activities and to private profitability, at least for large-scale estates that often can market timber felled as a by-product of land clearing. Recall that natural forest cover is the starting point underlying these calculations (and all the other estimates in this report). Thus all the forest-derived land uses (rubber, oil palm, cassava, and even upland rice) started out with felling of forest timber. And, as already noted, there is substantial (but as yet unquantified) timber felling in conjunction with NTFP extraction. Thus, in many cases it would be appropriate to add the value of the harvested wood to the profitability of each activity overall. This modification is debatable for private profitability of smallholder systems, however, because most of the felled timber is burned instead of marketed. Yet, this simply may be a result of trade restrictions that make it artificially difficult for smallholders to sell timber legally (Section VII.2). The estimate of timber values was not added to other land uses in the tables presented in the report, however, because the one-off value of timber extracted as a by-product of land clearing often exceeds the value of the derived land use. **Thus, although it is technically correct to do so, adding the value of timber – which admittedly is subject to considerable uncertainty – would simply obscure differences in profitability among the derived land uses. This problem in presentation is linked to a problem in conservation: if regulations can be circumvented – as often is the case -- forest conversion is privately profitable simply for the value of timber regardless of the subsequent land use. Of course, for the social profitability calculations, timber values would have to be balanced against losses of ecological and other environmental functions of natural forests.**

Oil palm is widely viewed as the most profitable alternative for Sumatra's peneplains and Indonesia's oil palm producers have the lowest unit costs in the world. Thus, it is no surprise that large-scale oil palm monoculture is among the most profitable alternatives, either in terms of returns to land valued at social prices or in terms of returns to labor valued at private prices. The later measure is of limited relevance, however, because the official wages for plantation workers are well below these estimates of returns to labor. But, much as they had earlier in Malaysia (Barlow 1986),

plots of 2-5 ha of oil palm planted by independent smallholders began to appear in Sumatra beginning in the 1980s. These merit study for their possibility to combine high potential profitability from a national perspective with attractive returns to smallholders' labor. For the time being, however, Government development strategies discriminate against the emergence of independent smallholder oil palm producers. For example, some provinces will not license palm oil mills unless the enterprise also has its own oil palm plantation or associated smallholders in nucleus estate/smallholder (NES) schemes. This is intended to prevent NES participants from selling their produce outside the project (as happened in the case of rubber) in order to avoid repayment of loans. But not licensing independent mills in an effort to prevent free trade in fresh oil palm fruit also retards development of the market for independent smallholder oil palm producers.

The three contrasting rubber systems produce a wide range of results. First, as already noted, it is encouraging that returns to labor at private prices are virtually identical to the market wage for rubber agroforests planted with seedlings. Although these smallholders are the lowest cost producers of natural rubber in the world (Barlow *et al.*, 1994), returns to land at social prices are not much above upland rice with a long bush fallow rotation and are well below oil palm monoculture.

Perhaps the most striking result in Table IV.3 are the returns to land at social prices for rubber agroforests planted with PB 260 clones, which rival large-scale oil palm monoculture. This system also produces attractive returns to labor at private prices. ***These data must be treated with caution – which is why they are in italics – since they are based on projections from farmer-managed trials and have not been verified through broader experience by smallholders.*** The top of the range of profitability estimates might actually be attained by 10-25 % of smallholders (E Penot *pers comm.*) However, the lower figure in the range represents an expert's best guess about a 'worst case' scenario for yields in this system for the bottom quartile. The big question is where the middle of the profitability distribution would be for this system – and that can only be answered through farmers' experience. But these results support the idea that potential profitability of rubber agroforests planted with clonal material (and other smallholder agroforests planted with appropriate, higher-yielding germplasm) may be comparable to large-scale oil palm plantation monoculture, at least as long as wages are low.

The profitability estimates for smallholder rubber monoculture planted with GT 1 clonal seedlings provide a cautionary tale to balance the encouraging projections for rubber agroforests planted with PB 260 clones. These monoculture plots were part of a government-sponsored rubber replanting project that was undertaken with high expectations. But the disappointing yields that were obtained because of institutional shortcomings involving supply of planting material, technical information, and credit – these will be taken up in Part V -- could not offset the high costs of that project's approach. Instead of the high-cost approach in this case of rubber monoculture, the strategy to introduce clones into smallholders' agroforests seeks a moderate increase in yields at minimal

incremental costs. Yet the costly lessons of earlier failures in smallholder rubber development should be borne in mind (Tomich 1991), including difficulty in supplying clonal planting material. The sites studied, for example, were designed to be planted with clones but were actually planted with clonal seedlings because of this problem.

IV.2 Labor requirements indicators

Table IV.4 presents three different indicators of labor requirements. First is total person-days required to establish a system, where ‘establishment’ refers to the period before positive cash flows begin. The two systems with highest potential profitability in the previous section – smallholder rubber agroforests planted with clones and large-scale oil palm—both have very high labor requirements for this phase. However, recall that each system also had high returns to labor. Thus, problems in the labor market or credit market that will be discussed in Part V could impose a serious barrier to adoption, but returns to labor itself is not a problem here.

- More generally, **returns to labor valued at private prices**, which was selected above as an indicator of smallholders’ production incentives, **also is a good indicator for smallholders’ concerns with labor constraints if combined with assessments of institutional barriers in markets for labor and capital.**

The two other indicators of labor requirements in Table IV.4 are closely related, labor requirements for the operational phase (defined as the period after positive cash flow begins) and total labor. Both measures are averaged over time and the units are person-days per hectare per year.

- **From the perspective of policymakers concerned with employment generation, total time-averaged labor requirements is a good indicator that is related to equity and stability criteria.** Note, however, that while labor-intensive alternatives should be attractive for policymakers who are concerned with job creation, these alternatives will only be attractive to households if they provide attractive returns to labor, the indicator discussed above.

For the rubber and oil palm systems that were evaluated, total time-averaged labor requirements are similar, ranging between 100 and 150 person-days per ha pa. Harvesting labor is the biggest component in these systems. Because of lack of pronounced seasonality in much of Sumatra, harvesting of rubber and oil palm can go on roughly 10 months a year. The two extractive activities – community based forest management and commercial logging – fall at the opposite extreme. Neither of these extractive activities nor the upland rice / bush fallow rotations can provide many employment opportunities compared to treecrop-based alternatives.

Table IV.4 Labor requirements matrix, July 1997
(total labor inputs for establishment and averages over time for operations and total labor)

Land Use System	Establishment phase (Person-days/ha)	Operation phase (Person-days/ha/yr)	Total Labor (Person-days/ha/yr)
Community - based forest management	na	0.2 - 0.4	0.2 - 0.4
Commercial Logging	15 to 100	17 to 41	31
Rubber agroforest (seedling)	271	157	111
<i>Rubber agroforest (clones)</i>	444	74	150
<i>Rubber monoculture</i>	344	166	133
Oil palm monoculture	532	83	108
Upland rice / bush fallow rotation	na	15 to 25	15 to 25
Monoculture cassava / <i>Imperata cylindrica</i>	na	98 to 104	98 to 104

IV.3 Cash flow constraints indicators

Because perennials are so important among the Sumatran alternatives, our analysis of cash flow constraints focused on multi-year (rather than seasonal) cash flow constraints in order to assess whether the investments required by these systems are barriers to adoption by smallholders. Table IV.5 takes two perspectives on multi-year cash flow constraints: years to positive cash flow and the NPV of establishment costs, which we define as costs prior to positive cash flow. The imputed value of family labor is included in these establishment costs because these labor inputs presumably represent foregone earnings in other activities even if they do not require cash outlay.

