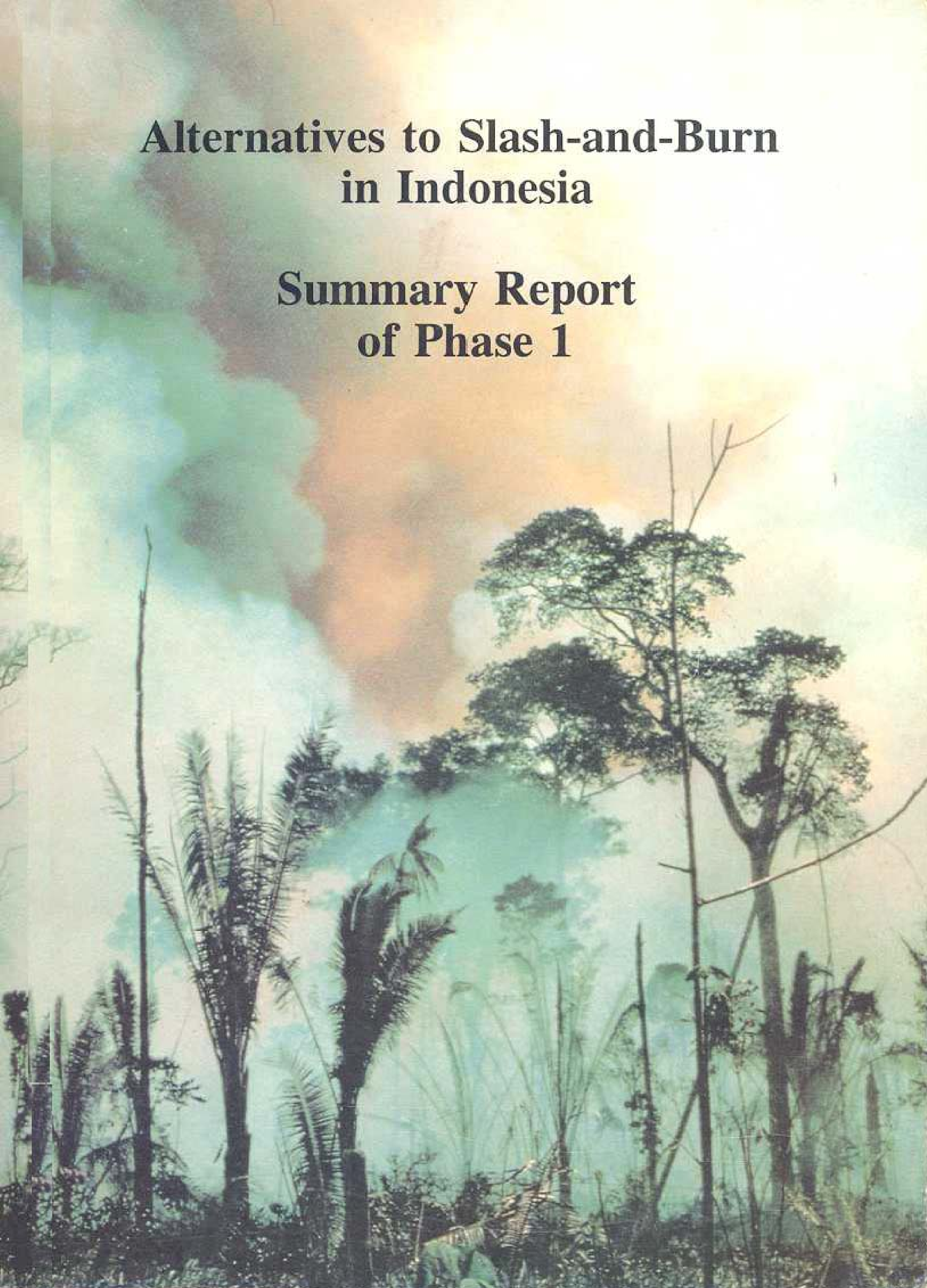
Alternatives to Slash-and-Burn in Indonesia

Summary Report of Phase 1



Alternatives to Slash-and-Burn in Indonesia

Summary Report of Phase 1

edited by:
Meine van Noordwijk, Thomas P. Tomich, Retno Winahyu, Daniel Murdiyarso, Suyanto, Soetjipto Partoharjono and Ahmad M. Fagi

ALTERNATIVES TO SLASH-AND-BURN

ICRAF

Indonesia

S.E. Asia

ASB-Indonesia Report Number 4
1995, Bogor, Indonesia

The ASB project is financially supported by the Global Environment Facility (GEF) with UNDP sponsorship.

Alternatives to Slash-and-Burn in Indonesia, Summary Report of Phase 1

Meine van Noordwijk, Thomas P. Tomich, Retno Winahyu, Daniel Murdiyarso, Suyanto, Soetjipto Partoharjono and Ahmad M. Fagi (editors)

ASB-Indonesia Report Number 4
1995, Bogor, Indonesia

For further information please contact:

ASB-Indonesia consortium
Secretariat: Central Research Institute for Food Crops (CRIFC-AARD)
Jl. Merdeka 147
Bogor 16111
Indonesia

ICRAF-S.E.Asia
P.O.Box 161
Bogor 16001
Indonesia
e-mail: icraf-indonesia@cgnet.com

Acknowledgement
UNDP has been a major facilitator, helping establish ASB with encouragement and funds. The Global Environment Facility (CEF) finances the initiative, with UNDP sponsorship. Co-financing is generated from core budgets of all partner institutions. Generous assistance also comes from many governments and institutions around the world.

For more information on the Alternatives to Slash-and-Burn initiative (ASB), or to subscribe to the ASB quarterly newsletter, *Slash-and-Burn: Update on Alternatives,* contact: ASB/ICRAF, PO Box 30677, Nairobi, Kenya; fax: (254-2) 521 318; e-mail: d.bandy@cgnet.com.

cover photo: Heinz Müller

published 1995

International Centre for Research in Agroforestry
PO Box 30677
Nairobi, Kenya

Table of contents

Summary 4

Preface: Why Alternatives to Slash and Burn in Indonesia? 6

1. Composition of the ASB-Indonesia Consortium 8
2. Training 10
3. Sumatra as an ASB-benchmark Region
   - 3.1 Rationale for choice of benchmark areas 11
   - 3.2 Biophysical characterization of benchmark area 16
   - 3.3 Socio-economic and policy characterization 24
4. Characterization of Land Use Systems in the benchmark areas
   - 4.1 Community and household survey 34
   - 4.2 Sitiung benchmark area (West Sumatra) 36
   - 4.3 Bungo Tebo and Rantau Pandan benchmark area (Jambi) 39
   - 4.4 North Lampung 52
   - 4.5 From characterization to diagnosis 59
5. Highlights of Phase 1 Research
   - 5.1 Land use categories in relation to remote sensing 62
   - 5.2 Effects of land use on soil carbon content in Sumatra 64
   - 5.3 C, N and P in young 'jungle rubber' in Sitiung 68
   - 5.4 Greenhouse gas emissions and sequestration 70
   - 5.5 Soil organic matter dynamics in North Lampung ASB benchmark area 75
   - 5.6 *Eupatorium inulifolium* (kirinju) as preferred fallow species in Air Dingin . . 78
   - 5.7 Root distribution of multipurpose trees for acid soils 81
   - 5.8 Tree-soil-crop interactions in hedgerow intercropping 83
   - 5.9 Smallholder rubber agroforestry 86
   - 5.10 Rubber wood: environmental opportunity and policy barriers 93
   - 5.11 Changing land tenure institutions in the bufferzone of Kerinci Seblat Nat. Park 97
   - 5.12 Role of agroforests in reducing farmers' forest product gathering in KSNP 100
   - 5.13 Gender difference and gender relations in a translok and Lampung community 101
   - 5.14 Policies relevant to deforestation 106
   - 5.15 Damar agroforests 108
   - 5.16 Imperata grasslands: a policy perspective 110
   - 5.17 Segregate or integrate nature and agriculture for biodiversity conservation? 114
6. Planning Phase 2 and Phase 3 for ASB-Indonesia
   - 6.1 Introduction 119
   - 6.2 Stepping back from the trees to reconsider the forest 119
   - 6.3 Constraints and opportunities from the farmer's perspective 126
   - 6.4 Forces driving deforestation 129
   - 6.5 Integrating biophysical, land use and policy research at the benchmark level . 137
   - 6.6 Research priorities for phase 2 and phase 3 141

Publications of ASB-Indonesia and references used in this report 144
Appendix 1. List of personnel involved in ASB Indonesia, 1994-1995 150
Appendix 2. List of participating institutions 153
Reports of ASB-Indonesia 154

Summary

During the first phase of the Alternatives to Slash-and-Burn (ASB) project, we formed interdisciplinary teams involving scientists from national research institutes, universities and NGO's, as well as from international institutions. In the meantime the outcome of the earlier site selection process was reviewed on the basis of the guidelines for the characterization process. It was decided that four sites would be characterized in order to cover the various ecological zones and the major expected gradients within these zones. A project management structure was developed with a national steering committee to ensure linkages with national policies, a technical working group and a secretariat. Through a competitive mechanism, partners were found for the various aspects of the characterization work. Two training courses/workshops were held to strengthen the scientific base of the work on carbon dynamics and greenhouse gas emissions and on participatory rural appraisal methods. At the end of Phase 1 a national workshop was held to review the results obtained and prepare plans for Phase 2.

The guidelines for characterization, diagnosis and prioritization of research developed at the global level were translated to the Indonesian situation. During the second half of 1994 characterization work was started in the field, as well as by critically reviewing existing data on land use dynamics in its socio-economic, policy and biophysical context. Although traditional 'shifting cultivation' has virtually disappeared in Sumatra, slash-and-burn methods are used by a broad range of land users, ranging from the original population, via spontaneous and government sponsored migrants to large scale timber and tree crop plantations. For small farmers the dominant land use is rubber, ranging from extensive 'jungle rubber' to intensive plantation type systems. Food crops can be grown during the first years, but some (migrant) farmers depend fully on cash income to provide their food. The transformation of secondary and logged-over forests into permanent tree-based production systems ('agro-forests') can serve as an example for developments elsewhere.

The Rantau Pandan area in the piedmont zone, neighbouring the Kerinci Seblat national park, has a fairly stable population, without much inflow of migrants, and its land use is dominated by agroforests (mainly jungle rubber) with recent increases in the share of cinnamon (*Cinnamomum*, kayu manis or cassiavera).

The nearby peneplain site in the Bungo Tebo area has at least six groups of actors relevant to ASB: 1. a small number of the Kubu hunter-gatherer families who represent the oldest land users, 2. local Jambi farmers with jungle rubber as their main land use, 3. a government transmigration area (Kuaman Kuning), with an emphasis on food crops, 4. a forest concession held by Gadjah Mada University, 5. a group of spontaneous settlers ('forest squatters') who entered the forest after logging and started an intensified form of the jungle rubber system and 6. a recently-started oil palm plantation. A major focus for Phase-2 activities here could be the development of 'community forestry' arrangements between the forest concession holder and the (spontaneous) migrants which could allow protection of the remaining parts of the production forest as well as meeting the objectives of the farmers already established in the area. Preventing inflow of new migrants to the area by such arrangements would be a major achievement.

The North Lampung benchmark area in the peneplain has a higher population density and appears to be an out-migration area. Dramatic changes in population pressure due to the inflow of government-sponsored as well as spontaneous migrants over the past 15 years led to disappearance of nearly all forest remnants and to a clear need for development of more sustainable (probably tree-based) cultivation systems to prevent further degradation of the land. Recent farmer interest in oil palm, rubber and fast growing timber (*Paraserianthes*) trees could be merged with short term needs for food production. A more detailed analysis of the tree-soil-crop interactions in the initial years of tree (e.g. rubber) based production systems can contribute to improved design of such systems, balancing the conflicting requirements of short and long term benefits. Tests of improved rice, maize and grain legume germplasm in such systems is needed. Especially for the 'degraded lands', a combination with soil fertility improvement methods will be necessary.

