Alternatives to slash-and-burn

Site selection for alternatives to slash-and-burn in Indonesia

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UNDP has been a major facilitator, helping establish ASB with encouragement and funds. The Global Environment Facility (GEF) finances the initiative, with UNDP sponsorship. Co-financing is generated from the 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.

Site selection for alternatives to slash-and-burn in Indonesia

report of a site-selection exercise in Kalimantan and Sumatra

18–27 August 1992

Site selection team

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INTERNATIONAL CENTRE FOR RESEARCH IN AGROFORESTRY

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Contents

Introduction

A global research effort is under way to develop sustainable alternatives to slash-and-burn agriculture. It is a collaborative effort among eight tropical countries and six international research centres. The programme, which is funded by a consortium of donors, is divided into four parts; a global project and three regional projects in the humid tropics of Africa, Latin America and southeast Asia.

The southeast Asian component is being conducted in Indonesia, the Philippines and Thailand. Indonesia, which has the largest forest area in Asia, represents the equatorial tropics. The Philippines represents the mid-latitude, wet-dry tropics, while Thailand represents the hilly region of mainland southeast Asia.

The southeast Asian project aims to reduce the rate of deforestation, rehabilitate the degraded uplands and improve the welfare of Asian populations all of which will enhance the state of the environment. These goals will be achieved by identifying technologies and by developing and implementing policies that promote sustainable land uses, including alternatives to slash-and-burn systems. The focus is to develop sustainable small-scale farming systems on the marginal soils to enable farmers to make an adequate livelihood.

This report presents the findings of a site-selection exercise undertaken by a team of scientists from several Indonesian institutions (Forestry Research and Development Center, the Central Research Institute for Food Crops, the Center for Soils and Agroclimatic Research) and two international centres (the International Centre for Research in Agroforestry and the International Rice Research Institute) (appendix 1.)

Several prospective research sites were visited in each of the three Indonesian provinces: South Kalimantan, South Sumatra and West Sumatra. This report summarizes the team's findings and recommendations. First, it presents a simple classification of the major land-use categories of Indonesia relevant to slash-and-burn agriculture. The various sites visited were classified into the three broad land-use types, and the major characteristics of these agroecosystems were defined. The recommendations are presented in light of the prospective research agenda for each land-use type. Finally, detailed information on the sites visited is given. The information is of two types: first, that obtained from open-ended interviews with farmers in villages; second, that on the programmes and facilities of the research stations visited. The appendices list the participants, people met during the site visits,

the trip itinerary, and some significant background material on the soils and agroforestry species encountered.

Criteria for site selection

The general guiding criteria for site selection were:

- the area should be located in a region with a substantial primary forest; the ecological conditions (human, natural, and agricultural) should be representative of inherently infertile lands of the equatorial tropical zone
- there should be adequate research infrastructure to support the research effort; prospective linkages should exist with the International Upland Rice Research Consortium

A one-day workshop was held prior to the site visit to clarify the criteria for site selection. The workshop agreed upon a set of more specific criteria for site selection (table 1). A basic principle in the site-selection process was that the problems of slash-and-burn can best be solved through the joint efforts of several institutions: government and non-government, national and international. Besides, the selection criteria took into consideration the concerns of the Indonesian government. In fact, the government of Indonesia has already identified the slash-and-burn farming system as a constraint to the country's development efforts. There are collaborative efforts toward controlling it between the Agency for Forest Research and Development and the Agency for Agricultural Research and Development. Both agencies have ongoing work relevant to the slash-and-burn research programme. Therefore, sites that would be both supportive of the efforts of the two agencies and complementary to them received preference.

Visits to research stations and farms

Prior to the workshops, a tentative itinerary was developed in consultation with the directors of the Central Research Institute for Food Crops (CRIFC) and the Forest Research and Development Center (FRDC). This itinerary was discussed and confirmed during the workshop on criteria for site selection. Some modifications were made in the field. Most modifications were visits to some alternative locations suggested during discussions with provincial officials.

Table 1. Site selection criteria

Category	Criteria selected
Biophysical criteria	Active deforestation by slash-and-burn or degraded grasslands in · lands with secure tenure · protection forest areas · community forest areas Representative of the predominant soils/climate complex of the equatorial tropics of southeast Asia
Social and economic criteria	Tenure systems (traditional or legal) with relatively secure land rights Focus on less stable systems (shorter fallow period) but learn from existing stable systems of shifting cultivation; access to markets and local agro-industries Strong local government support for the research programme
Research infrastructure (for rigorous, process-oriented and on-farm research)	· available laboratories on-site · basic research equipment · staff availability · good communication · housing, schooling available

NB: The criteria were determined by the participants of the workshop on site selection for the alternatives to slash-and-burn project held in Bogor on 18 August 1992

Visits were made to locations in South Kalimantan, South Sumatra and West Sumatra. Significant observations were made on the research facilities of the Forest Research and Development Center and the crops research institutes within each province; diverse findings were also made from on-farm interviews on land-use management and constraints. Meetings with provincial planning, forestry and agricultural officials at the end of each visit generated detailed information about the forest and agricultural environments and about ongoing government development programmes affecting the slash-and-burn agricultural system.

Synthesis of land-use systems

Indonesia has classified its agricultural and forest lands. The team considered three selected land categories relevant to marginal upland

sustainability: (1) agricultural lands where farmers have fairly secure land tenure and sustainable farming systems is dominant, (2) protected forest lands (including national parks, other protected areas and critical watersheds) where an agroforestry buffer zone is dominant, and (3) commercial forests (including industrial timber estates in alang-alang grasslands) where reforestation by small-scale farmers is significant.

A simplified classification of these land types was developed, showing major land type, the direction of anticipated change in each land type and the type of agroforestry and farming systems research activities that may address these problems (table 2). The first column presents the simplified land categories; the second column, the social systems that differ among the land types; the third, the land tenure systems; and the fourth, the indicative direction in which the various systems are evolving or are being encouraged to develop through various government interventions.

The fifth column suggests possible roles of agroforestry in the various land types and major prospective issues for agroforestry and farming systems research. In the protected areas there is major potential for agroforestry research on buffer zones to stabilize the village farming systems. Tupangsari systems (modified taungya) are important alternatives for reforesting imperata grassland areas. Some agroforestry systems may be suited to the agricultural land with secure tenure. The last column lists the sites visited within the various land types, except the buffer zone. Only one buffer zone site was visited (Riam Kanan in South Kalimantan).

The types of farms within the three land types are presented in table 3. The farm types are assessed on the following factors: the probable constraints to sustainable farming, the requirements for success and the impact of successful solutions.

Recommendations

Research prioritization by land type

The proposed order of research priority in relation to the three broad land-use categories follows.

Top priority should be given to the marginal agricultural lands with (fairly) secure tenure, including transmigration areas (government-sponsored and spontaneous). These are small-scale farming systems on lands with secure tenure including private titled lands and transmigration areas. It may also include lands with traditional adat

Table 2. Characterization of sites visited in Sumatra and Kalimantan

Land types	Social systems	Tenure	Direction of current activity	Role of agroforestry	Site and institutions
FOREST					
Conservation areas	local people	no tenure, very limited usufruct rights	protection, conservation	buffer zone agroforestry	Kerici Seblat National Park, West Sumatra
Protection forest	forest pioneers	no tenure, greater usufruct rights	protection, reforestation	buffer zone agroforestry	Riam Kanan, South Kalimantan*
Production forest, conversion forest	transmigrants	permanent rights, title to the land	large-scale industrial timber estate (HTI), nucleus estates, transmigration	tumpungsari agroforestry with fruit trees, silvopastoral systems	Riam Kiwa Rantau, South Kalimantan*
AGRICULTURAL LANDS					
Uplands	transmigrants, local people	titled or untitled, but secure tenure recognized under customary laws	dryland agricultural systems; estate crops; food crops; livestock; horticulture based	tumpungsari silvopastoral systems, agroforestry with fruit trees	Pleihari, South Kalimantan,* Kemampo, South Sumatra, University Sriwijaya, BRLKT, BTR, Sembawa Res. Inst. Sitiung, West Sumatra, University Andalas, SARIF, Sitiung Station, FFI, Hort. Res. Inst IRRI

