Characterization of the Air Dingin - Muara Labuh Area of the Kerinci - Seblat National Park: Farm and National Park Interactions

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ABSTRACT

Buffer-zone agroforestry has strong potential to stabilize the farming systems of villagers living adjacent to protected forests, enabling them to prosper without encroaching into the forest. An area on the north-eastern border of Kerinci-Seblat National Park *(KSNP)* in West Sumatra was chosen as a prospective ASB research site to provide insights on interactions between slash-and-burn practices and the buffer zone of the national park. The study focused on harvesting of forest products by farmers; sought correlations between the degree of reliance on forest products and type of farming system; and measured the contribution of mixed gardens and nagari forests to reducing farmers' dependence on KSNP resources. The Air Dingin-Muara Labuh study sites provide a unique laboratory for careful observation of the interaction between farming systems and protected wildlands. Farming communities nestled within the central rift valley are squeezed between the boundaries of KSNP on the western slopes and protected forest on the eastern foothills. With a rising population and only this narrow corridor of land legally at their disposal, the stage is set for exacerbated tensions between the dual objectives of ecosystem conservation by the state, and resource exploitation by smallholder farmers. Understanding the indigenous communities and their customs governing resource tenure will be a vital prerequisite to any interventions. This paper represents a modest beginning by characterizing farm and KSNP interactions and proposing emerging research issues for the ASB research plan.

INTRODUCTION

To initiate ASB research in Indonesia, an area on the northeastern border of the Kerinci Seblat National Park (KSNP) in West Sumatra was chosen as a prospective research site to provide insights on the interaction between slash-and-burn and the buffer zone of a major national park (see Map 1). An underlying premise was that buffer zone agroforestry has strong potential to stabilize the farming systems of villagers living

adjacent to the protected forest, enabling them to prosper without encroaching into the forest. The first phase of the programme was understanding and characterizing the dynamics of agroecosystems and farmers' resource management strategies. Obtaining a clearer picture of the complex, whole-farm system provides strategic direction in developing a framework for a long-term research effort. Hypotheses could then be formulated that would be more sharply focused on farmers' perceived problems and park - farming system conflicts.

With this intention, ICRAF fielded a multi-national team of three graduate student researchers in April, 1994: an Indonesian staff member of the Forest and Nature Conservation Research and Development Centre (FNCRDC) examined the potential for agroforestry development in the study area to reduce dependency on park resources; a Japanese scientist documented institutional mechanisms for forest protection and resource management; and a Canadian conducted agroecosystem analysis with a special focus on the bush-fallow component of Minangkabau farming systems.

Now that this first characterization phase has been completed and the reports written up, it is time to pause and reflect on what we now know, and the emerging research questions that remain to be answered. This collaborative paper briefly introduces the site, highlights the research findings, and dwells on the question, '*So where to now?*'

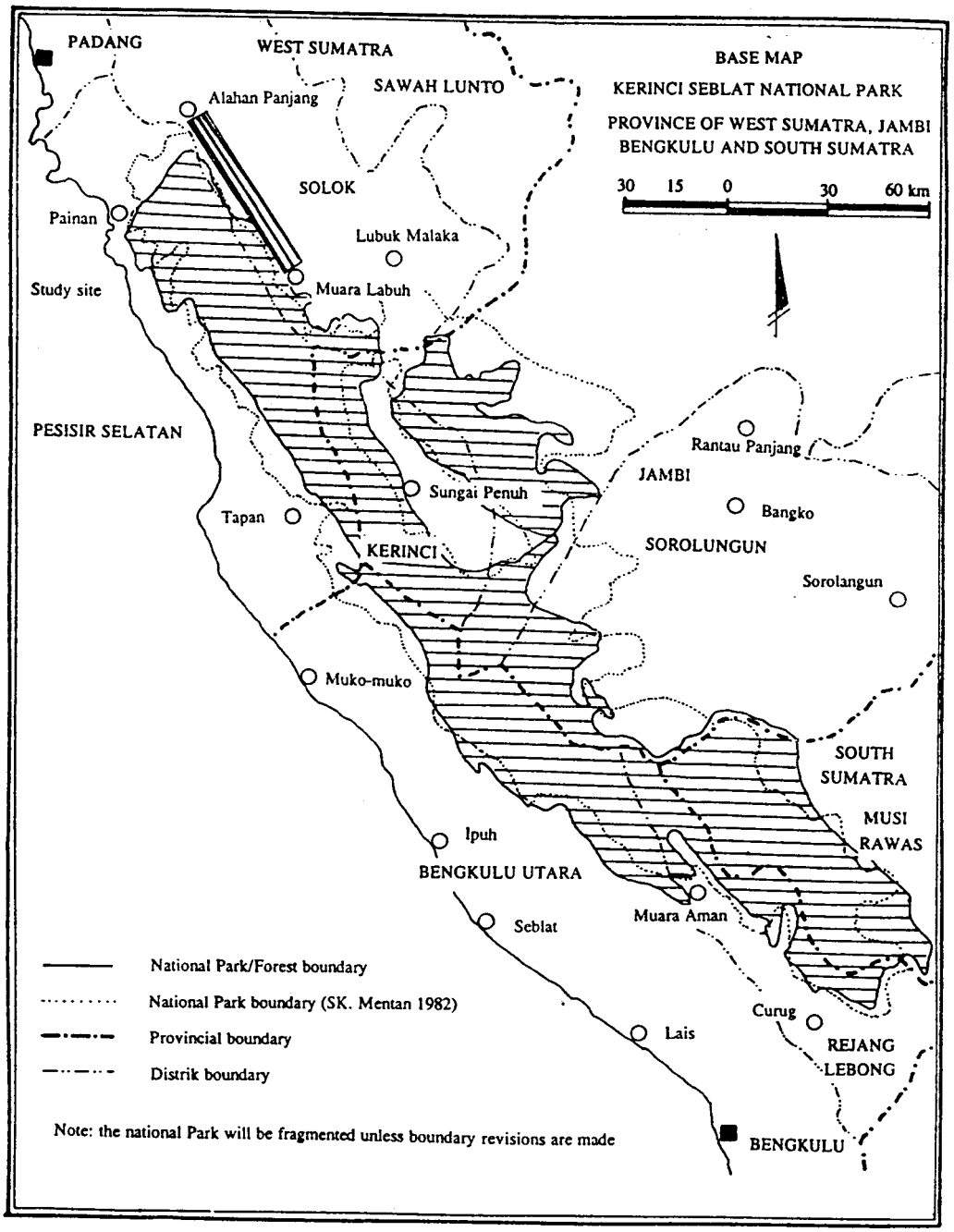
KERINCI-SEBLAT NATIONAL PARK

KSNP encompasses almost one million ha that stretch for 350 km along the Barisan mountain range between Padang and Bengkulu in the southern half of Sumatra. The park and contiguous forest lands cover the largest remaining block of tropical rain forest in southern Sumatra. Its large size and diversity of habitat have nurtured a remarkable species richness that include endangered endemic species and large mammals. KSNP is included on the World Heritage List and is considered to be one of the largest and most important conservation areas in Asia. The World Bank is currently in the process of mapping a strategy for a major integrated conservation development project (ICDP) in the park's boundary areas.

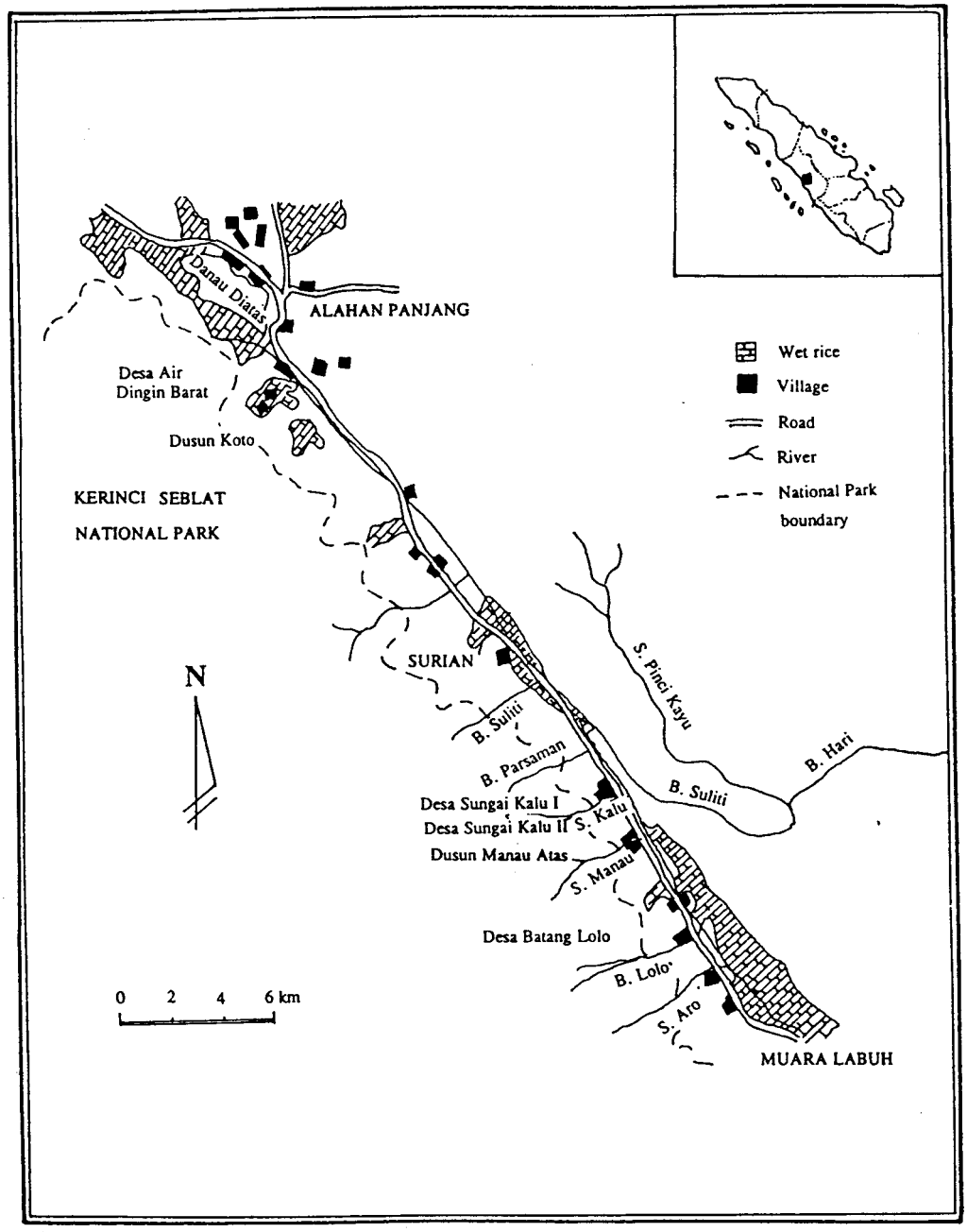
AIR DINGIN - MUARA LABUH STUDY AREA

During the initial site selection process, attention was drawn to the interesting bush-fallow systems practiced by Minangkabau farmers on the foothills in the Air Dingin area. Since slash-and-burn appeared to constitute the immediate interface between farming systems and the National Park, this site appeared to fit well within ASB's research mandate. Further 'windshield surveys' revealed that as one drove