The characterization made clear that a succession of vertebrate pests (elephants, wild pigs, monkeys and rats) form an important constraint to food crop production in the transition from 'forest margin' to 'degraded lands'. In some situations this stops farmers from growing food crops all together, and should be addressed before soil or germplasm improvement will have any impact.

Analysis of recent remote sensing data and comparison with the vegetation map made in the early 1980's confirms that substantial changes have occurred over the last decade and allows estimates of the net C emission due to land use change in the benchmark areas. A net carbon release of 6.8 and 9.0 t C ha^{-1} yr^{-1} was estimated for the Bungo Tebo and North lampung benchmark areas, respectively, and a net C sequestration of 3.1 t C ha^{-1} yr^{-1} in Rantau Pandan. Changes in below-ground C stocks due to land use changes are likely to be small in comparison with above-ground changes. Consequences of land use change for greenhouse gas emissions are not confined to the total C budget. However, preliminary measurements on methane (CH_4) and nitrous oxide (N_2O) flux suggest considerable changes: the methane sink strength of upland soils, which partly offsets the methane production by lowland rice, is reduced after forest conversion, along with a decrease in specific organic matter fractions. N_2O emissions, however, appear to change in the opposite direction and make clear that further quantification is needed.

Low-management intensity rubber ('jungle rubber') does allow the survival of a considerable part of the original forest biodiversity. A major issue for further research is whether the introduction of more productive rubber germplasm into this system can allow intensification without much loss to the remaining biodiversity.

The global ASB project is built on the hypothesis that development of agroforestry-based forms of intensified land use as an alternative to slash-and-burn agriculture can help to alleviate poverty as well as conserve biodiversity. The Sumatra case shows that a) such agroforestry solutions indeed exist and help to alleviate poverty, but b) they may speed up rather than slow down forest conversion and thus reduce biodiversity. The rapid spread of rubber as a smallholder crop in Sumatra since the beginning of the 20'th century has contributed to large scale forest conversion, to the point that there is hardly any lowland primary forest left. The logging concessions, especially of the 1960's-1980's, followed by an inflow of spontaneous settlers with rubber-based agriculture have completed the process. It is clear that the migration issue should be incorporated into the ASB research programme.

Preface: Why Alternatives to Slash-and-Burn in Indonesia?

Slash-and-burn stands both for a certain technique of converting forested land into other land use, temporary or permanent, and for an extensive system of agriculture which leaves land fallow after a few years of growing crops to open up new land ('slash-and-burn agriculture', 'shifting cultivation'). The search for 'alternatives' is based on a number of concerns:

- slash-and-burn as a technique of land clearing leads to both visible (smoke) and invisible (especially the greenhouse gasses methane and nitrous oxide) air pollution, as well as a release of CO_2 into the atmosphere; alternative techniques of land clearing, including slash-and-mulch systems as well as biomass utilization (as timber, firewood, pulp) will reduce the air pollution (at least the visible part of it), although not essentially changing the C balance,

- forest clearing as such, independent of the technique used, leads to a loss of biodiversity as well as stored carbon; extensive forms of agriculture, such as slash-and-burn agriculture, need more land per unit production than more intensive forms and thus lead to a greater loss of biodiversity per unit production.

Concerns about global warming (due to the release of greenhouse gasses) and loss of biodiversity were combined in formulating the 'Alternatives to Slash-and-Burn' (ASB) project. Poverty alleviation and securing food supplies also are central objectives, as many of the small-scale farmers practicing slash-and-burn agriculture worldwide appear to do so out of poverty and lack of other feasible livelihood alternatives. A global project was formulated to address the issue in various parts of the tropics, as broadly similar patterns appear to exist in the different continents. Before specific 'alternatives' can be formulated and tested, however, a better characterization and diagnosis of the problems is needed, combining social, economic, agronomic, environmental and biological aspects. The same phenomenon, slash-and-burn, may be practiced by different actors and caused by different factors under different circumstances. Universal answers (alternatives) are probably not appropriate. Indonesia was chosen as one of the first three countries (along with Brazil and Cameroon) for the project.

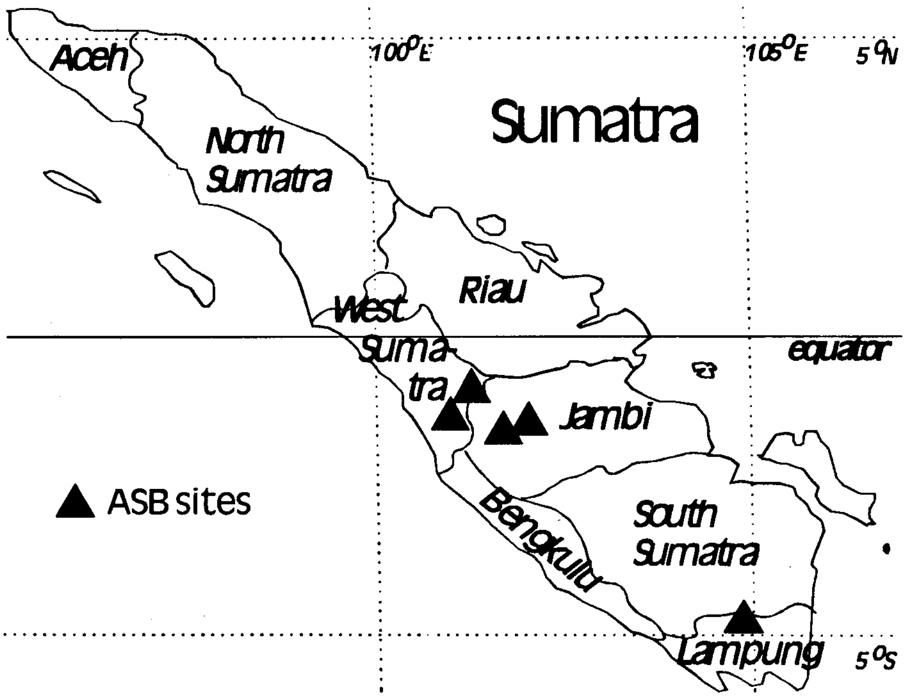
In the long dry season of 1994 large amounts of smoke, released by forest fires, slash-and-burn, and other activities in Sumatra and Kalimantan caused problems of poor visibility and air pollution for neighbouring countries (Singapore and Malaysia) and thus caused considerable embarrassment for the Indonesian government. A lively debate followed on who were the main culprits (forest concessions, traditional shifting cultivators, recent 'forest squatters') and what can be done to reduce the problems. Alternatives to Slash-and-Burn thus became a high priority area. But in the debate, the focus was on the smoke and thus on slash-and-burn as technique and not on the broader aspects of land use change. Technical alternatives such as 'slash-and-mulch' or biomass utilization may reduce the most visible part of the problems (and thus improve the visibility for air traffic), but may have a small effect on the net emission of greenhouse gasses. New government regulations were issued ('slash-and-burn practices are no longer allowed...'), but they will be difficult (if not impossible) to implement and control and they do little to address the concerns over rural poverty, global warming and biodiversity loss.

First of all, we need a better understanding of the dynamics and driving forces of land use change and forest conversion. The ASB project started in Phase 1 with a careful review of the available evidence and detailed characterization of a number of 'benchmark areas', chosen to represent a range of environmental and socio-economic conditions. A multidisciplinary and multi-institutional team of researchers was formed in Indonesia, with support of international institutions, to carry out this research. The present report of the first year's activities summarizes the highlights of that work. The research has certainly deepened our understanding of the complexity of the problems. Priority areas for developing alternatives can now be formulated, as the last chapters of this report show and we hope to examine these in Phase 2 and 3 of the project.

This report is a compilation of the various research activities presented at the Regional Workshop in June 1995 and is based on the contributions of all researchers mentioned in appendix 1. The reader is referred to the various reports listed at the end of this report for more detailed accounts.

Bogor, September 21, 1995

The editors



1. Composition of the ASB-Indonesia Consortium

Preparations for the Alternatives to Slash-and-Burn (ASB) project in Indonesia started in August 1992 when a 'site selection team' of researchers from ICRAF, IRRI, the Ministry of Agriculture and the Ministry of Forestry visited three prospective sites (one in Kalimantan, two in Sumatra) and recommended that the Sitiung area and neighbouring bufferzone areas of the Kerinci Seblat National Park in West Sumatra province would be used as benchmark areas (ICRAF, 1995). During a research methodology workshop following the second Global Steering Group meeting in February/March 1993 (Garrity and Khan, 1994) and a subsequent training course in May 1993 (Garrity *et al.*, 1993) the area was visited again and initial data were collected.

A national workshop in December 1993 with prospective participants in the project reviewed the initial site selection and recommended that an additional site in North Lampung be added for a contrast in population density and that the Sitiung site would be augmented or shifted to an area in neighbouring Jambi province, more central to the peneplain zone.

To implement the ASB project in Indonesia, a 'national steering committee' was formed, consisting of representatives of various national institutions and a 'technical working group', which includes representatives from international institutions as well. The composition of both groups was confirmed in March and April 1994 (Appendix 1).

Funding for the ASB project in Indonesia was confirmed in early 1994 and funds finally became available by mid 1994. A call for research proposals was circulated in May 1994. Ten out of 17 proposals received were approved by a proposal evaluation team and the technical working group. Notification of accepted proposals was sent during August 1995 and field work started in the second half of 1994.

The research titles, the names of leading institutions and research coordinators and the time table are listed in Table 1. Names of all researchers involved are listed in Appendix 1. Two activities deal with biophysical aspects, six with socio-economics and land use/production systems, one deals with gas emissions and one with policy, including a workshop on participatory rural appraisal (PRA) methodology. A workshop on the use of the Century model was included in the greenhouse gas emission activities.

All the ten activities were adjusted to fulfill the seven activities programmed for phase I, i.e. :

1. Characterization and Diagnosis,
2. Development of Alternatives,
3. Soil Carbon and Nutrients,
4. Policy Research,
5. Training,
6. Green House Gases and
7. Biodiversity.

All research activities were completed and reported at the national workshop in June 1995. This report summarizes the main results. Detailed reports are available on request (see list of publications in References).

Table 1. Research Activities ASB-Indonesia, August 1994 - June 1995

No.	Title/Activities	Leading Institute	Research Coordinator
1.	Characterization of Biophysical Parameters for Determining Alternatives to Slash and Burn Practices	CSAR	Dr. Soleh Sukmana
2.	Vegetation Characterization and Parameterization	BIOTROP	Dr. Upik Rosalina
3.	Characterization of Production and Land-Use Systems at Rantau Pandan Sitiung, Muara Bungo and N. Lampung	CRIFC	Dr. Zulkfli Zaini
4.	Characterization of Slash and Burn Agricultural System in Bungo Tebo, Jambi	UGM	Dr. Sambas Sabarnudin
5.	Study on Sustainable Land Use Development Pattern (Sitiung, Muara Tebo and North Lampung)	Transmigr.	Ir. Harry S. Setiawan
6.	Study on Agro Forestry Characterization in Rantau Pandan, Muara Tebo and North Lampung	FNCRDC	Dr. A. N. Ginting
7.	Greenhouse Gas Emissions and Carbon Balance in Slash and Burn Practices*	IPB	Dr. Daniel Murdiyarso
8.	Workshop on Participatory Rural Appraisal Methodology (PRA)	CASER	Dr. Husein Sawit
9.	Socio Economic Characterization in Three Ecological Zones of Sumatra	CASER	Prajogo Utomo Hadi,MSc
10.	An Analysis of Slash-and-Burn Policy : The Case of Three Ecological Zones in Sumatra**	CASER	Dr. Andin Taryoto

* Including workshop on modelling and measuring soil organic matter dynamics and greenhouse gas emissions after forest conversion in cooperation with TSBF.
** Including workshop on participatory rural appraisal (PRA) methods.

2. Training

Training was an important element in Phase 1 activities of ASB Indonesia and consisted of three elements: formal training workshops, graduate student research, and 'on the job training'.