By either measure, community-based forest management is the only profitable system without any multi-year cash flow constraints. For the other systems, years to positive cash flow range from 2 years for logging and cassava to 6-10 years for smallholder rubber and 10 years for large-scale oil palm. Time is not a constraint by itself, as evidenced by almost 3 million ha of rubber agroforests that have been planted by smallholders without any formal credit. The NPV of establishment costs at private prices, which is derived directly from the PAM cash flows, probably is the best indicator of cash flow constraints for smallholders. In interpreting these estimates, keep in mind that the existing rubber agroforests are evidence that the Rp 1.3 million required to establish them has not been an insurmountable barrier for smallholders. These estimates suggest that replacing seedlings with higher-yielding clones in rubber agroforests more than doubles investment costs to roughly Rp 2.6 – 2.9 million per ha. Since there is no long-term institutional credit for smallholders in Sumatra, whether these investment requirements are barriers to adoption depends in large part on the divisibility of the activity (i.e., is it possible to plant a bit at a time?).

At Rp 8 million per ha, investment costs for large-scale oil palm plantations are the highest of all. Investments of this magnitude would be difficult for many smallholders. But capital costs for large-scale plantations may be inflated for at least two reasons. First, large-scale oil palm plantations

formerly received heavily subsidized credit from the Government, which would tend to make them artificially capital intensive. Second, there may have been a tendency among respondents to overstate investment costs in order to mask the profitability of these investments. Even more than rubber, adapting high-yielding oil palm systems as alternatives for smallholders will require research to develop options that are less capital intensive.

Table IV.5 Cash flow constraint matrix, July 1997

Land Use System	Years to positive Cash flow Private prices (Years)	NPV of Establishment cost Private prices (Rupiah / ha)	Years to positive Cash flow Social Prices (Years)	NPV of Establishment cost Social Prices (Rupiah / ha)
Community - based forest management	na	na	na	na
Commercial Logging	2	820,669 to 869,199	2	716,917 to 764,238
Rubber agroforest (seedlings)	10	1,305,536	10	1,477,735
<i>Rubber agroforest (clones)</i>	<i>6 to 7</i>	<i>2,593,458 to 2,862,422</i>	<i>6 to 7</i>	<i>2,950,338 to 3,303,338</i>
<i>Rubber monoculture</i>	<i>10</i>	<i>2,085,257</i>	<i>10</i>	<i>2,192,584</i>
Oil palm monoculture	10	8,041,847	9	8,182,015
Upland rice/bush fallow rotation	never	na	never	na
Cassava / <i>Imperata cylindrica</i>	2	na	2	na

IV.4 Household food security indicators

Food nutrient content measures, as in Table IV.6, can be seriously misleading because food security derives from the ability to obtain food, including purchases, and not just capacity to grow it. An unsustainable, low-productivity shifting cultivation system that is suffering decreasing yields because of nutrient depletion and increasing variability in yields because of pest problems may be a riskier basis for securing household food supply than a rubber plot that reliably produces a steady stream of output that can readily be marketed in exchange for rice that trades at a stabilized price.

To accommodate land use alternatives that do not involve foodcrops, our food security indicator is based on Sen's (1982) concept of risk of food entitlement failure, which encompasses trade-based and production-based entitlements to food as well as security of property rights over productive assets (inheritance and transfer entitlements). Moreover, one of the key dimensions of this analysis is the 'path' of food entitlement – is it derived from consumption of one's own food production, exchange of one's own production for food, or working for wages to buy food? These 'paths' determine the measure of risk of entitlement failure. If the path is production of one's own

food, **one simple indicator of production risk is the coefficient of variation of yields.**² If the path is exchange for food, terms of trade risk must be considered in addition to production risk. **A simple indicator of terms of trade risk is the coefficient of variation of the ratio of revenue (price of output times yield) to the price of the staple food, which for Sumatra is rice.** This can also be viewed as the coefficient of variation of purchasing power in terms of rice. (Note that if one's product is rice, the prices cancel out and all that is left is the coefficient of variation of yields, our indicator of production risk.) Finally, if the path is wage labor, risk of entitlement failure is a function of the employer's financial situation, which is only partly related to production or terms of trade risk. These simple measures do not adapt easily to multiple output systems, such as extraction of non-timber forest products. Although many of these commodities may be important to households' food and nutritional security, data for food security indicators are not available for NTFPs. Calculations in Table IV.6 indicate that production risk for rubber agroforests may be less than the upland rice/bush fallow rotation. Terms of trade risk for rubber is twice its production risk, as measured by its coefficient of variation. Although these measures suggest upland rice/bush fallow is less 'risky' than rubber, the superior production incentives for rubber agroforests are the reason why they have displaced upland rice over the past century.

IV.5 The 'missing middle': scaling up from plots to landscapes

Work is needed to expand the assessments of sustainability from plot-level agronomic issues to include environmental externalities at the landscape level and watershed functions. In addition to the two existing study areas in Lampung, the ASB-Indonesia Consortium is planning to have a serious look at the issues of watershed degradation and rehabilitation in the foothill/ mountain zone of Lampung . This is a zone of major conflicts between migrants who are attracted by the fertility of the soils (allowing for coffee production), but who come into conflict with forestry officials who try to maintain this zone as 'protection forest'. This site, together with Mae Chaem in Northern Thailand and Manupali in Mindanao, the Philippines, are the 3 areas that will be the focal points for our regional program's research on policies and technologies to address environmental externalities at the landscape level.

The policy-driven agenda will require new biophysical insights into landscape-level processes of soil and water conservation, as current plot-level insights can not be easily scaled up (Figure IV.1). The Sumber Jaya area, halfway between Krui and the North Lampung ASB benchmark area seems eminently suitable to take up this challenge (see Map 3). In order to complete the landscape transect, it is necessary to expand from the present focus on the penepains and piedmont agroecological zones in order to include the montane zone and coastal swamps.

² The coefficient of variation is the standard deviation in a series divided by the mean of the series. It is a relative measure that expresses variation as a proportion of the average level.