Map 1. Kerinci - Seblat National Park



Map 2. Air Dingin - Muara Labuh Study Area



southward along the central rift valley, farming systems changed rapidly in response to the diversity of agroecological niches created by variations in elevation, weather patterns and topography. To encompass this diversity and glean some sense of its interactions with KSNP, a research transect was chosen between the major towns of Alahan Panjang (01° 05'S, 100° 48'E) and Muara Labuh (01° 28'S, 101° 04'E). As depicted in Map 2, the team spread out along this 40 km transect and conducted independent research in a total of 23 subvillages purposely chosen to encompass a diversity of farming systems. Table 1 presents a breakdown of each researcher's study sites and the corresponding elevations.

Biophysical Environment

Climate

Rainfall is well distributed throughout the year with wet and dry seasons much less clearly defined than in eastern Indonesia. Rainfall peaks during March to May; drops abruptly for a relatively dry season between June and August; and then builds to another rainy peak from September to January. February is usually a dry month and offers a brief respite between the two monsoons. Rainfall data from three meteorological stations located along the study transect indicated an average rainfall of about 1700 mm during 180 rainy days annually. The central rift valley receives much less annual rainfall than the west coast of Sumatra due to rain shadowing effect from surrounding mountain ridges. While total rainfall is clearly lower, the paradox is that the total number of rainy days per year is higher. Thus a lower intensity type of drizzle rainfall is typical of the study site. Lighter rainfall poses a decreased threat of large surface run-off and consequent soil erosion and allows more opportunity for water percolation into the soil for crop uptake. The higher altitude in the Mountain Zone also results in cooler temperatures and reduced evapotranspiration, again increasing water availability to crops.

Favorable topography and an abundance of mountain streams flowing down the slopes has enabled simple irrigation of most of the rice paddy on the valley floor in the study area. In this manner, higher rainfalls descending on the surrounding mountain ranges are effectively channelled into irrigated rice fields so water deficits for agricultural purposes are seldom an issue.

Located so close to the equator, temperatures tend to be high and constant with small yearly amplitudes. Altitude does have a significant influence on temperatures in the study area, particularly at the northern tip of the study transect; a rule of thumb is that each increase of 100 m in altitude will result in a temperature decrease of about 0.6°C. Thus at 1600 - 1700 m., mean daily temperatures at Air Dingin are considerably lower than the southern end of the transect, having a large influence on the natural flora of the area and the choice of crop varieties grown. Colder temperatures in Air Dingin

Table 1. Research sites within study transect

Murniati				Masahiro				Malcolm			
Subdistrict	Altitude	Desa	Dusun	Subdistrict	Altitude	Desa	Dusun	Subdistrict	Altitude	Desa	Dusun
Sungai Pagu	450-700	Batang Lolo	Sungai Rambutan Sako Batang Lolo Atas	Sungai Pagu	400-700	Lundang Sungai Cangka	Sungai Cangkar I Sungai Cangkar II	Sungai Pagu	1000-1300	Sungai Kalu II	Sungai Manau Atas
	630-850	Sungai Kalu I	Pasa Koto Baru Km. 21 Lubut Sampia		400-700	B.S.M	Mudik Lawas	Pantai Cermin	900-1000	Alang Lawah	Bawah Manggis
	620-800	Sungai Kalu II	Sungai Manau Bawah Pinang Balirik Batang Bajaweh		500-800	Batang Lolo	Batu Kerambai Sungai Rambutan Sako Pandung	Lembah Gumanti	1350-1750	Air Dingin Barat	Koto
					600-900	Balun	Sungai Ipuh				
					700-1000	Batang Pasampan	Pasampan Barat Pasampan Selatan Pasampan Timur Tanjung Limau Kapas				
					1000-1300	SungaiSungai Kalu II	Manau Atas Sungai Manau Bawah				

are both a blessing and a curse. Due to lack of short-duration rice varieties amenable to higher altitudes and cooler temperatures, Air Dingin continues to be restricted to single crops of rice each year, resulting in large rice deficits. Its altitude is also extremely limiting as to what tropical tree crops could be incorporated into agroforestry systems on its hill slopes. On the positive side, the cooler temperatures are ideal for mid-latitude vegetable crops such as cabbage or potato and more recently, passion fruit (*Pasiflorea quandrangularis*) has proven to flourish there. Altitude is the main determinant dictating the evolution of very different farming systems along the study transect.

Soils

The alluvial soils on the floor of the central rift valley are volcanic in origin, relatively fertile and suitable for wet-rice culture. Rice paddies are often deep, making them difficult to drain and offering limited possibilities for other crops.

Soils on the sloping lands of adjacent foothills are highly variable. Air Dingin slopes are characterized by black andisols of volcanic origin that are well-drained, acid, very low in bases, high levels of Al saturation, and high organic matter and N. Upland soils sampled at sites further south were red-yellow ultisols, also acid but with lower levels of C and N and higher exchangeable Ca, Mg, and K. In most cases, soils on slope gradients in the study area are unstable in structure, highly exposed to erosion and leaching, and prone to sliding. Erosion control technologies are seldom practiced and the landscape is often scarred by numerous landslides after heavy rains.

Topography and Land Use Systems

The valley floor of the central rift valley undulates, sometimes widening to several km. across but other times tapering down to a narrow corridor with steep slopes on both sides of the highway (see Figure 1). In concert with altitude, topography of the landscape is the other main determinant of farming systems in the study area. A series of young volcanos punctuate the length of the Barisan mountain system and the study area is situated between two of them, Mt. Talang to the North (last erupted in 1942) and Mt. Kerinci to the South. Consequently, seismic activity is common. More importantly, the chambers of wide valley bottoms probably benefited from considerable volcanic ejecta, leaving pockets of fertile soils. It is not by accident that these pockets with wide valley bottoms suitable for irrigated rice culture tend to have the highest population densities and the oldest settlements. Centuries ago when the Minangkabau were forced to expand their frontier in response to increasing demographic pressures in the heartland, areas near what is present-day Air Dingin, Surian or Muara Labuh would have posed attractive settlement sites with the promise of wide expanses of sawah. Farming systems in these areas still tend to be based on irrigated rice culture, with rainfed cropping on the slopes of adjacent hills of only peripheral importance. In contrast, the narrow valley corridors with little land suitable for rice paddy construction have been more recently

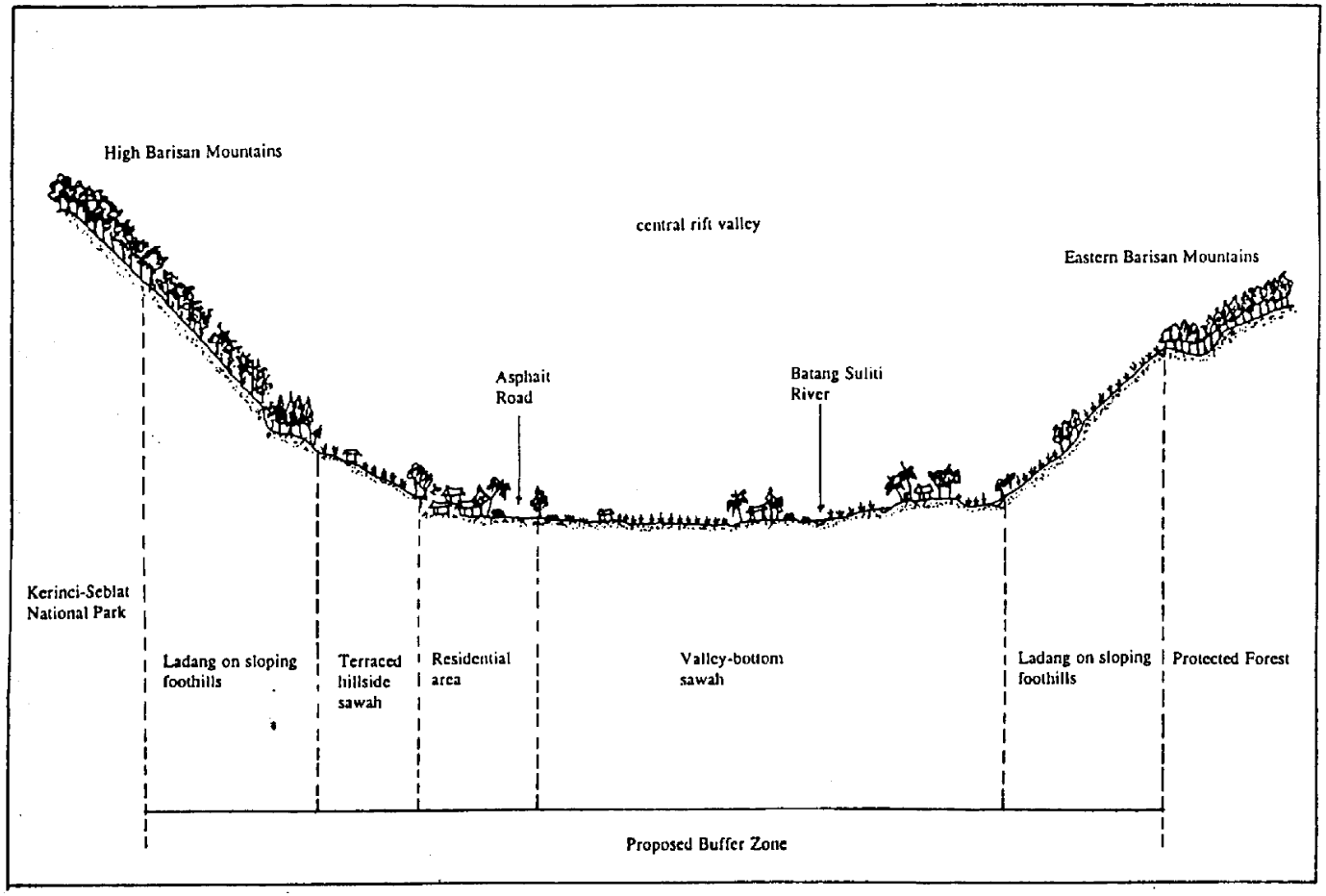


Figure 1. General transect across central rift valley in research area

settled. The farming systems here rely heavily on rainfed annual/perennial crops on the mountain slopes for household food needs and to finance rice purchases.