Two training workshops have been implemented in Phase 1 to strengthen the national research team. The first, a training workshop on Modelling and Measuring Soil Organic Matter Dynamics and Greenhouse Gas Emissions after Forest Conversion was conducted from 7 to 15 August 1994 in collaboration with TSBF - Nairobi. A general introduction and computer sessions with the CENTURY model in Bogor were followed by field exercises in Muara Tebo, Jambi. Seventeen ASB researchers from 12 different institutes actively participated in the successful workshop. The workshop stressed the use of the Century model to evaluate soil carbon and nutrient dynamics. Methods to measure greenhouse gas emissions and sinks were tried and further developed during the workshop. A report was published as ASB-Indonesia report no. 1 (Murdiyarso *et al.* 1994).

The second training activity was a three day workshop to introduce and discuss the merits of the Participatory Rural Appraisal (PRA) methodology for characterization of biophysical, socioeconomic, land use, and policy aspects by ASB researchers. The workshop was held at Mega Mendung, Bogor, from 21 to 23 November 1994 and was attended by 22 ASB researchers from 12 different institutions. The workshop benefitted from the active involvement of local NGO researchers. The workshop concluded that a full-fledged PRA was not appropriate at this stage of the ASB site characterization, as it might raise expectations of a direct 'development' involvement of the ASB project in the near future. Nevertheless, various methods involving participation by villagers in the identification of their opportunities and problems were found valuable. A report was published as ASB-Indonesia report No. 2 (Husen Sawit *et al.*, 1995).

A number of graduate students participated in the ASB project in Phase 1. Two MSc students (one from Institut Pertanian Bogor and one from York University (Canada)) carried out field research in the bufferzone of Kerinci Seblat National Park ('Air Dingin'). Four MSc students from Brawijaya University (Malang) participated in soil fertility research in the N. Lampung benchmark area. One PhD student from the University of London (UK) did her field work in the N. Lampung benchmark area, looking at gender aspects of livelihood strategies in transmigrant and local communities. Plans were made and/or finalized for a number of PhD students to participate in Phase 2 research. These include PhD students from the University of Hawaii, University of Wales (UK), University of London (UK) and Tsukuba University (Japan). Other proposals are being developed.

'On-the-job training' was clearly an element of the Phase 1 research, as the characterization called for a more integrated, interdisciplinary mode of working. Close cooperation was maintained throughout between the national scientists of the ASB-Indonesia consortium and ICRAF S.E.Asia. The national workshop in June 1995 to report on Phase 1 research and to develop plans for Phase 2 (and 3) research contributed to the 'on-the-job training' of all participants, as it was truly interdisciplinary in nature.

3. Sumatra as an ASB-benchmark Region

3.1 Rationale for choice of benchmark areas

At the start of Phase 1 the initial choice of research sites was revisited in the light of the procedural guidelines developed globally. For the ASB project, Indonesia was chosen to represent the humid tropical forest zone in Asia. Indonesia still has large forest areas, but forest conversion to other land uses is rapid. The transformation from primary to secondary forest types is largely due to timber extraction, with a smaller role for traditional shifting cultivation systems. Subsequent transformation of secondary and logged over forest types generally is based on 'slash-and-burn' practices, by a variety of actors (large-scale as well as smallholder) for a variety of reasons. Part of the forest is converted to (temporary) crop land, either in government-sponsored schemes or by spontaneous migrants. These lands can evolve into *Imperata* grasslands (alang-alang) or into permanent tree-based production systems (agroforests or tree crops). Both the 'forest margin' and the 'degraded land' focus of the global ASB project are relevant in Indonesia.

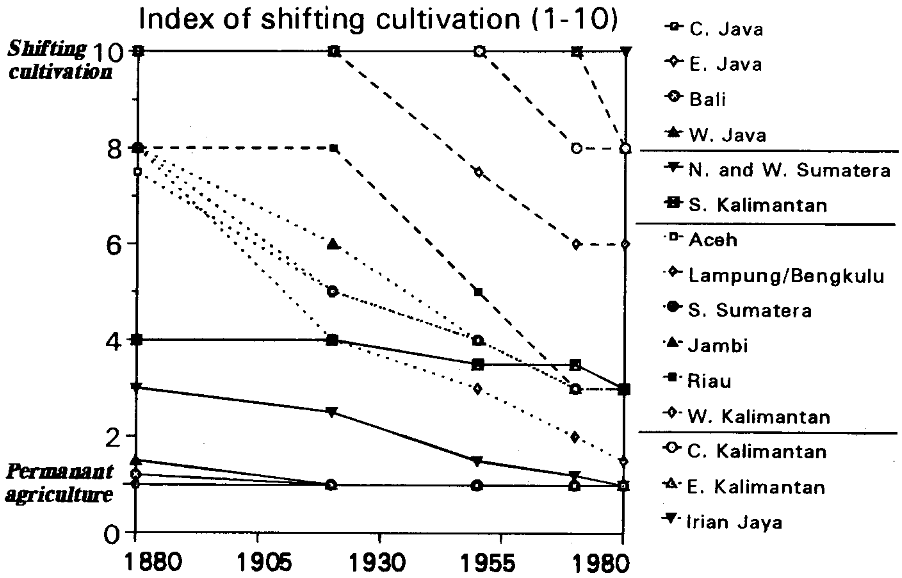


Figure 1. Historical transition of shifting cultivation into permanent agriculture for different provinces of Indonesia, according to Richards and Flint (1993)

Characterization at the regional/national scale should identify broad agro-ecological-economic areas. The historical transformation of 'shifting cultivation' to 'permanent agriculture' has occurred at different rates in various provinces of Indonesia. Broadly speaking four groups can be distinguished (Fig. 1; Richards and Flint, 1993):

I. Java + Bali, where the transformation to permanent agriculture occurred before 1880

II. North and West Sumatra and South Kalimantan, where the transformation was nearly complete by the middle of the 20'th century,

III. Most of Sumatra, where most of the transformation took place during the middle of the 20'th century,

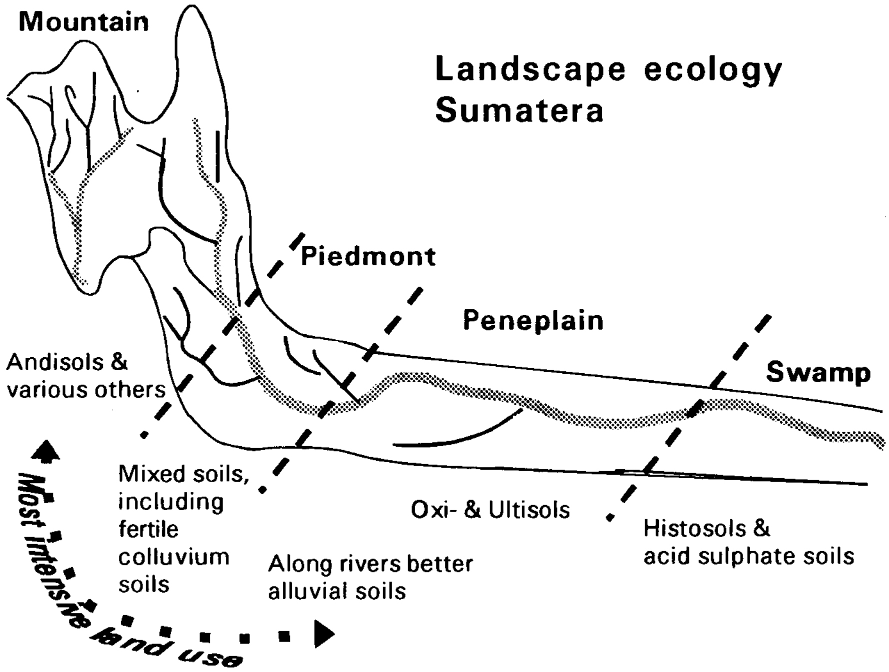


Figure 2. Landscape ecology of Sumatra and transect through ecological zones on the N.E. side of the mountain range

IV. The rest of Kalimantan and Irian Jaya which are still in the early stages of the transformation.

It was decided to start the ASB project in Sumatra (group III), but Kalimantan and Irian Jaya may offer other perspectives in a later stage.

The next step is to identify 'benchmark areas', defined as 'homogenous areas in terms of the biophysical and general socioeconomic factors that influence slash and burn activities'. Sumatra is 350 km at its widest, almost 1 700 km long, and is cut in two roughly equal parts by the equator; the highest peak is Mount Kerinci (3804 m a.s.l.). Its total land area is 480 000 km^2. The agro-ecological zonation of Sumatra which has found the widest acceptance is the one given by Scholz (1983) in "The natural regions of Sumatra and their agricultural production pattern, a regional analysis" (Fig. 2 and 3).

Most of Sumatra is in the humid tropics. Oldeman *et al.* (1979) classified climatic regions in Sumatra according to the number of humid (> 200 mm of rain) and dry (< 100 mm of rain) months. Climate zones A (> 9 humid months, <2 dry), B (7-9 humid, < 2 dry) and C (5-6 humid, 3 dry) cover most of the island; drier climate zones D (3-4 humid, 2-6 dry) and E (<3 humid, up to 6 dry) occur especially in the northern part. Within Sumatra five major agro-ecological zones are identified with boundaries running from N.W. to S.E. approximately parallel to the coast:

1. a narrow Western coastal zone, the lower slopes of the mountain zone on the S.W. side, with various soil types; climate zones A and B;
2. a mountain zone, dominated by andosols and latosols of reasonable to high soil fertility; climate zones A and B and small patches of D and E;

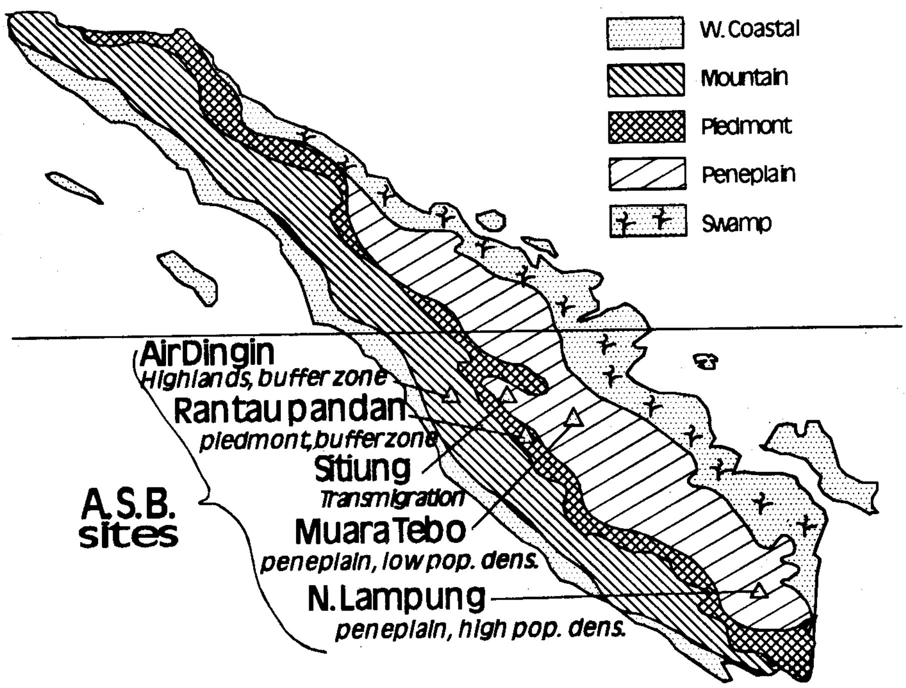


Figure 3. Ecological zones of Sumatra and ASB research sites

3. a narrow piedmont (foothill) zone, the lower slopes of the mountain range on the N.E. side, dominated by latosols and red-yellow podzolics; climate zone B;
4. a broad peneplain zone, almost flat land with Tertiary sediments, deposited in the sea; at present its altitude is less than 100 m above sea level and it consists of about 10% river levees and floodplains with more fertile alluvial soils and 90% uplands with a gently undulating landscape and mostly red-yellow podzolic soils; climate zone mostly B, with zone C in the S.E.;
5. a coastal swamp zone with peat and acid sulphate soils; climate zones C, D and E.