Conservation areas include national parks, Cagar Alam, Suaka Margasahon, Hutan Rekreasi Protection Forests (Hutan Lindung)
Production forests include limited production forests, permanent product forests
* Includes South Kalimantan University, Lamburgan Karet, BARIF, BRLKT, BTR

Table 3. Characterization of farmers and factors for success

Land type	Type of farms	Constraints to farming systems	Requirements for success	Impact of success	Possible implications for other target areas
Agricultural land	Type 1: small-scale, settled tenure on marginal lands	low soil fertility; decline in yield; low income; lack of access to markets; access to forest products; fodder supply, local processing industry; lack of labour	sustainable technologies; stability of income; institutional support (research, markets, roads, communications); community interest; policies; population	sustainable, diverse, equitable and stable land-use systems; reduced pressure on forest; reduced spread of alang-alang; improved environment; increased employment	extrapolation to other regions and countries of methodologies; technologies; policy prescriptions; human resources development
Protection forest	Type 2: small-scale, in buffer zones, secure tenure	same as above	same as above	same as above	same as above
Production forest (alang-alang grassland)	Type 3: small-scale, working with industrial timber estates	no property rights; lack of crop diversity	profit-sharing; good management practices	alternative timber sources; reduction in alang-alang; reduced deforestation; employment, improved environment	same as above

tenure systems. The farmers in these land categories would be more inclined to adopt farming systems recommended by research findings. The recommended farming systems should be more productive and consequently reduce the need to use forest lands for agricultural production.

The second priority should be given to lands in the buffer zones (along protection forests) that are occupied by small-scale farmers. Agroforestry systems would be developed in the buffer zones to reduce demands on forest resources, national parks and wildlife sanctuaries. These lands are critically in need of conservation, and any research effort that can contribute towards this end would be most useful.

Third priority should be given to the small-scale farms involved in reforestation efforts through industrial timber estates in imperata-infested areas. Research should promote reforestation and regeneration systems in collaboration with small-scale farmers. Research would focus on developing improved technology for reforestation by industrial timber estates in imperata grasslands. Leadership in these research efforts would be provided by the Center for International Forestry Research (CIFOR) with significant support from ICRAF. Small-scale farmers may, under certain conditions, profitably participate in the overall reforestation effort by integrating food crop cultivation with timber production.

Choice of research area

A number of prospective research sites in each land-use category were identified. The province selected offered the most favourable opportunities for sustainable land-use systems on all three land types. Selection was based on the most favourable combination of factors, including the representativeness of the agroecological conditions and the quality of the research infrastructure available. Therefore, an area-based approach was adopted, rather than a focus on an individual site.

The observations on sites visited were summarized by province (following page). The three provinces were ranked independently by each team member using the site-selection criteria established during the initial workshop. The criteria were given separate weights depending upon their perceived relative importance. Criteria considered important from a global and research perspective were given a weighting of 3, while those considered important from a national perspective and for implementing the research programme were weighted 2; criteria that are important from a local level perspective were weighted 1. The rankings of all members were tallied (table 4). On the basis of this analysis, West Sumatra was ranked highest for research on alternatives to slash-and-burn, followed by South Kalimantan and South Sumatra.

Summary of recommendations on sites

South Kalimantan

Riam Kanan watershed (Pt F): An important priority area for rehabilitation, as it contains a large hydroelectric dam. Smallholders living in the watershed have uncertain tenure; hence a research programme in this area may encounter difficulties.

Riam Kiwa (Pd F): Successful reforestation technologies, particularly for industrial timber estates, have been tested on this site. Good infrastructure for this research. This is a difficult area in which to establish food crops because of pest problems. The research prospects may be limited for small-farmer participation.

Rantau (Pd F): Area is available for research. Joint work with concession holder. Facilities limited. Accessibility good. The team was warmly invited to collaborate with the three industrial timber estate companies in the area.

Pleihari (Ag L): Interesting for grassland ecosystem studies. Little work in progress. Limited infrastructure.

Summary: Institutions are keenly interested but research infrastructure at field sites is limited and distances are considerable. The university has experience in social forestry and agroforestry. Analytical laboratories are well equipped.

South Sumatra

Sembawa (Ag L): Focus on smallholder rubber-based systems; favourable opportunities for on-farm research; working on clones for timber estates and rattan rubber; strong social science component.

Kenampo (Pd F): Area available but no facilities. High priority by local government expected. Not research driven, but field area available for research. Community area available for on-farm research. Prospects might be explored for collaboration with HPI, but no information is available as yet.

Kerinci-Seblat (Pt F): The provincial government is interested in research on buffer zones, but the area is remote from Palembang.

Summary: The institutions visited in South Sumatra are interested and supportive of the Slash-and-Burn Research Programme. The existing estate crops research programme is relevant for agroforestry research. The infrastructure for research at Sembawa is good, but in Kenampo it is currently underdeveloped. The team could not visit the University of Sriwijaya or the local fertilizer industry, which may be conducting relevant research.

West Sumatra

Sitiung (Ag L): On-farm research environment is favourable because of the wide range of agroecosystems and the length of transmigrant settlement. The site is convenient for on-station research. On-station facilities are being developed at both Sitiung and Sukarami to cover most anticipated needs. There are adequately developed sites for experimentation on agricultural fields and primary forest. Considerable prior research has been completed, including site characterization. Counterpart scientists are available in major agricultural disciplines.

The Horticultural Crops Research Institute in Solok and the Forestry Research Institute substation at Sawalumto are both conveniently accessible to Sitiung and Sukarami.

Critical watersheds (Singkarak and Bukit Sileh) and Kerinci: Seblat National Park (Pt F): **Quite accessible from SARIF and it has a high priority for buffer-zone agroforestry.**

Industrial Timber Estates (Pd F): **P T Ragusa has an industrial timber estate concession (HT1) of 10 000 ha in the Sitiung area, which is being planted to rubber-based systems. Currently 500 ha is under rubber. There are prospects for conducting research on this site.**

Summary: **The research environment for slash-and-burn agriculture is very good in the Sitiung area. This site represents a wide range of conditions typical of slash-and-burn agriculture. The Sitiung research station is also mandated with developing improved upland farming systems, particularly for transmigration sites. The red-yellow podzolic soils present in this area represent 40% of Indonesia's upland areas. There are very good on-station research facilities at Sitiung. The potential is good for broad intersectoral collaboration in this province, with easy logistical access to a number of land types (Ag L, Pd F, Pt F).**

Pt F = protection forest Pd F = production forest Ag L = agricultural land

The attributes favouring West Sumatra were:

- a well-established experiment station at Sitiung with promising research infrastructure within an area with a range of relevant agroecosystems (young and old transmigration communities, local peoples and pioneer cultivators, four types of shifting cultivation and an industrial timber estate reforesting alang-alang grasslands)
- easily accessible areas of critical watersheds for buffer zone work
- a major national park (Kerinci-Seblat National Park)
- a Horticultural Crops Institute at Solok well located for ease of collaboration
- a major university at Padang (Andalas University) with interest in relevant research issues
- NGOs for possible linkages

South Sumatra and South Kalimantan also have favourable attributes in several important areas. For environmental contrast, the multipurpose tree evaluation work would be conducted at two locations: one in Kalimantan at Riam Kiwa, in collaboration with the Indonesia-Finnish Forestry Program; the other in Sumatra.

The activities of CIFOR in Indonesia may strongly influence future research on slash-and-burn systems. It may therefore become necessary to develop collaborative and complementary efforts with CIFOR once its role, research agenda and prospective research sites become known.