Table IV.6 Household Food Security Matrix

Land Use System	Nutritional Value of Food Produced by the System			Food Entitlement via: Own Production, Exchange, or Wages		Risk of Food Entitlement Failure		
	Calories: avg kcal /ha/yr	Protein: Avg. kg /ha/yr	Micro-nutrients	Establishment	Operation	Production Risk		Terms of Trade Risk
						Food	Non-food	
Community-based forest management	?	?	Important	n.a.	Own prod'n & exchange	?	?	?
Commercial logging	Nil	Nil	Nil	Wages	Wages	n.a.	n.a.	n.a.
Rubber agroforests	118	2.2	?	Own prod'n	Exchange	n.a.	0.13	0.26
Oil palm	19,800	Nil	Nil	Wages	Wages	n.a.	n.a.	n.a.
Upland rice / bush fallow rotation	441 - 490	8.3 - 9.2	Nil ?	n.a.	Own prod'n	0.18	n.a.	n.a.
Monoculture cassava degrading to <i>Imperata cylindrica</i>	9,900	13.6	Nil	n.a.	Own prod'n & exchange	0.06	n.a.	0.22

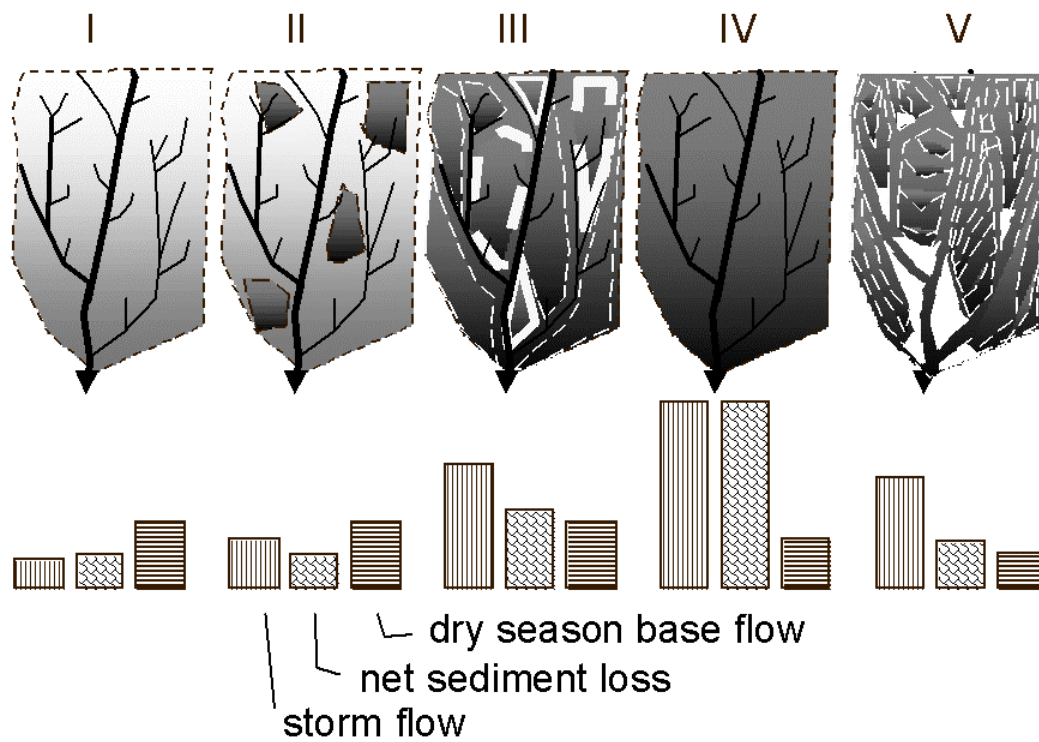


Figure IV.1 Schematic development of the landscape in a sub-watershed and its effects on storm flow, net sediment loss and dry-season base flow: I. original forest cover, II. patches of forest opened for shifting cultivation, III. intensification of land use has brought most land into cultivation, except for riverain borders and hedges along paths, IV. reclamation of all 'wastelands' has removed all filter strips causing a disproportional rise in net sediment loss, V. restored agroforestry landscape with permanently vegetated contour strips and riparian woodlands (Van Noordwijk et al., 1998)

Managing smoke. As will be discussed Part VI, banning burning has not worked. What policy options and policy instruments presently exist to manage the recurrent regional problem of too much smoke in the wrong place at the wrong time? What data would be useful in designing and implementing a strategy to manage burning in order to address the smoke problem? What are the consequences of land clearing without the use of fire? What is the role of remote sensing data? Of studies of local institutions? What other types of data or research would be useful to policymakers? If those data were available, how could they be used? (And, given the inaction to date, under what circumstances would they be used?)

Changing roles of biodiversity in the landscape. Much discussion of biodiversity conservation focuses on existence values – i.e., preventing extinctions. Landscape ecology currently emphasizes managing corridors and bufferzones to improve opportunities for dispersal and recolonization. Much less attention has been given to local functional values of biodiversity in the landscape (belowground as well as above), ranging from the tangible (but not yet well quantified) roles of biodiversity in sustainability and resilience of production systems to less tangible esthetic and spiritual roles of biodiversity for local people who experience its pluses (and minuses) daily. Which among these—and other roles—are felt to be most important at the local and national level? To what extent is it feasible to go beyond plot-level measures of richness and to scale-up to the landscape level? Are there important functions that are unquantifiable? If so, how can these be incorporated in the debate? More broadly, how can diverse societies identify these functional roles of biodiversity and assess tradeoffs with other public policy objectives?

Loss of watershed functions. National concern for forest conservation and reforestation often focuses on the loss of the watershed functions of natural forests. While some land uses may be as good as natural forest in this regard, land uses differ significantly in their ability to supply these watershed functions. Loss of watershed functions can be a combination of:

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

Research on this topic will seek to quantify erosion from natural processes, agriculture or other activities (such as road construction) and to assess the impacts (positive as well as negative) of resulting sedimentation and to assess how land use change affects risks of floods and seasonal water shortages.

IV.6 Tradeoffs and complementarities between smallholders' concerns and policymakers' objectives

- **Policymakers' concerns with potential profitability and smallholders' concerns with production incentives and household food security.** If they *really* are more profitable than smallholder alternatives, all the large-scale systems involve tradeoffs with smallholder production incentives and household food security, since such projects often displace local smallholders with little or no compensation. (In the case of large-scale logging, there also is a tradeoff with employment creation.)
- **The potential profitability of some tree-based alternatives for smallholders (viz., rubber agroforests planted with clones) appears to be comparable to large-scale estates and logging.** However, this requires further verification through additional studies of smallholder rubber and other alternatives, such as smallholder timber and smallholder oil palm. **This result holds promise for complementarity between policymakers' concerns with potential profitability and smallholders' production incentives. It also suggests that policy concerns with equity and mounting concerns about social and political instability can be addressed through a smallholder-based development strategy without a significant reduction in economic growth.**
- **If they can be adapted for smallholders, the treecrop-based systems offer attractive production incentives.** Since labor markets appear to work well, labor should not be a serious constraint to adoption. Thus, **smallholder treecrop systems also offer complementarity with employment creation objectives.**
- Potential impacts on household food security depend crucially on government policy regarding rice marketing. **If the government can sustain its commitment to rice price stabilization, households' production of treecrops for sale should not jeopardize their food security.** However, it remains to be seen whether rice price policies can be sustained.

