5.10.2 Environmental and socio-economic advantages of developing the rubber wood industry

Table 28 gives estimates of the C-emissions saved per year if rubber wood were utilized instead of burned at the time of rubber replanting. The amount of carbon release per ha is calculated based on Murdiyarso and Wasrin (1995). According to them, the amount of carbon released as a result of land use change from the secondary forest, including jungle rubber, is estimated at 245 ton/ha C DW (dried weight). This is equal to 45% C or about 110 ton C/ha. This C release includes both CO_2 and CH_4. Roughly 95 % of carbon from burning rubber wood will be released as CO_2 and 5% as CH_4. The effect of CH_4 on global warming is 25 times the equivalent CO_2 in terms of radiative forcing. C-emissions would be reduced about 30% if rubber wood were used. The total amount of carbon released is calculated by multiplying the rate per ha times the area of rubber replanting. The estate subsector replants approximately 3% of its area each year, amounting to 16,000 ha. Even by the most conservative estimates, smallholders replant well over 30,000 ha per year (Tomich, 1991). But some of the smallholder area is isolated, so it is unlikely that it would be economic to market all of this rubber wood even if policies were changed. Assuming that only one-third would be marketable yields a conservative estimate of 10,000 ha for the smallholder subsector. Thus, a conservative estimate for the total of estates plus smallholders is 26,000 ha.

The volume of rubber wood per ha can be calculated by multiplying the wood density (0.4 kg m^{-3}) by the amount of rubber wood biomass (30% of total biomass). From this calculation, it is estimated that the output of rubber wood per ha could be 185 m^3. On the other hand, the output of natural forest wood under selective cutting is 40-80 m^3 ha^{-1}, with an average of 60 m^3 ha^{-1}. Therefore, one ha of rubber wood can produce the same volume of wood as three ha of natural forest.

The total amount of carbon released from burning rubber wood *in situ* during rubber replanting is around 2.87 million tons of carbon. This corresponds to almost 10 million tons of CO_2 and 13.1 million tons CH_4 equivalent to CO_2 radiative forcing to the atmosphere. The amount of CH_4 released is only 200,000 tons, but the effect on global warming is 25 times the equivalent of CO_2 radiative forcing. If the rubber wood were utilized, not burned, it would save a total of 859,950 tons of carbon. This is equal to almost three million tons of CO_2 and 3.94 million-ton CH_4 equivalent to CO_2 radiative forcing.

Compared to the total net C-emissions released as result of deforestation in Indonesia, which is estimated at 192 million ton (Murdiyarso *et al.*, 1994), the total amount of C-emission saved through utilization of rubber wood is only 0.5 percent. However, besides reducing C-emissions, rubber wood utilization also can reduce pressure on natural tropical forests since rubber wood can substitute for ramin, agathis, meranti, and other woods from tropical forests in Asia.

Development of rubber wood in Indonesia is in line with the smallholder rubber replanting program and it will generate economic benefits for the rural population. By selling rubber wood, farmers can cover costs of land clearing and still receive around Rp600,000 ha^{-1}. This money could cover about half of the costs of purchasing higher-yielding clones and fertilizer for rubber replanting.

Table 28. Estimates of C-emission saved per year under utilization of rubber wood at the time of rubber replanting

Type of Carbon	C-emission releases under rubber wood burned *in situ*		C-emission releases under utilization of rubber wood		C-emissions saved under utilization of rubber wood	
	Per Ha (Ton)	Total (Mt)	Per Ha (Ton)	Total (Mt)	Per Ha (Ton)	Total (Mt)
1. Amount of Carbon released	110	2.87	77	2.00	33	0.86
2. Amount of CO_2 released (ton)	384	9.98	269	7.00	115	3.00
3. Amount of CH_4 released (ton)	7.0	0.19	5	0.13	2	0.057
4. CO_2-equivalents in radiative forcing (ton)	481	13.1	344	9.17	138	3.94

The development of rubber wood also will increase foreign exchange earnings. The rubber wood market has a good prospects. Since the late 1980s, the international price of rubber wood has increased because of rapid depletion of ramin and agathis wood. The consumption of rubber wood in the major importing countries in 1991 is estimated at 238,000 m^3 and it is projected to increase to 350,000 m^3 by 1996 (ITC 1993).

5.10.3. Barriers resulting from policy distortions

Unfortunately, policy-induced distortions probably present a greater barrier to use of smallholder's rubber wood than the technical issues discussed above. The opportunity of improving both environmental and socioeconomic conditions by developing rubber wood in Indonesia still has not been achieved. According to ITC (1993), utilization of available rubber wood in India, Thailand and Malaysia is 96%, 83% and 62%, respectively, while Indonesia was using only 27% of its potential supply of rubber wood. Even though current use of rubber wood in Indonesia is still low, Indonesia has substantial potential for rubber wood production since it has the largest area of rubber in the world (3.4 million ha or around 34 percent of the total rubber area).

Local trade regulations and export taxes are the two main policy barriers to development of rubber wood marketing in Indonesia. Local trade regulations have restricted processors from purchasing rubber wood from smallholders in some regions. CPIS (1993) reported that the Governor of West Kalimantan issued Decree No. 03/1991 dated 4 January 1991 that imposed levies of Rp30,000 and Rp12,000 per cubic meter on sawn rubber timber and medium density fiber wood, respectively. Similarly, in South Sumatra levies also have been imposed on operators of rubber wood plants, include a replanting levy set at 13.5 percent of the processed wood prices (*The Jakarta Post*, 6 December 1988). Besides that, the Treecrops Advisory Service in West Kalimantan has issued extremely complicated guidelines on authorization for and mechanisms of felling rubber (CPIS, 1993). The regional levy and the bureaucratic mechanisms retarded the development of rubber wood marketing. It is not surprising that the only rubber wood factory in West Kalimantan is now operating at only 30 percent capacity; and several rubber wood factories in South Sumatra have stopped operation.

Since 1989 Indonesia has imposed an export levy for rubber wood. Through the Finance Minister's decree No. 1134/1989, government set export levies on three major groups of sawn timber at \$250-\$2400 m^{-3}; including an export levy for rubber wood of \$250 m^{-3}. Then, in 1992 the government raised the export levy to \$500-\$1200 m^{-3}, depending on the product. Indonesia and Malaysia are the only two rubber wood producers that impose export levies on the sawn timber of rubber wood. The export levy in Indonesia is the higher of the two by far; since 1990, Malaysia's was only \$ 50 m^{-3}.

Indonesia's policy stems, in part, from official concern that processors will exploit smallholders, enticing them to cut their rubber trees prematurely. There is no evidence, however, to support this view. On the contrary, it is older rubber tress that are most valuable to processors, who are free to buy wood from large-scale plantations anywhere in Indonesia. Thus, trade restrictions (unintentionally) are biased in favor of large-scale plantations and reinforce plantations' technical advantages as rubber wood suppliers.

The official anxiety that smallholder farmers will cut their young rubber trees is not reasonable. Analysis based on net present value (NPV) calculations of the economics of replacing rubber trees at different ages indicates that farmers are unlikely to cut rubber trees for wood before rubber trees are about 26 years old. This conclusion that rubber wood sales would not encourage farmers to cut young rubber trees is consistent with the results of other researchers. For example, Sumana *et al* (1991) reported that their studies in Lampung showed 84 percent of respondents only cut trees aged 20 years and over for rubber wood. The average age of rubber trees cut for wood was 27 years, and only 16 percent of respondents reported cutting trees less than 20 years old (with the average age for that group being 19 years). As expected, farmers do not cut young trees. Instead they wait until yields are low and the number of trees on the plot has decreased. Thus, the available evidence indicates that official fears are groundless: smallholders will not irrationally cut young rubber trees.

5.11 Changing tenure institutions and tree crop growing in park buffer zones: A case study from Kerinci Seblat National Park

5.11.1 Introduction

Minangkabau communities in West Sumatra have preserved their systems of matrilineal land control and communal forest management (Murniati *et al.*, 1995) economic change has drastically transformed Minangkabau farmers' life style. Has this changed traditional land tenure institutions? If so, what is the influence on forest land uses. Many assumptions regarding successful buffer zone management are widely accepted, such as:

1. Preservation of the local custom (*adat*) is crucial for community-based forest management;
2. Rural poverty aggravates forest degradation as farmers have no other resource alternatives;
3. Tree growing alleviates farmers' forest exploitation, by promoting farmers' sedentary farming.

A study was made of Minangkabau farmers' forest and land use systems in the buffer zone of the Kerinci Seblat National Park, between the Air Dingin and Rantau Pandan benchmark areas for the ASB project to test these assumptions. The study area is divided into three parts. The southern and central parts are old settlement areas, while the northern part has been opened up since the 1930's by in-migrants from the southern part of the study area and the northern highlands outside the area. The southern and central parts are located on alluvial plains between mountain ranges, while the northern parts are hilly and mountainous. The altitude ranges between 400 m and 1000 m. The population density is about 400 to 500 persons per km^2. Main dryland crops are coffee throughout the area. Rubber is also common in the southern part; annual crops such as chili are widely grown in the northern part. Cinnamon is gaining in popularity in the area.

5.11.2 Traditional customs on land control

Minangkabau communities are based on matrilineal and communal social structure. The custom stipulates egalitarianism and harmony within the clan/lineage. They have developed a social hierarchy with levels such as nagari, clan, sub-clan, lineage and sub-lineage. The clan is an exogamous honorary kinship group by matrilineal descent or adoption, headed by its head, or the king. Lineage (or extended family) is the kinship group sharing the same grandmother, but headed by a male leader. Mothers' brothers show strong leadership. The nagari is a closed and corporate community unit, composed of several clans. However the nagari is autonomously governed under mutual agreement of clans, without its own head.

Minangkabau communities have elaborate communal land and forest management systems. Each nagari, clan and lineage developed its own forest and land territories, under the mutual agreement of its members. No individuals were allowed to own land and lineages were the primary land holding corporations. Nagari land/forests were reserved for communities' public purposes. Farmers must ask for approval of all clan/lineage leaders before cultivation of nagari land. Tree tenure was relatively easier as compared with the land holding. After approval by the clan or lineage head, farmers can grow tree crops freely with full ownership. Perennial crop inheritance depends on lineage decisions, but planters' children can inherit at least part of the trees planted.