Minangkabau

West Sumatra is the traditional heartland of the ancient Minangkabau culture. As early as several centuries ago, the Agam plateau was already densely settled and irrigated wet-rice cultivation was practiced extensively. From this hearth, the expanding Minang population has long been overflowing into surrounding forest frontiers in search of new land. This geographic expansion flowed in a southerly direction down the central rift valley and colonized the study area of this investigation early in the 19th century. As a paddy-based society, these early settlers sought wide valley chambers with potential for extensive sawah development. It was in these favored locations that Minang pioneers first began to clear the land and establish independent and self-supporting villages called '*nagari*'.

Minangkabau society has probably drawn widest attention as the largest matrilineal culture in the world - and the seeming paradox of its strong embracement of patriarchal-oriented Islam. The clan is the basic social unit in Minang society. Important property such as the large family houses (*rumah gadang*) and land are communally owned within clans and passed down through the women's line of descent. The Minangkabau continue to be governed by an ambiguous fusion of adat regulations, Islamic rules and conventional civil law. They are noted for keen entrepreneurship and a strong tradition of voluntary out-migration known as *merantau.*

RESEARCH SUMMARIES

Contributions of Mixed Gardens and Nagari Forests to Farmers' Reduced Reliance on Harvesting Forest Products from KSNP

Research Focus

This study focused on harvesting of forest products by farmers; sought correlations between the degree of reliance on forest products and the type of farming system; and measured the contributions of mixed gardens and nagari forests to reducing farmers' dependence on Kerinci Seblat National Park (KSNP) resources. The research was conducted in three villages in the park buffer zone, located in Sungai Pagu Subdistrict of Solok District. See Murniati (1995) for a more comprehensive coverage of this study.

In Solok District, the park buffer zone is comprised largely of nagari forests and human settlements. Nagari forests had formerly been managed as production forests and provided significant cash income to the nagari. As population numbers and demand

for agricultural land increased however, nagari forest areas were gradually converted into farmland such as mixed gardens. Although natural nagari forests are still found today, they cover no more than 10% of the study area. The nagari and national park forests still function as a resource base to meet community needs, particularly for fuelwood.

Field observations and structured interviews of farm households were the primary research methods used in the study. Respondents were stratified based on the following farm typologies:

1. Farmers with only wetland rice fields;
2. Farmers with only mixed gardens; and
3. Farmers with both of these components.

Interviews focussed on the management of mixed gardens and nagari forests, as well as the gathering of forest products from park forests by farmers.

Highlights of Findings

Characteristics of Mixed Garden Vegetation

The dominant species of trees (>10 cm diameter) were Banana *(Musa paradisiaca)* and Rubber *(Hevea brasiliensis)*. The perennials <10 cm diameter were dominated by *Coffea* sp., and the undergrowth (<1.5 m height) were *Paspalum conjugatum* and *Kilinga monocephala.*

Characteristics of Nagari Forest

The dominant species of the community (Nagari) forest were trees of *Ficus procea*, poles (<10 cm) of *Bellucia asinanthera*, and undergrowth was dominated by *Coffea* sp.

Forest Product Gathering in the Park

Interviews with 60 respondents indicated that the gathering of forest products inside park forests took place on both a routine and an occasional basis. Those products routinely gathered were timber for boards and beams, and fuelwood (often sold). Rattan, incense, palm fibers, game animals (deer and monkeys) and fish were also hunted and gathered, but only occasionally.

Tree species logged for timber were: various kinds of 'madang', *Lauraceae* family; 'bayur' (*Pterospermum javanicum*), *Sterculaceae* family; and 'borneo' (*Shorea platyclados*), *Dipterocarpaceae* family. Species commonly harvested for fuelwood needs and sales were 'paniang-paniang' (*Quercus* spp.), *Fagaceae* family; 'baliak- baliak angin' (*Mallotus paniculatus*), *Euphorbiaceae* family; and 'jambu lelen' (*Bellucia asinanthera*), *Melastomaceae* family.

Table 2. Vegetation structure of mixed gardens.

Variable	Level of Vegetation		
	Tree	Belta (Pole)	Seedling (Undergrowth)
Canopy Stratification	- 2 layers I: Height : 30 m (rubber, durian, jengkol, petai, and coconut) II: Height: 3-10 m (banana, coffee, cinnamon, and citrus) - Commonly Widened	- 1 layer - Height : 2-10 m (coffee, Bellucia asinomthea, fern banana) - Widened	- height ≤ 1 1/2 m
Density	196 trees per 0.27 ha (725 trees per ha)	539 ind. per 0.0675 ha (7985 ind. per ha)	2427 ind. per 0.0027 ha (898 889 ind. per ha)
Canopy Cover	136.58%	_	166.67%
Basal Area	23.39 m^2 ha^{-1}	10.84 m^2 ha^{-1}	_
Biodiversity Index	1.85 (Range 0-5.28)	2.36 (Range 0-6.29)	2.53 (Range 0-7.79)

Statistical analysis (t-tests) showed differences (at the 10% error level) in degree of routine gathering of forest products within the park between the three farm typology groups examined. However, the level of occasional gathering of forest products was not different among them. Values of forest products routinely gathered were lowest for the mixed 'rice + mixed garden' farmers (Table 4).

The total value of forest products gathered occasionally and routinely from park forests was equivalent to total farmer income from forest products. Income from farm work, daily labor and others was considered to be non-forest farm income. Statistical analysis with a regression equation showed a linear relationship between incomes from forest products and non-farm incomes for both the rice farmer and mixed garden farmer groups. This indicates that these groups demonstrate a tendency to reduce reliance on

Table 3. Vegetation structure of Nagari forest.

Variable	Level of Vegetation		
	Tree	Belta (Pole)	Seedling (Undergrowth)
Canopy Stratification	- Top layer - Height : 40 m - Widened	- second layer - Height : 2-15 m - Widened	- forest floor to 1.5 m
Density	76 trees/900 m^2 (844 trees per ha)	156 ind./225 m^2 (6,933 ind. per ha)	110 ind./9 m^2 (122,222 ind. per ha)
Canopy Cover	296.39 %	_	67.89 %
Basal Area	51.06 m^2 ha^{-1}	8.04 m^2 ha^{-1}	_
Biodiversity Index	3.69 (Range 0-4.33)	4.00 (Range 0-5.05)	2.57 (Range 0-4.70)

Table 4. Average value of forest products gathered from KSNP during one year (May 1993 - May 1994).

Farming types	Value (Rp. yr^{-1}. HH^{-1})	
	Routine	Occasional
Rice field	376,630 a	17.500 a
Mixed gardens	287,200 b	28.300 a
Rice field + mixed Gardens	49.120 c	17.540 a

Note: Figures marked with the same letter have no significant difference at 10% error.

income from forest products if other sources of income are increased. This relationship is clear at the 6% and 8% error levels (Figure 2 and 3). However, no linear or quadratic relationship was detected for the rice + mixed garden farmer groups.

A quadratic relationship between farmer income from forest products and size of farm land was found for the rice farmer group at 1% error (Figure 4), while no linear or quadratic relationships were found for the other two farmer groups.

Two approaches may be employed to measure the economic contribution of mixed gardens to a reduced reliance on routine harvest of forest products from the park. The first is comparison of incomes derived from gathering forest products between the rice farmer and mixed garden farmer groups; it was found that rice farmers harvested Rp. 89,430/household/year greater value of forest products than farmers with mixed gardens. The second method is based on the assumption that contributions by mixed gardens to a reduced value of forest products gathered by the rice + mixed garden farmers were 50%, so that contributions by mixed gardens was half of the value difference between the rice farmers and rice + mixed garden farmers, amounting to Rp. 163,755/HH/year. Contributions by mixed gardens are very significant to national park protection when such economic effects are calculated for all farm communities in the park buffer zone.

Using this second method of calculation, the contribution by mixed gardens to reduced routine gathering of forest products was Rp. 44,312,850 per annum total for the three villages combined, with a total of 1,177 households (23% or 270 of these households were the rice farmers.). If we calculate a unit price of approximately Rp.

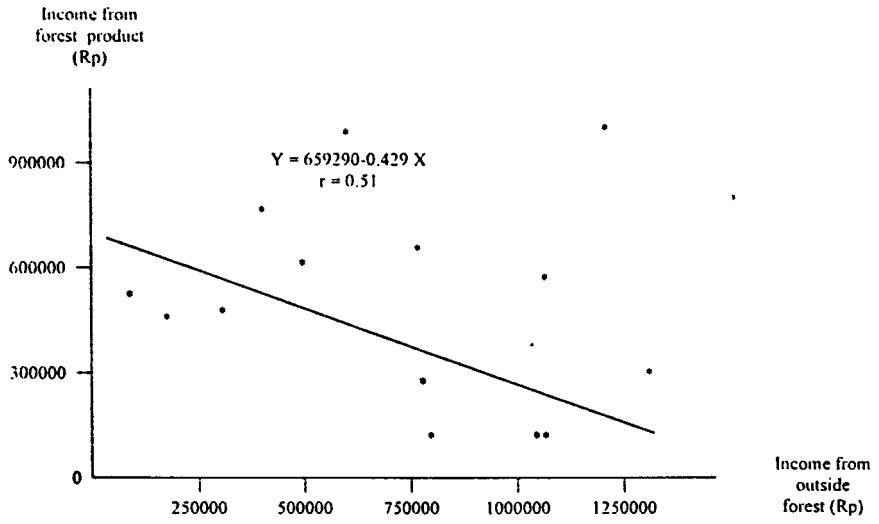


Figure 2. Relationship between income from forest products and income from out-side forest products for wetland rice farmer