Other potential constraints to adoption by smallholders will be examined in Part V.

V. Output 3.1. Linking global environmental benefits to sustainable land use alternatives

This part of the report concerns **Project Output 3.1**, *recommendations that link global environmental benefits to land use practices by (a) assembling and prioritizing alternatives to slash-and-burn in terms of sustainable agriculture and (b) analyzing environmental impacts and collating these analyses with data on agricultural productivity and sustainability of current and alternative land use*. If alternatives to slash-and-burn were to have hope for significant impact in Indonesia (or any of the countries involved in ASB), the scope of the research project had to expand beyond climate change and biodiversity reported in Part II. This ‘linking’ goal of the project, which necessarily involves assessments of tradeoffs (and complementarities) among impacts spanning the plot, household, landscape, watershed, and national level—as well as global environmental phenomena—could not be achieved meaningfully without assessment of the sustainability and adoptability of the alternatives reported in Parts III and IV.

V.1 ASB-Indonesia matrix

This ASB matrix approach was developed as a tool to link global benefits with sustainable alternatives that are adoptable by farmers (Vosti *et al* 1998; Tomich *et al*, 1998). The ASB-Indonesia matrix links environmental, agronomic, policy, socioeconomic, and institutional indicators and was developed in collaboration with scientists from other ASB sites. These criteria and selection of specific indicators were discussed in detail in Parts I-IV:

Indicators of global environmental impacts:

- Carbon sequestration, measured as time averaged carbon
- Biodiversity, using the aboveground species richness for vascular plants

Agronomic sustainability:

- Summary indicator and specific qualitative indicators for pests and diseases

National policymakers’ concerns:

- Potential profitability (comparative advantage), measured as the net present value of returns to land assessed at social prices
- Equity and stability, measured in part by employment opportunities. Indicators of adoptability presented below also are relevant to poverty alleviation objectives derived from concerns about equity and stability.

Smallholders’ socioeconomic concerns and adoptability of land use alternatives

- Production incentives (financial profitability) received by smallholders, measured as returns to labor valued at private prices.

- Household food security, where one of the most important considerations is the pathway for obtaining food: own production, exchange, or wage labor.
- Qualitative indicators of problems in markets that may create barriers to adoptability. Problems in input supply, output, labor, and capital markets are indicated respectively by an 'I', 'O', 'L', or 'K'. Uppercase letters indicate serious constraints; referred to as 'red lights' below. Lowercase letters indicate potential constraints; called 'yellow lights' below.
- Qualitative indicators of other institutional problems that also have the potential to create barriers to adoptability. The specific problems and issues considered below were access to non-market information (indicated by an 'N'), regulatory issues ('R'), local environmental issues ('E'), insecure property rights ('P'), equity biases ('B'), and need for social cooperation ('C'). Again, uppercase denotes a 'red light' and lowercase is a 'yellow light'.

Now that this array of indicators has been assembled in Table V.1, it is possible to examine tradeoffs and complementarities across the various criteria.

V.2 Relationships among global benefits, sustainability, and local/national objectives

Because of the multiple criteria regarding production and environmental services of forests, 'deforestation' must be viewed as a multidimensional phenomenon. Sometimes this policy problem may simplify to a few key dimensions (tradeoffs). Conversion of natural forest has the major effect on the supply of forest functions, but the subsequent land uses also matter a great deal for agronomic sustainability and the supply of global environmental benefits. Table V.1 presents very preliminary estimates of the orders of magnitude of these differences for 7 systems that represent the major land uses in Sumatra's peneplains, the low-elevation, undulating areas of poor soils that comprise the island's largest agroecological zone.

All the tree-based systems (smallholder agroforests and monoculture as well as large-scale plantation monoculture) in Table V.1 are agronomically sustainable. On the other hand, shortening of fallow rotations from 10 years or more to less than 5 years with rising land scarcity is undermining sustainability of shifting cultivation, which has been disappearing anyway as population pressure increases in Sumatra (van Noordwijk *et al.* 1995a) And continuous cultivation of cassava does not appear sustainable on this land because of depletion of nutrients and of soil organic matter. On these soils, marginal revenues from fertilizer applications to cassava do not cover fertilizer costs at current prices, which are near the world market price for most nutrients except nitrogen, which has been subsidized in Indonesia. (Subsequently, fertilizer subsidies were lifted.)

Table V.1 ASB Matrix for the Forest Margins of Sumatra

Land use		Global environment		Agronomic sustainability		National policymakers' concerns		Adoptability by smallholders			
Description	Scale of operation / evaluation	Carbon sequestration	Biodiversity	Plot-level production sustainability		Potential profitability	Employment	Production incentives	Household food security	Institutional & policy issues	
		Time averaged (Mg/ha)	Plant species/standard plot	Overall rating	Main sustainability issues (1)	Returns to land (Rp 000 / ha) at social prices	Time averaged labor input (days/ha/yr)	Returns to Labor (Rp / day) at private prices	Food entitlement via:	Market imperfections (2)	Other institutional problems (3)
Natural forest	25 ha fragment / 1 ha	254	120	1		0	0	0	n.a.		
Community-based forest management	35,000 ha common forest / 1 ha	176	100	1		9.4 to 18	0.2 to 0.4	11,000 to 12,000	own prod'n & exchange	o	N, R, P, C
Commercial logging	35,000 ha concession / 1 ha	150	90	0.5	C	(32) to 2,102	31	(17,349) to 2,008	wages	O, K	N, R, E, P, B, C
Rubber agroforest	1-5 ha plots / 1 ha	116	90	0.5	C	73	111	4,000	exchange		P, b, c
<i>Rubber agroforest w/ clonal planting material</i>	<i>1-5 ha plots / 1 ha</i>	<i>103</i>	<i>60</i>	<i>0.5</i>	<i>C,K,W,P</i>	<i>234 to 3,622</i>	<i>150</i>	<i>3,900 to 6,900</i>	<i>exchange</i>	<i>I, k</i>	<i>N, P, b, c</i>
<i>Rubber monoculture</i>	<i>1-5 ha plots / 1 ha</i>	<i>97</i>	<i>25</i>	<i>0.5</i>	<i>C,W,P</i>	<i>(993)</i>	<i>133</i>	<i>3,683</i>	<i>exchange</i>	<i>I, k</i>	<i>N, P, b, c</i>
Oil palm monoculture	35,000 ha estate / 1 ha	91	25	0.5	C,Fert	1,480	108	5,797	wages	I, o, K	N, R, e, P, B, c
Upland rice / bush fallow rotation	1-2 ha plots / 1 ha	74	45	0.5	Fert,P	(180) to 53	15 to 25	2,700 to 3,300	own production		n, P, c
Continuous cassava degrading to Imperata	1-2 ha plots within settlement project / 1 ha	39	15	0	C,Fert,W	(315) to 603	98 to 104	3,895 to 4,515	own prod'n & exchange	o, K	n, E, p, c

Notes for Table V.1

(1) Plot-level production sustainability: C = soil compaction; K = potassium balance; Fert = cost P = pest or disease problem

(2) Market imperfections: I = input market problem; O = output market problem; L = labor market problem; K = capital market problem

(3) Other institutional problems: N = non-market information problem; R = regulatory problem; E = local environmental problem; B = equity biases (gender or distributional); C = social cooperation required

For market imperfections and other institutional problems: upper case letters indicate more serious problems

C sequestration depends largely on cycle length (frequency of clear felling for rejuvenation). Where treecrop systems can be rejuvenated without clear felling, a substantial increase in C stock may be possible. Moreover, there do not appear to be big differences among forest extraction and the other tree-based systems regarding carbon stocks and greenhouse gases. Thus, as far as agronomic sustainability and climate change objectives are concerned, tree-based systems dominate among the alternatives.