Table 4. Mean rankings by the site selection team

Criteria (weighting)	South Salimantan	South Sumatra	West Sumatra
Active deforestation or grasslands (3)	6.4	4.5	8.3
Protection forest (2)	5.1	3.4	5.1
Production forest (2)	5.4	4.6	4.3
Agricultural lands	5.3	6.0	9.0
Representatiave soils and climate (3)	6.0	6.0	8.2
Secure tenure (2)	3.0	3.7	6.0
Access to market and agro-industry (1)	1.4	2.5	2.5
Research infrastructure (2)	4.0	4.3	6.0
Potential (local) support (1)	2.1	2.0	2.6
Total score	38.7	37.0	52.0

Proposed follow-up activities

A detailed characterization of the forest and agroecosystems of the prospective research sites should be conducted. In West Sumatra the studies would be conducted at Sitiung, on the P T Ragusa reforestation timber estate and on the buffer-zone areas of the critical watersheds or the national park. The work should be conducted in collaboration with institutions such as the Forest Research Institute, the Sukarami Research Institute for Food Crops, the university faculty, ICRAF, IRRI, international conservation organizations and local NGOs.

Characterization would benefit from participation by international specialists. The initial characterization phase was proposed for November 1992 through July 1993, with field work beginning in August. The West Sumatra sites would be used to refine the methodology for the global research programme.

Detailed analysis of sites

Detailed reports on each of the prospective research sites visited are presented by province. Details on the soil properties at the sites were provided by the Center for Soil and Agroclimatic Research (appendix 4).

South Kalimantan

South Kalimantan is the most densely populated province in Kalimantan. Of the 16 million hectares of grassland in Indonesia, about one million hectares are in South Kalimantan; shifting cultivation covers about 8% of the land area.

The team visited the offices of two of the six research and development sites of the Reforestation Technology Center (now part of the Forest Research and Development Center). It also visited Banjarbaru Research Institute for Food Crops (and its satellite site for upland farming systems), the Faculty of Forestry of the University Lambung Mangkurat in Banjarbaru (the only university in Indonesia having an agroforestry division), a village on a protected watershed social forestry project, and the Kanwil Offices of the Ministry of Forestry in Banjarbaru.

Reforestation Technology Center

The Reforestation Technology Center recently became part of the Forestry Research and Development Center. Formerly, it was part of the Directorate of Reforestation and Land Rehabilitation, responsible for reforestation adaptive research; within FRDC it continues the adaptive research, in addition to conducting applied and strategic research.

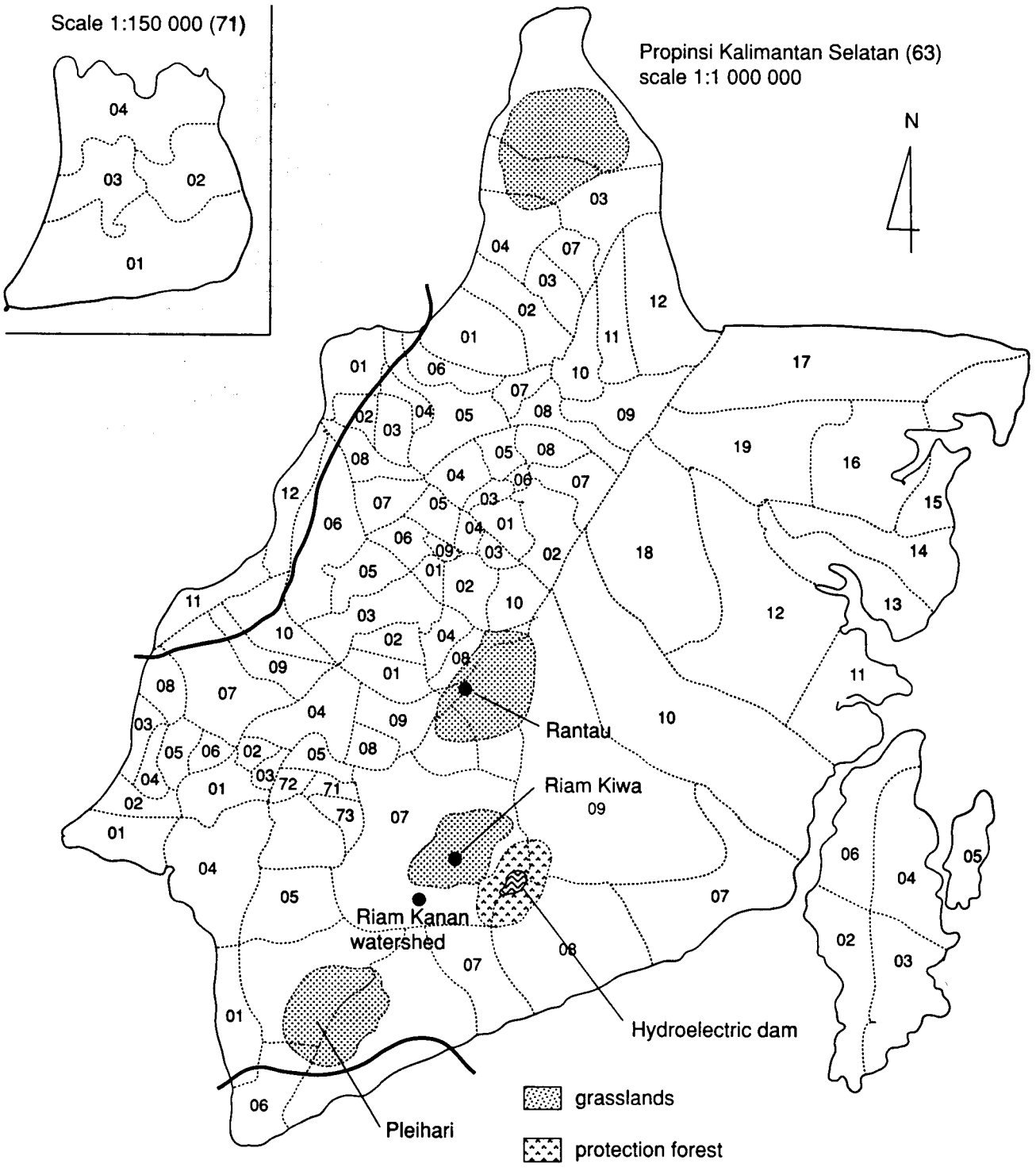
The six locations of the Reforestation Technology Center in South Kalimantan and their research foci are:

- Rantau (natural regeneration)
- Riam Kiwa (species trials for timber estates in alang-alang areas)
- Kintap (natural forest management on hilly terrain)
- Sumpol (lowland dipterocarp forests on flatter lands)
- Maliku (swamp forest in Central Kalimantan)
- Bukit Soeharto (fire prevention in natural forest)

Riam Kiwa

Riam Kiwa is the site of a research and development project rehabilitating the alang-alang lands by planting adapted tree species suited to plantation forestry. It is one of the six field locations of the Reforestation Technology Center (Balai Technologi Reboisasi Banjarbaru).

Ecosystem: The site is on a large, rolling grassland near a range of steep hills about a 1.5-hour drive from Banjarbaru. The upper slopes of the hills are covered with primary stands of conserved forest. Alang-alang extends up the ridges and is remarkably dense throughout the area. The area has deep, strongly acidic soils with low inherent fertility (probably Ultisols and/or Oxisols), and rainfall exceeds 2000 mm a year.



Map of South Kalimantan, Indonesia, showing possible sites

The access road is mostly unpaved, often requiring 4-wheel drive in the wet season.

Research programme: Over 1000 hectares has been allocated for research, but about half of it is under open grassland or firebreaks or has been burned. About 157 ha is devoted to research and production trials, including trials on species evaluation, fertilization, spacing, soil preparation methods, herbicide use in suppressing alang-alang in plantations, evaluation of shade-demanding trees, thinning regimes, multipurpose tree evaluation of *Acacia auriculiformis* (in collaboration with F/FRED), and the grow-out of base populations of selected provenances.

The research programme has a component in which villagers are involved in testing modified taungya methods for tree establishment. The villagers are also growing parkia, rambutan, citrus, jengkol (stink bean), jackfruit, candle nut, cashew nut and durian. There is also a large tree nursery located at the headquarters; it has been funded by FINNIDA since 1986, which is expected to continue doing so for another several years.