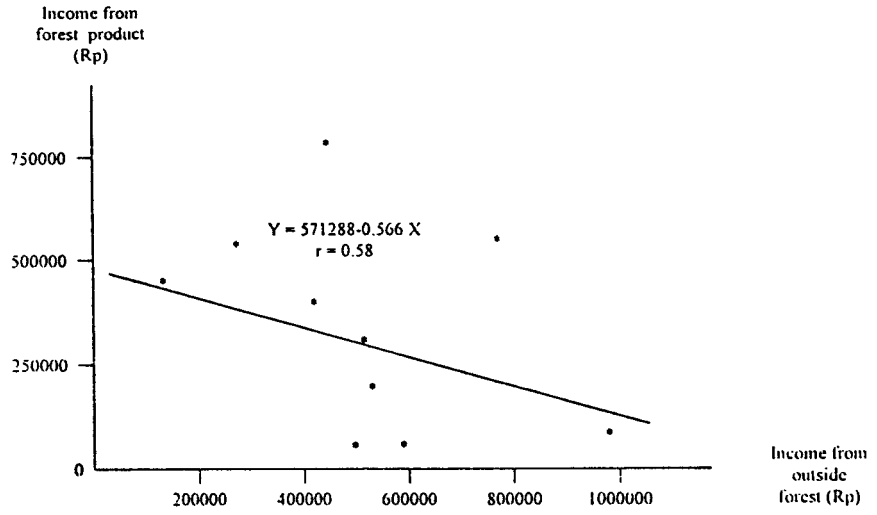


Figure 3. Relationship between income from forest products and income from out-side forest product for mixed garden farmers

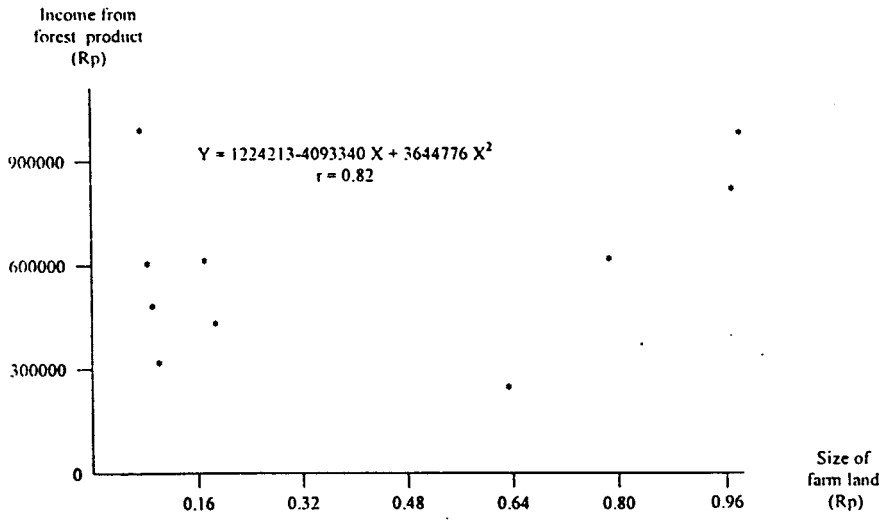


Figure 4. Relationship between income from forest products and income from out-side forest products for wetland rice farmer

1,250 per board at the study sites, this amount is equivalent to 35,371 boards per annum. It is estimated that a tree of 60 cm diameter and 20 m height without branches will yield about 100 boards (4 cm thick, 20 cm wide, and 4 m long). Therefore the contribution may be considered to amount to 354 trees per annum. This implies that inclusion of mixed gardens in farming systems substitutes for the cutting of 354 trees per annum from the park forest in the three villages.

Gathering Forest Products from Nagari Land

The nagari forest, both in its original state and after conversion to mixed gardens, provides resources to satisfy nearby communities' needs, particularly for fuelwood (for home consumption), vegetables and medicine. Interviews with all respondent farmers indicated that the average value of products gathered from nagari forests by surrounding communities was to Rp 81,364 per HH per year for fuelwood and Rp 8,395 per HH per year for vegetables and medicine. Thus, nagari forests contribute significantly to national park conservation, as communities would, in the absence of nagari forests, gather resources valued at Rp. 89,759 per HH per year from nearby park forests.

Emerging Research Issues and Suggested Approaches

Dominant crop species in the mixed gardens are commodity tree crops (coffee, rubber, and cassiavera), fruit trees and annual crops. Timber trees are rarely found and farmers still actively gather timber from park forests.

Farmer interviews indicated that 'surian' (*Toona sinensis*) was formerly common in park forests. Its wood is particularly suitable for construction purposes. It is very difficult to locate surian trees now, however, due to its selective extraction by farmers. Many respondents confirmed that surian trees are about a six-hour walk distant from their villages. Thus the majority of farmers interviewed are, given access to seedlings and extension, interested in planting surian trees as a component in their mixed gardens.

Hence, surian has strong potential for introduction into farmers' mixed gardens. Silvicultural technology packages need to be studied and developed for surian culture, including seed generation and storage, seedling propagation, plantation and tree care.

Based on this discussion of the findings, the next stage of research should focus on opportunities for intensification of mixed gardens in the study area.

TENTATIVE RESEARCH HYPOTHESES

Introduction of valuable timber tree species to farmers' mixed gardens and other strategies for intensification of these systems will absorb labor and increase farm income, thus leading to reduced reliance on KSNP resources.

Tentative Research Approaches:

1. Surveys and interviews with farmers who have mixed gardens:

   * with timber trees; and

   * without timber trees.

2. Inventorization of potential timber tree species found in mixed gardens, in addition to surian (*Toona sinensis*), that are preferred by farmers and are well adapted to the site.

   * Surveys and farmer interviews.

3. Silvicultural technologies for surian and other timber species selected.

   * Seed storage technologies;

   * Nursery development technologies;

   * Vegetative or tissue culture propagation technologies; and

   * Evaluation trials for promising species.

Application of soil conservation technologies such as contour hedgerows will alleviate soil erosion on sloping land and improve or maintain soil fertility and productivity. Therefore land use sustainability will be improved and farm incomes stabilized. However, caution is needed to recommend this technology only on fields with intensive cultivation. It is not likely to be useful or acceptable by farmers practicing either shifting cultivation or perennial cropping.

Tentative Research Approaches:

1. Establishment of plots in sloping areas demonstrating soil conservation technologies;
2. Measurement of soil erosion rates; and
3. Evaluation of crop and tree performance over a several-year trial period.

Changing Tenure Institutions and their Impact on Tree Crops in Buffer Zones

Research Focus

Minangkabau communities have preserved their matrilineal land control and communal forest management systems. However, recent socio-economic changes have drastically transformed the Minangkabau farmers' life style. Changes in the traditional land tenure institutions influence their use of forest land.

There are several assumptions on successful buffer zone management which are widely accepted:

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

This paper focuses on these assumptions through observation of Minangkabau farmers' forest and land use systems.

The study area is composed of three zones. The southern and central parts are old settlement areas, while the northern part has been opened up only since the 1930s by in-migrants from the southern part of the study area, and from the northern highlands outside the area. The southern and central parts are located on alluvial plains between mountain ranges, while the northern area is hilly and mountainous. The altitude ranges between 400 m and 1000 m. The population density is about 400 to 500 persons per km^2. The dominant dryland crop is coffee throughout the area. While rubber is also common in the southern part, annual crops such as chili are widely grown in the northern part. Cinnamon is a popular cash crop as well.

Highlights of Findings

Traditional Customs Governing Land Control

The Minangkabau communities have preserved their matrilineal and communal social structure. Their custom stipulates egalitarianism and harmony within the clan/lineage. They have developed a social hierarchy comprising the village (nagari), clan, sub-clan, lineage and sub-lineage. A clan is an exogamous honorary kinship group by matrilineal descent or adoption. Lineage (or extended family) is the kinship group coming from the same grandmother, headed by a male leader. The mothers' brothers show strong leadership. A nagari is a closed and corporate community unit, composed of several clans. However the nagari is autonomously governed through mutual agreement of the clans, and is without its own head.

Minangkabau communities have elaborate communal land and forest management systems. Each nagari, clan and lineage has developed its own forest and land territories, under the mutual agreement of its members. Individuals were not allowed to own land. Lineages were the primary land-holding corporations. Nagari land/forests were reserved for the communities' public purposes. A farmer must ask the approval of all clan/lineage leaders before cultivation of nagari land. Tree tenure was relatively loose as compared with the tenure of land holdings. After approval by his clan or lineage

head, a farmer can grow crops freely under his/her full ownership. Perennial crop inheritance depends upon lineage decisions, but the planters' children can inherit at least a portion of the trees planted.

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

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

In the Minangkabau area, the land is classified into inherited land and private land. The inherited land is composed of high ancestral land (*pusako tinggi*) and low ancestral land (*pusako rendah*). High ancestral land is inherited communally from lineage to lineage, and is controlled by its male leaders. This land cannot be inherited from parents to children, but from aunts to nieces. Low ancestral land is inherited jointly from parents to children - usually daughters, but sometimes also to sons. Newly opened or purchased land is private land, held jointly by the nuclear family. However, the land is converted into low ancestral land (family land) after inheritance. After inheritance for many decades, low ancestral land becomes high ancestral land (lineage land) which is controlled by its lineage. Although the process is not yet fully understood, conversion of family land into lineage land may be attributed to the following:

1. defunct family with no daughters must transfer the land to its lineage;
2. a family departing the area must transfer the land to its lineage upon leaving ; and
3. lineage leaders become more influential in land affairs after the family becomes larger.

It is noted that the cultivated land is controlled by blood relationship rather than territorial bond among lineages. Even out-migrants can still maintain claim to their land. In-migrants can similarly be given the land use right after acceptance by local lineages, without particular limitations.

Changing Land Tenure Institutions and Its Impact on Land Use

The southern part of the study area was first opened up by a group of pioneers in the nineteenth century. As the population grew, they expanded to land outside their community area. It is inferred that land distribution became unequal among lineages as severe competition occured among them for favorable land. Some poor lineages were obliged to move north to the central part of the valley for land acquisition. Nowadays

nagari and clan communal land has already disappeared in the study area, probably because:

1. population growth and expansion of clans made it impossible to manage large communal land without strong authority; and
2. massive in-migration resulted in disintegration of the clan/nagari communities of the area.