In older days forest territories were created among clans/lineages. In particular, lineages were the primary forest owners. Lineages determined the borders after consultation. However they had no limitation on clearance of the forest and could open the forest as far as they wanted.

The land is owned communally by the female members. Men can get nothing but land use rights. In general men work on parts of their mothers' lineage land before marriage. After marriage, however, they must move to their wives' land for their daily cultivation. Men's economic life depends largely on their wive's lineage assets. Despite that they cannot participate in land affairs of their wives' lineages.

In Minangkabau area the land is classified into inherited land and private land. Then the inherited land is classified into high ancestral land (pusako tinggi) and low ancestral land (pusako rendah). High ancestral land is inherited communally from lineage to lineage, controlled by its male leaders. The land cannot be inherited from parents to children, but from aunts to nieces. Low ancestral land is inherited jointly from parents to children - usually daughters, but sometimes also to sons. Newly opened or purchased land is private land, held jointly by a nuclear family. However the land is converted into low ancestral land (family land) after inheritance. After inheritance for many decades, low ancestral land becomes high ancestral land (lineage land) which is controlled by its lineage.

Cultivated land is controlled by blood relationship rather than territorial bond among lineages. Even out-migrants can still lay claim to their land. In-migrants can similarly be given land use rights after being accepted by local lineages (often through marriage) without particular limitations.

5.11.3 Change in land tenure institutions and its impact on land use

The southern part of the study area was first opened by a group of pioneers long ago. As the population grew, they had to open land outside their community area. It is believed that land distribution became unequal among lineages as a result of severe competition among them for favorable land. Some poor lineages were obliged to move to the central part of the study area to get new land.

Today nagari and clan communal land has disappeared in the study area, probably because of: 1. population growth and expansion of clans made it impossible to manage large communal land without strong authority; and 2. massive in-migration resulted in disintegration of the clan/nagari communities of the area. Lineage forest territories have also disappeared since the 1960's, when farmers' mobility got higher. Lineage leaders and members often migrated out for better economic opportunities, and thus they could no longer manage their forests. In-migration has also precipitated disappearance of lineage forests.

In-migration has been very active in the northern part of the study area, which has brought land tenure problems. In-migrants arrived in the northern and central parts from both the northern highlands and the southern part of the study area for different reasons. Large farmers, mostly from the southern part, acquired their own family land free from lineage control for their children, while preserving the lineage land in their older villages. Small scale farmers, mostly from the northern highlands, acquired the land for their daily livelihood, faced by land fragmentation and subsistence crisis in their older villages. Large farmers obtained control of the better land in the lower part, while small farmers were obliged to reclaim small plots of the upper forests.

Even large farmers rely mainly on their own family labor for cultivation, which often results in idle land due to labor shortage. Their children often migrate out to other areas. Many members of their family still live in the older villages, so they must move between the two areas to work the land. In a few cases they allocate labor to their own land from the outside, however.

Forest clearance patterns vary among farmers. In general large farmers open as much land as possible at once, where they gradually introduce crops. They want to secure the land for future generations. In other cases large farmers gradually increase small plots of land, by moving elsewhere after planting crops on the existing land. Small farmers usually open up only one small plot of forest at a time because of capital constraints. Then they gradually plant crops on the land.

Land selection is in principal free for slash-and-burn cultivation. However, a new farmer must ask for approval of the owners of land surrounding his plot in order to fix the land borders and to prevent future disputes that can lead to destruction of crops by fire or violent clashes. Lineage consultation is not required since disappearance of lineage territories in the forest.

Land control patterns are varied among the three parts of the study area, in accordance with social structure. In the southern part, land distribution has been unequal. Population growth precipitated land segmentation among these lineages. However lineage bonds are relatively strong in these old communities, which contributes to preservation of customary rules. High rice productivity and earlier crop diversification also encourage farmers' preservation of existing community land and acquisition of new land in and outside their villages. Severe competition drives farmers to encroach into the remote forest for coffee and cinnamon growing. In the central part lineages have held large rice fields with high rice productivity and farmers were less concerned with crop diversification. Lineage control has been relatively weak in this part, and even the lineage land was often sold out to farmers from the southern part. Consequently a lot of farmers have become landless. Swiddens have expanded far into the forest, but it is large farmers rather than small farmers who actively opened new land, mainly for coffee and cinnamon. In the northern part the land is newly cultivated on a private family tenure basis. Farmers are being organized, but traditional lineage leaders are rarely present. Although it depends on families' economic ability, the matrilineal land inheritance rule is generally preserved well.

Farmers have long lived on rice, but commodity crops are increasingly important for farmers' economic needs, and thus swiddens have expanded, mainly for cinnamon and coffee, but also some rubber.

The traditional forest control system has almost disappeared except in the former lineage and nagari forests in the southern part of the study area. Territorial forest control is relatively weak. Forest land is no longer controlled locally, especially with the increase in absentee land owners and in-migrants. Farmers can get land and grow crops easily in the inner forest, as the forest is free from lineage control.

In general communal land control is breaking down as seen in sales of lineage land. Poor farmers often divide their plots and give the land to their children, which is prohibited by the customary rules. However matrilineal land inheritance still operates. Transformation of the land tenure system could bring about disputes within lineages or families. Serious land segmentation also affects changes in the land tenure system. For example, communal land holding tends to reappear under severe land shortage.

The next phase of this research program will focus on economic analysis of the relationship between land tenure institutions and land use patterns. The follow-up study is being conducted in collaboration between ICRAF and IFPRI (International Food Policy Research Institute), led by doctoral student Masahiro Otsuka under the supervision of Keijiro Otsuka (Tokyo Metropolitan University and IFPRI) and Thomas P. Tomich (ICRAF SE Asia).

5.12 Contributions of agroforests and nagari forests to reducing of farmers' forest product gathering in Kerinci Seblat National Park

5.12.1 Introduction

Forest product gathering by farmers was analysed in relation to their farming systems to test the hypothesis that the presence of agroforests and nagari forests as a buffer zone outside the national park can help to reduce farmers' dependence on Kerinci Seblat National Park (KSNP). The research was conducted in three villages in the park buffer zone, located in Sungai Pagu Sub-District, Solok District, West Sumatra (Murniati *et al.*, 1995).

The park buffer zone consists of nagari forests and human settlement particularly in Solok District. Nagari forests used to be production forests that provided sufficient cash income to nagari. As the inhabitants' demand for agricultural land grew, however, nagari forest areas were gradually converted into farmland such as agroforests. Natural nagari forests are still found, although their area occupies no more than 10 % of the study area. The forest still functions as resource base to meet communities' needs, particularly fuelwood.

Farm household interviews were conducted with respondents stratified by farming activities such as: 1. farmers who have rice fields; 2. farmers who have only agroforests; and 3. farmers who have both. Interviews focused on management of agroforests and nagari forests, as well as farmers' forest product gathering from the park.

5.12.2 Results

Interviews with 60 respondents showed that some forest products are gathered routinely, while other gathering inside the park forest in intermittent. The forest products routinely gathered for farmers' livelihoods are timber for boards, poles and fuelwood (especially for sale). Rattan, incense, palm fibers, game animals (deer and monkeys) and fish are forest products that are gathered (or hunted) intermittently.

Tree species often logged for construction are various kinds of "madang" of the *Lauraceae* family, "bayur" (*Pterospermum javanicum*) of the *Sterculaceae* family and "borneo" (*Shorea platyclados*) of the *Dipterocarpaceae* family. Common species for fuelwood (particularly for sales) are "paniang-paniang" (*Quercus* spp.) of the *Fagaceae* family, "baliak-baliak angin" (*Mallotus paniculatus*) of the *Euphorbiaceae* family, and "jambu lelen" (*Bellucia asinanthera*) of the *Melastomaceae* family.

Farming households who have only rice fields or agroforests, but not both, collect (on average) forest products worth Rp300-400,000 per year per household. For households who have access to both rice fields and agroforests, the average value is only Rp66,000 per year per household.

Regression analysis revealed a tendency that income from gathering forest products is negatively correlated with income from other sources. However, some of the wealthier households may obtain additional income from forest products by employing labour to collect them.

The nagari forest, both in its original from and converted into agroforests, provides resources to nearby communities to satisfy their needs particularly for fuelwood (for home consumption), vegetables, and medicine. The average value of nagari forest products gathered by the surrounding communities amounts to Rp90,000 per year per household for fuelwood, vegetables, and medicine.

5.12.3 Emerging research issues

Dominant crops in these agroforests are tree crops (coffee, rubber, and cinnamon), fruit trees and annual crops. Timber trees are rarely found, while farmers are still actively gathering a timber from the park forest.

Farmer interviews show that surian (*Toona sinensis*) was often found inside the park. Its wood is suitable for construction. Despite that, it is very difficult to find surian trees nowadays due to farmers' frequent timber extraction. Many farmers said that surian trees were far away (six hours on foot) from their villages. The majority of farmers interviewed are ready to plant surian trees in their agroforests, given a supply of seedlings and extension on planting and maintenance.

5.13 Gender differences and gender relations in a 'translok' and original Lampung community

5.13.1 Introduction

Research on gender-specific aspects of livelihood strategies was started (Elmhirst, 1995) in two neighbouring villages in the N.Lampung benchmark area: Negara Jaya, a "translok" village, home to mainly Javanese migrants, and Tiuh Baru, a Lampungese village, home to the people of the suku (clan) Way Kanan. "Translok" means resettlement of migrants to transmigration project sites.