Infrastructure and facilities: There are sufficient buildings and facilities, including workshops, offices and a recently constructed training centre. An international training course on fire control had been scheduled for the training centre.

Summary: Riam Kiwa is potentially a good research site. It is particularly well suited to the multipurpose species evaluation.

RANTAU

Ecosystem: Rantau is about 90 km northeast of Banjarbaru. It is 100 m above sea level, receives about 2100 mm of rainfall annually; its topography is rolling, with 10–20% slopes. The soils are red-yellow Podzolics with a minimum depth of 1–2 m. The station is close to a transmigration area, and the landscape is alang-alang infested or with secondary vegetation to varying degrees, bounded by primary forest on one side and farmers fields on the other. A village exists close by, but there is little agricultural activity. The incidence of fire is low, probably because of the care exercised by the centre.

Research programme: Rantau is one of the six research stations of the Reforestation Technology Center. Its main area of activity is the regeneration of forest vegetation in alang-alang grasslands. Most activities are within large-scale operational plots that demonstrate the reforestation potentials of some species including: *Gmelina arborea, Acacia mangium, Eucalyptus albae* and *Cassia siamea.*

More valuable species such as ulin, meranti and rattan are also being established within secondary forest vegetation.

The station has 1000 ha, of which about 400–500 ha have been under trees. Land is available for experimentation, but delineating experimental fields can be difficult because of the nature of the terrain. Possible activities include testing reforestation technologies and reclaiming alang-alang infested lands for crops.

Infrastructure and facilities: Access to the station is by an all-weather road. There are five houses built for the farm manager and field technicians but there are no laboratories and no machinery.

BELANGIAN, RIAM KANAN

Ecosystem: Belangian is located at one end of the large hydroelectric reservoir (Riam Kanan) within a protection forest that is also classified as a wildlife sanctuary. The land surrounding the lake is dominated by alang-alang grassland, with little evidence of settlement or crop cultivation. There was little bird life, perhaps indicative of a deficiency of aviary feed sources.

Land use: The village area has clear zones of land use. Immediately near the houses is a zone of gardens growing a range of fruit trees (durian, rambutan, jackfruit, banana and others) planted in a non-systematic pattern. Beyond this is a zone of brushland and swampy grassland that extends to the river. There was an extensive *Acacia mangium* plantation bordering the river on both sides. Beyond the river is a zone of open grassland where cattle graze, followed by a steeper zone of grassland–*Chromolaena* brushland that is used for slash-and-burn cultivation. Further upslope is a clearly demarcated forest extending to the peaks of the hills.

Crop cultivation in the *ladang* (dryland shifting field) is basically fallow rotation. Plots are used for two seasons then fallowed. Plots with *Chromolaena* or brush are preferred but are becoming rarer with time. After a fire, alang-alang colonizes the area.

The community has supported forest protection by discouraging encroachment into forests for crop production or tree harvesting (except for subsistence). However, they harvest forest products such as honey.

Fire is a major problem: it threatens tree crops, creates favourable growth and rapid spread of alang-alang in the ladang area, and threatens protection forests upslope. However, communities have established village control systems. Now all burning is done after notification of the headman and is conducted in the late afternoon when the wind is weak.

Livelihood enterprises: The main crop in the slash-and-burn area is peanut, grown by dibbling the seed after slashing and burning the *Chromolaena* or brush in a zero-tillage system. Some maize, beans and other crops were intercropped with peanut. Upland rice was the dominant crop until 1987; now only a few farmers cultivate it. Peanut cultivation is preferred because it is less susceptible to wild pigs — the major pest of agricultural crops. Income from peanuts is used to buy rice. Some farmers fertilize their peanuts and other crops, a few of them use chicken manure. Some farmers use Roundup herbicide to suppress alang-alang in crop establishments.

There is a well-developed homegarden system: durian, kapok, parkia in the top layer; rambutan and banana in the second layer; and coffee, taro and other crops at the lowest level. The trees are planted overly densely; thus fruit yields are low. Tree crops growing near houses were most healthy, suggesting that ameliorating nutrient deficiencies may be important. Bananas and papayas are frequently marketed, but other fruit trees are not marketed significantly.

Cattle are raised by farmer groups in the alang-alang area. Fishing, a major daily cash-generating activity, involves 30% of the families. Gold mining is also a significant income source. Fulfillment of a government promise to establish a nucleus rubber estate is eagerly awaited.

Research programmes: The Outer Island social forestry programme aims to reduce the demands of farmers on forest land and to protect the watershed. The programme grew out of the Ford Foundation Java social forestry project, which was conducted from 1987 to 1991 through farmer cooperatives. Its objective was to make agroforestry an income-generating activity.

Infrastructure and facilities: Transport to the site involves a 30-minute drive from Banjarbaru and a 1.5-hour boat ride across the lake. There is a road from Banjarbaru, but the four connecting bridges have been out of use for some years. When in good condition, the drive is one hour. Currently, there are no facilities to support research.

Belangian village is potentially a good research site, largely because the inhabitants practise sustainable land-use systems, which include raising cattle in fenced corrals to utilize alang-alang areas and producing concentrated manure that may be used on crops or trees; expanding cultivation of horticultural crops and improving their management; sustaining production on open land for longer periods by increasing fertilizer use; and intensifying village-level fire control mechanisms to enable more alang-alang areas to regenerate into *Chromolaena* and woody vegetation and thus rebuild soil fertility.

These practices have the prospect of promoting improved fallow

practices. Besides, a nucleus estate of rubber would enhance conservation farming and provide a labour-intensive income source. For example, villagers could be involved in government reforestation efforts on the watershed. In addition, fishing and fish culture enterprises may be expanded.

BANJARBARU RESEARCH INSTITUTE FOR FOOD CROPS

Ecosystem: South Kalimantan has a vast tidal swampland that has been increasingly put under rice-based wetland farming system. The Banjarbaru Research Institute for Food Crops (BARIF) has as its primary goal the development of sound technology for farming the tidal swamps. These swamps have unique problems, which include severe soil acidity, salinity and tidal fluctuation. In addition, the institute has been conducting research on farming systems for the infertile upland soils of the region, particularly the development of upland rice and food crop cultivars. However, the upland rice project is comparatively modest, with 10 ha at Pleihari devoted to it.

Facilities and capacities: The soil laboratory facilities include two working units, each with an atomic absorption spectrophotometer, a flame photometer and a colorimetric spectrometer. BARIF has a full complement of scientific research staff, with significant capacity in tidal swamp rice breeding and soil management. BARIF collaborates with the Reforestation Technology Center in soil analyses.

PLEIHARI (UPLAND FARMING SYSTEMS SITE)

Ecosystem and climate: The soils at Pleihari are sandy Ultisols with low organic matter and a pH range of 4–5; rainfall is 2600 mm annually. The wet season is October–May with peak rainfall occurring in December–January (439–426 mm). The lowest rainfall occurs in August (64 mm). Pleihari is a transmigration site. Inhabitants have been settled for about 14 years with most households owning about 2.25 ha, for which they have assured tenure. The landscape is characterized by rolling alang-alang hills. There are no natural forests in the area.

Land use: Farmers subsist mainly on dryland crops such as maize, mungbeans and groundnuts grown along the roads. Maximum yields are up to 4 t ha^{-1} with heavy use of fertilizers and organic manure. Fields are double cropped and rotated for a short period to allow fertility to build up. Land preparation is done by hand in July and planted in September with maize.

Farmers are heavily dependent on cattle for ploughing and maintaining soil fertility. Alang-alang is not a problem as long as the land is continuously cultivated and organic matter is added to maintain fertility. During peak agricultural seasons farmers hire labour to till the land. A

number of tree crops are grown in various spatial arrangements. Around the houses are acacias, jackfruit and papayas; on field boundaries are jackfruit, parkia, atyricidis and sesbania; while in the fields are cloves, *Eucalyptus auriculiformis* and jackfruit.