The zones 1, 2 and 3 contain the most fertile soils and have been inhabited for long periods of time. The coastal swamps and the peneplain were inhabited sparsely as human population was traditionally concentrated along the river banks on relatively favourable sites.

Since the beginning of 20th Century, population density in Sumatra increased also in the peneplain by migration from Java both spontaneously and sponsored by the government. A clear gradient in population density occurs from the South (Lampung) to the middle (Jambi, Riau) of the island. Although the major part of the land in Sumatra is considered to be government forest land, a substantial part of this land is no longer under forest cover. Figure 4 shows that the amount of 'forest damage' is correlated with population density at the provincial level, with Riau and Jambi at one end of the spectrum and Lampung on the other.

In view of this zonation, five sites were chosen for detailed characterization for the ASB project. In addition to the Sitiung and Air Dingin sites recommended by the original site selection team and where preliminary data collection has already started, these include two

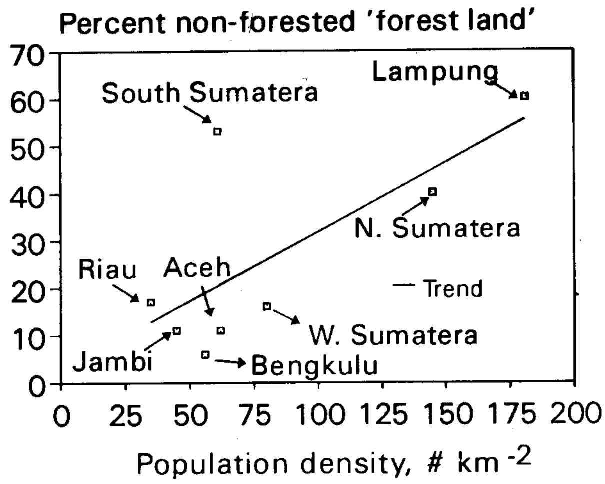


Figure 4. Relation between population density and 'forest damage' (percent non-forested state forest land), based on data of RePPProT (1990) and Haeruman (1992)

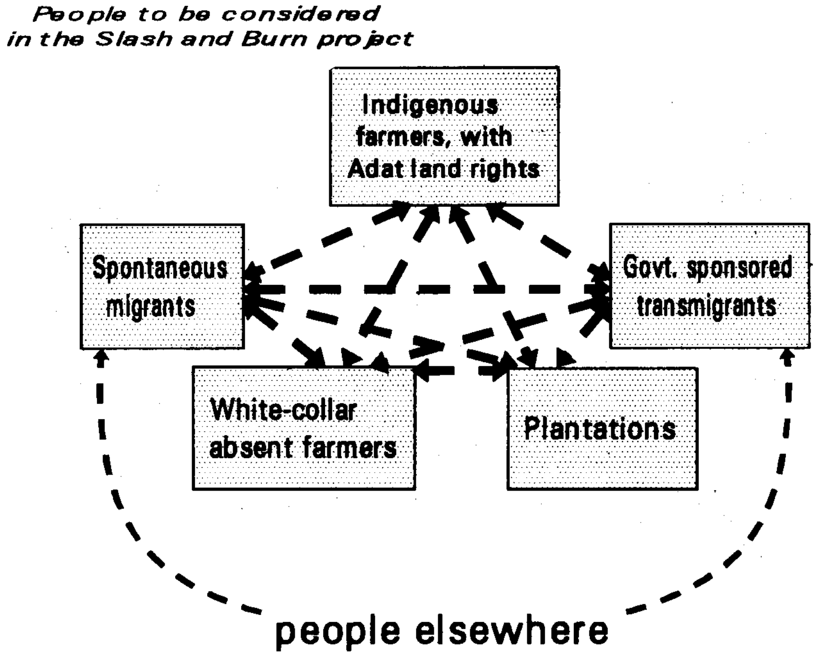


Figure 5. Major groups of land users to be considered in the ASB project; the 'people elsewhere' as a potential source of future migrants can not de directly sampled

sites in Jambi province (one in the peneplain and one in the piedmont zone) and one in North Lampung (in the peneplain).

In the benchmark areas various groups of land users are important (Fig. 5). For the community scale characterization emphasis was given to indigenous farmers, spontaneous migrants and government-sponsored transmigrants, but also to their mutual interactions and interactions with 'white-collar absentee farmers' and 'plantations' as far as these occur in the benchmark area. Figure 6 summarizes the stepwise selection process and the presumed extrapolation domains for the characterization data.

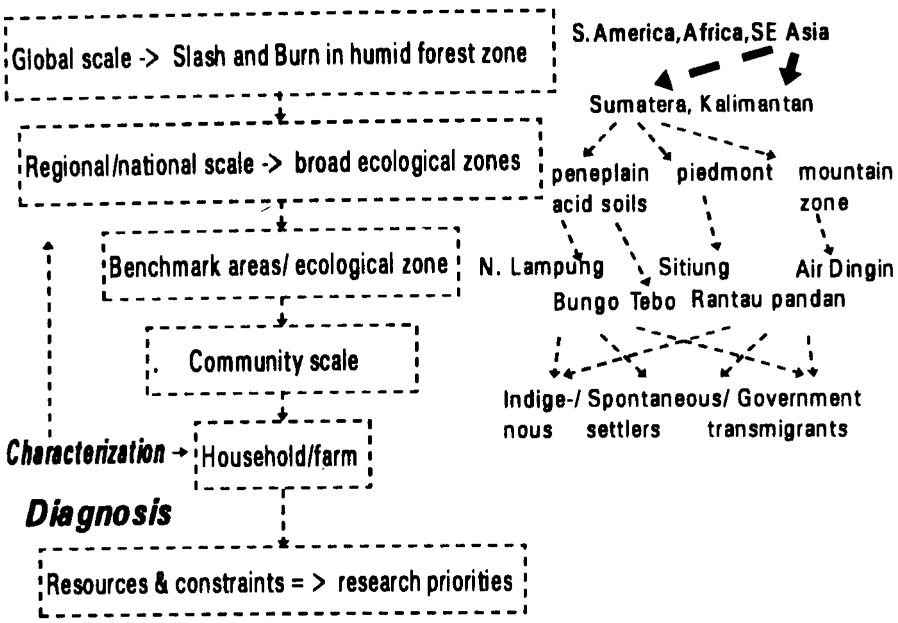


Figure 6. Stepwise choice of research sites and extrapolation domains

Table 2. Site selection for characterization and diagnosis activities by ASB-Indonesia

Benchmark Area	Ecological Zone	Main Focus in ASB	Population density relative to resources
Air Dingin, W. Sumatra	Mountain	Buffer zone of National Park (KSNP) in highlands	High, emigration
Rantau Pandan, Jambi	Piedmont	Buffer zone of National Park (KSNP) in piedmont, rubber agroforests, traditional shift. cult.	Intermediate
Sitiung, West Sumatra	Piedmont/ peneplain	Transmigration villages interacting with local farmers	Intermediate, recent immigration
Bungo Tebo, Jambi	Peneplain	Forest margin: spont. settlers, transmigrants	Low', immigration
North Lampung	Peneplain	Degraded land rehabilitation as alternative to migration	High, immigration + emigration

KSNP = Kerinci Seblat National Park

3.2 Biophysical characterization of benchmark area

3.2.1 Climate

Climate data were collected from nearby climatological stations for the four benchmark areas (Table 3). Annual rainfall ranges from about 2,471 to 3,012 mm. According to the rainfall classification of Schmidt and Ferguson (1951), all benchmark areas are in class A, with 11-12 months of more than 100 mm rainfall and only 1 month with less than 60 mm on average. The Jambi/W. Sumatra sites have 7-9 wet months (> 200 mm rainfall) and less than 2 dry months (100 mm rainfall); they thus belong to agroclimatic zone B1 (Oldeman, 1975). The North Lampung area has a more pronounced dry season and a slightly lower annual rainfall (2471 mm) than the other sites, 5-6 wet months (> 200 mm rainfall) and 2-4 dry months (< 100 mm rainfall); it thus falls in agroclimate zone C-2. The mean maximum temperature varies from 30°C in January to 32.3°C in May and October. While the mean minimum temperature varies from 22.1°C in July and September to 22.7°C in April and May.

Table 3. Climate stations close to the ASB benchmark areas in Sumatra (Rachman *et al.*, 1995)

Bench-mark area	Rainfall/Climate station	Map coordinates		Elevation (m asl)	Years of data	Annual rainfall (mm)
Sitiung	Sungai Dareh	00°53'S	101°30'E	50	51-79	3001
	Sungai Langsat	00°52'S	101°03'E	200	51-79	3945
	Sitiung*	00°59'S	101°32'E	55	78-94	2859
Bungo Tebo	Muara Bungo	01°27'S	102°06'E	80	52-88	2982
	Kuamang Kuning*	01°38'S	102°12'E	50	89-91	3012
	Muara Tebo	01°27'S	102°29'E	36	51-79	2149
Rantau Pandan	Tanah Tumbuh	01°26'S	101°52'E	100	51-79	2926
	Rantau Panjang	01°48'S	102°15'E	75	51-79	2898
	Bangko*	02°04'S	102°15'E	75	51-79	3146
North Lampung	Menggala	04°28'S	105°15'E	18	51-79	2613
	Negeri Besar	04°32'S	104°59'E	28	51-79	2634
	Tela*	04°35'S	105°01'E	30	84-93	2471

*) Climate station

3.2.2 Sumatra soil database

In the 1980's a coherent set of 1: 250 000 soil maps of Sumatra was prepared by the Centre of Soil and Agroclimate Research (CSAR-AARD, Bogor), in the context of the LREP (Land Resources Evaluation and Planning Project) project. The data are stored in a soil database. For the ASB project we analyzed the relation between soil type, land use and soil organic matter content (see also section 5.2).

To judge the validity of the data for the current purpose, consider how they were collected. For each map sheet aerial photographs and satellite images were interpreted for 'land forms' (physiographic). For each land form, a number of 'facets' (e.g. hill,slopes and valleys) were distinguished. For each facet a number of sample sites (pedons) was chosen (at random) and the soil profile was described in the field, soils were analyzed for texture and chemical characteristics and the current land use was recorded. The soil was classified according to the US Soil Taxonomy. The sampling procedure was thus a stratified random sample with two strata (land forms and facets). The total results may not reflect the true average values, as relatively rare pedons can be over-represented. Yet, this data set may be the best available for analyzing land use by soil type in Sumatra. Peat soils are of particular interest, as they contain about half of all organic C in all tropical forest soils of the world on only about 0.5% of the area still under tropical forests (Eswaran *et al.*, 1993). Peat soils thus contain 100 times the average C content per ha and 199 times the average of non-peat soils.

Figure 7 shows a classification of land use by soil type. The soil data were grouped to make five classes: Histosols (peat), all wetland soils (classified as aquic subgroups of various soil orders; previously classified as Gley soils), Andisols (recent volcanic soils), a group of fairly fertile soils (Alfisols, Entisols, Inceptisols, Mollisols and Spodosols; this group (very) roughly corresponds with the 'Alluvial' soils of earlier soil maps and partly overlaps with the Latosols mentioned before) and a group of acid soils of low fertility (Oxi- and Ultisols, including most of the previous 'Red Yellow Podzolics'). For figure 7 the 70 land use types were combined into 5 groups: swamp vegetation (mostly forest), primary forest, secondary forest (including 'jungle rubber' systems), a group tentatively indicated as S&B series (including shrub-land, *Imperata* grasslands (alang-alang) and land currently used for annual crops) and a group with permanent crops (various tree crop plantations and sawah rice fields). The size of the circles in Figure 7 shows the number of data in the five soil groups. The Andisols form only 3.9%, the Histosols 10.3, the wetland soils 23.9 and both of the upland soil groups about 31% of the data set. Figure 7 shows that swamp vegetation is mostly (but not completely) restricted to the two wetland soil groups. Secondary forest is the most important group overall (41.3%). This group includes large areas of 'jungle rubber' and 'fruit tree enriched agroforests', which were not separately classified for the LREP study. Primary forest is only 8% of the three upland soil groups. The S&B series is remarkably evenly distributed over the soil types (15.7-26.8% of all non-swamp land use, with the lowest value for the Histosols and the highest for the two main upland soil types).