Negara Jaya was established in 1982 as home to local transmigrants moved from closed forest areas in Central Lampung, notably the Sendang area (near Pringsewu). The village area is characterised by poor soils prone to invasion of *Imperata cylindrica.* Poor soils, coupled with frequent drought and high daytime temperatures, make the area inhospitable for many food crops without high input use. Food crops are largely grown in home gardens and some marshy areas have been converted to rice fields. In the last couple of years, may farmers have been contracted by the nearby Bunga Mayang Sugar Plantation to grow smallholder sugar cane. The population of the village is 3,845, comprising some 910 households, both sponsored and spontaneous migrants. While the majority are nominally own-account farmers, most augment their income with wage work on the sugar plantation and in a nearby concession forest plantation (HTI), or by selling timber to a sawmill in the village.

Tiuh Baru is located on the banks of the Way Kanan river and is home to the ethnic Way Kanan people from up-river, who established the village several hundred years ago. Until recently the village was extremely isolated and reachable only by boat. The area consists of a narrow strip of fertile land along the river surrounded by infertile higher ground, much of which is covered by bush and *Imperata cylindrica* and rarely is cultivated. The village, which consists of closely-spaced traditional-style houses (raised on stilts), has a population of 1,360 divided among 255 households. Residents describe themselves principally as farmers who cultivate the flood plain of the river. Previously, the land surrounding the flood plain was farmed by shifting cultivation, but in the last 10 years this had ceased.

5.13.2 Gender division of labour

The tables 29 and 30 describe in relatively general terms the gender division of labour observable in the livelihood system of each village. Results are given for a questionnaire, a group discussion, and direct observations by the researchers, as these three sources of information do not always agree.

Observation and discussions with both men and women suggest there is nothing that is considered taboo for either sex to participate in. Women say that this has not always been the case, however. In Java there were strong prescriptions against using a *cangkul* (hoe) but this has been abandoned here and women are often to be seen, particularly in pekarangan or dry land, hoeing. It is not clear whether this has been a response to changing times and a general freeing up of "difference" between men and women, or as a response to labour shortage and the necessity of mobilizing all family labour.

Changes over the life course within this division of labour are observable. For women, as small children they are most often to be found helping in the house or the home garden, and if in the fields, their job is weeding. On marrying, women may be confined to the house, unless the family is very poor, in which case her labour is needed. After bearing children, women begin to work in the fields again when the child is six months to one year old, and is carried to the fields with her, or if their is an older child, by the older child. Young unmarried men are most often the ones who will *merantau* - work temporarily elsewhere; in the oil palm industries of other parts of Sumatra as *buruh tani* (wage labourers), or as cultivators of forest land (effectively as squatters) in upland regions to the west of the province, returning after one or two years.

Table 29. Gender division of labour: women's involvement in tasks in Negara Jaya

	Questionnaire	Discussion	Observation
Household tasks			
cooking	women (and daughters) only	women (men say they never cook but women say they sometimes help)	women but if sick, men may step in
cleaning		women (daughters)	women but if sick, men may step in
washing clothes		women (daughters)	
child care	mainly women but men sometimes		men play. Often sibling's job
carrying water		women but men sometimes	
carrying wood	men	men but women sometimes	
maintenance	men		
Homegarden			
planting	both	women (but often both)	mostly women but men if women busy at plantation
weeding	women (daughters)	both together	mostly women but men if women busy
harvesting	both	both	both (when fruit or vegetables are required, so often women as they are cooking)
hoeing	men	men (sometimes women help)	
building		men	
Sawah			
ploughing	men	men	men - if with cattle, always men
hoeing	men	women (sometimes women help with a smaller hoe)	men, but sometimes women too
water management		men	
seed bed		both	
planting	women (daughters)	only women as men not telaten (careful)	men, but sometimes men if women at plantation
fertilizer	men	men	mostly men
spray		men	
weeding	women (daughters)	everyone together	
harvest	everyone together		-
carrying to truck	men		-

	Questionnaire	Discussion	Observation
Ladang (food crops)			
ploughing		men (see above)	
hoeing		men (see above)	
sow - tajuk	men	men	men
sow - seed	women	women	women
weeding	women	women	women, but in wealthier families women tend to stay at home rather than work in fields
fertilizer		both, but mainly men	
harvest		both	-
Ladang (sugar cane)			
land clearing		contractors from the plantation (men)	
planting		both	
weeding		both	
fertilizer		both	
removing old leaves		both	-
harvest		both	-
Off farm work			
sugar plantation	both	both, but women usually for daily work, men contracted for harvest	
forest plantation	both	both, but usually women	mainly women but some young men
saw mill	men	men	men
Trees	Women have greater control over the trees planted in the home garden and appear to possess more detailed knowledge about the use of such trees. Women are not allowed to climb trees to harvest fruit.		
Livestock			
chickens/ducks	women and children	women and children	women and children
goats	men	men, though women and children look for fodder	
cattle	men	men, though women and children look for fodder	

5.13.3 Decision-making and power in the household and community

Most of the major decisions made by households in Tiuh Baru are made by men. Decision-making on farming practices e.g "what to plant" is the men's domain. Women are only responsible for the daily household budget.

Decision-making in the Javanese transmigrant village is nebulous. What seems certain is that men are principally responsible for deciding on the strategy/response to events in the agricultural cycle. Women are an important component in the process of making a decision; suggesting alternatives, ruling out alternatives. One illustration of this is one farmer's desire to sell and move to Liwa (a mountain zone of West Lampung), a decision vetoed by his wife. All farming decisions are principally made by men, but after discussion with women. Household daily needs are the domain of women, as might be expected; but children's education many times also is decided by women.

Table 30. Gender division of labour and women's involvement in tasks, Tiuh Baru, a Lampungese village

	Questionnaire	Discussion	Observation
Household tasks			
cooking	Women. Men would never cook as it is regarded as demeaning and shows they are "weak		
cleaning	Women. Men would never clean as it is regarded as demeaning and shows they are "weak		
washing clothes	Women. Men would never wash clothes as it is regarded as demeaning and shows they ar "weak"		
child care	Women. Men would never look after children (except for very occasionally playing with them) as it is regarded as demeaning and shows they are "weak"		
carrying water	always women		
carrying wood	men	men	men but sometimes women
maintenance	men		
Sawah Tadah Hujan			
planting - tajuk	always men		
weeding - seeds	women and children		
fertilizer	men (but rarely used)		
spray	men (but rarely used)		
weeding	women and children (sometimes men too)		
harvest	together, although women cut rice and men load the boats		
Ladang kering			
plant - tajuk	always men		
plant - seeds	women and children		
fertilizer	men (but rarely used)		
spray	men (but rarely used)		
weeding	women and children (sometimes men too)		
harvest	together		
Trees	no special responsibilities but women are not allowed to climb trees		
Fishing			
catching fish	men		
drying fish	women		
Processing			
corn	women, but since the introduction of a hulling machine, this is now the men's job		
rice	women		
Off farm			
trade	women (some men). Men control the capital		
Tangerang factory	unmarried girls but some unmarried boys too		
Livestock			
cattle (buffalo)	men		
goats	men		
chickens	women		

5.13.4 Women's priorities, women's aspirations

For Negara Jaya women, their priority is making sure everyone in the family has enough to eat. After this has been fulfilled, education for children is extremely important, this is to ensure that the child "berhasil"-literally, has a result. Investment is often in terms of women's time, as wage labourer to earn the cash needed to pay for education, as a trader, even in terms of selling land. Women are an important force in deciding this strategy, in pressing children into education, and in persuading men to forego investment in the farm in favour of the children's future. The following are examples of women's priorities in their own words:

"I want my children to be clever, so they can become government employees. Because if they are farmers, life will be difficult for them".

"Before we owned 3/4 ha of sugarcane land. Now I've already sold it for Rp1.5 million so my child can go to school. My husband had a motorbike, he bought it for Rp2.9 million. I sold it for 2.2 million. I sold my land in Korabumi so my children could go to school".

Among the Lampungese there is also strong desire to educate children away from farming. In terms of household priorities, the priority for women, beyond supporting her husband in meeting food requirements, is to uphold the family's "P'il" - a Lampungese cultural concept which literally means "self respect". Fear of losing "P'il" means few Lampungese women are prepared to work in any servile capacity for other Lampungese families, and few are prepared to openly buy rice in the village (which is admitting to failure as a farming household). To quote one woman:

"The transmigration village means we are able to go and buy rice at the market if we have none here. I would never buy rice here in the village. People would talk and I could be embarrassed".

The results reported here are a portion of ongoing research by Beckey Elmhirst, a doctoral student from Wye College, UK.

5.14 Policies relevant to deforestation

The ASB-Indonesia policy working group (Taryoto *et al*, 1995) surveyed government policies in order to address two questions: Are there important *policy failures* that affect land use at the forest margins? Are there important *market failures* that affect land use at the forest margins? Some of the main findings concerning policies directly-related to slash-and-burn are:

5.14.1 Laws regulating forest use

The Government of Indonesia has two fundamental, but mutually inconsistent, laws on forest land use. On one hand, Government Law No. 5/1960 (UUPA) article 2, paragraph 4, protects the customary property rights of indigenous peoples dwelling in or near forest land.

Yet, Government Law No. 5/1967, chapter 17, subordinates these customary rights to Government's rights to use forests, including granting of forest concessions and government-funded development projects. These two laws create a legal basis for overlapping claims over forest land and, thereby, to conflicts between the customary claims of local people and forest production interests. This legal ambiguity causes insecurity for smallholders and large-scale operators alike and, therefore, is likely to undermine incentives for sustainable resource management.

The past six months have seen intensive discussion of new approaches to "People's Participation in Forest Management" including a workshop on that topic sponsored by the Department of Forestry on 12-13 June 1995 that brought together officials, NGO representatives, and selected researchers, including several from the ASB-Indonesia consortium. These discussions are reason for cautious optimism that there can be some steps toward resolution of contradictions in forest resource management policies sometime in the foreseeable future. In his closing statement, the Director General of Replanting and Forest Rehabilitation of Indonesia's Department of Forestry made a special request to ICRAF for "strong cooperation, not just in technical matters, but also in the field of policies, regulations, and institutions." In his words, these aspects "need to be united in an operational strategy to ensure success of international initiatives like 'Alternatives to Slash and Burn.'"