Several types of fodder are collected and stall fed to cattle, depending on the season. Soil fertility and fodder shortage during the dry season were identified as the major limiting factors to productivity. There is considerable room for introducing fodder trees on farm boundaries and soil management practices such as green manuring to improve soil fertility. Fire was not identified as a problem.

Infrastructure: It takes 2 hours (when the road is good) to drive to the site from Banjarbaru. There are no laboratory facilities on site, except an automatic weather station (from an Australian project), which provides data on rainfall, soil temperature, humidity and wind speed.

BARIF has some on-farm research with local farmers. A demonstration trial (established in 1991) tests different combinations of Macuna species with different levels of fertilizer as a means of suppressing alang-alang.

University Lambung Mangkurat, Faculty of Forestry

The University Lambung Mangkurat is the only university in Indonesia with a curriculum in agroforestry. Its Faculty of Forestry has been conducting extensive research on social forestry on the critical watershed of Riam Kanan, particularly in the village of Belangian.

South Kalimantan: Conclusion

If South Kalimantan were selected, the Reforestation Technology Center could provide the office space for the programme administration, while laboratory facilities could be arranged at the Banjarbaru Research Institute for Food Crops located nearby. Research trials relevant to alang-alang areas requiring more control could be conducted at the Raim Kiwa site, and on-farm research could be conducted at Raim Kanan or other suitable locations. The team did not visit any site where research could be conducted on slash-and-burn in primary or secondary forest. It might be necessary to explore other sites in Kalimantan.

The team was encouraged by the Ministry of Forestry to explore the possibility of doing research on reforesting alang-alang grassland in collaboration with the three major industrial timber estates in the province: P T Dwima, which is located near Rantau (2 hours from Banjarbaru); P T Inhutani, which is located near Pleihari (2 hours) or the station located near Pulaybaut (2 hours); and P T Barito Pacific, which is located at Tanjung (6 hours).

South Sumatra

The major upland areas in South Sumatra lie in the peneplain zone of the island, covered predominantly by red-yellow podzolic soils (Ultisols and Oxisols). 'The traditional ladang [shifting cultivation] practices with slash-and-burn clearing, 1–2 years of cultivation followed by an extended bush or forest fallow are nowhere else [in Sumatra] better preserved than here. Many ladang plots will be turned into a rubber kebun, with upland rice only intercropped for the first 1–2 years of the non-productive period of the rubber trees (initial shifting cultivation). Ladang rice is by far the dominating crop on these swiddens. All other crops (cassava, chilli, vegetables, sugar cane, bananas and papaya) are generally restricted to the nearby temporary field hut and are consumed by the hut dwellers during their temporary stay in the swiddens at labour peaks.

The general smallholder cultivation system is to open up the land by slash-and-burn, and plant upland rice and other food crops along with rubber seedlings. Smallholders usually continue food cropping for only 2 years, then shift their food cropping to another plot of land within the farm, which usually is about 2–4 ha. This results in rubber fields of varying ages. Old rubber is eventually cut down and the land is re-used for food crops to re-establish the cycle.

The team was informed that farmers open up only primary or secondary forest or scrublands, with woody vegetation. However, once imperata dominates a field or an area, farmers abandon it. They claim it is comparatively more expensive than cultivating new land, which is plentiful.

Most imperata land in Indonesia occurs in South Sumatra. The province has the fourth largest area of shifting cultivation (1.457 million hectares), 41% of the land classified as forest (3.562 m ha) in the province. The Imperata land has been largely allocated to several large timber concessions for industrial timber estates development (for example, Barito Pacific).

The team was informed that government policy for the alang-alang areas is three pronged: industrial timber estates, large-scale plantations, and sustainable farming systems for smallholders.

Sembawa Research Institute for Estate Crops

Land use: Smallholder rubber farming systems are common in the Palembang vicinity. Over 90% of Indonesian rubber is produced by smallholders, most of whom are private growers; a portion is in nucleus rubber estates. There is a range of possible perennial intercrops suitable for rubber plantations, including rattan, cinnamon, vanila and fruit trees.

Young rubber plantations are usually intercropped with calopogonium, centrosema and pueraria.

Research programme: Research efforts focus on smallholder rubber-based farming systems. The institution's mandate is, however, expanding to include a range of estate crops, such as oil palm, coffee and cacao. Much of the research is on prospective systems in which food and other crops are interplanted with rubber during its establishment phase. Many such systems are practised by small-scale farmers in South Sumatra.

Research efforts include minimum input systems of replanting rubber using herbicides. Recently completed projects include suppressing alang-alang. This project was supported by the Overseas Development Administration (ODA) of Britain and a French institute. The European Union (formerly EEC) was expected to support research on rubber-based farming systems. Potentially, there are many technologies to control alang-alang, but farmers lack the capital to use them. Some of these technologies include legume cover crops, rolling the grass flat, and herbicides (particularly glyphosate). Its research mandate excludes industrial crops.

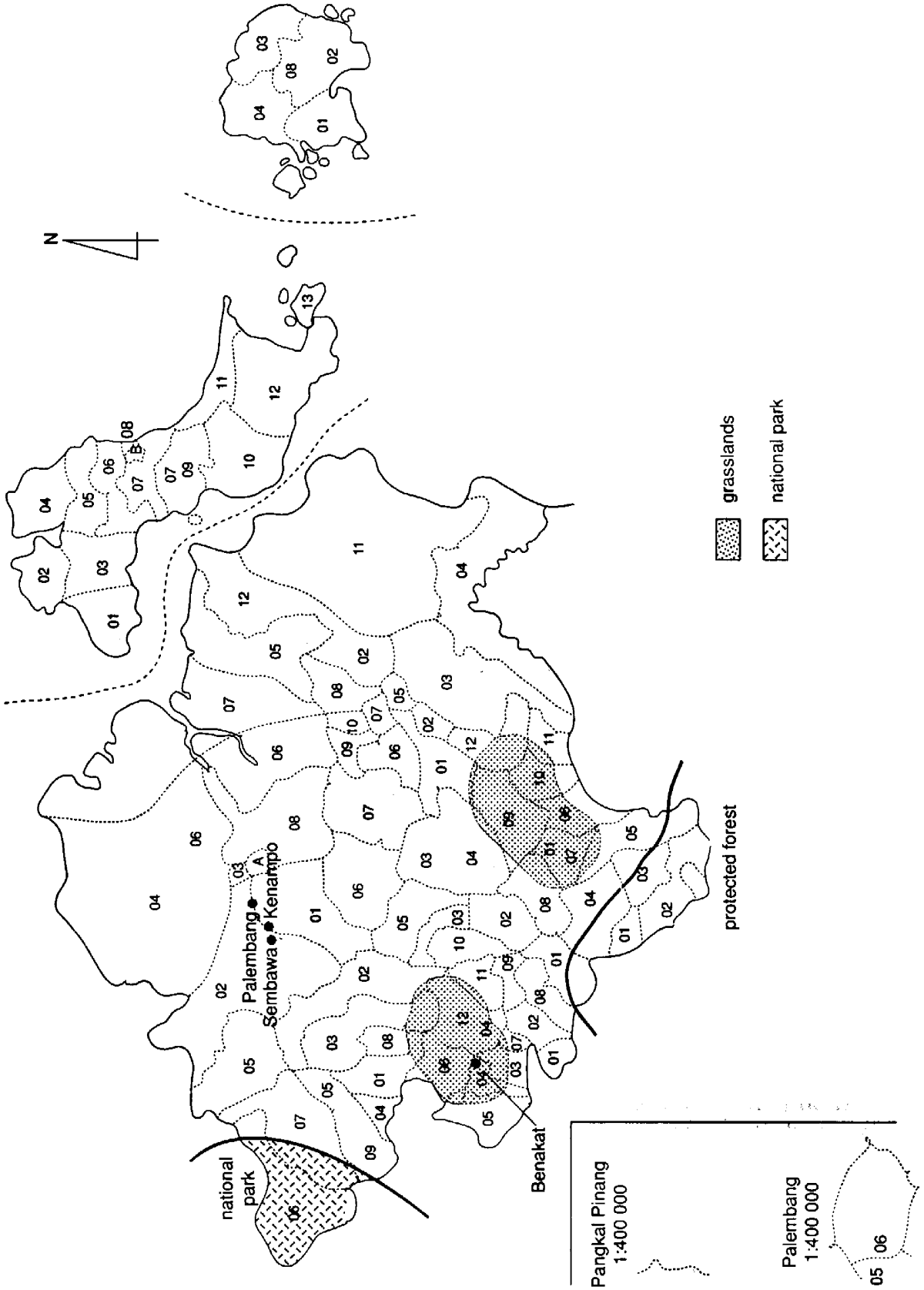
Research infrastructure: The experiment station is located about 30 minutes from Palembang and occupies 5000 ha, of which 1200 ha is under rubber and another 1000 ha is under oil palm. Its 1600-ha substation at Musirawas Libuklingga is a 6-hour drive. In addition, there is an institute experimental garden in Baturaja, where a crop–livestock farming systems project is also located. The institute operates a soil analysis laboratory, serving the institute and also rubber planters.

