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AGROFORESTRY RESEARCH NEEDS AT TRANSMIGRATION SITES IN SITIUNG, WEST SUMATRA, INDONESIA.

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SUMMARY

This report presents the findings of a mission that undertook a diagnosis of landuse systems in Sitiung in order to identify agroforestry technologies to overcome sustainability and/or productivity constraints in these systems.

In addition to soil erosion on sloping fields, the soils at Sitiung have high levels of aluminium saturation, are low in exchangeable Ca, Mg and K and possibly low in Mo, Mn, Zn, B and Cu as well. Moisture stress is a major problem for crop production due to shallow rooting of many crops (probably related to high Al saturation and low supply of bases in the subsoil) and the high permeability of most Sitiung soils. Although applications of lime and fertilizers result in good crop responses, both insufficient supplies and untimely delivery of fertilizers and pesticides were cited as problems by farmers at Sitiung.

Pests and diseases are also big constraints to crop production in Sitiung. Rice blast fungus, seedling fly, brown planthopper and stem borers are major pests of upland rice. Wild pigs often totally destroy fields containing peanut, maize or cassava. The weed Imperata cylindrica was also mentioned as a problem. Most farmers reported that they lacked cash resources to purchase pesticides.

Due to the above-mentioned constraints, most of the farmers interviewed reported that they had to purchase rice to meet year round family food needs. This results in competition for scarce cash resources that are also required for the purchase of lime and fertilizers in order to ensure adequate production in the next season. Cash income is limited by low yields and low prices. Farmers are unable to transport their produce to the larger urban markets and fall victim to the problems of oversupply and exploitation by middlemen in local markets.

All the transmigrant farmers at Sitiung have spontaneously developed agroforestry-based homegardens involving multistoried mixtures of trees, annual crops and stall-fed livestock. These homegardens account for up to 44% of total agricultural products and provide between 30% and 60% of the total cash value of agricultural produce in the various communities at Sitiung. Agroforestry technologies involving high value tree crops and/or livestock have excellent potential to significantly improve cash income for transmigrant farmers thereby enabling them to purchase the inputs essential for adequate crop production. Furthermore, agroforestry can address the problem of fuelwood all of which is currently obtained from natural forests surrounding the transmigration sites.

1. INTRODUCTION

An agreement to conduct collaborative research on soil management at the transmigration sites in Sitiung, W. Sumatra was reached in 1980. The institutions involved in this agreement are: the Indonesian Government; through the Agency for Agricultural Research and Development (AARD) and its Centre for Soils Research (CSR), the United States Agency for International Development (USAID), the University of Hawaii (the lead US institution) and North Carolina State University. The research is conducted under the framework of a Collaborative Research Support Project (CRSP) called TropSoils Indonesia.

The Indonesian Government wishes to transfer soil management and farming systems strategies developed at Sitiung to other transmigration sites. Consequently, the principal goal of the TropSoils project is:

> " To uncover principles which will enable resource-poor farmers to adopt soil management practices that will increase family income and farm productivity and at the same time preserve land quality. The research strategy is designed to ensure that social, cultural, economic, and environmental factors that enhance adoption of a soil management innovation are made an integral part of the research plan. To achieve its goal, the project conducts a major portion of the soil management research with farmers and in farmers' fields " (McCants, 1985).

Research at Sitiung has shown that lime, fertilizers and pesticides are essential for the successful cultivation of crops at Sitiung. Despite these inputs, which the farmers obtain at highly subsidized prices, farmers at Sitiung find it difficult to produce annual food needs and generate adequate cash for inputs to ensure good production in the next season. Furthermore, it is unlikely that current subsidies on inputs will be maintained due to declining government revenues as indicated by the recent 45% devaluation of the Indonesian Rupiah against the US dollar.

Oil and gas currently account for 70% of Indonesia's foreign exchange earnings and 55% of Government tax revenues. As a result of international oil prices, Indonesia's petroleum export revenues were predicted to decrease by US$ 5.8 billion (47%) in 1986 alone. It is hence imperative that the transmigrant farmers at Sitiung develop a range of sustainable food and cash cropping systems to counter the anticipated decline in Government subsidies and rise in cost of living.