Raising productivity of rubber agroforests, which span millions of ha, offers a promising pathway in Sumatra. There appears to be great potential for raising profitability of these systems through adaptation of existing higher-yielding clones within existing smallholder systems, which would also enhance household food security and expand employment opportunities. It may be possible to combine these potential benefits from the perspective of smallholders and national policymakers with significant biodiversity conservation because the mix of planted species is augmented by natural regeneration of forest species (Michon and de Foresta; van Noordwijk *et al.* 1995b). Indeed, these agroforests may approximate a number of forest functions, thereby providing the technical foundation for sustainable community-based forest and watershed management. But it must be emphasized that agroforests are *not* perfect substitutes for biodiversity conservation in natural forests. Indeed conversion of natural forests to agroforests involves a significant reduction in species richness. For assessments of higher plants made along 100 m line transects in Sumatra, over 350 species were found in primary forests while the number dropped to about 250 species for rubber agroforests. However, the richness remaining in agroforests still is much higher than the 5 or so species of higher plants found in rubber monoculture (Michon and de Foresta).

As discussed in Part IV, a key unresolved question is whether the potential for development of smallholder rubber agroforests can compete with the (private and social) profitability of large-scale alternatives, including oil palm plantations, industrial timber estates and logging concessions. These are viewed as ‘best bets’ for economic development by many policymakers and donors, in large part because of conventional wisdom of economies of scale in plantation development. **If** it turns out that large-scale development alternatives are more profitable—recall from Part IV that this is not a foregone conclusion—an important tradeoff between global environmental benefits and national development objectives will have to be faced. This is because there is an important tradeoff with biodiversity conservation for large-scale plantation monocultures such as oil palm.

Even if further analysis shows that the large-scale schemes hold no advantages in terms of private and social profitability compared to smallholder schemes (see Part IV), a potential tradeoff between profitability and biodiversity conservation remains to be addressed concerning smallholder systems (van Noordwijk *et al.*, 1995b). Farmer management aimed at increasing productivity of systems often decreases biodiversity. Whether or not this apparent trade-off between productivity and biodiversity is inescapable is the subject of debate--and further research. Very little is known about the shape of the family of curves describing the

trade-off function, or even whether a trade-off always exists (Figure V.1). If the relationship is convex to the origin, even modest productivity gains cause great loss of biodiversity. If the relationship is concave, biodiversity loss is relatively slow for initial increases in productivity. In this case, raising productivity to an intermediate level may involve a modest trade-off in terms of biodiversity loss. Thus, two of the most important research questions regarding the selection of ‘best bets’ in Sumatra are: what is the shape of this family of curves? and what factors influence the biodiversity of these complex, multistrata systems as productivity of their components increases? So while there may be a tradeoff between potential profitability and aboveground biodiversity in tree-based production systems, this requires further verification.

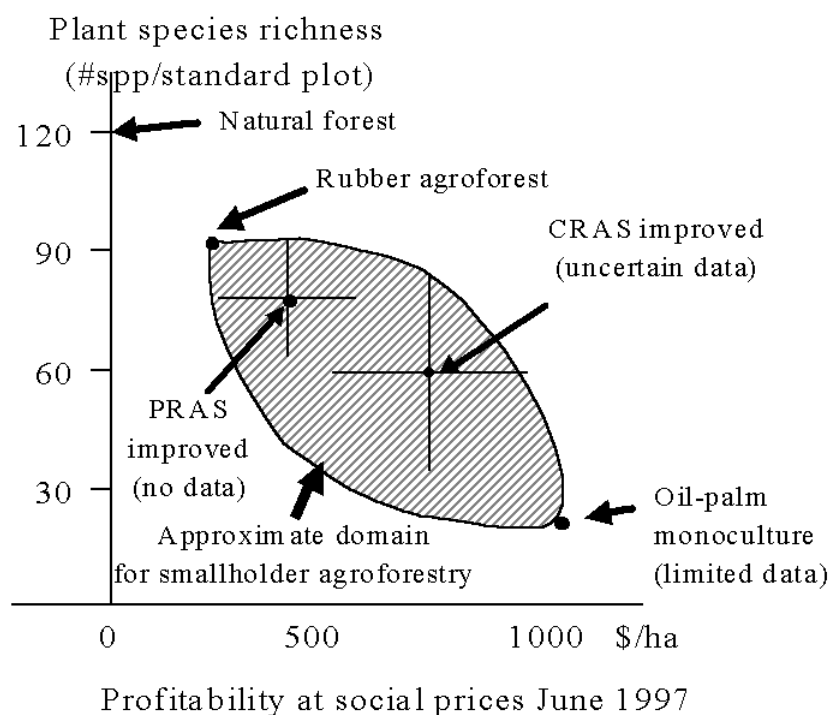


Figure V.1 Potential profitability versus biodiversity for new technology

V.3 Potential for development of technological options

A wider range of tree-based ‘best bet’ alternatives for smallholders should be examined regarding their environmental, agronomic, and economic impacts and feasibility of adoption. The priorities listed in Table V.2 were identified by scientists active in the ASB-Indonesia Research Consortium at a national meeting held in Bogor on 6 May 1998.

Table V.2 Priorities for further studies of Sumatran land uses

‘Meta’ land use	Corresponding land use in Sumatra	Type / scale of operation	Landscape mosaic context	Remarks
Candidates for new studies in the Penneplains				
Simple treecrop systems	Smallholder oil palm monoculture	Smallholders’ plots of 1-5 ha	Indigenous smallholder landscape mosaic	Identified as a priority at May ASB-Indonesia meeting: need for study in Jambi and Lampung?
	Smallholder timber monoculture	Smallholders’ plots of 1-5 ha	Indigenous smallholder landscape mosaic	Identified as a priority at May ASB-Indonesia meeting: need for study in Jambi and Lampung?
Candidates for new studies in the Piedmont				
Multistrata agroforestry systems	Robusta coffee under shade	Smallholders’ plots of 1-5 ha	Indigenous smallholder landscape mosaic	Linked to watershed work in Lampung – high priority as part of ‘scaling up’ efforts.
	Damar agroforests (rice-pepper-coffee-fruit-damar)	Smallholders’ plots of 1-5 ha	Indigenous smallholder landscape mosaic	Lots of data on this system are available.
Simple treecrop systems	Robusta coffee monoculture	Smallholders’ plots of 1-5 ha	Indigenous smallholder landscape mosaic	As noted above, linked to watershed work in Lampung – high priority as part of ‘scaling up’ efforts.
	Cinnamon monoculture	Smallholders’ plots of 1-5 ha	Indigenous smallholder landscape mosaic	Most of the data needed are available from a recent dissertation.