Nearly half of the Andisols (43.2%) are used for permanent cropping (mostly tree crops). On the other soils permanent crops represent 13.5-19.8% of the data set, with the lowest value for the Oxi- and Ultisols and the highest for the wetland soils (mostly sawah).

The group indicated as S&B group consists of annual crops and two vegetation t ypes which may be interpreted as fallow land: shrub and *Imperata* grasslands. This interpretation is only a first approximation, as some of the shrubland, especially on the wetland soils, may be natural. Figure 8 shows the relative composition of the S&B series on the three upland soil types. Crops are 14% of the S&B series on the Oxi- and Ultisols (indicating an overall crop: fallow ratio of 1:7, a very rough estimate), 21% on the alluvial upland group (tentative

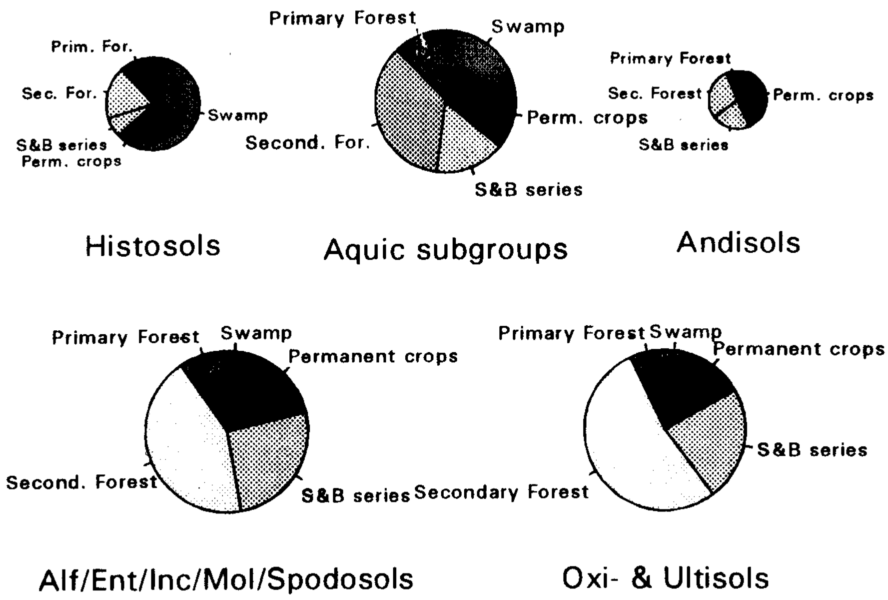


Figure 7. Land use by soil group in the CSAR soil database for Sumatra

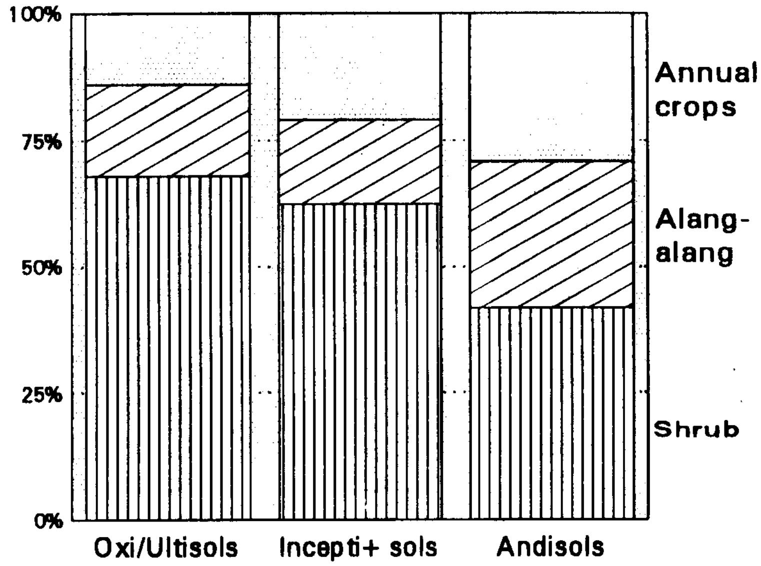


Figure 8. Composition of slash-and-burn (S&B) series on the three groups of upland soils in Fig. 7.

crop: fallow ratio 1:5) and 29% on the Andisols (1:3.5). This ratios correspond with a trend of increasing soil fertility from the Oxi- and Ultisols to the Andisols. Interestingly, on all soils the area under *Imperata* grasslands is equal to the area used for annual crops. The ratio of permanently cropped land and the S&B series is lowest on the Oxi- and Ultisols (1: 2), highest on the Andisols (2:1) and intermediate (1.2:1) on the other soil orders.

3.2.3 *Soil maps of benchmark areas*

For the ASB project about 5 000 ha in each benchmark area was mapped at the 1 : 50 000 scale. Field soil characterization was conducted along transects, based on the differences in land form, soil catena, and land use. Undisturbed soil and bulk samples were collected to determine the soil physical and chemical properties respectively.

Bungo Tebo and North Lampung are dissected peneplains, consisting of acid tuffaceous sediments. Sitiung is also a dissected peneplain and consists of acid clayey sediment alternating with acid volcanic tuff cover. Rantau Pandan represents a piedmont area which was built mainly by granite and andesitic lava.

Soils in Bungo Tebo and Sitiung are very deep, well drained, very acid, and have low soil fertility status. Soils in Rantau Pandan are more varied and complex than the ones in Bungo Tebo. The soils range from shallow to very deep, moderate to fine in texture, well to moderately-excessively drained, very acid, and low soil fertility status.

Soils in North Lampung are very deep, well drained and very acid, with low soil fertility status; iron concretions are often found within the soil profiles. Soil erosion has occurred throughout the area with various intensities depending on land management.

Dominant soil types are: Typic Hapludox in Sitiung, Typic and Oxic Dystropept (Rantau-Pandan), Typic Kandiudox (Bungo-Tebo) and Plinthic and Typic Hapludox (N. Lampung).

Table 4. Relative area (%) covered by the four great soil groups in the detailed soil maps of the four benchmark areas (Rachman *et al.*, 1995)

Great groups	Rantau Pandan	Sitiung	Bungo-Tebo	North Lampung
Entisols	12	7	11	7
Inceptisols	88	-	-	29
Ultisols	-	62	-	-
Oxisols	-	31	89	64

3.2.4 *Vegetation*

A vegetation map (scale 1: 250 000) for Sumatra has been published in three map sheets by SEAMEO-BIOTROP, based on Landsat MSS satellite data for the period 1983-1985. A description of the various vegetation types is given by Laumonier (*in press*). The vegetation description is based on natural vegetation (100 legend units, 82 for uplands and 18 for swamp vegetation) and cultivated types (21 legend units, often 'mosaics' of one or more crops and secondary vegetation).

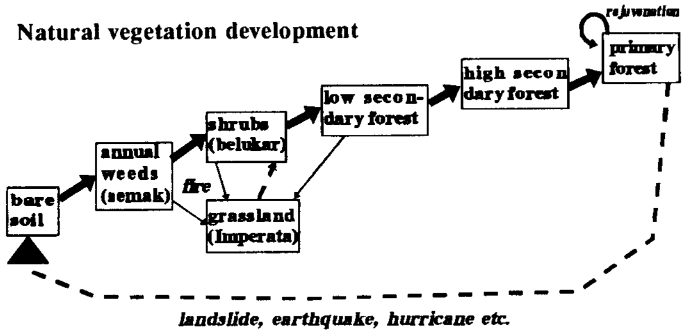


Figure 9. Natural vegetation succession in the humid tropics

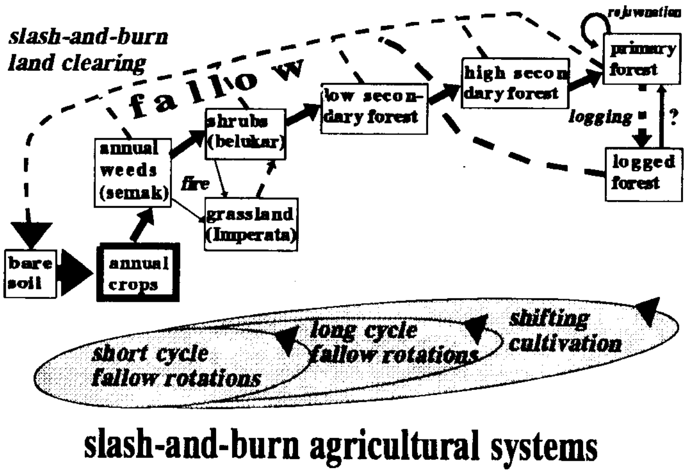


Figure 10. Slash and burn land use systems in the humid tropics

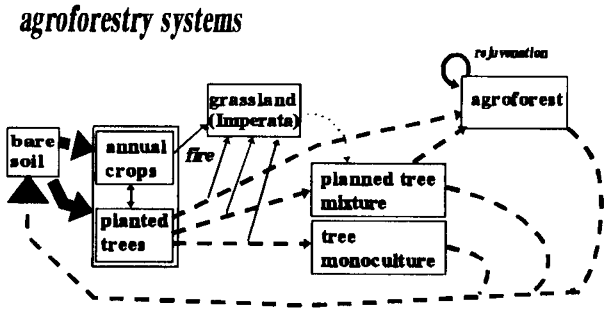


Figure 11. Agroforestry systems in the humid tropics, ranging from simultaneous tree-crop systems to 'agroforests' with only a short intercropping phase

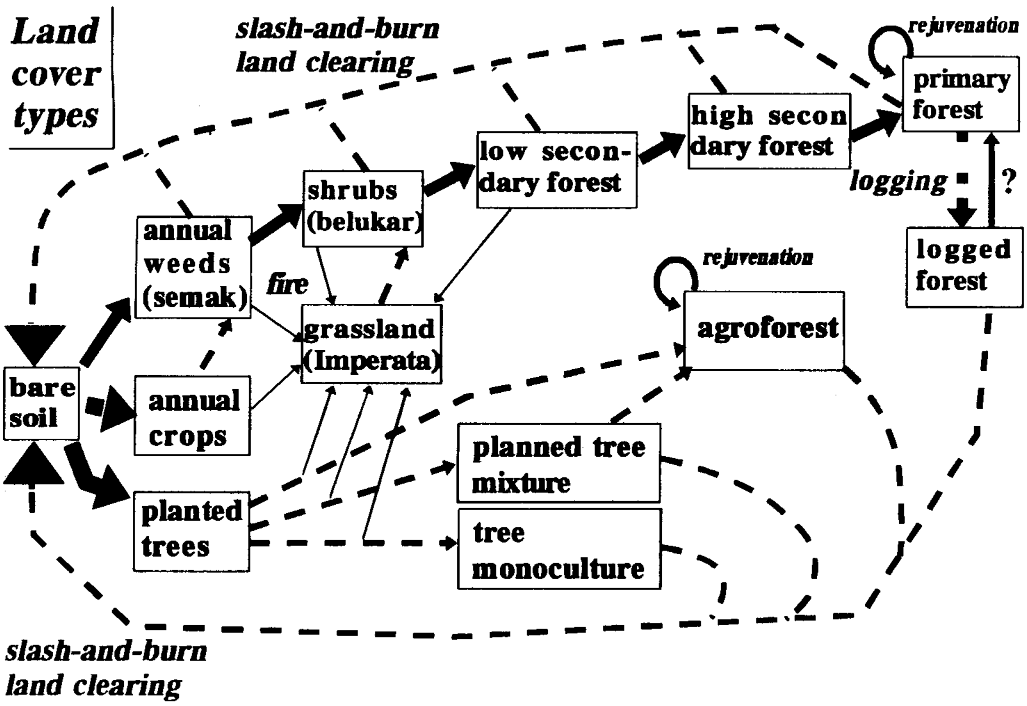


Figure 12. Combined natural and man-made vegation types in the humid tropics

Fig. 9 shows the natural succession in a schematic form; volcanic eruptions, land slides, earthquakes and similar events will initiate a 'primary succession', leading to various forest types, depending on elevation and soil type. Fig. 10 shows the various types of 'shifting cultivation', 'long rotation fallow' and 'short rotation fallow', where forest or shrub land is opened to grow food crops. The grass fallows which are formed, especially after prolonged cropping, tend to be perpetuated by fire and can lead to an 'arrested succession' in the form of large ('sheet') alang-alang (*Imperata cylindrica*) grasslands. Fig. 11 shows the major 'alternative to slash and burn' in Sumatra, in the form of 'agroforests' or man-made forests, with a large share of directly useful trees. These can be seen as the ultimate form of 'enriched fallow systems', in the sense that the trees planted in the fallow are the major source of income for the farmers and the food crops grown in the initial years are no longer the major 'raison d'être' of the land use system.