Agroforestry technologies have the potential to reduce the levels of inputs and, more importantly, to provide a diverse range of cash generating enterprises. This not only minimizes risk, but also enables the farmer to raise cash to purchase the inputs required for successful cropping. This report presents a diagnosis of the constraints within the various production subsystems at Sitiung and identifies agroforestry alternatives that have the potential to provide solutions to pressing problems of declining productivity and sustainability.

2. OBJECTIVES OF THE MISSION

The primary objectives of this mission were:

1. to undertake a diagnosis of the current landuse systems in Sitiung and identify suitable agroforestry technologies to overcome productivity and/or sustainability constraints in the existing systems. This would enable TropSoils to determine what research is needed to generate and refine the required technologies. Implicit in this is the development of a research-extension methodology and general prototypes of agroforestry technologies to be modified and tested in similar environments at other transmigration sites in Indonesia.

2. to identify individuals and institutions involved in agroforestry research in Indonesia. This would facilitate not only an exchange of research experiences and data, but also provide an indication of potential collaborators for the future.

3. AGROFORESTRY DEFINED

Agroforestry is a collective name for systems of landuse in which woody plants (trees and shrubs) are deliberately managed on the same land management unit, either simultaneously or in rotation, with annual crops and/or animals. For a landuse to qualify as agroforestry, there should be both ecological and economic interaction between the woody plants and the other components of the system (Lundgren 1982).

Agroforestry may involve the integration of trees and shrubs into farming systems or crops and livestock into forests. In practice, a high proportion of agroforestry systems involve the growing of trees (for various products and services) on what is essentially farmland.

4. METHODOLOGY

The mission proceeded according to the general approach developed by the International Council for Research in Agroforestry (ICRAF) for diagnosis of existing land management practices and design of agroforestry alternatives (Raintree, 1983).

The procedural sequence was as follows:

(1) Review of baseline biophysical and socio-economic information for Sitiung from TropSoils' and CSR publications and discussions with researchers at Sitiung and CSR, Bogor.

(2) Diagnostic interviews with sample farmers to identify:

(a) Problems as perceived by the farmer with respect to household needs

(b) Land management problems and constraints resulting in present (productivity) and future (sustainability) problems.

(c) Current farmer strategies to counter these problems

(3) Diagnostic analysis to evaluate the landuse problems clarifying relationships among contributing factors and assigning priorities to them.

(4) Derivation of functional and general specifications for problem solving interventions.

(5) Analysis of a range of agroforestry technology options for addressing the identified design specifications.

(6) Analysis of alternative systems plus technologies and comparison with technological improvements in existing systems.

(7) Evaluation of design alternatives and choice of a limited set of best bet options.

(8) Identification of research needs to generate the required technology if not already available.

(9) Analysis of the existing institutional infrastructre responsible for developing and disseminating the proposed technological alternatives.

The aim of ICRAF's Diagnosis and Design (D&D) methodology is to assist in the design of appropriate agroforestry systems, as a conceptual basis for the identification of research needs and the formulation of agroforestry research and development projects. The methodology incorporates elements of the Farming Systems Research (FSR) approach (Collinson, 1981; Hildebrand, 1981; Zanstra et al. 1981; Shaner et al. 1982) but goes beyond the context of existing FSR methodologies in order to address the broader range of production and conservation roles which can potentially be played by agroforestry.

The D&D method seeks to ensure that:

a. research orientated towards the development of new land management technologies, should be relevant to the actual needs and potentials of the landuse systems.

b. priority is given to developing agroforestry's potential to provide urgently needed solutions to pressing problems of declining productivity and sustainability.

c. realization of landuse potentials is achieved through the identification and removal of system constraints.

It is important to realize that at the present stage of the scientific development of agroforestry, there are few tried and tested agroforestry technologies. Hence the need for research before there is widespread extension of agroforestry technology. Hence, also, the need for identifying priorities for cost effective research based on sound agroforestry designs.

5. STUDY AREA

5.1 Location

The transmigration sites of Sitiung occupy approximately 100,000 ha along the Trans-Sumatran Highway and the Batang Hari river in West Sumatra. Sitiung is located 220 Km south east of Padang, a port city and capital of the province of West Sumatra.