5.14.2 Settlement programmes

Indigenous forest dwellers are one of the target groups of settlement policy. Up to 1981, programmes were oriented toward resettlement of people out of forest areas. However, this approach had little success because many people simply moved back to their former places of residence. Since 1981, the emphasis of settlement programmes changed to *in situ* development.

There are numerous programs for *in situ* development. For instance, the Ministry of Forestry operates three programmes. One aims to control shifting cultivation through employment in projects for reforestation and development of industrial forest plantations or by promoting sedentary agriculture. The Ministry's social forestry programme is another strategy to protect forest areas by allowing people living within or near forests to exploit the forest within limits set by the Ministry. Finally, the Ministry's Timber Concession Holder Village Development Programme (HPH Bina Desa) requires concessionaires to promote sedentary agriculture and other economic activities in villages located within timber concessions and to recruit those villagers as workers.

The recently-renamed Ministry of Transmigration and Forest Squatter Resettlement also has programmes to resettle shifting cultivators and other local people along with its mandate to resettle people from Java and Bali to the Outer Islands of Indonesia. In 1980, a programme called the Allocation Scheme for People Living in Transmigration Areas (APPDT) was initiated with the objective of resettling people from the forest to transmigration project units, particularly those based on the nucleus estate/smallholder (NES) model. A similar scheme called the NES-Transmigration Programme (PIR-Trans) was introduced in 1986. The newest addition to the list of settlement programmes for shifting cultivators is based on a joint decree of the Ministers of Forestry, of Home Affairs, and of

Transmigration and Forest Squatter Resettlement called the Transmigration Community-Owned Forestry Settlement Pattern (Trans-PHR). This model will be implemented as a pilot project in fiscal year 1995/1996.

These settlement programmes share underlying premises that *traditional* shifting cultivation is widespread and that it is a major cause of deforestation. Data collected by ASB-Indonesia researchers will enable policymakers to examine these premises and other aspects of the implementation of settlement programmes in Indonesia.

5.15 Damar agroforests

Dipterocarp resins, collectively known as "*damar,*" are, together with other resins, among the oldest traded items from natural forests in Southeast Asia (Dunn 1975). Before the 19th century, they were traded as bases for incenses, dyes, adhesives and medicines (Burkill 1935), but also locally served for caulking and lighting purposes. The first damar exports to Europe and America started at the beginning of the 19th century, with the development of industrial varnish and paint factories. Between 1850 and 1920, commercial harvesting of damar represented one of the main income-generating activities for many communities in Sumatra and Borneo.

Since the end of the last century, Lampung, the southernmost province of Sumatra, and especially the "*Pesisir,*" a hilly-mountainous area stretching north to south along the western coast, gradually emerged as the main damar producing area in Indonesia. Today, the Pesisir produces more than 80% of the damar resin traded in and from Indonesia. The bulk of the Pesisir damar is provided by a single species: *Shorea javanica* K&V.

Until the end of the 19th century, farmer communities in the Pesisir mainly relied on collecting wild damar from the forest for income generation. The high increase of resin prices, initiated after 1850 with the opening of new industrial markets, entailed intensification of tapping of damar trees in the forest. Over-exploitation soon occurred, which made the damar a rare and almost non-renewable resource as soon as the end of last century. Quarrels and conflicts for appropriation of damar trees, similar to those presently encountered in Indonesia concerning the access to common property resources such as rattan, gaharu, or ironwood (Siebert 1989; Peluso 1992), broke out between and even inside village communities. In 1935, a Dutch forester visiting the area reported the total exhaustion of the wild damar resource throughout the remaining Pesisir forests (Rappard, 1937).

But in this same period damar plantations started developing. Damar cultivation boomed after 1930, partly because of the disturbance of the balance between subsistence and commercial strategies in cropping systems induced by a virulent disease which killed most pepper vines. In 1935, Rappard mentions 70 ha of productive damar gardens and notes that production doubled from year to year. In 1994, mature gardens covered more than 10,000 ha whereas several other thousands of hectares of young plantations will start to produce in the next 10 to 20 years. They stretch over traditional fallow lands and reach the boundaries of state forest reserves. Among the 70 villages of the region, 57 are presently fully involved in damar production, which concerns more than half of the total active population of the area (Dupain 1994). Almost exhausted at the turn of the century, damar trees presently dominate the Pesisir landscape. It will have required less than fifty years to switch from an apparently irreversible exhaustion of the resource to a massive restoration, which, in terms of forest dynamics, is noticeably fast.

5.15.1 Damar agroforests develop from slash-and-burn

The damar story in the Pesisir constitutes a highly original process of spontaneous appropriation of a forest resource by local farmer communities, carried out as the wild resource itself was vanishing. Pesisir villagers have succeeded in what most foresters dream (but fail) to do: establishing, maintaining, and reproducing, at low costs and on huge areas, a healthy Dipterocarp plantation (Michon and Bompard 1987). This is a unique example in the whole world of forestry.

This system's success is closely related to swidden agricultural practices. Indeed, it is through *ladang* (fields opened in the forest) to produce upland rice, coffee, or pepper, that damar trees have been restored to the landscape. Introduced in the *ladang* below coffee bushes, pepper vines, and their associated shade trees, damar seedlings find a suitable environment to establish. After the abandonment of the coffee or pepper stand, damar trees are strong enough to grow along with secondary vegetation and overcome competition from pioneers. The subsequent fallow can freely develop until damar trees reach a tappable size. Besides its ecological advantages, allowing this agroforestry system to overcome common problems linked to artificial reproduction and establishment of Dipterocarps, this process is totally suited to smallholder management since it benefits from the site preparation carried out for *ladang* establishment, it involves minimal additional investment in labor and capital, and it can be established in conjunction with activities related to the maintenance of the *ladang* crops.

5.15.2 Ecology of damar agroforests

Mature damar gardens are not monoculture plantations. On the contrary, they assume the same patterns of diversity and heterogeneity as does a natural forest ecosystem (high botanical richness, multi-layered vertical structure) as well as specific patterns of forest dynamics (Torquebiau 1984; Michon 1985). This "forest reconstruction" appears as a consequence of a particular mode of management which favors the re-establishment of the original biodiversity. The planting process, associating damar with other useful tree species, recreates the skeleton of a forest system. Then, common mechanisms of natural vegetation dynamics are given the major role in the evolution and the shaping of the cultivated ecosystem. As in any secondary vegetation dominated by trees, the maturing damar plantation provides a suitable environment and convenient niches for the establishment of forest plants carried from the neighboring forests through natural dispersion. It also offers shelter and feed to forest animals. In this natural enrichment and diversification process, humans merely select among the possible options given by ecological processes.

In no more than five decades of such a balance between free functioning and integrated management, a mature damar garden constitutes a forest on its own; a complex community of plants and animals and a balanced ensemble of biological processes reproducible in the long term through its own dynamics. At least 50% of the global biodiversity of the forest is restored. Inventories of the tree population in mature damar agroforests have recorded 39 common tree species (including fruit trees -durian, langsat, mangosteen, the legume tree *Parkia speciosa*, rambutan, jacktree and several water apple species-, palms like the sugar-palm *Arenga pinnata* or the betel-palm *Areca catechu*, trees producing spices and flavourings - *Garcinia spp.* fruits, which are used as acid additives in curries, Eugenia polyantha, the local laurel tree- as well as bamboos and some timber species -*Apocynaceae, Lauraceae-*). and several hundred kinds of plants, from trees to lianas and epiphytes. Soil mesofauna diversity levels are quite similar between forest and agroforest. Bird richness in damar agroforests is 50% lower than in primary forest, and almost all mammal forest species are present in the agroforest (Deharveng 1992; Michon and de Foresta 1990; Michon and de Foresta 1994; Sibuea and Herdimansyah 1993; Thiollay, 1995).

5.15.3 A new type of forest resource management

As far as natural forest management is concerned, the establishment of damar agroforests represents an interesting example of forest product development for commercial purposes. This development strategy does not preserve the forest as a whole. Instead, it entails a total transformation of the original ecosystem. (Indeed, it was even part of the process of forest conversion.) Nevertheless it succeeds in preserving most of the forest's functions and biodiversity.

As a forest plantation strategy, the agroforest model of the Pesisir runs counter to conventional timber, pulp, or rattan estates which are presently developed in Indonesia and elsewhere. While favoring a selected resource, as estates do, the agroforest allows the maintenance of numerous other resources that otherwise would not have been conserved, including a high diversity of species. Moreover, the establishment process restores integral biological and ecological processes which constitute resources in their own: these are "functional" resources more than commodities, but they are essential to the overall survival and reproduction of the agroforest as an ecosystem.

5.16 *Imperata* grasslands: a policy perspective

Seventy-one experts from Indonesia and 12 other countries participated in an international workshop on *imperata* grasslands (known as *alang-alang* in Indonesia) held in Banjarmasin from 23-27 January 1995. Results from the workshop were reported to Indonesia's Minister of Forestry and other officials at a policy seminar held in Jakarta on 30 January (Tomich, 1995).

A new perspective on opportunities for *imperata* grassland rehabilitation emerged during the workshop and was reinforced at the seminar. This new view focuses on the capacity of individual smallholders to re-establish trees on these grasslands. Government can support local farmers' initiatives through policies and programs that reduce risks and the costs of rehabilitation and that increase the returns to smallholders' investments in trees. Since profitable opportunities for low-income farmers are the driving force, this strategy combines sensible grassland rehabilitation with poverty alleviation.

5.16.1 Area and distribution of alang-alang grasslands in Indonesia

Alang-alang grasslands have retreated gradually in some regions of Indonesia through farmers' efforts. This is most likely where land is scarce and market links are good. Conversion of *alang-alang* to other uses by smallholders has been documented in Java, Sumatra, and Kalimantan. Nevertheless, large areas remain and, in some regions, grassland area may be increasing.