The institute has 29 staff, of whom 11 are socioeconomists, who mainly conduct on-farm research. The research team also has agronomists, entomologists and postharvest experts.

The institute is one of 10 under the Indonesian Planters Association for Research and Development (IPAT) (oil palm 2, rubber 5, cacao and coffee 1, tea and chinchona 1, agribusiness 1). The station is well funded. It generates 70% of its budget through profits from the sale of rubber and oil palm. The remainder is received from the parastatal of which it is a part. It collaborates with the food crops research institutes.

Reforestation Technology Center, Benakat

The Reforestation Technology Center at Benakat has a large experimental, demonstration and seed production station. The station, which was established with JICA support, aims to develop and disseminate technology for the reforestation of alang-alang grasslands. It has a large plantation of many tree species, which has been turned over



Map of South Sumatra, Indonesia, showing possible sites

to the Barito-Pacific Corporation and is now part of its adjoining industrial timber estate. The site is about a 5-hour drive from Palembang on roads that are difficult in parts. Development of research work at this location is problematic because of these changes.

Reforestation Technology Center, Kenampo

The Reforestation Technology Center (RTC) at Kenampo has been allocated a 600-ha site near Palembang for research on reforesting alang-alang grasslands. The site is currently occupied by imperata, young secondary growth, and some smallholder rubber farmers. There are no research facilities at present, but the site is being surveyed for development. Consequently, it will be some time before research could be conveniently done there.

The area around the RTC experimental site was formerly a community forest. Now it is farmland, and the team visited a number of these farms, where it conducted interviews. The basic farming system is slash-and-burn of secondary forest (or old moribund rubber) and planting food crops intercropped with rubber and other perennials. After food crops are grown for 2 years the land is left to the rubber trees with minimal weeding or maintenance. After several more years the rubber is ready for tapping, at which time the field also has abundant natural secondary growth. Tapping continues until the rubber is 20 years old or so, at which time the cycle is repeated.

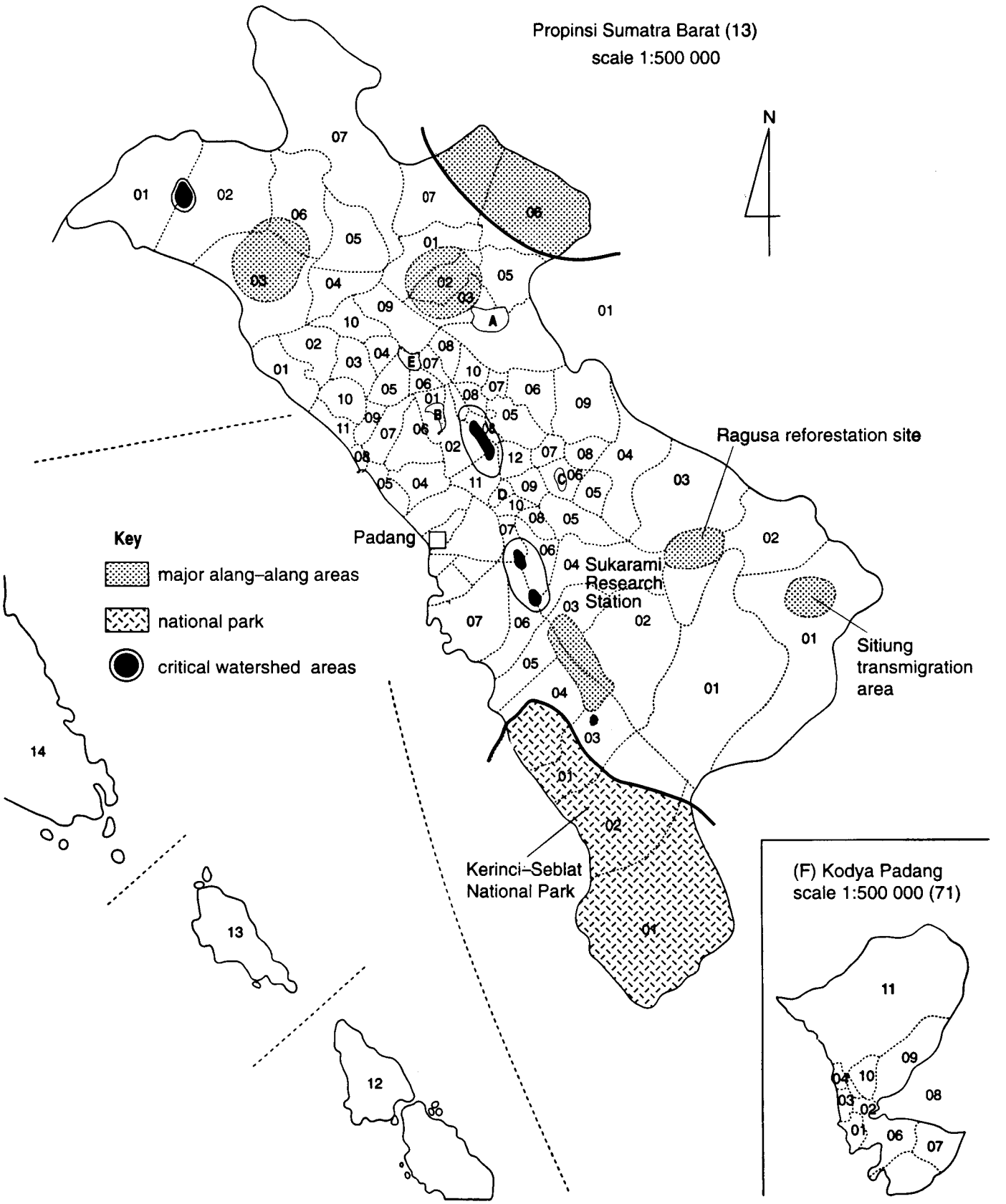
West Sumatra

There are four categories of shifting cultivation in West Sumatra. Under these systems, about 200 000 hectares are critically degraded, and this is increasing. Critically degraded areas are located in the watershed of Cingkarak Lake, Maninjau Lake, Bukit Seleh and East Pasanum. In addition, a large part of the Kerinci-Seblat National Park is located in the southern part of the province.

Sitiung Substation of Sarif

Ecosystems: The Sitiung Station is on the peneplain landform near the centre of the island of Sumatra. The red-yellow podzolics cover approximately 50% of the land surface of the country. Soil pH has a range 3.5–5.5, with a cation exchange capacity <16 meq/100 g, aluminum saturation of 20–80%, low available P and high P-fixing capacity. The soils are dominantly Ultisols, Oxisols and acid Inceptisols. The Sitiung area receives between 2500 mm and 3500 mm of rainfall annually.