Fig. 12 finally combines the elements of figures 9, 10 and 11 into a flow scheme of the major vegetation types of interest to the ASB project. The 'agroforest' land use type has not been recognized in many of the previous descriptions. For example, the land use classification system proposed for Indonesia by Malingreau and Christiani (1981) and used in the LREP project (see 3.2.2) only recognizes 'taungya' type tree plantations with food intercrops as 'agroforestry'.

Fig. 13 shows the vegetation/land use types of the three benchmark areas according to the 1986 vegetation map. Figure 14 shows the new situation in 1994. Figure 15 gives the changes in land cover for Jambi province as a whole for the 1986-1992 period.

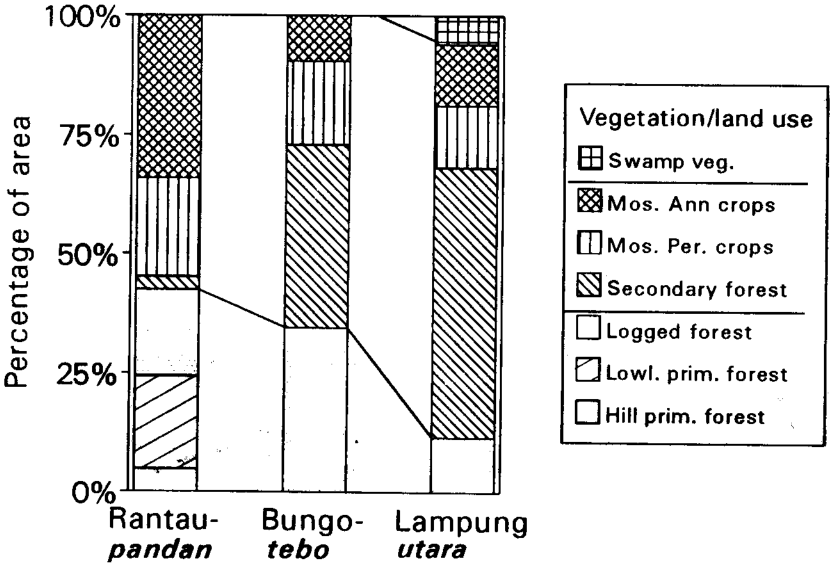


Figure 13. Land use in three benchmark areas according to the 1986 vegetation map

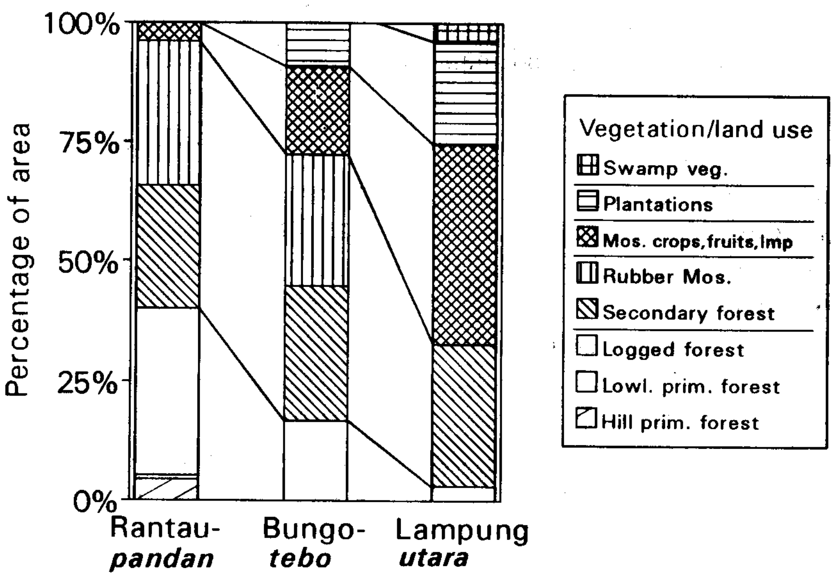


Figure 14. Land use in three benchmark areas according to 1994 satellite images

3.2.5 Forest conversion in Sumatra

Fig. 16 shows the distribution of remaining forest in 1932 (based on Van Steenis, 1935). Although the major part of the island was still under forest cover at that time, it started to look like an Emmenthaler cheese with big holes. Forest conversion by that time had taken place mainly in a) coastal zones, especially Aceh, W. Sumatra, Bengkulu and Lampung, b) close to the major rivers in the eastern peneplain, especially the Musi river in S. Sumatra and the Batanghari river in Jambi and c) N. Sumatra, the area of the plantation boom in the late 19'th, early 20'th century (tobacco, rubber).

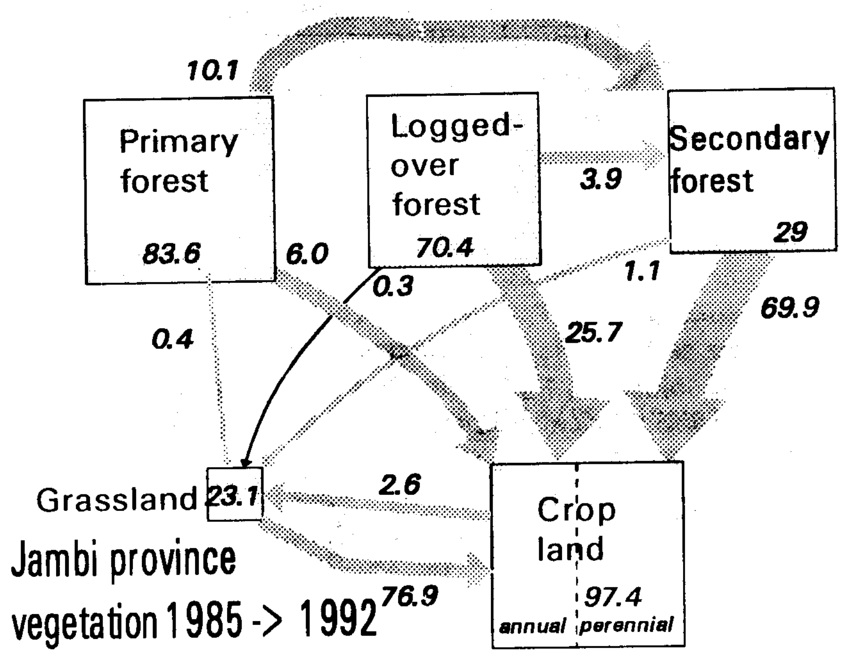


Figure 15. Land use change in Jambi province in the 1986-1992 period, according to Murdiyarso and Wasrin (1995); size of the boxes reflects area in, size of arrows absolute change, numbers in boxes and arrows relative changes (%)

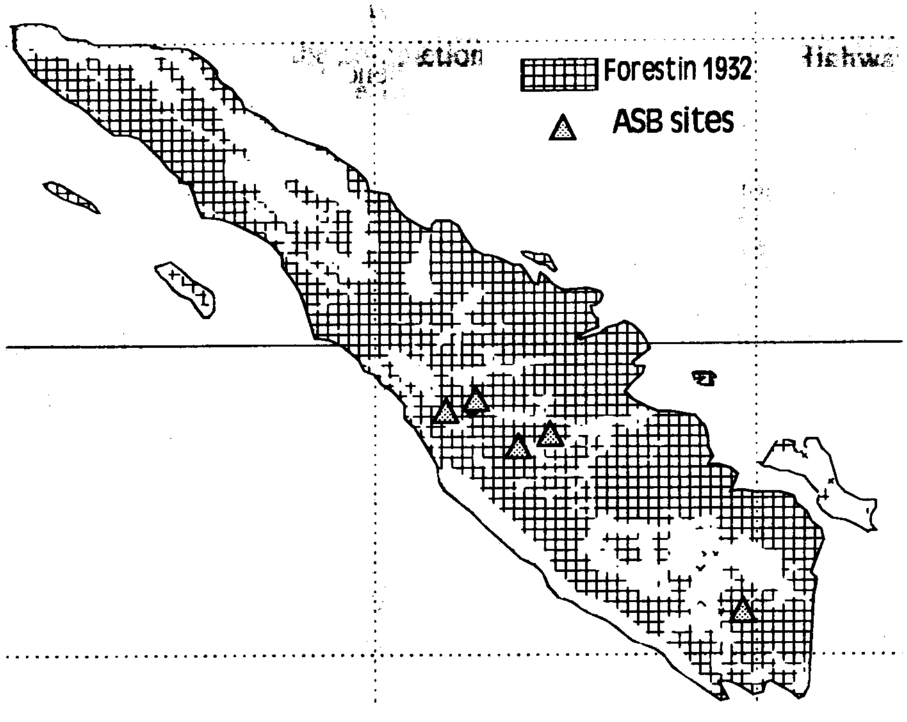


Figure 16. Remaining natural forest in Sumatra in 1932 (based on: Van Steenis, 1935)

Fig. 17 compares these 1932 data with a map of forest for 1982 (FAO/MacKinnon, 1982). Forest conversion had by then affected most of the remaining forest in Lampung and South Sumatra, but in Jambi had not changed much in comparison with 1932. The completion of the Trans-Sumatra Highway and associated Transmigration projects in the early 1980's would

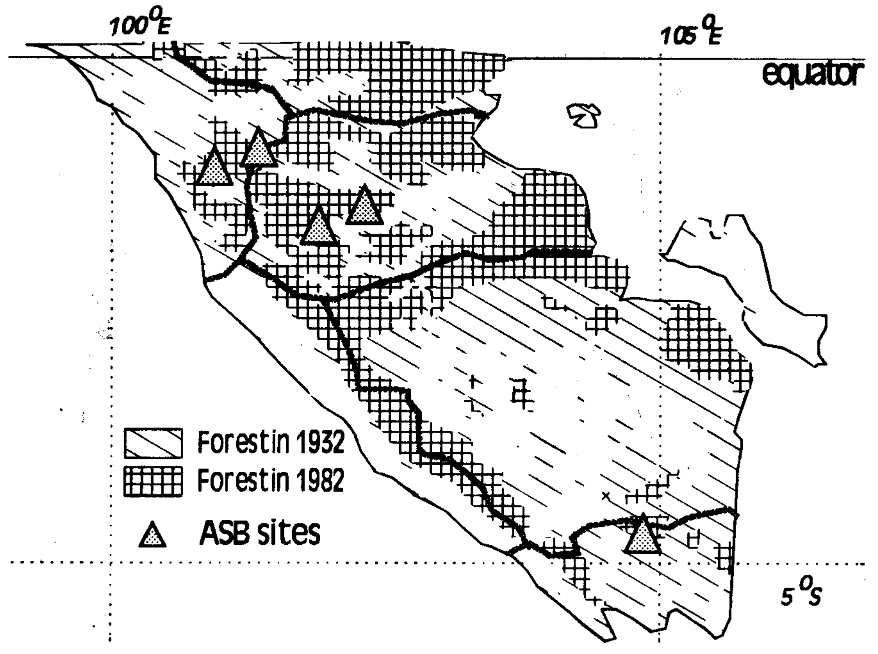


Figure 17. Remaining forest in Sumatra south of the equator in 1932 (compare fig. 16) and in 1982 (based on: FAO/MacKinnon, 1982)

soon make their presence felt, however. The ASB-benchmark areas in Jambi are thus located in an area where forest conversion along the major rivers took place before the 1930's but which remained under forest cover at least until the early 1980's. The N. Lampung benchmark area neighbours one of the few forest patches left in the Lampung-S.Sumatra part of the E. peneplain.