There have been a number of efforts to estimate the extent of *alang-alang* grasslands in Indonesia. Available estimates of *alang-alang* area vary widely, mainly because they differ regarding the *scale* of measurement used. Four distinct scales of grasslands can be distinguished:

- *mega* grasslands (also called "sheet *alang-alang*") are contiguous areas larger than 10,000 ha
- *macro* grasslands span more than one community
- *meso* grasslands lie within a single community
- *micro* grasslands are patches in a farmer's field.

Mega *alang-alang* grasslands cover 8.6 million ha in Indonesia, 5% of the land surface. That estimate would increase if the area of smaller grasslands and patches in farmers' fields could be added to this estimate of contiguous areas covering 10,000 ha or more. But data are not available to provide a comprehensive estimate at a finer scale. Kalimantan has the largest area of mega grasslands in Indonesia (2.2 million ha), followed closely by Sumatra (2.1 million ha), and Nusa Tenggara (2 million ha).

Remote sensing and other new technologies should make it feasible to improve Indonesia's grassland maps, particularly to add the macro and meso scale *alang-alang* grasslands. This information would be useful to policymakers and land use planners in Indonesia, particularly if maps could be prepared for different years to indicate the advance and retreat of *alang-alang* in different regions.

5.16.2 Converting mega alang-alang grasslands to other uses

There are big differences between control of small patches in farmers' fields compared to conversion of mega *alang-alang* grasslands. Indeed, no panacea exists for conversion of large contiguous blocks of grassland to other uses.

Profitability of conversion to other uses depends on the biophysical, social, and economic conditions of specific sites, including the value of existing uses. These grasslands are not "wastelands." They have a number of uses for local people. Even if these uses are of relatively low value, they are important to the people who use them.

Indeed, it is hard to find large blocks of grassland that are not already used by local people. For example, a 300,000 ha block of grassland in Kalimantan that was believed to be "empty" was designated for an industrial timber plantation. After the project started, it was discovered that the entire block was claimed and managed by local villagers. Overlapping claims create tenure insecurity for local people *and* forestry companies. This undermines incentives for sustainable resource management on both sides. Case studies are needed for representative locations regarding how many people already are using mega *alang-alang* grasslands, how they use the grasslands, and the extent of existing claims.

Many land use systems could be sustainable alternatives if smallholders want to convert these grasslands to other uses. Most of the main alternatives are agroforestry systems, which involve trees for a variety of uses, usually in combination with annual crops and/or livestock. Success of any effort to establish trees on Indonesia's mega grasslands -- whether for large-scale plantations or through promotion of agroforestry innovations for smallholders -- depends on at least three elements that have a big effect on profitability and other incentives to invest:

- access to markets
- fire control
- clear, secure tenure

Marketing opportunities depend mainly on access to roads. But markets for tree products also can be distorted by transport restrictions and local levies, barriers to entry, and price distortions in the public sector.

5.16.3 Community-based fire control

Effective fire control is a prerequisite to establishment of trees on *alang-alang* grasslands because *alang-alang* thrives on fire. Yet fires are a persistent problem, destroying trees and reestablishing *alang-alang*.

Community-based initiative for prevention and control is a necessary ingredient for effective fire control in grasslands. Local people are in a better position to know about fire risks and to know when a fire starts. Moreover, although they may not be able to manage all fire risks among themselves, local people are in a good position to take timely, on-the-spot actions to extinguish fires while they still are small.

Public fire services will still be needed, especially to assist with big fires. But more effective community-based fire control would reduce demands on the limited resources of the fire service for monitoring and fighting small fires, allowing the fire service to focus on its essential role in fighting big fires. More research is needed to understand existing community-based initiatives and to identify ways in which government can help strengthen those fire control efforts.

5.16.4 Tree tenure for people who rehabilitate imperata grasslands

The key recommendation of the workshop concerns the mega *alang-alang* grasslands (blocks of 10,000 ha or more) that occupy certain land classed as Production Forest. Local people are prohibited from using these grasslands but, in practice, it is difficult to exclude established communities. Under these circumstances, local people lack incentives to control fires or to plant trees.

> ***Policy recommendation.* Where Production Forest land is covered by *alang-alang* grassland in blocks of 10,000 ha or more, smallholder farmers who rehabilitate that grassland by planting and managing trees in small plots should receive property rights over all the products, including the timber.**

Clear rights of ownership of the trees they plant will create incentives for local people to cooperate in fire prevention and to take the lead in fire control. Without this local cooperation to control fire, sustainable rehabilitation of *alang-alang* grassland is extremely difficult. Property rights over all products, including timber, create incentives necessary for local people to do the hard work to re-establish trees on grasslands.

Evidence from Indonesia and elsewhere in Southeast Asia demonstrates that local people invest on their own to plant trees for timber and other products if (a) they have secure claims over the products, (b) natural risks, such as fire, are not too high, and (c) they have access to a markets. Research presented at the seminar from Indonesia, the Philippines, and Vietnam documented cases where smallholders rehabilitated *alang-alang* grasslands through their own initiative by planting trees, including timber species.

5.16.5 Imperata control in farmers' fields

The workshop established that plenty of techniques are known to control *imperata*. Examples of techniques that can be used (individually or in combination) to suppress *alang-alang* in farmers' fields include hoeing, rolling and pressing, animal-drawn or tractor-drawn cultivation, and herbicide. Herbicide adoption has not been widespread. But there is intensive herbicide use by smallholders in some specific locations.

Intercropping of annuals in early years while trees are established in agroforestry systems helps control alang-alang. Shade from mature trees controls *alang-alang* in agroforestry and other tree-based systems. Shade from young trees contributes to *alang-alang* control, but may not be sufficient by itself to control *alang-alang* from the end of intercropping to the closing of the tree canopy. Shade usually needs to be supplemented by other forms of control during establishment of agroforestry systems.

A manual is being prepared on *alang-alang* grassland rehabilitation. But more work is needed to adapt *alang-alang* control techniques to farmers' constraints. For example, there is some evidence that if *alang-alang* is slashed and then allowed to begin to regrow before it is sprayed, the amount of herbicide required to kill *alang-alang* can be reduced by half. Further applied research is needed to adjust recommendations in ways that will reduce farmers' costs.

Examples of programs to support smallholder initiatives include:

- Provide information to smallholders on the new techniques that already are available for *alang-alang* control.
- Conduct applied research on existing techniques in order to reduce the costs of *alang-alang* control in farmers' fields.
- Revive research on improvement of multipurpose tree species (MPTS):
- Conduct research to adapt the improved genetic material that already exists for rubber and other species to conditions in smallholder agroforestry systems.
- Provide smallholders with practical information they can use to become more discriminating consumers of improved tree planting material.

These programs would help to lower costs of *imperata* control and to increase the benefits of planting trees, thereby expanding the area of *imperata* grasslands where conversion to more productive agroforestry systems can be profitable for smallholders.

5.17 Segregate or integrate nature and agriculture for biodiversity conservation ? criteria for agroforests

5.17.1 Introduction

Human use of biotic resources ('agriculture' in its widest sense) and biodiversity ('nature' in its widest sense) are both needed by society at large, but there are generally conflicts between these two aspects of 'land use'. Conflicts between 'nature' and 'agriculture' can be solved in two ways:
- by *segregating* nature and agricultural land; maximizing agricultural production on a relatively small part of the land will leave as much land for nature as is possible,
- by *integrating* nature and agricultural land use by intensifying production as little as strictly necessary and so maximizing the biodiversity value of land under human use.

Mixed solutions may exist as well, but the area available for complete protection of biodiversity decreases when agriculture remains below its potential productivity under the integration option. Both options have strong advocates, and it is not clear which solution is optimum under which conditions. Objective criteria are needed for distinguishing which solution may best meet the multiple goals formulated under different circumstances.

High expectations exist that 'agroforests' are an intermediate intensity land use form in the tropics that can help to conserve biodiversity while allowing sufficient production of economically attractive crops, such as rubber or resin (damar) (Sanchez, 1995). Agro-forests contain considerable biodiversity value, as their planned biodiversity of planted trees is augmented by naturally invading species of the original forest (Michon and De Foresta, 1992). It is not enough, however, to state that such agroforests represent a vastly higher biodiversity value than more intensively managed tree crop monoculture systems. If productivity of the monocultures is substantially higher, it might allow a large(r) area of natural forest to be conserved and, under certain conditions, this might satisfy the biodiversity agenda to a larger degree. We need a quantitative criterion to evaluate the two options. 'As far as environmental impact is concerned, large-scale development of complex agroforests as those developed by peasants in Indonesia appears highly desirable. However, their productivity in terms of cash income per unit land is low and irregular. Complex agroforestry systems can no longer compete with other agricultural systems which may be more risky, but are more profitable in the short term' (De Foresta and Michon, 1992). Increasing the profitability of these complex agroforestry systems may be based on genetic improvement of the main cash earning components of the system, or by more complete utilization of the existing components, such as the timber.

In order to avoid an 'agroforest debacle' by first raising unrealistic expectations (compare the 'alley cropping debacle,' Sanchez (1995)), we need a clear criterion to judge for which parts of the total biodiversity and for which commodities such an approach may indeed be possible and for which ones not. 'Agroforests can drive back natural forests', as suggested in the title of Mary and Michon's (1987) paper in a title later regretted by the authors, but nonetheless indicating a possibility.

5.17.2 Discrete systems

Suppose that there is a choice between two land use systems, one with yield Y_1 and internal biodiversity value B_1, and one with Y_2 and B_2, respectively. If not all land is needed for production, it can be used as 'nature' with biodiversity value B_n and a zero yield. If f_1 and f_2 indicate the fraction of land needed for production under the two systems, the need for an equal amount of products leads to:

$$f_1 \, Y_1 = f_2 \, Y_2 \quad , \therefore f_2 = \frac{f_1 \, Y_1}{Y_2} \quad (1)$$

At equal total productivity the choice between the two systems will be based on the biodiversity value, which consists of an 'internal' (f_1 B_1 and f_2 B_2, respectively) and an 'external' component $(1 - f_1)$ B_n and $(1 - f_2)$ B_n, respectively. A choice for system 1 is justified if:

$$f_1 \, B_1 + (1 - f_1) \, B_n > f_2 \, B_2 + (1 - f_2) \, B_n \quad (2)$$

Rearranging and substitution of equation (1) leads to:

$$\frac{Y_1}{Y_2} > \frac{1 - B_1/B_n}{1 - B_2/B_n} \quad (3)$$

or,

$$\frac{Y_1}{1 - B_1/B_n} > \frac{Y_2}{1 - B_2/B_n} \quad (4)$$

Equation (3) compares relative yields of the two systems and relative biodiversity losses (taking B_n as point of reference), equation (4) compares the 'agricultural yield per unit biodiversity loss' for the two systems.