Lineage forest territories have also disappeared since the 1960s, when farmers' mobility increased. Lineage leaders and members often migrated out for better economic opportunities, and thus they could no more manage their forests. In-migration has also precipitated disappearance of lineage forests. Since the 1960s the prevalence of nuclear families increased, reflected in farmers' preference for independence from lineage control. The increased in number of nuclear families raised farmers' demands for timber to build their houses.

In-migration has been very active in the northern part. In- migrants arrived in the northern and central parts from both the northern highlands and the southern part of the study area. Large farmers, mostly from the southern part, acquired their own family land free from lineage control for their children, while preserving the lineage land in their older villages. Small farmers, mostly from the northern highlands, acquired land for their daily livelihood. They had been faced by land segmentation and subsistence crises in their older villages. Large farmers monopolized the favorable land in the lower landscape, while small farmers were obliged to reclaim small plots on the forested slopes . Thus land distribution inequality is more apparent in this area.

Large farmers use only their own family labor for land cultivation. This often results in a large increment of idle land on their farms due to labor shortage. Their children often migrate out to other areas and further reduce the family labor supply . Many of their family still live in older villages, whose children must move between villages to work the land. In a few cases they obtain labor power for their own land from the outside, however.

Forest clearance patterns are varied among farmers. In general large farmers open as much land as possible at once, where they gradually introduce crops with their capital.

They want to secure the land for future generations. They often monopolize the open-access forest up to the hill top without the lineage control. In other cases large farmers gradually increase small plots of land, by moving elsewhere after planting crops on the existing land. Successful crop growing depends on their labor availability rather than their capital ability. Small farmers usually open up only one small plot of forest. Then they gradually plant crops on the land. In this case their capital ability largely affects crop growing conditions rather than their labor availability.

Land selection is in principle free for slash-and-burn cultivation nowadays. However a new farmer must ask for approval of the owners of land surrounding his plot, to fix the land borders and to prevent future disputes such as destruction of the crops by the fire or felled trees. Lineage consultation is no more required after the disappearance of lineage territories in the forest.

Land control patterns are varied among the three parts of the study area, in accordance with social structure (see Table 5). In the southern part, land distribution has been unequal, due to historical lineage land competition. Population growth precipitates land segmentation among lineages. However lineage systems are relatively strong in old communities, which contributes to preservation of customary rules. High rice productivity, and earlier crop diversification partly due to Dutch government's support, encouraged farmers' preservation of existing community land and acquisition of new land in and outside their villages. Severe competition drives farmers to encroach into the remote forest for coffee and cinnamon growing. In the central part the lineages have held large paddies with high rice productivity. However, farmers were less concerned with crop diversification without external support. Lineage control has been relatively weak in this part, and even the lineage land was often sold out to farmers from the southern part for cash needs. Consequently a lot of farmers have become landless. Swiddens expand far into the forest, but it is large farmers rather than small farmers who actively open up the forest, mainly for coffee and cinnamon. In the northern part the land is newly cultivated on private and family bases. Farmers are being organized, but traditional lineage leaders are rare, as they are not accepted by the local clan authority. The community is organized homogeneously in each settlement as farmers' in-migration is often localized. The matrilineal land inheritance rule is generally preserved well. Rice productivity is not satisfactory to farmers due to cold temperatures at the higher elevation of northern villages, and the economy is more dependent on other cash crops.

Table 5. Land area of each tenure type on paddy and swiddens of the study area.

Parts/ tenure	Paddy (%)			Dryland (%)		
	Private	Family	Lineage	Private	Family	Lineage
Southern	31.7	0.0	68.3	37.4	17.1	45.5
Central	47.6	34.8	17.6	69.8	21.8	8.4
Northern	68.4	31.6	0.0	89.2	10.7	0.0
Total	56.0	28.1	15.9	66.1	17.0	16.9

Tenancy or other land-labor exchange could make up for severe land distribution inequality. On paddies a number of landless farmers get their rice harvest by equal sharecropping. On dryland, however, sharecropping is not as easy to practice, except for rubber tapping. Rubber tapping can be shared by tenants as they can acquire regular harvests, almost daily during the rainy season. However coffee and cinnamon are not as suitable for sharecropping, mainly because the harvest cycle is long, unlike rubber, and yields fluctuate.

Farmers have long based their livelihood on rice, but cash crops are becoming more and more important for farmers' economic needs. Thus swiddens have expanded these past several decades. Nonetheless, it rarely happens that farmers sell their paddies to start slash-and-burn cultivation. It might be because of the relative importance of rice for food security. In addition, farmers are reluctant to depend solely on dryland crops due to their price instability. Landless farmers have limited opportunities for forest access as farmers must prepare capital for living costs in the forest during their forest clearance and cultivation. Cultivation sites get further and further from the village, except in newly opened forest areas.

Among the three major commodity crops, coffee is the most popular among farmers due to its easy seedling collection in the fields. By contrast, cinnamon is the most unadvantageous for small farmers due to its difficult seedling availability as well as long growing period. It is favorable for large farmers who can afford to purchase its seedlings. Rubber is easy to grow, but it is vulnerable to damage by wild boars.

Conclusions: Minangkabau Custom and Land Management

Minangkabau customary rules should be considered from the following aspects:

Forest management. The traditional forest control system has almost disappeared except in the former lineage and nagari forests in the southern area. Minangkabau people have been rice- based farmers and insensitive to forest management. Territorial forest control is relatively weak. Forest land is no longer controlled locally after the occurrence of absentee land owners and in-migrants. Farmers have no perception of the forest boundary, and thus conservation activities would depend largely on government leadership.

Land tenure. In general communal land control is breaking down, as seen in the sales of lineage land. Poor farmers often divide and give the land to their children, which is prohibited by the customary rules. However matrilineal land inheritance is still practiced, and so the land privatization process is incomplete. Transformation of land tenure systems brings about disputes within lineages or families. Land security cannot be enhanced with certificates due to the discrepancy of land tenure policy between the government and the communities. Serious land segmentation will also have impacts on land tenure system change. Communal land holding might reappear under severe land shortage, in which tree plantation would be more difficult.

Successful Buffer Zone Management and Tree Plantation

It is not easy to demarcate the appropriate buffer zone between the conservation forest boundaries and the villages in the study area. Below the forest boundary the land is already controlled by lineages and large farmers, much of which becomes idle. Consequently a number of farmers own productive dryland only inside the conservation forests. Farmers can get the land and grow crops almost freely in the inner forest, as the forest is free from lineage control.

A large area of idle land impedes equitable dryland distribution. Idle land is created because:

1. Farmers lost interest in growing crops, particularly coffee, after a slump in their prices;
2. Farmers cannot continue to cultivate the land due to shortage of capital and labor shortage;
3. Land owners are often absent after out-migration; and
4. Pests and unsustainable land use. Idle land cannot be borrowed by other farmers particularly for perennial crop growing. Even the seemingly vacant land is often planted with some fruit trees, by which its owner can lay claim to his land.

Under such circumstances, it must be carefully considered who can benefit from agroforestry and what impacts agroforestry may have on the forest. Idle land could be cultivated to some degree with external financial assistance. However, landless farmers can hardly benefit from tree plantation programs. As seen in the above, tree growing is practiced on a private basis in most areas, and share-labor arrangements are harder on tree crop land than on paddies, except for rubber plantations. On the other hand actual private land and tree holding would induce farmers to convert the natural forest into tree cropland as far as possible, even though the forest is almost fully cultivated near villages.

Successful buffer zone agroforestry will depend on the following factors:

Boundary change and establishment of buffer zone inside the park. One solution to land shortage in the buffer zone might be to modify the park boundary in accordance with farmers' current land uses. In another case the buffer zone must be established inside the national park. The key problem is how much farmers' current cultivation is justifiable inside the forest. It must be noted that even tree crops have negative impacts on the forest as farmers can plant them more easily with private tenure.

Land tenure security. Communal land tenure may not be suitable for tree plantation. Although it is being modified, the traditional custom still controls land tenure. Uniform government policy does not hold true in the area, as seen in poor land registration. With attention to traditional land tenure institutions, the government must support commu-

nities in raising land tenure security for ensuring farmers' cultivation outside the conservation forest.

Land reallocation to poor farmers. Land reallocation would be desirable for landless farmers, although it would be a long process with involvement of absentee land owners. Farmers' future land demand and present subsistence needs must also be carefully balanced to prevent rich farmers' monopoly on land.

Introduction of tenantable crops. Poor farmers have less advantages in growing perennial crops. However, rubber creates opportunities for income generation for landless farmers by sharecropping. Such tenantable crops must be found for more equitable income distribution among farmers.

Emerging Research Issues and Suggested Approaches

Based on the above findings, the next stage of the research program will focus on the relationship between land tenure institutions and land use patterns, with economic analyses. This follow-up study is being conducted in collaboration between ICRAF and IFPRI (International Food Policy Research Institute), under the supervision of Dr. Keijiro Otsuka (Tokyo Metropolitan University and IFPRI).

The study is based on the following assumptions:

1. Communities' land tenure institutions influence farmers' tree growing conditions;
2. Communal tenure arrangements bring about inefficient land uses such as emergence of idle land;
3. Private tenure is much more effective for farmers' tree plantation than lineage tenure;
4. Large-scale farmers have a more negative impact on the forest in single tree growing areas, while small farmers cannot afford forest reclamation due to their capital shortage; and
5. Successful forest management depends on the establishment of a buffer zone inside the conservation forest, not only outside the forest, unless involuntary resettlement is practiced.

The study is comprised of two kinds of surveys: an extensive survey and an intensive survey. The extensive survey is aimed at comprehension of land tenure and land use variations at the village level, using official statistics and field data. Change in land tenure and land use patterns will be compared between the 1980s and the 1990s. People-forest interactions will also be estimated from the data on population density, cultivation area in the forest, etc. The relationship between land tenure and land uses will be elucidated through statistical analysis.

In the intensive survey several (4-5) villages will be selected for about 50 household surveys each. Detailed data will be collected on the land use condition and land tenure status of each farmer. The following functions will be used for testifying hypotheses:

1. area-choice functions using the proportion of the land planted with tree crops and fallow as dependent variables;
2. profit or production functions for rice cultivation; and
3. profit or production functions for cultivation of tree crops commonly grown on various types of land tenure.

Some problems must be paid attention to for prevention of possible error, such as:

1. land measurement with local units to demarcate ambiguous borders; and
2. control of physical and other aspects in assessing impacts of land tenure change in land use conditions, such as market prices, altitude, soil types, slopes, etc.