3.3 Socio-economic and policy characterization

3.3.1 Regional economics

The per capita Gross Regional Domestic Product (GRPD) of Jambi and Lampung provinces are both below the average for Sumatra and are less than neighboring provinces such as S. Sumatra, Riau and West Sumatra (Mubyarto *et al.*, 1991; RePPProt, 1988). However, it should be noted that GRDP per capita is a purely statistical computation and may not reflect the actual level of welfare, especially where oil production and related industries contribute to the GRDP of several of the other provinces.

The GRDP statistics show that the industrial and manufacturing sectors have grown rapidly within the past decades, much more so than the agricultural sector. In Jambi such development was largely based on forestry and the rubber processing industry (crumb rubber). These two industries contributed about 99% to the total exports from the province in 1993. In the rubber industry, smallholder rubber plays a crucial role. The total area of rubber cultivation in Jambi in 1993 was 502 642 ha, of which only 3 447 ha was planted with high yielding varieties under intensive management and the rest was 'jungle rubber' (BPS Jambi, 1993).

In Lampung, the manufacturing sector consists largely of agro-processing enterprises e.g., coconut oil, crumb rubber, tapioca (cassava) pelletizing (RePPProt, 1988).

The agricultural sector requires seasonal labor during the harvest period. Many transmigration sites are close to large scale plantations and thus provide a relatively cheap labour force for these plantations, as off-farm income is usually needed to supplement the on farm production. Many 'spontaneous migrants' start as seasonal labourers, who decide to stay on after observing the opportunities still available. In Lampung, migrants start by picking coffee and pepper in the better soils of the piedmont zone. The sugarcane plantation close to the ASB benchmark area brings in new groups of labourers from Java every year during the harvest period. In Jambi migrants often start as rubber-tappers or working for a logging concession. A substantial part of the agro-based settlers, however, occupy land illegally and are often the cause of environmental degradation, especially in the piedmont/mountain zone in Lampung.

3.3.2 Accessibility and population movement

The populations of Jambi and Lampung have increased dramatically since the 1970s. Of the total number of migrants that went to Sumatra since the beginning of the 20'th Century, 50% settled in Lampung (RePPProt, 1988). Since the 1980s Jambi has become a popular destination of migrants after the completion of the Trans Sumatra Highway. Many of these migrants were not recorded in the official statistics, however, as they were 'spontaneous migrants' or 'forest squatters'.

Data for the Lampung benchmark site show that in the 1983-1993 period the population in the Pakuan Ratu sub-district doubled and the annual growth rate has been as high as 9.4%, while it was only 2.3% for Lampung as a whole. Possible factors contributing to the high rates of migration to Lampung are: 1) Lampung is adjacent to Java and inter-island travel is easy and relatively cheap, 2) Lampung has been receiving migrants and transmigrants from Java since the beginning of this century and the cultural and family links between the two regions are by now well cemented, 3) Many (trans) migrants have been modestly successful, and the favorable reports sent to relatives and friends in the area of origin have induced them to join a new life in Lampung. The earlier (trans)migrants, however, have occupied most of the available good quality land and what remains now is the less-fertile, acid peneplain land in North Lampung, as well as the mangrove swamps. Most of the transmigrants to Pakuan Ratu came under the 'local transmigration' scheme and were re-settled from forest reserves elsewhere in the province, where they had started as 'forest squatters'.

In the case of Jambi, the flow of migrants, apart from government-sponsored transmigrants and spontaneous migrant who came directly from Java, can be seen as a sort of spill-over from Lampung. Most of the ASB benchmark areas are easily accessible, as there are relatively good feeder roads of the Sumatra Highway that go to the sites. Apart from that, logging roads made by the (previous) logging concessions in Jambi are a good entrance for migrants. Both types of roads have also created good access to markets and enable traders

Table 5. Population size of the benchmark areas

A. Jambi	Jambi Piedmont			Jambi Peneplain				Jambi Province		
	Rantau Pandan			Pelepat	Tebo Tengah					
	1983	1993	Δ%	1993	1983	1993	Δ%	1983	1993	Δ%
Population	19636	22543	12.9	17962	30380	34325	11.5	1572701	2099489	33.5
Area, km^2	820	820	0.0	1022	3000	2841	-5.6	53435	53435	0
Density (# km^{-2})	24	27	11.1	18	10	12	16.7	29	39	34.5
Population Growth rate (%) 1983-1993		1.39				1.23			2.93	
No. of Household	4744	4910	3.4	4018	6154	7273	15.4	322183	454759	41.1
People/HH	4.1	4.6	12	4.5	4.9	4.7	-4	4.9	4.6	-6.12

1. No data for 1983, as boundaries changed; Pelepat was still part of Muarabungo subdistrict in 1983
Source: BPS Jambi 1983 and 1993

B. Lampung	Lampung Peneplain			Lampung Province		
	Pakuan Ratu					
	1983	1993	Δ%	1983	1993	Δ%
Population	31433	77025	145.00	4902106	6173540	25.94
Area, km^2	1291	1283	-0.62	35376.5	35376.5	0.00
Density (people km^{-2})	24	60	150.00	139	174	25.18
Population Growth rate (%) 1983-1993		9.38			2.33	
No. of Households	7199	17823	59.61	929501	1268741	36.50
People/HH	4.4	4.3	-1	5.3	4.9	-7.55

Source: BPS Lampung, 1983 and 1993

Table 6. Roads within the region

Length of Road (km)	North Lampung	Bungo Tebo
Asphalt Road	1217.06	775.92
Paved Road	710.85	188.05
Dirt Road	379.10	972.63
Other	129.00	-
Total length	2436.01	1940.10
Density, km km^{-2}	0.169	0.174

Source: BPS Jambi 1993 and BPS Lampung 1993 to come to the sites. As many of the 'illegal settlers' were unrecorded, the official statistics on annual population growth rates in the Jambi benchmark area may be too low. From the household and community survey, it became clear that both the Pelepat and Tebo Tengah study sites have a considerable portion of migrants. It is interesting to note that the Rantau Pandan benchmark area has very few spontaneous migrants, even though the soils are better than in the neighbouring peneplain. Further study of underlying reasons is needed.

3.3.3 Agricultural policies

3.3.3.1 General. Indonesia's agricultural policies in the past decades have been dominated by the urge to reach self-sufficiency in rice, the major staple food. The considerable investment in infrastructure for technical irrigation in Java began to pay off in the late '60's when genetic improvement (Indonesian ancestors contributed to the famous IR8), soil fertility management (based on locally produced N fertilizers and imported P and K) and pest management combined with intensive extension efforts, political stability, and favourable incentives led to a 'green revolution'. These factors were responsible for the remarkable *increase* in domestic rice production from 12.3 million tons in 1969 to 30.7 million tons in 1992, and for steady rice productivity increases from 1.5 ton ha^{-1} to 3.2 ton ha^{-1} per year over the same period. Indonesia, once the world's biggest rice importing nation, achieved rice self sufficiency in 1984 and maintained it since, except for the drought effects in 1994 and 1995. This is a major accomplishment in view of the pessimistic outlook in the 1950's and 1960's and continued population growth.

The last decade saw a significant reduction of pesticide use, due to the success of 'integrated pest management' and a new approach to extension. The high P fertilizer recommendations of the '60's and '70's had solved the major P deficiencies of rice fields and this strengthened the argument to reduce fertilizer subsidies. N fertilizer is produced in Indonesia from domestic natural gas, and is still relatively cheap, giving little incentive to improve technical efficiency of fertilizer use.

Most of the attention has been on intensifying rice production, but after the mid '80's attention was shifted to other food crops and conditions in the uplands as well.

3.3.3.2 Fertilizer Policy in Indonesia. The total fertilizer subsidy in 1974/1975 was 227 billion rupiah or 29.7 percent of the rupiah development budget. In absolute value these subsidies peaked in 1987/1988 at 756 billion rupiah, or 18.7 percent of the rupiah development budget. In 1991/92, the total fertilizer subsidy had decreased to 301 billion rupiah, or to 2.3 percent of the rupiah development budget.

In 1969, at the start of first five-year plan (Pelita I), consumption of nitrogen fertilizers amounted to 171 thousand tons. But this increased dramatically, by about 9 times to 1.55 million tons (N) in 1992. Similarly, the consumption of phosphate increased 13 times, from 42.8 thousand tons to 0.56 million tons (P_2O_5), and that of potash increased 20 times, from 13.74 thousand tons to 0.28 million tons (K_2O) over the same period.

Except for KCl, most of the fertilizer consumption is used for food crops. During 1989 to 1993, more than 81 percent of urea consumption, more than 78 percent of TSP consumption and more than 80 percent of AS (ammonium sulphate) was used for food crops. On the other hand, more than 52 percent of KCl consumption is used for estate crops.

Domestic fertilizer production also increased rapidly. In 1969, total nitrogen fertilizer production amounted to only 39 thousand tons. By 1992, this had increased some 61 times, to 2.4 million tons. Since 1977, domestic urea production had exceeded domestic demand and urea export began. Export of nitrogen fertilizer increased about 3 times, from 189 thousand tons in 1977 to 600 thousand tons in 1992. The phosphate production in 1992 was 0.58 million tons, an increase of 680 times from the 850 tons in 1969. However, only during 1983 to 1988 did Indonesia enjoy phosphate self-sufficiency, albeit on the basis of imported raw materials. From 1988, it started to import phosphate fertilizer again. Unlike nitrogen and phosphate, all domestic potash fertilizer requirements have always been imported. Imports of potassium (principally KCl) in 1992 amounted to 297 thousand tons, an increase of 23 times from 13 thousand tons in 1969.

To encourage wider fertilizer use among rice farmers, the government launched a subsidy program in 1967/68 by making cheap chemical fertilizer (then mainly urea) available to farmers nationwide. Retail prices were set lower than equivalent border prices, thereby resulting in net economic subsidies at the farm gate.

It is clear that fertilizer price policy, particularly urea prices, has played a key role in support of rice policy and hence of rice farmers. Gabah (paddy) support prices were also increased accordingly. Some other non-rice farmers and estates also benefited from subsidized fertilizer prices.

The financial subsidy is defined as the difference between the ex-factory price and the retail price. The economic subsidy is defined as the difference between the world price and retail price. During 1988/89 to 1992/93, the financial subsidy per kg of urea was between 7 and 74 rupiah and the economic subsidy was between 62 and 88 rupiah. During the three fiscal years 1990/91, 1991/92, 1992/93, ex factory prices were below the world price. In other words, Indonesia has a competitive advantage in urea production and hence it can export urea.

Financial and economic subsidies for TSP per kg are the highest among these fertilizers: a financial subsidy between 121 - 171 rupiah per kg and an economic subsidy between 41 - 192 rupiah per kg. TSP accounted for 56 percent of the overall 1992/93 financial subsidy to fertilizer although it accounted for only 22 percent of all fertilizer used in Indonesia. The ex-factory price of TSP is higher than the world price and domestic TSP production relies on imported raw materials. Clearly, further expansion of domestic production is not economically competitive. On the acid upland soils the direct use of rock-P (without industrial processing to make TSP) is of potential interest. Current direct use of rock-P is largely restricted to large-scale plantations of tree crops and industrial timber. TSP no longer is subsidized to any significant degree.

The financial and economic subsidy for AS per kg is already small. In the year 1992/93, the retail price of AS exceed the ex-factory price. This means there is no longer a subsidy for AS. Unlike other kinds of fertilizers, Indonesia does not produce KCl; all KCl is imported. Since 1993, the government withdrew official subsidies for KCl, allowing KCl prices henceforth to be determined in the market.