If 'plantation rubber' is four times more productive per unit area than 'jungle rubber' and jungle rubber has three-quarters of the biodiversity value of natural forest, while plantation has a biodiversity value of near-zero, the 'segregate' or 'integrate' debate comes to a draw, as both the left and right hand term of equation (3) are 0.25.

5.17.3 Continuous intensification, with homogeneous land quality

Rather than describing discrete versions of land use systems, we may consider an 'intensification continuum'. Figure 44 shows the results of optimizing total biodiversity based on a simplified description of both productivity and biodiversity consequences of more intensive land management. Results of a theoretical analysis (Van Noordwijk *et al., in prep.)* show that the key aspect is whether or not proportionality exists between relative biodiversity, *i.e.* actual divided by potential biodiversity, and relative productivity per unit land, *i.e.* actual divided by potential productivity. For resource use systems with a ratio above 1 the integration pathway may be best, below 1 segregation is better.

If systems with intermediate productivity are associated with a less than proportional biodiversity, the best solution will be to segregate and maximize production on a small area. From the available evidence, most food crop based production systems fall in this category, as annual plants will not grow well unless major changes in the vegetation (such as 'slash-and-burn' activities) have been made, to reduce competition. If systems with intermediate productivity allow a more proportional biodiversity, 'integration' will be the best solution, based on the lowest degree of intensification which still meets the total productive demand.

5.17.4 Practical application: jungle rubber in Sumatra

From the evidence available, the jungle rubber as found in the lowlands of S.E. Sumatra in comparison with the best available approximation of 'primary forest' has about equal biodiversity for soil mesofauna as evidenced by Collembola (Deharveng 1992), very similar lists of observed mammals (Sibuea and Herdimansyah, 1993), 30% less species of higher plants (Michon and De Foresta, 1994) and 50% less species of birds (Thiollay, 1995). We may assume that these values were about the same in the 1930's when the first generation of jungle rubber systems (rubber started spreading as a smallholder crop in Sumatra at the beginning of the century) reached maturity. In that period, however, the rubber yields of the jungle rubber (about 500 kg ha^{-1} y^{-1} of dry product, Van Gelder 1950) were close to the maximum attainable in monoculture plantations. Now, jungle rubber yields are still about 500 kg ha^{-1} y^{-1}, but monocultures can reach 2 000 kg ha^{-1} y^{-1} (or even more) under research station conditions and at least 1 500 kg ha^{-1} y^{-1} in commercial practice. The situation in the 1930's would have clearly indicated that 'integration' was the best choice. At current production levels, however, the conclusion depends on the relative weight one attaches to the various components of biodiversity. A bird watcher will favour 'segregation', a collembola enthusiast 'integration' (80% of the species in the survey were new to science) and a botanist should feel hard-pressed to make a choice.

A choice between the 'integration' and 'segregation' pathway should also be based on likely future developments. Most of the biodiversity in the agroforest does not result from a deliberate choice of the farmers to conserve biodiversity per se, but is more the logical consequence of structural features of the agroforest and of associated management practices. The main incentive for establishing an agroforest is economic and is closely linked to the market economy. Biodiversity results from two types of dynamics. One is semi-intentional, deriving from planting a combination of useful species to create a 'multipurpose tree stand' (not necessarily consisting of 'multipurpose trees'). The other one is accidental, the establishment of a diversified flora and fauna as in any sylvigenetic process. If rubber germplasm with a higher production per tree can be integrated into the system without much need for additional 'weeding' or other measures reducing biodiversity, farmers' choices are likely to stay with the 'jungle rubber' version, until land becomes scarce and higher valued. Continuation of the system will also be favoured by good markets for other components, such as rubber wood, fruits, etc.

In Sumatra, efforts to conserve large national parks tend to concentrate on the mountain zones (e.g. Kerinci Seblat National Park and the Gunung Leuser National Park) while little of the rich lowland forest has been effectively protected. Allowing some utilization of highland park areas while protecting more of the lowlands would probably increase conservation efficiency, while allowing the same number of people to achieve a similar livelihood level. In the near future we hope to quantify such choices based on more specific data for the area.

More complex models will be needed for dealing with heterogeneity in both agricultural and biodiversity value of land classes. In view of the irreversibility of biodiversity reduction during intensification of land use, a choice for 'segregation' should not be postponed until little biodiversity remains.

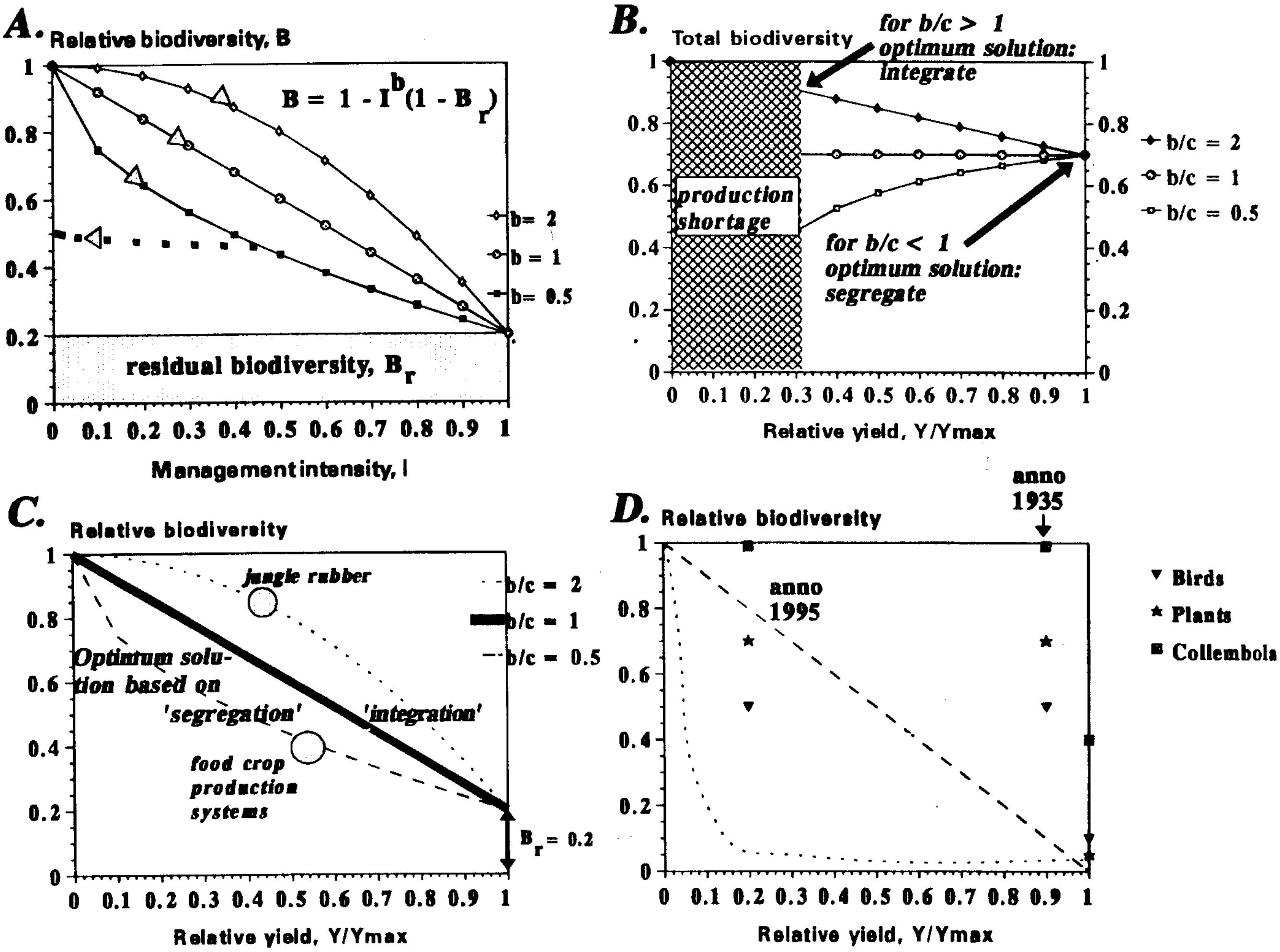

Figure 44. A. Relative (internal) biodiversity B_t as function of management intensity; curves can be convex, linear or concave, depending on the value of the parameter b. B. Total biodiversity (internal *plus* external) as a funtion of relative yield, for different values of the b/c ratio ($P = 0.3$, $B_r = 0$); for increasing curves the best choice is to segregate, for declining curves it is to integrate. C. Decision scheme for the 'integrate' versus 'segregate' option for maximizing total biodiversity in the biodiversity - relative yield relationship. D. Tentative application to jungle rubber systems, showing the current biodiversity estimates, but two values of the 'relative productivity': due to increase of the productivity of monoculture plantations between 1930 and present, the X-axis value of 'jungle rubber' has changed dramatically.

Planning Phase 2 and Phase 3 for ASB-Indonesia

6.1 Introduction

Interaction among members of the ASB-Indonesia team has generated ideas for research that span disciplinary boundaries. For example, research questions about the use of rubber wood (see 5.10 above) emerged from parallel work on measurement of greenhouse gas emissions, on land use systems and household economics, and on national policy. Such links from public policies to land use choices at the forest margins and, ultimately, to global climate and biodiversity resources are not confined to smallholders' uses of land. Public policy choices about road construction, transmigration schemes, forest concessions, and large-scale plantations have their own impact on global problems and on the opportunities and constraints faced by Sumatran smallholders. Deforestation involves a complex combination of these and other policy variables, such as price policies and exchange rates. A central task for the ASB-Indonesia team in Phase 2 will be to draw on the array of biophysical, land use, socioeconomic, and policy studies that have been conducted and, where necessary, to extend these studies in order to develop empirical models of the main driving forces behind deforestation at this benchmark site and the environmental consequences of changes in land use.