Smallholder rubber production continues to be the most important source of income in most of the lowland peneplain of Sumatra and W. Kalimantan. The current economic crisis has benefitted rubber farmers as their rupiah income has increased more than inflation, despite the decrease of world rubber prices when denominated in dollar terms. Yet, to remain an attractive option, rubber productivity (per unit labor and per unit land) will have to increase. We are exploring the potential to incorporate higher yielding clonal rubber into smallholder rubber gardens, building on farmers' current knowledge and decision-making skills. Past efforts have been geared toward part of the target group only, and may have insufficiently addressed the concerns and constraints of small scale farmers.

Our experiments have shown that selected high-yielding clones can be successfully established in smallholder systems at substantially reduced management intensity, compared to the monocultural plantations for which they were originally selected. Weeding intensities of 1-3 times per year are sufficient for good rubber growth, and this need only be done within the rows of rubber trees. We find that fertilizer application can usually be reduced or eliminated. The main constraint to rubber establishment appears to be pig and monkey damage, which can be controlled by fences, bamboo shafts around individual trees, or regular guarding of the plots. The bamboo shaft technique, a common practice in one of the study villages, but not known in others, appears to be effective against pig damage.

Rotational Agroforestry Systems ('RAS') consist of an establishment phase, during which food crops can be interplanted with young trees and a phase in which the trees dominate, before the cycle starts all over, by a (field-level) clearing (often by slash-and-burn) to prepare the land for a next cycle. The harvested fraction of total biomass differs widely from near zero in classical fallow systems to over 50% when most wood is harvested and only branches and 'slash' are left in the field. A wide range of RAS system has been developed in various parts of the world, ranging from crop-(improved) fallow rotations, where annual food crops provide the main value to systems where trees such as rubber make the 'fallow' by far the most important phase for continuous revenue generation or where the final harvest of an established wood-lot dominates, as in 'taungya' systems. Where the annual food crops dominate, system improvement will often tend to shorten the cycle, by choosing fallows which restore soil fertility faster. Where the trees (formerly thought of as 'fallow') provide the main value, the systems may evolve toward longer cycles. But all RAS systems have in common that the rotation has a clear end point at which the farmer decides to fell the trees and re-plant (when the expected gains of doing so are higher than the expected gains of waiting). This means that slow-growing trees have little chance to mature, unless they are very profitable. Some forms of RAS such as rubber agroforestry systems can allow the regeneration of part of the natural forest vegetation, but only for those species that reproduce within the maximum age of the stand.

In contrast to these rotational systems, we may distinguish a class of **Permanent Agroforest Systems ('PAS')**, where rejuvenation takes place at a patch level of one or a few trees, without slash-and-burn land clearing. The system approaches the character of a permanent, forest-like vegetation, even if it started in the same way as a RAS. Prime examples of PAS are Damar agroforests of Krui West Lampung (Sumatra) and mixed fruit tree gardens ('Tembawang') of Kalimantan and Sumatra. Part of the rubber agroforests has evolved in this direction, where gap replanting leads to mixed-age vegetation. Slow-growing elements can be retained in such a system to reach maturity, as decisions are made on a tree rather than forest basis. Environmental values, such as biodiversity conservation and C stocks, which tend to increase with age, can be substantially higher in PAS than in RAS, while environmental problems associated with the slash-and-burn methods used in starting a new cycle in RAS are absent in PAS.

Does this mean that Permanent Agroforest Systems are a 'better bet' than Rotational Agroforestry Systems within the frame of the 'Alternatives to Slash and Burn' project where environmental values are considered as well as profitability? For the time-averaged C stock we may expect an increase of about 30 Mg C ha⁻¹ as the average age goes up from 15 – 20 years for a 30-40 year cycle, to 30 for a 60 year's life span of individual trees. Net GHG emissions are likely to be reduced as the agroforest soil can probably maintain a loose topsoil structure and phases with excess mineral N and thus N₂O emissions can be reduced by managing the regeneration process. No problems are to be expected with the sustainability criteria used in our evaluation, so the profitability and institutional issues may be the main concerns. Returns to labor may be reasonable, if a comparison is made with NTFP collection and rubber agroforestry, but the returns to land will probably be less than the maximum in Table IV.3. There also are institutional concerns: PAS systems that mimic natural forests have been mistaken for natural forests and classified accordingly by state forestry officials, denying access to the farmers (or their children) who planted and managed the trees.

PAS normally occur in a mosaic with land uses that allow food crop production on a rotational or permanent basis, such as in paddy rice fields. Full reliance on the market as a way of ensuring local food security has not generally been attractive, even for PAS systems which generate a constant flow of revenue such as the Damar agroforests. Agroforest managers can spread risks by maintaining a broad portfolio activities, which may yield or earn good prices in different years. The opportunities of benefiting from genetic selection in tree planting material may be no less than in RAS, provided the planting material suits the more competitive environment of an established stand, with less opportunities for the farmer to manage above- and belowground growth conditions to meet the needs of a young individual tree.

All tree-crop based production systems evaluated during the second phase of the ASB project in Indonesia are Rotational Agroforestry Systems. Yet, information on the scope of rubber agroforests evolving towards PAS has gradually accumulated. Sandy Williams (*pers comm.*) documented farmers' experiences with gap replanting in Jambi and found evidence of active relocation of rubber seedlings to make use of relatively open places in existing rubber gardens and selective cutting of non-rubber trees to facilitate rubber sapling establishment. Since damage by pigs and monkeys is a major risk to young rubber planted after field-level slash-and-burn, farmers experimented with planting young rubber among partially-cleared fields. This may reduce the risk of predation, but at the same time does not allow the farmers to take further measures such as fencing. Franz Gatzweiler (*pers comm.*) working in West Kalimantan found that rubber agroforestry systems can gradually evolve into mixed fruit/timber PAS ('tembawang') by interplanting and allowing natural regeneration to take place.

To complement current data, a further analysis of PAS management of rubber agroforests is needed. Two options for management should get attention:

- rubber regeneration by gap planting, and
- enrichment of rubber gardens with fruit and timber species.

Best bets for rehabilitating degraded lands

The options for farmers who are trapped in the cassava/*Imperata* cycle are reduced in comparison with those in the forest margin. The soil has been depleted of those forms of organic matter that can feed crops of young trees by mineralization. However, the soil is not depleted of soil organisms, including micro-symbionts such as mycorrhiza and N fixing microbes. Development of tree-based production systems can be hindered by the landscape context of such plots, with a large chance of fires raging through plots where individual farmers would plant trees. The soil seedbank is nearly exhausted and there is a limited array of tree species that can reach the plot and start the process of succession towards forests – most trees will have to be introduced by the farmer. In what may seem a hopeless situation for any individual, it may be more attractive to abandon the land, look for employment in the city, or open new land where the forest margin is still accessible.