TENTATIVE RESEARCH HYPOTHESES

Cash crop introduction leads to transformation of land and tree tenure systems from communal holdings to private holdings. Minangkabau farmers' customary rules were elaborated on paddies, but they were not suitable for tree growing due to the long periods and possible future land disputes. Prompted by high profitability of cash crops, farmers prefer private tenure for facilitating crop introduction.

Communal land tenure arrangements bring about inefficient land uses such as emergence of idle land. Due to its complicated agreement process, farmers are reluctant to cultivate communal land, such as lineage or nagari land. However, owners still retains control even after They out-migrate. Other farmers will not use this land for tree growing, and the communal land is eventually left idle without any crops.

Private tenure is more suitable for tree growing, but it may also aggravate farmers' forest encroachment. Private tenure encourages farmers' tree growing due to its simpler land and tree holding rates. However, easier land control may result in farmers' further encroachment into the forest.

Large-scale farmers have a more negative impact on the forest in single tree-growing areas, while small farmers cannot afford forest reclamation due to their capital shortage. Rich farmers can spend their money and time in expanding their land for tree growing, but poor farmers must depend on annual crops for their emergent cash needs. Poor farmers cannot introduce tree crops on their land unless annual crops are available.

Successful forest management depends on establishment of a buffer zone inside the conservation forest, not only outside the forest, unless involuntary settlement is

practiced. More and more farmers are obliged to open up the conservation forest for land, as the land outside the forest has long been controlled and cultivated by local farmers. One effective solution would be establishment of a buffer zone inside the conservation forest including farmers' dryland, with encouragement of land use intensification through agroforestry.

Stabilization of Upland Agroecosystems as a Strategy for Protection of National Park Buffer Zones

Research Focus

This research project provided the framework for the execution of four separate studies designed to telescope from a very broad analysis of land use - park issues, to an increasingly focussed examination of specific components.

The first study was based on the observation that park boundaries in the study transect have been relatively well respected by neighboring farm communities - an oddity in the realm of park protection in S.E. Asia. This raised compelling questions regarding the genesis of this benign co-existence between the conservation objectives of KSNP and the socio-economic needs of the Minangkabau communities on its periphery. Through a literature review, and supported by oral histories, both historical and contemporary influences on land use were elucidated and linkages drawn with the retained integrity of the park's boundaries.

The second study consisted of a diagnostic survey to characterize farming systems, understand their interactions with adjacent National Park forests, and to identify and give priority to problems and needed research. Three case-study villages were selected to provide variation in altitude and age of settlement, and to understand how physiographic heterogeneity influences farm typologies and park - farm conflicts. Based on farmer problem definitions and plans for future farm development, a tentative agenda of problem-solving research was proposed. Finally, issues and lessons emerging from the study that are widely applicable to park buffer zone management and the design of Integrated Conservation Development Projects (ICDPs) were outlined.

Building on our understanding of the complex, whole-farm systems, this third study narrowed its analytical focus to the farm and field level in three case study hamlets. Using ethnographic eliciting it, traced the evolution of the bush-fallow system over the past half century. The implications of these changes to agroecosystem properties were then analyzed and discussed in the context of stabilizing land use in buffer zones of National Parks.

An anthropological study of resource-poor Minangkabau farmers' perceptions and management of *Austroeupatorium (Eupatorium) inulaefolium* H.B.K. within the bush-fallow system comprised the forth and final research focus. This is a fast-growing

Compositae sp. introduced to West Sumatra near the end of the 19th century and now often dominates fallow successions. The ecological role of *A. inulaefolium* in bush-fallow agroecosystems was discussed and farmer-generated innovations to exploit its agronomic properties documented. Laboratory data of soils and vegetation analysis of *A. inulaefolium*-dominated fallows were compiled and compared to alternative *Imperata cylindrica* and *Pteridophyta* spp. succession communities to provide empirical evidence of the validity of farmer technical knowledge and demonstrate the rationality of their management practices. Throughout the analysis, parallels were frequently drawn with *Chromolaena odorata*, another *Compositae* sp. occurring at lower altitudes that is the focus of controversy over the advisability of eradication efforts.

It was envisaged that this four-tiered research approach would be effective in portraying a clear picture of farming systems in the research transect, and their interactions with adjacent National Park boundaries. Based on this holistic understanding, the ASB project can then proceed to design a carefully considered, long- term research programme that closely reflects farmer objectives and strategies they adopt to achieve them, farmer perceptions of their most pressing problems, and results in well-adapted agroforestry solutions to park - farming system conflicts. Each of the four case studies has been written up as a separate chapter in a bound volume (Cairns, 1994) which is available to ASB collaborators at the ICRAF Southeast Asia office.

Highlights of Findings

The underpinnings of the relative harmony between farming systems and West Sumatra's natural environment were found to be a unique fusion of socio-cultural characteristics of the Minangkabau, historical events that have shaped West Sumatra's development, and agroecological attributes of the landscape. The analysis showed clearly that the study area can not be considered typical of upland conditions in S.E. Asia because: the marginal role shifting cultivation plays within farming systems; soils are not the infertile and acidic red-yellows podzols that dominate much of S.E. Asia's uplands - but relatively less infertile ultisols and andisols of volcanic origin; the remarkable history of the Minangkabau in institutionalizing mechanisms of out-migration to maintain a population - land base equilibrium; the system of land tenure that to an extent, ensures everyone born into a Minang family access to land and prevented in-migration by non-Minang and alienation of ancestral land; their long history of producing tree crops for world markets; the entrepreneurship of the Minang and their ability to find outside means of supplementing agricultural incomes; the high level of subsidization of many farming systems effected by merantau remittances; and the dwindling economic importance of land. Each factor influences why shifting cultivation in the study area has not had the same malign relationship that has characterized swidden - National Park interactions throughout S.E. Asia.

Although Kerinci Seblat was an island surrounded by a sea of agriculture long before its designation as a National Park, its inaccessibility, steep slopes and minimum potential for sawah development drew little interest from the Minangkabau. Given the same topography and ecosystem - but a different highland ethnic group with their traditional farming methods, e.g., the Yao of northern Thailand, the Tai of northern Vietnam, the Hmong of Laos, or the Ifaguao of the Philippines - and the upper slopes of KSNP probably might have been colonized centuries ago. The mountain range that now constitutes the park had the good fortune of evolving at its base a culture that placed strong emphasis on wet-rice culture, had no strong appreciation for continually re-clearing regenerated forest, and out-migrated in large numbers to distant lands at every opportunity.

While migration of rural populations to urban centres is a global trend fraught with its own set of problems, e.g., over-taxation of urban infrastructure, squatting of public lands and slums, rising unemployment and crime rates, it can play an invaluable role in siphoning off excessive population pressure from park peripheries and other fragile ecosystems. This points to a beneficial impact from, for example, urban industrialization in Jakarta or Bangkok, on reduced encroachment pressure on the boundaries of Kerinci Seblat and Khao Yai National Parks respectively. The exodus of large numbers of Minang from West Sumatra following the tradition of *merantau* is an extreme example. If estimates that 50% of the Minang population live outside West Sumatra are accurate, this suggests that *merantau* is responsible for halving the province's population density and extraction pressure on resources.

At both mature villages studied, rural development has reduced human pressures on forest margins through: expansion of non-farm economic sectors, offering alternative ways of making a living; higher levels of education that in turn, have led to increased out-migration to attend universities and seek urban jobs; and adoption of family-planning, reducing population growth. In contrast, the pioneer case study village receives few government services, development has stagnated and villagers have remained impoverished and heavily dependent on timber extraction from the National Park. This emphasizes the need for ICDPs to not restrict themselves to activities that are directly conservation-oriented - but to employ a broader, integrated approach that include education, health and family planning, village infrastructure, provision of credit and agricultural extension, and other rural development components. If village maturation brings with it reduced reliance on park resources, then we need to consider how to shorten the interim transition period.

Farm typologies have evolved differently in response to the potentials and constraints at each case study village: the '*high altitude mature*' settlement is placing decreasing dependence on sawah in the valley bottom and focussing more on intensive cultivation of mid-latitude vegetables on lower terraces, and passion fruit on upper slopes; intensive management of two crops of wet-rice per year is now the core

component of farm strategies at the '*mid-altitude mature*' site, with sloping lands extensively managed under cassiavera, coffee, or even left idle due to lack of labor; the '*mid-altitude pioneer*' hamlet has made comparatively less progress in intensifying its farming systems - and remains reliant on extensive use of park lands. At both mature settlements, substitution of more intensive production systems for the traditional extensive systems has caused a contraction of cultivation pressure away from forest margins on upper slopes and an intensified focus on land with higher agricultural potential on lower slopes and in valley bottoms. Stabilizing and intensifying farming systems *outside* park boundaries is an effective means of ameliorating encroachment pressure *within* the National Park. The causal links between rural development and biodiversity conservation are clear.

Directly related to the above point is the need for provision of rural credit on terms accessible to resource-poor farmers. Lack of operating capital to purchase inputs necessary for agricultural intensification was the complaint most often repeated throughout the study area. Farmers would adopt more intensive technologies if they could afford them. This suggests that the poorest strata of resource-poor farmers should be the target group of ICDP interventions. Unable to afford agricultural inputs or access other work, they are the '*critical users*' of park resources. Provision of 'soft' loans, subsidized fertilizer, buffalo and cattle banks, and vocational training courses could be components of a programme to provide access to new income-earning activities and the capacity to respond. Farmers engaged in illegal logging inside KSNP are struggling to meet daily needs and have little recourse but to turn to the forest: there is every reason for optimism that they will refrain from illegal logging when other options are provided.

During farmer interviews, a consistent complaint that spanned the length of our study area was the increase in wild boar (*Sus scropa*) populations since the end of the colonial era. Damage levels to ladang crops accordingly rose from tolerable to almost complete destruction. Not fussy eaters, pigs claimed increasing shares of most supplementary food crops grown by Minang in their ladangs - upland rice, corn, taro, bananas, cassava and sweet potatoes. This caused an impoverishment in the diversity of cultigens planted in ladang as farmers admitted defeat and 'pig- resistance' became the major criteria in crop selection. In addition to direct crop losses, farmers' constant struggle with pigs demands scarce labor resources that could otherwise be invested in more productive activities, and can result in lower incomes. With labor relatively scarce, the diversion of household labor due to pigs is serious. As one farmer concluded, "*Pigs keep us poor*".