A workshop held in Bogor on 6-9 June 1995 was a key event in the Phase 2 planning process for ASB-Indonesia. Plenary discussions and small working groups engaged in planning and priority setting for preparation of the next round of research proposals. The main topics of discussion during Phase 2 planning have included:

- Stepping back to reconsider the big picture
- Constraints and opportunities from farmers' perspectives
- Forces driving deforestation
- Integrating biophysical, land use, and policy research at the benchmark level
- Research priorities for Phase 2 and Phase 3

6.2 Stepping back from the trees to reconsider the forest

The second phase of the Alternatives to Slash-and-Burn project is built on a number of hypotheses. These can be summarized as: 'Intensifying land use as an alternative to slash-and-burn farming can help to reduce deforestation, conserve biodiversity, reduce net emission of greenhouse gasses and alleviate poverty'.

As we embarked on detailed planning of Phase 2 activities that follow the various leads from Phase 1 Characterization and Diagnosis, participants in the planning workshop also took some time out to reconsider some of the big questions.

First of all, under which conditions does the basic global hypothesis appear to be reasonable, under which ones is it not?

For the conditions where it does, Phase 2 research can have a strong 'agroforestry technology development' component responding to farmers' needs and developed with their participation. But for conditions where the hypothesis does not seem to apply, we may focus on other types of activities.

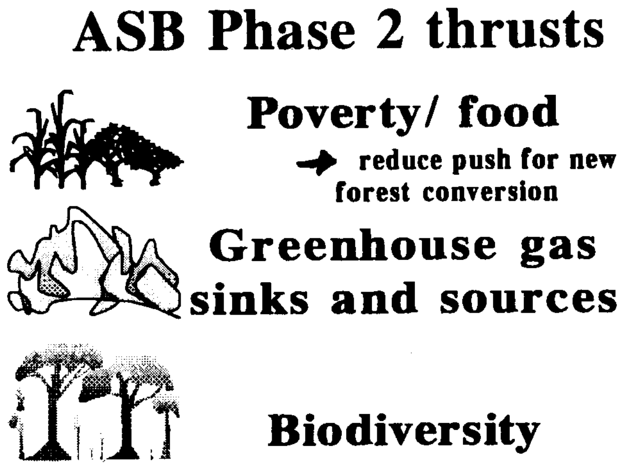

Figure 45. The three main thrusts of the ASB project are linked to the three stages of a slash-and-burn cycle: forest, fire and crops

A simple model of the idea underlying the intensification hypothesis is : Y = 1/X, where Y is the amount of land (ha) needed for a given amount of agricultural output and X is the productivity per unit of land (kg of product per ha) (Fig. 2):

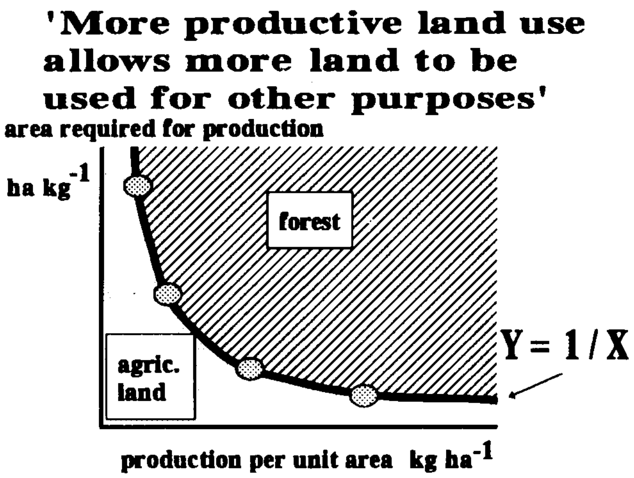

Figure 46. The amount of land needed per unit product is the inverse of the yield per ha: Y = 1/X

Comparing rice yields in a true shifting cultivation system (say 1.5 and 0.5 Mg/ha in two years of cultivation, alternating with 28 years of fallow: this leads to 2/30 = 0.067 Mg ha^{-1}) with the 10 Mg ha^{-1} that is possible in intensive irrigated rice fields (at least two crops of rice per year at 5 Mg/ha each, no extended fallow periods), it is easy to see that practicing intensified rice production on irrigated fields instead of shifting cultivation under rainfed conditions gives a 150-fold increase in production per ha and a commensurate reduction of the amount of land needed to feed one person (say, if all nutrients come from rice, 250 kg per person per year) from 3.7 to 0.025 ha. Provided it is technically possible and economically feasible, intensification can thus reduce the land needed for conversion to agriculture and thereby allow more forest to be conserved.

But will it happen that way?

The first thing to note is that in Figure 46 it was assumed that demand for agricultural products is constant. Figure 47 shows that increased demand for agricultural products -- resulting from population growth or rising income -- can be met by area expansion (the vertical arrow), intensification (the horizontal arrow), or by mixed strategies. Thus, additional pressure on the forest could arise from either natural increase in population or growth in income and the outcome depends on the scope for further intensification.

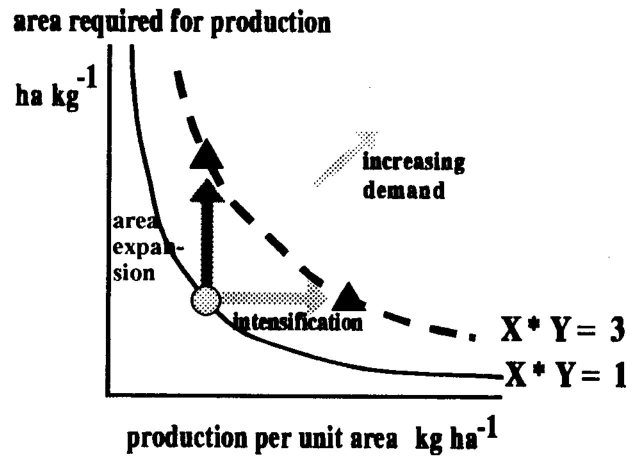

Figure 47. Production can be increased by area expansion (vertical arrow), intensification (horizontal arrow) or mixed strategies

Intensification merely may help to keep up with growing demands (population size and demand per person) as an alternative to area expansion, rather than actually allowing agricultural land to revert to forest. Even if intensification can keep ahead of rising demand, a second point of concern is that the model assumes that the transition from 'forest' to 'agricultural land' is completely reversible. This is not the case in practice. An impoverished version of 'forest' is obtained after agricultural use (even at low intensity of agricultural management). Full recovery requires a long time, if it is possible at all.

The most important weakness in this simple model is the possibility (indeed the likelihood) of migration, either spontaneous or government-sponsored. An important body of theory predicts intensification will occur only *after* the "extensive margin" of readily-available, productive land has been exhausted (Boserup 1965, Hayami and Ruttan 1985). This brings us to one of the main lessons from Sumatra for the global ASB project.

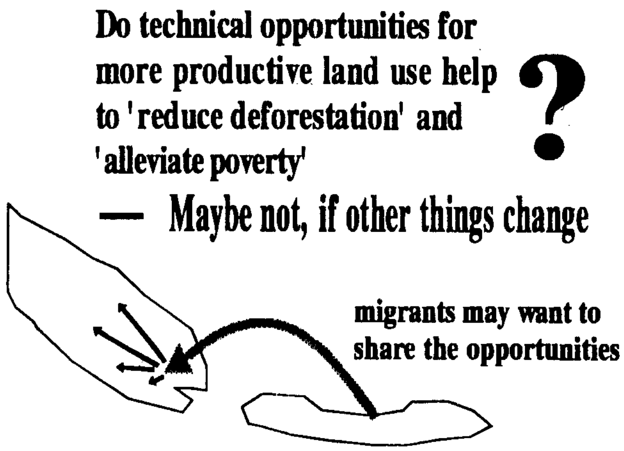

Figure 48. Migration can easily swamp the potential environmental benefits of land use intensification

The experience of the rubber agroforests in Sumatra, which go back to the start of the 20th Century, shows that:

- Tree-crop based systems exist that are economically-attractive alternatives to extensive food-crop based systems.
- These "alternatives to slash-and-burn" help to alleviate poverty.
- But they speed up rather than slow down the rate of natural forest conversion, especially because they attract an inflow of migrants seeking a share of the economic benefits of these profitable systems.

Other reasons under which the central ASB hypothesis would not hold true are that the driving forces of forest conversion may have little to do with agricultural production. Within smallholder communities, slash-and-burn followed by tree planting are the chief means to establish private claims over (formerly) communal land. This is one reason for the existence of extensively-managed "jungle rubber." This "speculation" appears to be an important driving force, whether the objective is a quick profit or a legacy for future generations. Then there are a range of other uses (logging, mining), engaged in by smallholders and large-scale operators alike, that have no direct link to crop production.

In summary, three necessary conditions can be formulated for validity of the intensification hypothesis:

- First, at the *field level*, the intensification techniques must be ecologically and agronomically sound, socially acceptable, and financially profitable for smallholders.
- Second, at the *community level*, there must be effective monitoring and enforcement of the boundaries of the forest that is to be saved from conversion to other uses.
- Third, at the *benchmark/national level*, attention must be given to reducing the broader forces that drive deforestation. In particular, an inflow of migrants driven by lack of economic opportunity elsewhere can swamp the effects of field level and community level interventions.