Research programme and land use: The station is one of the six research stations of SARIF. It was established with a national mandate



Map of West Sumatra, Indonesia, showing possible sites

for food crops research (physical, biological, and socioeconomic) on the humid uplands with strongly acidic, infertile yellow-podzolic soils. The station is within a major transmigration project; settlement began in 1974 and is still continuing. Settling families are allowed 2 ha of cleared primary forest land. These farmers initially cultivated food crops. However, most of this land has been abandoned to alang-alang or planted to rubber that was established in the food crops. There is substantial slash-and-burn farming in the areas surrounding the transmigration site, done mainly by the settlers. The local Minangkabau villagers have practised shifting cultivation for centuries.

Research infrastructure: The station is about 150 km east of Sukarami. It is well developed, with laboratories, conference and training facilities, guesthouse and staff housing. There are 20 ha of open experimental fields. Some contour hedgerow systems are being researched, and about 70 ha of primary forest land has potential for controlled process-oriented experimentation.

The Sukarami Research Station is about 900 m above sea level, and about one hour drive east of Padang. This station has fully developed research facilities and a full complement of research staff at PhD, MSc, and BSc levels.

West Sumatra: Summary

Favourable prospects exist in West Sumatra to conduct research on the three major land systems of interest to the project. For agricultural lands there is the Sitiung Station and the surrounding transmigration area for on-farm research. For research on buffer zone agroforestry systems or protected areas there are several accessible watersheds in the vicinity of Sukarami and along the national highway. Also, the Kerinci-Seblat National Park further to the south is slated for a major conservation research effort by the Ministry of Forestry. Finally, research on small-scale farmer integration into the reforestation of alang-alang grasslands could be explored with the industrial timber estate located adjacent to the Sitiung V transmigration site. There are indications that the support of the provincial government for the project would be strong.

Appendix 1. Participants in the research site-selection team

FORESTRY RESEARCH AND DEVELOPMENT CENTER (FRDC), BOGOR

Dr A.N. Gintings, Head, Soil and Water Conservation Division
Ir Taulana Sukandi, Researcher, Agroforestry

CENTRAL RESEARCH INSTITUTE FOR FOOD CROPS (CRIFC)

Dr Soetjipto Partohardjono, Head, Farming Systems Research
Dr Kedi Suradisastra, Agricultural Sociologist (West Sumatra only)

CENTER FOR SOIL AND AGROCLIMATOLOGY RESEARCH (CSAR)

Dr Soleh Sukmana, Senior Researcher, Soil Conservation

INTERNATIONAL CENTRE FOR RESEARCH IN AGROFORESTRY (ICRAF)

Dr Peter Cooper, Director of Research
Dr Dennis Garrity, Southeast Asia Regional Research Coordinator (designate)
Dr Fred Owino, Programme Leader, MPT Improvement
Dr M.R. Rao, Programme Leader, Component Interactions
Ms Asmeen Khan, Consultant, Social Science

INTERNATIONAL RICE RESEARCH INSTITUTE (IRRI)

Dr Genaro San Valentin, Agronomist (Sitiung only)
Dr Dennis Garrity, Agronomist/Crop Ecologist (until November 1992)

Appendix 2. Itinerary of the site selection team

18 August 1992	CRIFC, Bogor. Workshop to discuss site selection criteria. Planning for site visits
19 August 1992	Travel: Bogor-Jakarta-Banjarbaru: briefing at Banjarbaru Food Crops Research Institute (BARIF), and Indonesia/Finland tree nursery project
	Field visits to potential experimental sites: Riam Kiwa, Reforestation Technology Center, Miawa (Rantau), Pleihari on-farm site of BARIF
20 August 1992	Reforestation Technology Center, Banjarbaru. Briefing by Mr. Sagala, Director. Visit to Belangian (Riam Kanan) by pump boat
21 August 1992	Regional Office for Forestry, Banjarbaru (Ministry of Forestry). Briefing and discussion. Faculty of Forestry, Lambung Mangkurat University, Banjarbaru. Briefing and discussion. Visit to laboratories of BARIF, Banjarbaru. Travel: Banjarbaru-Jakarta-Bogor
22 August 1992	Travel: Bogor/Jakarta-Palembang Research Institute for Estate Crops, Sembawa. Briefing and discussions. Visit to farmers' fields (Lubukranji Sterio)
23 August 1992	Visit to farmers' fields (Kenampo) and proposed site of the new Reforestation Technology Center (Kenampo). Discussion among participants, Palembang
24 August 1992	Regional Office for Forestry of South Sumatra, Palembang. Briefing and discussion. Travel: Palembang-Padang by air. Presentation and discussion at Sukarami Agriculture Research Institute for Food Crops (SARIF)
25 August 1992	Visit to Sitiung Research Station of SARIF and the transmigration sites in Sitiung
26 August 1992	Discussions at the Regional Board of Planning and Programming (BAPPEDA) for West Sumatra, Padang. Travel: Padang-Bogor. Report preparation and discussion among team members, FRDC, Bogor
27 August 1992	Final workshop of the site selection team. Presentation of the team recommendations and findings in South Kalimantan, South Sumatra, and West Sumatra. Discussion of the recommendations
28 August 1992	Call on the Minister of Forestry. Discussion with the Ford Foundation representatives in Indonesia
29 August 1992	Meeting with the Director of the Forest, Research and Development Center, Bogor

Appendix 3. Important persons met during site selection

Banjarbaru Research Institute for Food Crops (BARIF)

Mansur Laude, Director
Ahmadi, Researcher
H. Supardi Suping, Head, Chemical Laboratory, BARIF-Netherlands Tidal Swamp Project
Mr Hairunsyah, Head, Soils Laboratory

Regional Office of Forestry, South Kalimantan (Banjarbaru)

Mr Syahrir, Director
Mr Sirajudiri
Mr Parmanto, Administrator, Land Rehabilitation Regional Office

Land Rehabilitation and Soil Conservation

Lili Amin, Director
Mr Tarwoco, Staff, Forest Utilization
Dedi, Chief, Natural Conservation
Mr Permanto, Chief, Reforestation

Reforestation Technology Center, Banjarbaru

A.P.S. Sagala, Director
S. Panjaitan, Researcher
Dian Lazwardi, Researcher

Regional Office for Agriculture, South Kalimantan (Banjarbaru)

Sutra Ali, Staff of Administration

Faculty of Forestry, Lambung Mangkurat University, Banjarbaru

Ir Darni, Dean of Faculty
Muktar Effendi, Division of Agroforestry

Indonesia/Finland Reforestation of Tropical Forest Management Project

Goran Adjers, Forest Management Adviser
Juha Mantyla, Training Adviser
Ari Mikkila, Research Adviser
Koerdi Nuryanto, Research Forester (Kintap)
Sudin Panjaitan, Research Forester (Sumpol)

Research Institute for Estate Crops, Sembawa (formerly the Rubber Research Institute)

Amin Tjasadihardja, Director
Agus D. Gozali, Socioeconomic Researcher
Djadja Mohammed Gozalli, Public Information Officer

Inu Ismail, Head, Swamps II Project, Palembang

REFORESTATION TECHNOLOGY CENTER, PALEMBANG

Mr Soedaryanto, Director
R.A. Hambali, Chief, Extension and Information
Herv Diri Riyanto, Agroforestry Counterpart

SUKARAMI AGRICULTURAL RESEARCH INSTITUTE FOR FOOD CROPS (SARIF)

Agusli Taher, Acting Director
Zainal Lamid, Agronomist, Farming Systems
Syahrial Abdullah, Agronomist
N. Hosen, Socioeconomist
Ishadi Manti, Entomologist
Firdos Nurdin, Entomologist
B. Buharman, Socioeconomist
Harmel, Rice Breeder and Head, Administration
Asdirman Arief, Soil Scientist
Irmansyah Rushi, Plant Pathologist
Iswandi H. Basri, Agronomist, Farming Systems
Nasrul Masen, Agricultural Economist
Ishak Manti, Entomologist
Ferdaus Kasim, Breeder
Ferdos Nurdin, Entomologist
Buharman, Socioeconomist
Marme, Agricultural Engineer
Edy Mawardi, Agronomist
Syafnuddin Ibka, Head, General Services

MEETING AT THE WEST SUMATRA BAPPEDAS OFFICE

Alidinar Noerdin, Vice-Chairman, BAPPEDA
Anwar Kasim, Agriculture Faculty, Andalas University
Zukri Saad, Research Associate, Community Development Specialist, PELANGI Policy Research for Sustainable Development and Board of Directors, WALID

Appendix 4. Detailed information on the soils of the locations visited

Miawa (Rantau)

The site is located at about 100 meters above sea level. The terrain is rolling to hilly (slope 15–25%). The annual rainfall is about 2000 mm, with the wet months occurring from October through March. The major soils are classified as red yellow podzolics (Oxisols, Ultisols and Inceptisols). Their general characteristics (obtained from the reconnaissance soil survey reports) are that they are deep, fine textured, acidic (pH < 5.0), low in fertility, macronutrients and cation exchange capacity, with aluminium toxicity to certain annual food crops and high erosion potential on steep slopes.