Table 7. Fertilizer prices and subsidies in Indonesia, in Rupiah per kg product

Year (1)	Ex-Factory Price (2)	Retail Price (3)	World Price (4)	Financial Subsidy (3-2)	Economic Subsidy (3-4)
Urea:					
1988/89	239	165	230	74	65
1989/90	209	185	n.a	24	n.a
1990/91	217	210	272	7	62
1991/92	243	220	308	23	88
1992/93	255	240	308	15	68
TSP:					
1988/89	310	170	362	140	192
1989/90	381	210	331	171	121
1990/91	384	260	341	124	81
1991/92	444	280	338	164	58
1992/93	431	310	351	121	41
AS:					
1988/89	211	165	176	47	11
1989/90	226	185	174	41	-11
1990/91	232	210	154	22	-56
1991/92	269	220	158	49	-62
1992/93	226	240	164	-14	-76

Source: Suyanto (1994)

3.3.4 Forest policy

In the 1980's, 'Agreed Forest Use Categories' (TGHK) were established on all state forest land in Indonesia. According to this system, forest land is categorized as:

1. National parks/Conservation forest - in which nature conservation gets priority

2. (Watershed) Protection forest - this class is mainly defined on the basis of slope and serves to protect water supplies for downstream sites

3. Limited production forest - only collection of non-timber forest products is allowed in this category, which is seen as a 'bufferzone' around conservation or protection forest

4. Production forest - here the 'Indonesian selective logging system' is supposed to be followed. Under this system only a few large diameter trees are harvested per hectare, followed by a 30-year regrowth period before the next logging operation to secure sustained harvest with little loss of biodiversity. In practice, however, few (if any) logging concessions have met this target. Forest damage in the concessions was much larger than

anticipated by a combination of logging more trees than allowed, using inefficient techniques which unnecessarily damage the remaining forest and the use of forest land for other purposes by large- or small-scale 'forest squatters', following the logging roads.

5. Conversion forest - officially targeted for conversion to other land use, including industrial timber plantations (HTI), transmigration projects, and plantations (oil palm, sugar cane and other crops).

Most of the major national parks (Kerinci Seblat, Gunung Leuser and South Barisan) are in the mountain zone. Table 8 summarizes data from FAO/MacKinnon which show that for Sumatra as a whole 6.6% of the original forest is protected in reserves and 16% of the forest which remained in 1982. The (Sub)montane forest has a better-than-average protection status, while the mangrove and swamp forest is most endangered.

Table 8. Natural, remaining and protected area of three major vegetation types in Sumatra (after FAO/MacKinnon, 1982), in 1 000 km^2.

	A. Original area	B. Remaining area (as % of A)	C. Area in reserves (as % of A and B)
(Sub)montane forest	56.8	39.5 (70)	9.9 (17 25)
Lowland forest	256.9	88.0 (34)	16.6 (6.4 19)
Mangrove and swamp forest	159.5	67.4 (42)	5.0 (3.1 7.4)
Total	470.3	195.1 (41)	31.5 (6.6 16)

The forest classification may have little bearing on the situation on the ground as there is often confusion over the exact location of boundaries. Figure 18 shows that the relation between 'forest damage' and population density between provinces of Sumatra is virtually the same for 'protection' and 'production' forest categories. Only the national parks are relatively well protected.

3.3.5 Land utilization and agricultural performance

Of the benchmark sites, only the Pakuan Ratu sub district in North Lampung has no forest left, except for the 'industrial timber plantation' HTI (Production forest). All other forest remnants have been converted into agricultural areas or are too small to be included in the statistics. At the Rantau Pandan benchmark, 97% is designated as state forest land, categorized as conservation and production forest. As these areas were already inhabited before portions of the area were declared a national park, conflicts exist between the government and the local community. In Pelepat and Tebo Tengah, there are problems of encroachment into the production forest following concession roads.

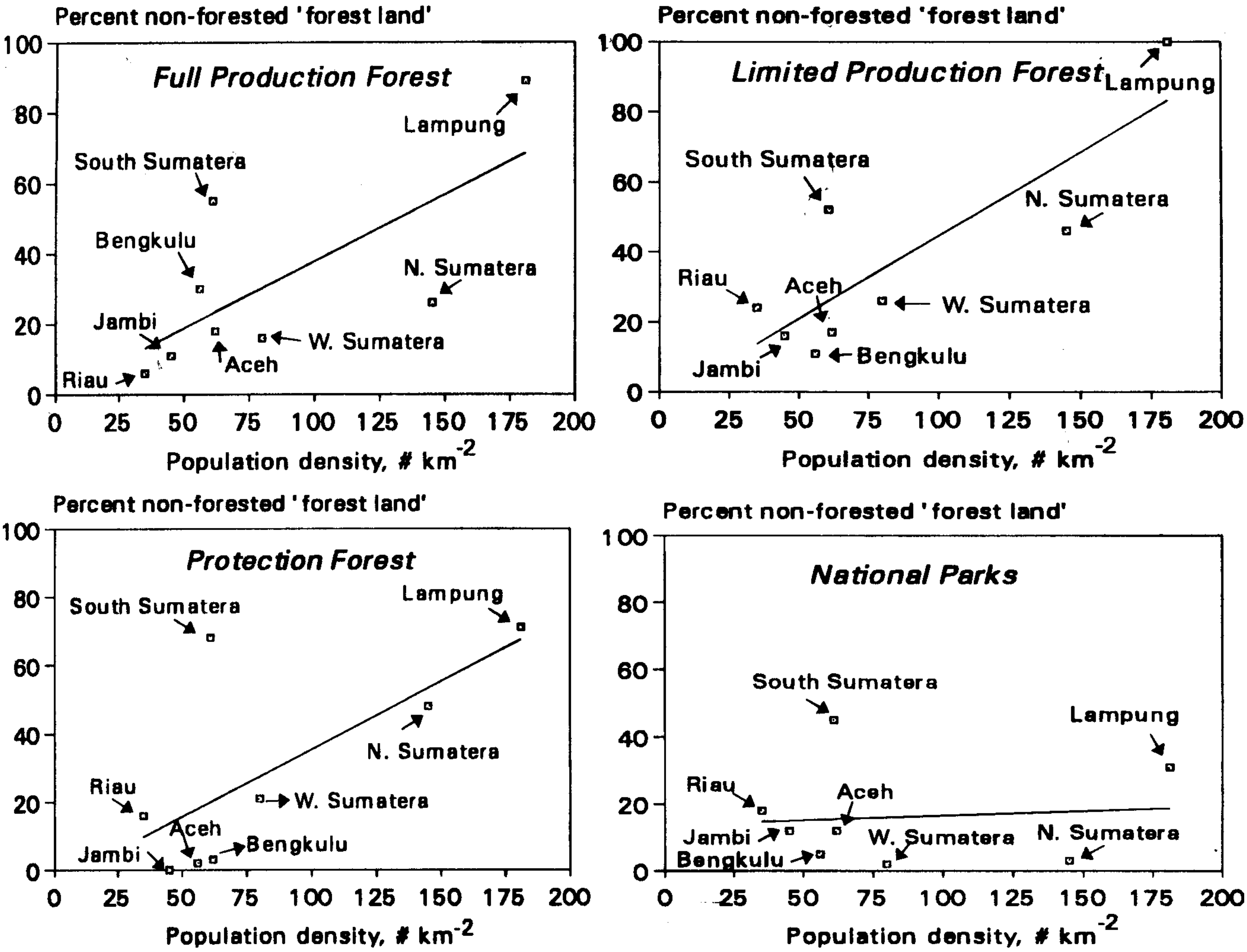


Figure 18. Relation between forest damage and population density per province of Sumatra, according to official forest status (compare Fig. 4)

Table 9. Status of state forest land (ha) according to statistics at subdistrict level

	Jambi Piedmont		Peneplain	Lampung Peneplain
	Rantau Pandan	Pelepat	Tebo Tengah	Pakuan Ratu
Protection Forest	35720	7270	110	0
Limited Production Forest	2540	6320	4410	0
Production Forest	41580	47740	83530	53375
Conversion Forest	0	83440	14530	0
Total Forest Area	79840	144770	102580	53375

Source: BPS Jambi, 1993; BPS Lampung, 1993

Most of the land used by farmers in the benchmark areas is unirrigated, but all benchmark areas have roughly 10% of the area as wetlands along streams and rivers. Often such wetlands have been converted into sawah's (wet rice fields).

Table 10. Food crop performance according to available sub-district statistics

	Jambi Piedmont			Jambi peneplain				Lampung Peneplain		
	Rantau Pandan			Pelepat	Tebo Tengah			Pakuan Ratu		
	1983	1993	Δ%	1993	1983	1993	Δ%	1983	1993	%Δ
Wetland paddy (ha)	1514	1036	-46	365	2383	2170	-10	111	715	84
Wetland rice prod.(ton/ha)	5.4	5.4	0	4.8	4.3	5.3	19	4.4	4.2	-5
Upland paddy (ha)	82	1154	93	421	632	695	9	409	6700	94
Upland rice prod.(ton/ha)	2.1	2.2	5	2.5	2.1	2.3	9	1.6	2.6	38
Corn (ha)	45	103	56	127	15	156	90	572	11120	95
Corn (ton/ha)	1.4	3.4	59	1.2	1.4	2.5	44	1.2	2.6	54
Soybean (ha)	132	89	-48	127	17	164	90	36	5900	99
Soybean (ton/ha)	0.7	1.4	50	1.2	0.7	1.1	36	0.7	0.8	13
Cassava (ha)	52	41	-27	47	62	45	-38	851	10694	92
Cassava (ton/ha)	4.5	8.6	48	15	4	15.3	74	11.6	12.3	6

Source: BPS. Jambi 1983 and 1993; BPS Lampung. 1983 and 1993

In the North Lampung benchmark, most of the land is used for food production and, more recently, mainly sugar cane. In Bungo Tebo most of the land is used for perennials (rubber). It is interesting to compare sub-district level statistics for food production of North Lampung and Bungo Tebo. There has been a great increase of wetland rice production in Pakuan Ratu of North Lampung through conversion of marshy lands. In the same period, wetland rice production decreased in Rantau Pandan and Tebo Tengah due to the drying of streams. Cassava cultivation decreased in Bungo Tebo, but it increased considerably in North Lampung. This may be explained by the decreasing soil fertility in the case of Lampung so that planting cassava is the logical choice (it can grow on poor soils); at the same time there are many pelletizing factories that guarantee a market for cassava tubers. Fluctuating prices cause considerable year-to-year variation in cassava area. In Bungo Tebo the decreasing cassava production may reflect the better opportunities for other crops, e.g. corn or rubber. In terms of productivity per hectare, it seems there is no big difference between these benchmark sites. The official statistics for tree crops show that Bungo Tebo is dominated by rubber, while North Lampung has various kinds of perennial crops e.g. coconut, cloves and sugarcane are grown; few tree crops are grown within the ASB benchmark, however, which occupies the Easternmost part of Pakuan Ratu sub disctrict.

Table 11. Tree-crop production data (smallholder sector)

	Jambi Piedmont	Jambi	Peneplain	Lampung Peneplain
	Rantau Pandan	Pelepat	Tebo Tengah	Pakuan Ratu
Rubber (ha)	12787	8825	18746	1000
Production (ton)	11307	8141	20032	113
Coffee (ha)	2700	no data	no data	70
Production (ton)	no data	no data	no data	39.5
Cassiavera (ha)	180	no data	no data	2.5
Production (ton)	no data	no data	no data	0.75
Clove (ha)	no data	no data	no data	102
Production (ton)	no data	no data	no data	11
Coconut (ha)	159	no data	no data	571
Production (ton)	no data	no data	no data	342.5
Coconut Hybrid (ha)	2	no data	no data	146
Production (ton)	no data	no data	no data	73
Oil Palm (ha)	no data	no data	no data	no data
Production (ton)	no data	no data	no data	no data
Sugarcane (ha)	no data	no data	no data	no data
Production (ton)	no data	no data	no data	no data

Source: BPS Jambi, 1993; BPS Lampung, 1993