The high altitude and harsher climate at the northern end of the study transect imposes site-specific problems of: frequent crop damage/failures due to high winds and frequent overcast, rainy weather; low productivity of wet-rice and lack of HYVs tolerant of cool temperatures; and altitudinal limitations on tropical tree crops. Research is needed to assess weather-related crop losses and identify dryland crops less vulnerable

to bacteria and fungi infection. Suitable agroforestry trees for high altitudes should be investigated for potential inclusion in on-farm agroforestry systems that would provide a natural resource buffer for timber, fuel, fertilizer and fodder needs, and reduce farmer reliance on National Park forests. Tree windbreaks on field perimeters may help to reduce wind speeds and mechanical damage to crops. A major research thrust should conduct field trials to evaluate germplasm of temperate fruit trees. Air Dingin's agroclimate may be suitable for apples, plums, pears and other exotic fruits that command high prices in urban markets. These could conceivably form the basis of highly profitable agroforestry systems on degraded hillslopes.

During the early years of this century, *Austroeupatorium (Eupatorium) inulaefolium* H.B.K., an aggressive shrub native to tropical America, was introduced to West Sumatra as a means of combatting *Imperata cylindrica* (alang-alang) in commercial tree plantations. It became naturalized throughout the study area and is now a keystone pioneer species that often dominates fallow successions. It is highly valued by farmers for its agronomic and ecological functions within bush-fallows and provision of several directly useful products such as poles and firewood. It is of particular interest as a spontaneous fallow succession species at higher altitudes. Rapid regrowth and high biomass production, copious shedding of branch and leaf litter, efficient scavenging of nutrients and fast fertility regeneration have allowed Minang farmers to shorten fallows and intensify land use without surpassing the ecological capacity of the local environment. This has had important implications to ameliorated encroachment pressure on protected forest margins.

Data from chemical analysis of soils and fallow vegetation provide empirical evidence corroborating the validity of indigenous knowledge accumulated by Minang farmers since *A. inulaefolium*'s appearance in the study area 50 years ago (see Figure 5-7). It demonstrates the rationality of farmer-generated innovations in managing it to their advantage and supports farmer claims that even short fallows can achieve much in terms of soil rehabilitation. The introduction of *A. inulaefolium* to West Sumatra has mitigated the tendency towards ecological decline in intensifying swiddens by playing a valuable bridging role in the transition phase between relatively longer fallow rotations of the past and today's increasing adoption of permanent cultivation. It is precisely this critical stage - when the ecological sustainability of traditional shifting cultivation systems has been lost but appropriate sedentary alternatives not yet adopted - that underlies the serious degradation of swidden communities' biotic resource bases throughout much of Asia. Minang farmers appear to have found at least a partial solution in *A. inulaefolium*'s spontaneous role in improved fallow management.

The Minang experience is particularly cogent because it is an example of successful indigenous intensification of swidden systems with a potentially wide domain of extrapolation. *A. inulaefolium* not only performs critical ecological services within farming systems of isolated and marginalized upland communities, but its benefits are

specifically targeted at the poorest strata within these villages who lack financial resources to purchase inorganic fertilizers, and cannot make the transition from fallow rotation to permanent cultivation. The role *A. inulaefolium* has played in enabling intensification of bush-fallow systems and mitigating pressure on forest margins in the study area suggests that its skillful management could be an important component of stabilizing farming systems on sloping highlands.

The one cropping system that fulfills both farmer production-oriented criteria (intensively managed, highly productive, and profitable) and conservation-oriented buffer zone properties (tree crops, stable land use, provides wildlife habitat, performs ecological functions) is complex agroforestry. ICDPs need to identify and implement mechanisms to encourage farmers to develop simple tree cropping patterns into multi-strata, complex agroforests.

Given the vast border of KSNP and the minuscule resources available to the national park agency (PHPA) in protecting it, there is a need for strategic early prediction and close monitoring of 'encroachment hotspots'. This would allow more proactive vigilance of attractive, and hence vulnerable, park areas - rather than the

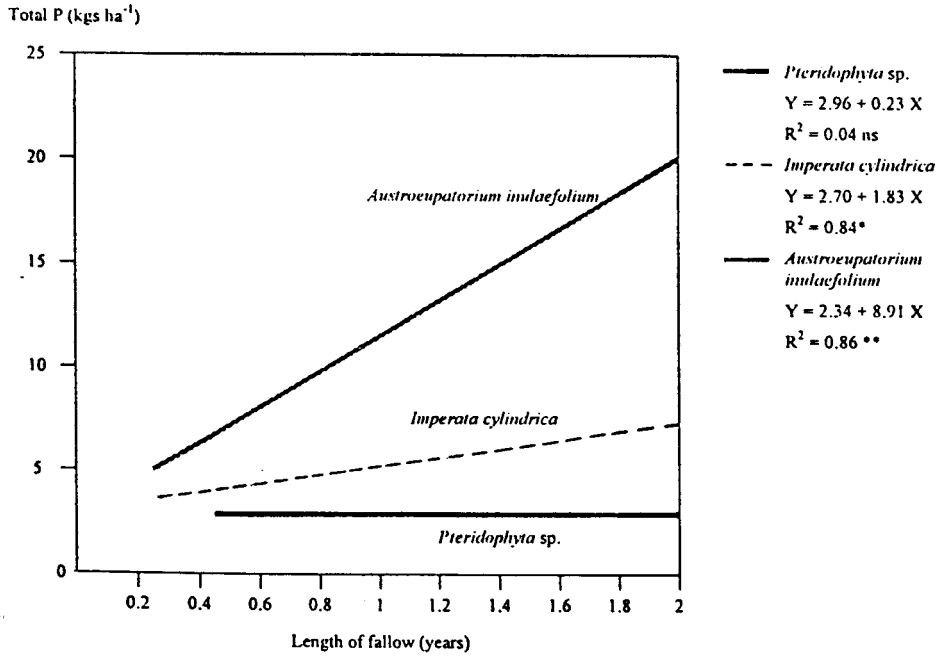


Figure 5. Above-ground P stock in fallow vegetation of *Austroeupatorium inulaefolium*, *Imperata cylindrica*, and *Pteridophyta* sp.

current reactive attempts to evict farmers after forests have already been cleared, crops planted, and villages established. As shown in this study, the presence of riverain valleys or basins amenable to sawah development should be a clear warning that agricultural encroachment will be imminent in the absence of close monitoring and the threat of punitive sanctions. Other indicators of probable poaching of park resources might include: close proximity of settlements; accessibility provided by incursion of roads; presence of valuable hardwood trees; the number of chainsaws and sawmills in the area; and roadside firewood sales.

Unfortunately, there is little compelling evidence to convince villagers that Kerinci Seblat National Park should be preserved for the sake of biodiversity conservation. KSNP does not have the tourism marketability and revenue-generation of Annapurna Conservation Area, set in Nepal's majestic Himalayas, or of Volcanoes National Park, Rwanda, with the mountain gorillas that were popularized by Diane Fossey's work. Nor, as in African game parks, is there wildlife to generate income from meat sales, safari and hunting fees. The park generates no local jobs in the study area and there are no revenues that can be redirected back to local communities. Although the forested slopes of the High Barisan mountains do provide ecological services important to farming systems in the central rift valley, this is not likely to be widely appreciated as

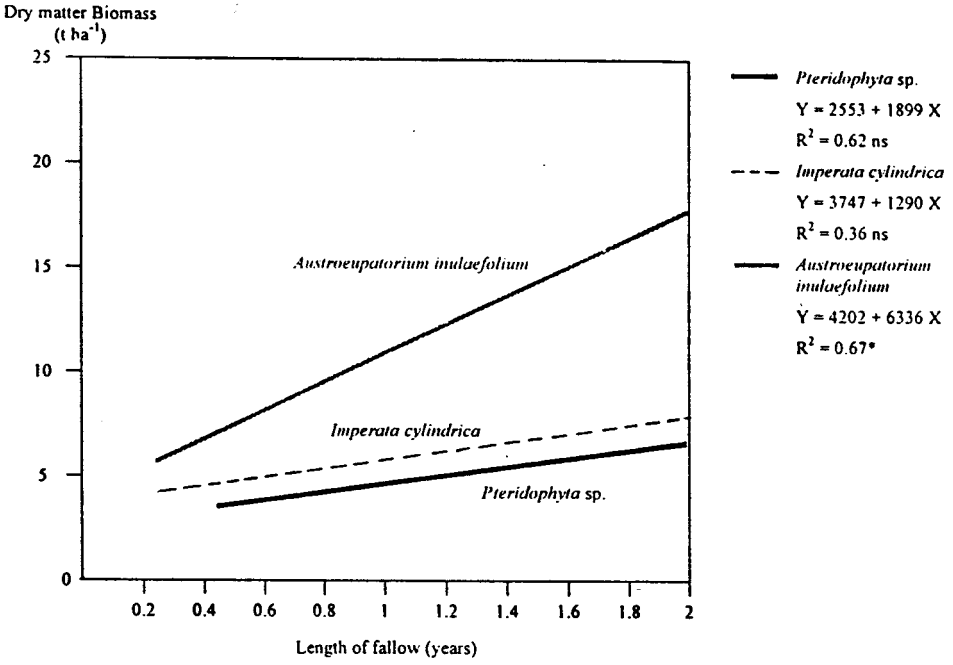


Figure 6. Total above-ground biomass (dry weight) during the fallow period

a rationale for their preservation. Opportunities for local communities to participate meaningfully in the park's management are limited.

Since conservation of the park can offer few tangible benefits to farmers, distraction from park resources by offering more attractive livelihood alternatives becomes critically important. Towards achieving that end, a major thrust of any ICDP must address improved productivity and stability of farming systems on park boundaries. As a preliminary planning phase, field studies will be necessary to build a farming systems understanding, incorporate farmers' perspectives, and identify priority constraints and problems.

Emerging Research Issues and Suggest Approaches

From this brief synthesis of findings, a number of key researchable issues have been identified and are presented as potential hypotheses that may warrant consideration for testing in the next phase of ASB activities. They have been categorized as research and development-oriented hypotheses and tentative approaches are noted for each postulation.