The situation in the North Lampung ASB benchmark area illustrates these hardships, aggravated by the long dry season of 1997 and its effects on the trees that had been planted (against the odds). A long drought and intense fires were followed by a locust plague during the next growing season, devastating rice, maize and sugarcane crops. Opportunities for off-farm employment meanwhile were reduced as the sugarcane plantation in the neighbourhood barely survived. The local (illegal) sawmill (which transformed the last trees left in the landscape into construction wood and provided local employment), closed down as timber supply was depleted and the building boom in Jakarta collapsed.

Are there any bets which are still worth making for farmers in such circumstances? Our rather abstract analysis of 'best bets' may need a reality check. Cassava prices have increased after the drought and cassava production is gaining in popularity – despite our judgement that this is not sustainable. Intensive food crop production is biophysically possible, but requires substantial investments beyond the means of local farmers. Oil palm and rubber are feasible, although for both tree crops the length of the dry season is near the limit. The long dry season of 1997 may have caused a 40% decline in oil palm yields in this area (with effects on fruit production for about a year after the drought), while rubber yields in plantations were only reduced by 10 % (S. Budiman, *pers comm.*). Farmers in the benchmark area still see smallholder oil palm production as an attractive option and are willing to work hard to clear *Imperata*-infested plots. They reckon they can clean only ¼ ha per year. This type of oil palm production differs substantially from the 'nucleus estate – smallholder scheme' on which most government projects are built. It definitely deserves a further study of its prospects, opportunities and constraints. Rubber agroforestry may be the other main opportunity for farmers in the area, managed as pure stands or mixed with timber trees or fruit trees (*Paraserianthes* is popular but did not perform well in the long dry season of 1997, except for the wettest places in the landscape). A wider array of trees is needed to diversify production for these circumstances. Initial farmer surveys have shown interest in a number of local trees (including *Alstonia* or 'pulai') as well as introduced species. Markets for locally-produced wood may be well enough developed, as there is hardly any wood coming from forest remnants. There are some remnants of mixed fruit tree agroforests, as well as early stages of such a system, based on local fruit trees that have undergone little selection and 'domestication'. Marketing of such fruits is not well developed, but road access may be good enough. Outside the ASB benchmark area many farmers have planted rubber already, often intercropped with cassava. The cassava – rubber combination is considered risky in the rubber literature as it entails a risk of root diseases shared in the *Euphorbiaceae* family to which both belong. Farmers may not be aware of these risks, or simply feel that they have no choice, as direct income is needed while waiting for rubber to become productive.

Would this type of tree-crop based intensification of land use be relevant to interest groups aside from the farmers directly involved? The answer to this question has a local/direct part and an indirect one, based on migration as an option for people in the benchmark area. (This depends whether improved opportunities in areas such as the benchmark area reduce the pressure on the forest margins). Direct consequences for biodiversity conservation of a tree-based intensification in the degraded lands are likely to be small, but a change from a land use with a time-averaged C stock of 40 Mg ha⁻¹ to one of 100 Mg ha⁻¹ could be significant. Net GHG emissions may increase during such rehabilitation, as the availability of mineral N will have to increase, but excess N fertilization (standard practice in intensively managed oil palm plantations) may be less likely to occur under smallholder management.

V.4 Potential for adoption of existing land use alternatives

The ASB-Consortium will marshal its research results in order to inform key planners and policymakers about the potential environmental, social, *and* economic benefits of a smallholder-based development strategy as an alternative to large-scale plantation monoculture. But, as already mentioned, there are some important institutional questions that must be addressed to enable widespread adoption of profitable alternatives by smallholders. Table V.3 on market institutions and Table V.4 on other institutional issues are summaries of a more elaborate assessment of institutional requirements following Vosti *et al.* (1998). Although it does not capture all the nuances of these complex institutional issues, the following notation was developed to ‘flag’ the most serious **institutional barriers to adoption by smallholders** for further detailed analysis:

- ⊕ indicates **no constraint**, interpreted as a ‘green light’ to go ahead with development
- ◆ indicates a **possible constraint**, a ‘yellow light’ meaning proceed but with caution
- flags a **serious constraint**, a ‘red light’ that jeopardizes prospects for adoption of the alternative by smallholders

Market institutions

Input supply markets. Planting material supply markets are the greatest barrier to adoption of profitable alternatives by smallholders – indicated by ‘red lights’ for clonal rubber and for oil palm. For example, farmers have little access to improved rubber planting material. The Treecrops Advisory Service, which is virtually the sole provider of rubber budwood, has focused its efforts on supplying planting materials to project participants in the past and largely has ignored the much larger number of non-participants (Tomich 1991). Except in a few areas of Sumatra, the private nursery industry has only begun to develop. For public and private sources alike, there are serious problems of reliability regarding quality of planting material, which is difficult to assess until several years after planting. Current delivery pathways for improved planting material (and the information needed to use it) seem inadequate, but direct government intervention to supply germplasm may be neither feasible nor desirable. For example, subsidizing germplasm would hamper development of a private nursery industry.

Table V.3
Institutional capacity vis-a-vis system-specific institutional needs
--A market checklist

Land Use	Input Supply Markets	Output Markets	Labor Markets	Capital Markets
Community forest		◆	⊕	⊕
Commercial logging	⊕	•	⊕	◆
Rubber agroforest (seedlings)	⊕	⊕	⊕	⊕
<i>Rubber agroforest (clones)</i>	•	⊕	⊕	◆
<i>Rubber monoculture</i>	•	⊕	⊕	◆
Oil palm monoculture	•	◆	⊕	•
Upland rice / bush fallow rotation			⊕	⊕
Continuous cassava degrading to <i>Imperata cylindrica</i>	⊕	◆	⊕	◆

blank = n.a, ⊕ = no constraint, ◆ = possible constraint, • = constraint

Output markets. Government restrictions on marketing and international trade are the greatest barriers to development of smallholder timber-based alternatives and also hinder community-based forest management. Beginning in 1998, government has agreed to begin deregulation of timber exports, to abolish joint-marketing associations (that functioned as cartels), and to end export quotas and numerous other restrictive marketing arrangements. Although export taxes still are high, private firms now should be free to trade timber as they wish. In Part VII, detailed attention is given to export taxes on timber from agroforestry species, which currently are set at 30%.

Previous restrictive marketing practices damaged most timber companies' marketing capacity by inhibiting development of marketing networks that could respond to buyers' needs. The situation is particularly bad for rattan, since the export ban on raw rattan destroyed overseas markets or induced importers to seek alternate supplies. There also is concern that old 'rent seeking' practices (like the plywood and clove cartels) will re-emerge under new guises. These risks are increased by lack of market information on these commodities. The lack of information probably is worst for non-timber forest products, especially those occupying narrow market niches.