Riam Kanan

The site is located at 100–250 m above sea level. The terrain varies from undulating, rolling to hilly (slope 8–25%). The annual rainfall is 2000–2500 mm. The major soils are Latisols (Oxisols, Ultisols). Other soils are Lithosols and red yellow podzolics (Oxisols, Ultisols, Inceptisols). They are generally deep (except the Lithosols, which are shallow), low in fertility in terms of macronutrients, cation exchange capacity (and low pH for red yellow podzolics), aluminium toxicity to certain annual food crops for the red yellow podzolics, high erosion potential on steep slopes. The Latisols are more friable than the red-yellow podzolics.

Sitiung

The site is located at about 100 m above sea level. The terrain varies from flat to rolling (slope 0–15%). The annual rainfall is 2500–3500 mm. The wet season (200 mm mo^{-1}) is from October through May. The major soils are classified as red-yellow podzolics, with a deep profile, fine texture and low fertility in terms of macro- and micronutrients. The pH range is 3.5–5.5, and the cation exchange capacity is <16 meq/100 g. They have high erosion potential on steep slopes.

Kenampo

The site is located at about 15 m above sea level. The terrain is undulating (slope 3–8%). The annual rainfall is 2400 mm. The wet season (200 mm) is from October though April. The major soils are medium-textured red-yellow podzolic (Oxisols, Ultisols and Inceptisols), sharing the same properties as the soils described above. Data from recent field sampling at the Kenampo site of the future Forest Research and Development Center Station indicated that the pH (1:2.5 H_2O) ranged from 4.5 to 4.8; organic C 1.79–5.01%; total N 0.16–0.39%; P (Bray extractable) 3.5–7.0 ppm, potassium 0.07–0.18 meq/100 g, and aluminum 2.4–5.7 meq/100 g, with an aluminum saturation of the effective cation exchange complex of 70–90%.

Appendix 5. Multipurpose trees for agroforestry development in Indonesia

The indigenous humid forests of Indonesia are reputed to contain the world's greatest diversity of tree and shrub species. Some, such as *Dipoterocarpus* spp and *Shorea* spp, dominate global timber trade. In the past two decades, plantations of *Eucalyptus deglupta, Acacia mangium, Paraserianthus (Albizia) falcataria* and others have been established to cater for rapidly growing timber demands. The rubber tree (*Hevea brasiliensis*) is still the backbone of estate crop production, in both large-scale plantations and small-scale family holdings.

Throughout Indonesia, homegardens feature such valuable tree species as *Naphelium lapaceum, Lansium domesticum, Gnetum gnemon, Durio zibethinus* and *Artocarpus heterophylla.* Such species provide farmers with valuable fruits, vegetables, timber and often additional income.

Some of the above and many other tree and shrub species could play important roles in agroforestry technologies. For example, grassland-competitive species like *Aleurites mollucana* could play an important role in suppressing alang-alang and at the same time provide valuable nuts to the farmer. Commercially important tree species like *Hevea brasiliensis* and *Swietenia macrophylla* ('mahoni') could be grown as shade trees in multistrata agroforestry systems. Other species such as *Flemingia congesta* and *Sesbania grandiflora* could be grown by farmers for food, fodder and soil improvement.

A partial list of some of the species that could be considered for specific agroforestry roles is contained in appendix 6. ICRAF's research initiative on improvement of multipurpose tree and shrub species for agroforestry development will focus on the species of greatest benefit to small-scale farmers, as assessed on the background of sustainable agricultural production systems and additional income generation. Furthermore, priority species for improvement research will be selected on the basis of a regional assessment in Indonesia, Thailand, Philippines and Vietnam.

Selecting priority species for improvement research will also take into account the diversity of 'niches' and roles in agroforestry technologies as follows:

Protected forest areas: Indigenous forests of Indonesia are the centres of diversity of such valuable multipurpose tree species such as *Durio zibethinus* ('durian'), *Nephelium lapaceum* ('rambutan') and *Aleurites mollucana* ('kemiri'). Earliest attempts should be made for comprehensive germplasm collection, documentation, evaluation and conservation within Indonesia.

Homegardens: Throughout the country, homegardens contain valuable indigenous fruit and vegetable trees such as *Artocarpus macrophylla, Lansium domesticum* and *Gnetum gnemon.* These species are grown together with food crops or in pure clusters at the homestead.

Estate crop production areas: Rubber is the dominant estate crop throughout Indonesia. Other important crops include cashew nuts, coconut, oil

palm and coffee. These estate crops can grow and are often grown in mixture with other crops as understorey or shade crops. Thus, rice, black pepper and cassava are often grown within young rubber plantations. Other tree species like *Pithecelobium dulce* are valuable volunteers in rubber plantations. The intercrops in estate crop production areas provide additional income to the farmers before the estate crop comes into full production, compensate for weeding costs for the estate crop, and diversify production from the same land unit.

Food crops production areas: Many farmers grow *Gliricidia sepium* on farm boundaries and continuously coppice the live fences for fuelwood and, to a much lesser extent, fodder. *Sesbania grandiflora* is commonly planted by farmers around rice fields and provides farmers with fuelwood besides improving soils through nitrogen fixation. Experiments and demonstration plots on alley-farming technology, which have been established in some parts of Indonesia, are showing promising results. The alley-farming technology has particularly great potential on steep slopes where the multipurpose trees planted on soil conservation structures also help to control soil erosion.

Appendix 6. Priority multipurpose tree species for Indonesia

Botanical name	Local name	Main uses
Acacia mangium	acacia	poles, timber, pulp and paper
Paraserianthes (Albizia) falcataria	sengon	poles, construction timber
Aleurites molucana	kemiri	food, fuelwood
Anacardium occidentale	jambu mente	food, fuelwood
Casuarina equisetifolia	casuarina	poles, soil improvement
Eucalyptus deglupta	eucalyptus	poles, timber, pulp and paper
Eucalyptus urophylla	ampupu	poles, timber, pulp and paper
Leucaena leucocephala	lamtorogung	poles, fodder, soil improvement
Melaleuca leucadendron	kayu putih	fuelwood, poles
Peronema canescens	sungkai	timber, fuelwood
Pinus merkusii	tusam	timber, pulp and paper
Schima wallichii	puspa	timber, fuelwood
Schima wallichi var. *bancana*	seru	timber, fuelwood
Swietenia macrophylla	mahoni	timber, shade
Pithecelobium	jengkol	food, fuelwood
Nephelium lappaceum	rambutan	food, timber, fuelwood
Artocarpus heterophyllus	nangka	food, timber
Mangifera indica	mangga	food, timber
Lansium domesticum	duku (langsat)	food, timber
Hevea brasiliensis	karet	rubber, timber
Agathis dammara	damar	timber, resin
Gnetum gnemon	melinjo	food, timber
Flemingia congesta	flemingia	soil improvement, food
Sesbania grandiflora	turi	soil improvement, fuelwood, food
Durio zibethinus bancana	durian	food, timber