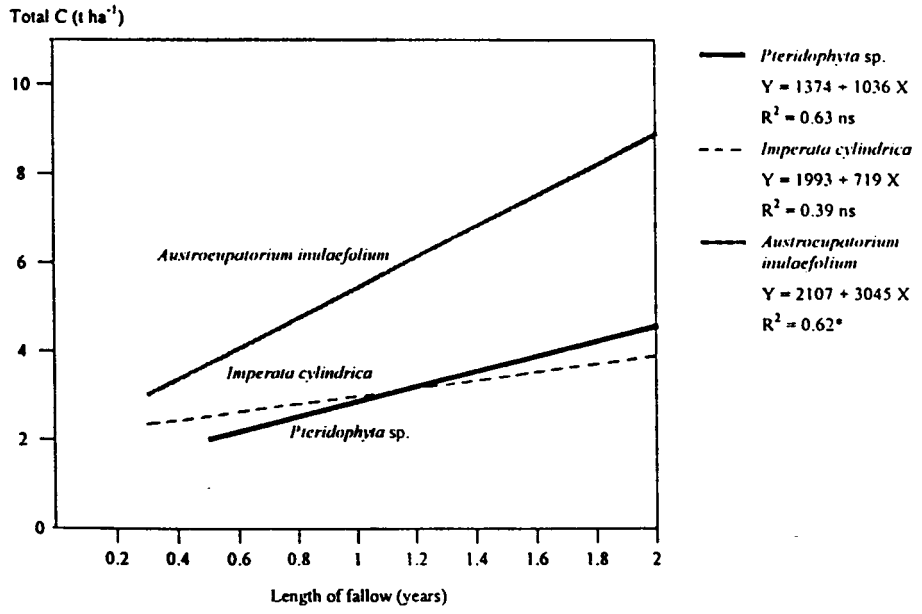


Figure 7. Above-ground Carbon stocks in fallow vegetation of *Austroeupatorium inulaefolium*, *Imperata cylindrica*, and *Pteridophyta* sp.

TENTATIVE RESEARCH HYPOTHESES

Research-Oriented

Austro-eupatorium inulaefolium H.B.K. and potentially other *Compositae* species offer beneficial agronomic properties that can be managed by farmers: a) as green manure crops during fallow periods; and b) as tools to smother out *Imperata cylindrica* and other hard-to-control weeds, and bring degraded land back into productive cultivation. *A. inulaefolium* is thus conducive to intensified land use by allowing bush-fallow systems to cycle more rapidly without declines in yields and soil properties; and through rehabilitation of abandoned *Imperata* grasslands.

Tentative Research Approaches:

1. Identify sites where declining swidden systems are a priority issue and intensification of the fallow rotation appears to be a tenable solution, possibly as an intermediate step enroute to adoption of permanent cultivation;
2. Identify the interrelationship between land degradation and colonization by problem weeds, i.e., understand ecological processes underlying evolution from *A. inulaefolium* to *Imperata cylindrica* and ferns, and identify points of intervention;
3. Farmer solutions for land reclamation documented;
4. Ethnographic eliciting of current farmer practices in managing *A. inulaefolium;*
5. Experimental field trials to understand effects of *A. inulaefolium* on soil fertility; and
6. On-farm plots to experiment with the agronomics of:
   a) actually planting *A. inulaefolium* on degraded soils; and/or
   b) assisting its natural regeneration on fallowed land.
7. Identification of a protocol for management practices easily adopted by farmers.

As bush fallows shorten and land cultivation becomes more sedentary, '*live fences*' are an increasingly viable strategy to prevent *Sus scropa* (wild pig) predation on crops.

Tentative Research Approaches:

1. Survey and evaluation of existing case studies of farmer attempts to adopt the 'living fence' concept to deny wild pigs access to fields;
2. Identification of species:
   - capable of forming a dense physical barrier, impenetrable by pigs;
   - easily propagated;
   - preferably of some economic or ecological value.

3. Experimental field trials of:
   - the agronomy of establishing/maintaining live fences, and
   - the degree of effectiveness in blocking entry by hungry pigs.

The agroclimate of the highest elevation areas such as Air Dingin is suitable for apples, pears, plums and other exotic subtropical fruits that command high prices in urban markets. This could form the basis of highly profitable agroforestry systems on degraded foothills.

Tentative Research Approaches:

1. Market surveys and economic analysis; comparison of potential remuneration from exotic fruit orchards to other uses of land and labor;
2. Experimental plots on agronomy of establishing/managing temperate fruits on degraded upland soils;
3. Variety performance trials; and
4. Design of synergistic planting patterns and associations.

Tree-based land use on the park perimeter is dominated by cassiavera (*Cinnamomum burmanii*) and coffee (*Coffea spp.*) plantations, reflecting current strong market prices for these two commodities. Interventions aimed at encouraging gradual enrichment planting has the potential to evolve these simple tree crop patterns into complex, multi-strata agroforests that are more stable, able to absorb surplus labor, provide extended habitat for wildlife, and more effectively buffer the park from human impacts.

Tentative Research Approaches:

1. Case studies of existing complex agroforests that would characterize them and elucidate farmers' internal logic in developing them;
2. Comparative economic analysis of yields and profits per unit of land/labor invested in simple tree crop patterns vs. complex agroforests;
3. Survey of current constraints to enrichment planting;
4. Measurement and indices of the ecological services provided by complex agroforests, i.e., regulation of hydrology, soil conservation, and biodiversity habitat, and comparison with natural forests;
5. Investigation of synergistic tree-crop associations.

Development-Oriented

In view of the labor constraints faced by most farm households, and the frequency of land abandonment due to colonization by hard-to-control weeds, the introduction of

animal draught power would be a critical labor-saving technology that could bring idle foothills back into cultivation.

Tentative Research Approaches:

1. Focussed farmer interviews to clearly identify why animal draught power is currently limited only to paddy fields - while all sloping land continues to be cultivated by hand;
2. Comparative analysis of time/labor investments and economic returns from hand tillage vs. use of animal draught power;
3. Cross visits by Minang farmers to other upland areas in Sumatra where animal power is effectively exploited on sloping lands;
4. Evaluation trials with animal-drawn tillage instruments that are currently available and possible design modifications for local conditions;
5. Careful impact assessment of adoption of animal draught power, the likely intensification and expansion of annual crops on the foothills, and the implications to park buffer zone function.

In the study area, the poorest strata of farmers unable to afford inorganic fertilizers, sprays, and other inputs necessary for intensified sedentary cropping, are most heavily dependent on park resources. As the '*critical users*' whose continued exploitation of National Park resources most seriously threatens biodiversity conservation, interventions targeted carefully at this group will be most effective in reducing encroachment pressure.

Tentative Research Approaches:

1. Farm household interviews to confirm correlation between lack of resources and increased reliance on encroachment into protected areas;
2. Identification and quantification of what park resources are being harvested by farmers; then an economic analysis comparing profitability of continued park encroachment with potential returns from intensified farming systems *outside* park boundaries;
3. Design of low-cost credit schemes accessible to poorest strata of farmers to encourage intensified land use outside park boundaries. Subsequent monitoring of effects on degree of park encroachment;
4. Accompanying park boundary enforcement and sensitization of farmers to the ecological services provided by the park to the central rift valley - and its centrality to the water resources that feed their irrigation systems.

Continued penetration of pioneer settlements up narrow rift valleys into the park interior constitutes one of the greatest threats to KSNP. By forging a cooperative

alliance, PHPA can negotiate stewardship agreements with these communities that will both grant them legitimacy and enlist them as the 'eyes and ears' of PHPA and the first line of defense against further park encroachment.

Tentative Research Approaches:

1. Assessing the degree to which the park's integrity is currently threatened by these illegal settlements; likely impacts if the problem continues to be ignored; and comparison with best and worst case scenarios emerging from a stewardship agreement programme;
2. Evaluation of similar approaches at other parks, e.g., the Philippines land stewardship programme;
3. Identification of terms of a stewardship agreement acceptable to all stakeholders, and assessing the probability that they would be respected and enforced. Working out a pragmatic system of incentives and sanctions.

Traditional out-migration (*merantau*) by the Minangkabau has been key in ameliorating demographic pressure on KSNP's perimeter in the study area. A negative spinoff that ICDPs must overcome is the potential that interventions aimed at improving infrastructure and standards of living in the park buffer zone would logically discourage continued out-migration, and could even reverse the flow by attracting Minang settlers to return to their homeland.

Tentative Research Approaches:

1. Case studies of existing ICDPs in similar circumstances;
2. Documentation of why Minang out-migrate, where they go and what they do, and an analysis of how their decisions may be altered by improved opportunities in their home villages; and
3. Forecast of best and worst case scenarios of how an ICDP may affect population densities within the buffer zone, demand for agricultural land, labor absorption by expanding service industries, and the net impact on park conservation. This needs to be compared with the current status quo to judge if ICDP interventions will have a net positive effect and are justified.

Contrary to conventional wisdom, resource-poor farmers in the study area are most likely to invest in long-term tree crops - while wealthy farmers prefer to concentrate on annual cash crops with a fast cash turnover.

Tentative Research Approaches:

1. Further surveys that would stratify farm households by economic affluence and examine interrelationship with propensity to plant tree crops vs. annuals;

2. Eliciting of farmer views of relative merits and rationale of planting trees vs. annual crops;
3. Comparative economic analysis of potential returns from agroforestry systems vs. annual cash crops;
4. If increased standard of living is found to translate into less likelihood of adopting agroforests - but a more profit-driven, exploitative mentality in resource management, then we need to think through what this means in terms of designing ICDP interventions in park buffer zones.

FINAL COMMENTS

The over-arching core issue that challenges ASB collaborators is optimized use of a limited resource base to support a growing population. Although non-farm sectors are slowly developing and opportunities to accelerate their expansion should be pursued by any proposed ICDP strategy, the study area continues to rely overwhelmingly on an agricultural economy. Thus, the central thrust of any interventions must focus sharply on intensification of farming systems, and addressing any technological, economic, institutional or policy constraints that hinder optimum resource management.

Clear understanding of the unique socio-cultural aspects of the Minangkabau and their customs governing resource tenure will be a vital prerequisite to any interventions. A further dimension to the challenge posed by this site is the dynamic land use practices that have evolved in diverse ecological niches as the study transect descends from up to 1700 m in Air Dingin down to 400 m at Muara Labuh. Farming systems even in neighboring communities may vary enormously in response to physiographic differences. This heterogeneity confirms that blueprint solutions applied blindly are not feasible. Participatory, bottom-up approaches are necessary to ensure sensitivity to local needs, knowledge of local biophysical and socio-economic conditions, and the development of site-specific technical options. This paper represents a modest beginning by characterizing farm and National Park interactions and proposing emerging research issues .

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