Oil palm also has been subject to export taxes (set at 60% through the end of 1998) and at times export bans (Tomich and Mawardi 1995) that seriously depress farmgate prices. For oil palm and cassava there also are some concerns about development of local markets that can link smallholders with processors. However, these seem to be emerging.

Local markets for natural rubber have functioned for a century or more. Although there are some imperfections affecting quality – viz., difficulty of assessing dry rubber content -- these markets

transmit world price changes to the farmgate rapidly and marketing margins reflect transport and other costs. Natural rubber markets have been subject to few distortions from national policy, but at times the international buffer stock has depressed prices.

Table V.4
Institutional capacity vis-a-vis system-specific institutional needs
--A checklist for other institutional issues

Land Use	Non-Market Information	Regulatory Issues	Local Environmental Impact	Property Rights	Equity Biases	Social Cooperation
Community forest	•	•	⊕	•	⊕	•
Commercial logging	•	•	•	•	•	•
Rubber agroforest (seedlings)	⊕	⊕	⊕	•	◆	◆
<i>Rubber agroforest (clones)</i>	•	⊕	⊕	•	◆	◆
<i>Rubber monoculture</i>	•	⊕	⊕	•	◆	◆
Oil palm monoculture	•	◆	◆	•	•	◆
Upland rice / bush fallow rotation	◆	⊕	⊕	•	⊕	◆
Continuous cassava degrading to <i>Imperata cylindrica</i>	◆	⊕	•	◆	⊕	◆

blank = n.a., ⊕ = no constraint, ◆ = possible constraint, • = constraint

Labor markets. Although the complete analysis also included skilled labor requirements, the summary analysis presented here focuses on unskilled labor. Instead of hiring permanent skilled workers, smallholders may be more likely to develop certain technical skills themselves. So the relevant barrier is the acquisition of technical information (considered in Table V.4) rather than the market for skilled labor. Although labor markets in Sumatra fall short of the theoretical ‘ideal’ of economics textbooks, recent empirical studies linked to ASB (Suyanto *et al.*, 1998a and 1998b) indicate that labor markets work reasonably well. All alternatives get ‘green lights’ regarding unskilled labor markets. It is worth noting that casual markets for skilled labor (e.g., chainsaw operators) also are emerging.

Capital markets. Capital market problems are second only to planting material supply as a barrier to adoption resulting from market imperfections. As already noted, there is no long-term institutional credit available in rural Sumatra. Household savings, which financed investments in existing smallholder agroforestry systems like rubber agroforests, are often underestimated. In rural Indonesia, farmers are able to receive considerable credit from informal sources (relatives,

moneylenders). However, current economic hardships – especially rising food prices -- may be straining these resources. Capital market imperfections (lack of credit and interest rates well above the social price of capital) may constraint smallholders' nutrient purchases for cassava production, use of clonal rubber planting material, and certainly are a barrier to smallholder oil palm. Whether or not smallholder timber extraction is constrained by capital market imperfections depends in part on development of contract markets for chainsaw services and log transport.

Other institutional issues

Non-market information. Information acquired from research (e.g., new technologies) comes primarily from the Government and existing research facilities are inadequate to meet research needs of the diverse productions conditions of these land uses. This constraint is particularly severe for alternatives, such as NTFPs and smallholder timber, that are not high priorities for Government, especially compared to rice, the staple food. This bottleneck on technical information is a concern for all systems, except rubber agroforests using seedlings where indigenous knowledge is well developed.

Regulatory issues. As discussed above under output markets, policies that restrict access to markets are a particular concern for timber and non-timber forest products and for oil palm. This is compounded for timber and NTFPs by policies that attempt to restrict access to State Forest Land, even if it has been used by local people for generations (see property rights below). Thus, especially for timber and NTFPs – but to a lesser extent for oil palm – success in these alternatives requires considerable investment of time (and often money) to ‘work the system’ under current policies.

Local environmental issues. Based on available data, production of most of these systems earns a ‘green light.’ (However, there may be water and air quality concerns arising from the processing of rubber, oil palm, and cassava.) The exceptions are large-scale logging and continuous cassava cultivation, which are susceptible to erosion. As we emphasized at the end of Part IV, further work is needed to assess the environmental impacts, including air quality, landscape biodiversity, and watershed functions, of expansion of particular alternatives.

Property rights. This is a highly-charged political issue that draws a ‘red light’ for all systems except continuous production of foodcrops on a transmigration site; even here there can be problems of tenure conflicts with indigenous groups that pre-date the settlement. In most cases, tenure status of lands at the forest margins (and the products derived from those lands) needs to be clarified between the government and local communities. The damar agroforests in Krui exemplify this situation. Although developed and managed by smallholders for over a century, this land recently was classed

as State Forest Land. As discussed in Part VII, a breakthrough came in this particular case with the former Minister of Forestry's decision to declare the damar agroforest as a 'Special Use Zone' (*Kawasan dengan Tujuan Istimewa; KdTI*) recognizing farmers' rights to manage these agroforests and enjoy the benefits derived from them (See section VII.1). It is hoped that this approach can develop into a prototype for addressing this serious institutional problem.

Equity biases. The primary concern is that potential economies of scale will lead to concentration of land under commercial logging, for which scale economies have been documented elsewhere, and for oil palm, where scale economies probably are not intrinsic but may result from current development policy. Despite the conventional wisdom, the prevailing faith in economies of scale in production of so-called 'plantation' commodities receives little (if any) support from agricultural economics (Hayami; Tomich, Kilby and Johnston). This is, nevertheless, an empirical question that requires further investigation in the next phase of ASB research. Unlike production, marketing and processing of primary products often are characterized by increasing returns to scale. This is the case for three of the most important land use alternatives--rubber, pulp, and oil palm--in Sumatra. The natural rubber industry in Southeast Asia provides an excellent example of the efficiency with which markets can integrate low-cost production by smallholders with processing in factories that achieve economies of scale; similar marketing arrangements should work for pulp. Oil palm conventionally has been viewed as an estate crop in Southeast Asia (but not in Africa) because of its perishability. Even in this case, however, oil palm production on independent plots as small as one ha began to emerge in Sumatra in the 1980s. Outgrower schemes, contract farming, and other institutional arrangements all can help reduce transactions costs in linking efficient smallholder producers with efficient large-scale processors.

There also is some cause for concern regarding gender bias since recent studies have shown that tree planting induces a shift from matrilineal inheritance to partilineal inheritance for some categories of trees in some areas of Sumatra (Suyanto *et al.*, 1998b). Ongoing studies led by the International Food Policy Research Institute (IFPRI) should add to our understanding of potential gender biases.

Social cooperation. The main need for social cooperation concerns the two forest extraction alternatives, community based extraction of NTFPs and logging. In each case, sustainability of the land use is in doubt if communities cannot manage a system to restrict access to their common property resources. Indigenous communities with their customary laws intact appear to have this capacity (see discussion of 'KdTI' in Part VII); recent settlers may not. Collective action also is required for fire and pest control, and may be an emerging constraint in many agricultural systems.