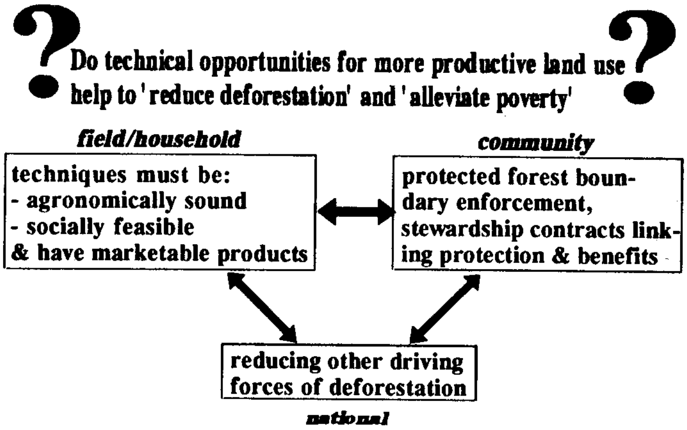

Figure 49. Three conditions have to be fulfilled before the central ASB hypothesis can be expected to work

So far, ASB planning mainly emphasized the first requirement. It is a challenge for the ASB-Indonesia team to incorporate the second and third aspect. One of the most exciting ideas in the Indonesian situation is the increased involvement of local communities in forest management. If properly done, this may help to address the second requirement.

The simple contrast in geomorphology between the piedmont site of Rantau Pandan and the peneplain Bungo-Tebo benchmark areas suggests the third requirement may be a bigger challenge. In the piedmont there is an element of natural protection of the hill-side forests since migrants have to come in via the valley, which acts as 'front door'. This contrasts with a high vulnerability in the peneplain, where the villages along the river have little control over migrants entering through the 'back door' created by construction of the Trans-Sumatra highway.

In the project documents ASB has emphasized two situations: 'forest margins' where active forest conversion occurs and 'degraded lands'. The links between these two situations are manifold:
- forest conversion for unsustainable land use systems can lead to land degradation and continued 'land hunger' for the remaining forest,
- more sustainable land use systems directly following forest conversion may thus reduce the rate at which degraded lands are formed and slow down forest conversion,
- intensified land use on degraded lands may be an alternative to forest conversion.

This last point may be the strongest reason for ASB to be involved in land rehabilitation, yet it will only be effective if the remaining forests are adequately protected.

This also brings us to another basic question: ***What are these forests being saved for?***
The economic value of forests in Sumatra spans at least two broad categories of forest functions:

Forests function as sources of beneficial environmental externalities, including:

1. Global environmental externalities
   - Carbon sequestration, believed to ameliorate global climate change
   - Biodiversity conservation

2. Community/watershed/regional environmental externalities
   - Soil and water conservation affecting sustainability of agricultural production
   - Local climate effects

Forests function as productive assets yielding private goods and services, including:

1. Forests as stocks of natural resources (timber, non-timber forest products--NTFPs-- and soil nutrients)
2. Forest land as a factor of production
   - Sustained production of timber and/or NTFPs or
   - Conversion to other productive land uses
3. Forest Land as a financial asset (as forest or, more often, converted to other uses)
   - Stock of wealth/inflation hedge
   - Speculative asset held in anticipation of capital gains

Many of these functions are mutually exclusive. In particular, the use of forests for private production functions often (but not always) involves forest conversion, thereby conflicting with the broader environmental functions that depend on existence of intact forest. How likely is it that private calculus focused on forests as productive assets will leave too little forest from a broader point of view encompassing the forests as sources of beneficial environmental externalities? In short, ***why is deforestation a policy problem?***

The following three hypotheses are the basis for understanding the policy problem --and indicate some options to deal with it.

DEFORESTATION HYPOTHESIS 1. EXTERNALITIES

The supply of "forest functions" is suboptimal because externalities are unvalued. Markets do not value externalities, institutions do not yet exist to provide appropriate incentives, at least where global externalities are concerned, and regulatory approaches are difficult to monitor and enforce. Thus, incentives to manage forests (or convert them) are restricted to their value as productive assets, while their environmental role remains valueless from an individual perspective.

DEFORESTATION HYPOTHESIS 2. DISTORTED INCENTIVES

The supply of "forest functions" is suboptimal because production incentives are distorted. Policy distortions and failures in markets and institutions make it more profitable for individuals to mine forest resources (timber, NTFPs, nutrients) and to convert forests to other uses than to undertake sustainable production of forest products (timber, NTFPs).

DEFORESTATION HYPOTHESIS 3. FOREST FUNCTIONS

Alternative land uses at the forest margins differ significantly in their ability to substitute for forests as sources of environmental externalities: biodiversity conservation, carbon sinks, and soil and water conservation. Complex agroforests, in particular, approximate a number of these forest functions. While conversion of primary forest has the major effect on the supply of forest functions, the resulting land uses also matter a great deal for the supply of environmental externalities. The environmental implications of the mix of forest and derived land uses and the forces driving these land use choices are a major focal point of Phase 2.

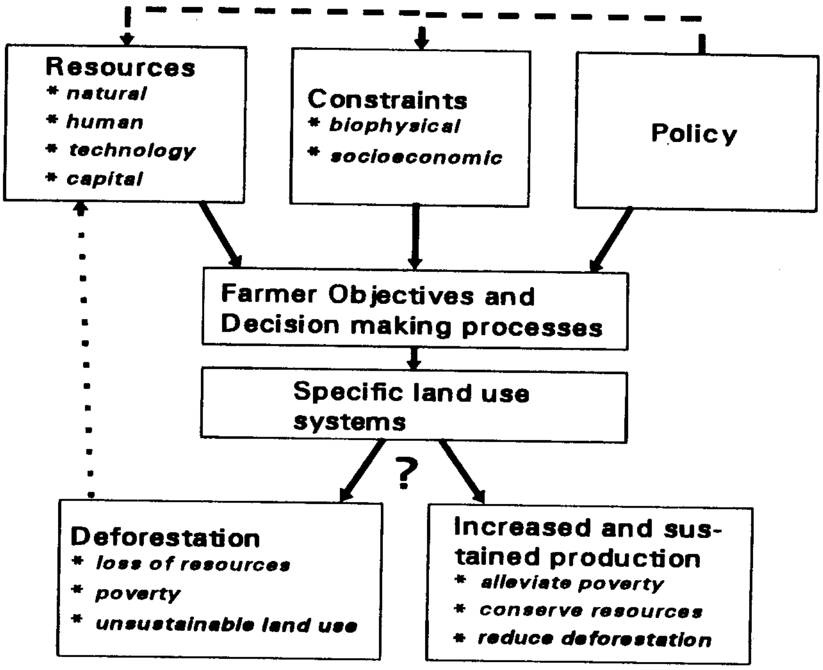

Figure 50. Conceptual scheme of land use decisions of farmers as focus of the ASB project

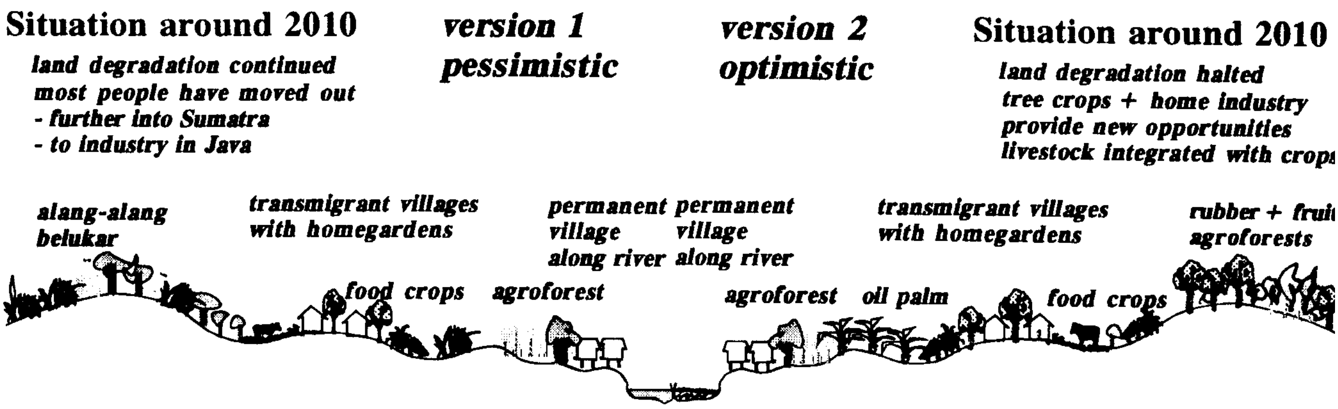

Figure 51. An optimistic and a pessimistic vision of further developments in the North Lampung ASB benchmark area (compare figure 27).

6.3 Constraints and opportunities from the farmers' perspectives

6.3.1 Sustainability criteria

Figure 50 puts the land use decisions of farmers as the focus of interest for the ASB project. Farming decisions depend on (perceptions) of opportunities and constraints, and are thus (often indirectly) influenced by government policies. The figure suggests that the results of land use decisions can be two-fold: either leading to a 'degradation spiral', in which the resource base is degraded by unsustainable practices, or to increased and sustained productivity. Figure 51 gives an optimistic and a pessimistic vision of further developments in the North Lampung ASB benchmark area. The ASB project obviously wants to stimulate the optimistic vision and stimulate choices of the 'sustainable' pathway. But what is 'sustainable' in this context? Table 31 gives a list of four main reasons why systems can be considered 'un-sustainable' at the level of fields and households.

Table 31. Sustainability criteria at local scale (based on Van der Heide *et al.* 1992)

1. Maintaining basis for future production
- soil (erosion control, soil structure)
- soil fertility (nutrient balance)
- weed control
- genetic diversity in food crops

2. Maintaining adequate productivity
- financial profitability

3. Safeguarding against major risks of weather, pests and market prices
- maintaining 'meaningfull diversity' (components with their own 'niche')
- increasing buffering capacity of the agro-ecosystem

4. Maintain possibilities for improvement/development
- technology within experimental scope of farmers
- no fixed 'package' technology, but flexible components

If we compare the actual situation with such a list, we can identify a number of major problems in the current situation, as well as options currently within the scope of farmers in the benchmark areas. Farmers are experimenting with all kinds of solutions to the problems as perceived by them - it is the challenge for 'outsiders' such as the ASB project to try and support them in doing so.