5.2 History and Settlement

In an attempt to relieve the high population pressure on the islands of Java and Bali and to develop the sparsely populated rainforest areas of Sumatra, Kalimantan and Sulawesi, the Indonesian Government has undertaken a large transmigration project. The earliest transmigration projects were started by the Dutch in 1905 and approximately 200,000 people had been relocated by the time Indonesia gained independence in 1945. The transmigration program is currently administered by the Department of Manpower and Transmigration. The third five year development plan for 1979-1984 called for the transmigration of 500,000 households or about 2.5 million people (Christanty, Iskandar and Abdoelah, 1982).

Typical transmigrants are farm families from Java where population densities often exceed 750 people per square kilometer. Villagers express their desire to become transmigrants by registering for the program with local officials. Transmigrants are then selected on prescribed characteristics such as poverty, health, youth and marital status (adult transmigrants must be married). Occasionally, as in the case of Wonogiri (Central Java) where a new dam resulted in flooding of farmland, an entire community may be relocated resulting in a transmigrant population that includes not only the poor and landless but also farmers who are well off.

Sitiung contains an estimated 12,000 families who moved into the area between 1975 and 1985. The area is divided into 8 administrative units (Sitiung I-VIII). Units are divided into blocks with each containing between 300 and 500 families. Sitiung I and II were established in 1976 and 1977 respectively, by farmers relocated from a single community from Wonogiri (Central Java) due to construction of a dam which flooded their original lands. In contrast, the other Sitiung sites (III-VIII) are populated by Javanese from Central Java, Sundanese from West Java and some Minangkabau (Minang). The Minang are the indigenous ethnic group and are scattered among the various transmigration sites.

5.3 Climate

Sitiung is located at 100 meters above sea level and is classified as having a Tropical Rainforest Climate (Af) in the Koppen System. The mean annual rainfall is 2500 mm with a short relatively dry period of about 100 mm rain per month during June, July and August. Rainfall generally increases from August to October and remains high until May, usually reaching peaks of 300 to 400 mm per month in November and December. The mean annual temperature is 26 C (Sigman et al., 1986).

Table 1. Population Distribution Pattern in Sitiung I-IV

SITE	AREA (Ha)	MEN	WOMEN	CHILDREN (7-12 yrs)
Sitiung I	1768	2523	2366	928
Sitiung II	2040	2268	2328	803
Sitiung III	2210	3650	3194	1201
Sitiung IV	3400	4630	4485	233
Total	9410	13071	12373	3165

Source: Scheme Administration Office, Sitiung II.

5.4 Topography and Soils

A detailed account of the soils of the Sitiung area is contained in Trangmar et al. (1984). Although there is a high variability, the major soils include:

- fairly level Inceptisols in Sitiung I
- moderately rolling Oxisols in Sitiung II, III and IV
- relatively steep, dissected Ultisols in Sitiung V and VI

These soils are generally well drained, acid, infertile (low in bases, P, CEC) and high in aluminium.

5.5 Vegetation

Prior to clearing, the natural vegetation consists of mixed, multistoried tropical rainforest with main canopy 30-50 m high. Most important timber species are those of the Dipterocarpaceae family with Shorea, Hopea, Dipterocarpus, Dryobalanops, Anisoptera, Parashorea and Vatica as the main timber

species. Weed species invading after repeated cutting of the rainforest include Eupatorum spp., Hyptis suaveolens, Lantana camara and Mimosa invisa. Regular burning gives rise to fields of Imperata cylindrica (alang-alang). Ferns of Blechnum, Nephrolepis and Gleichenia are characteristic of clearings on degraded, infertile soils.

5.6 Landuse systems and land tenure

Each transmigrant family is supplied with a house surrounded by 0.25 ha for a homegarden and 1.0 ha for field crops at a distance of 1 to 2 kilometers fron the house. In addition, all the families are entitled to another 0.75 ha of land which is presently under forest and is about 5 kilometers away. Due to lack of resources and labor, farmers have not utilized this plot yet although many have indicated a desire to do so in the near future (Evensen et al., 1986)

The Government stipulates that transmigrant farmers have to reside on their allotted holdings for 10 years before receiving the title deeds to the land. If a farmer and his family leave before this period, the village headman is authorized to allocate such land to young married couples who have no land of their own.

In the earlier settlements of Sitiung I-IV, the allocated land holdings were mainly cleared by bulldozing, resulting in compaction and exposure of subsoils with less favourable physical and chemical properties. The transmigrant farmers recognize this damage and in recent settlements (Sitiung V and VI), most farmers used cutting and burning to remove trees and stumps despite the availability of government provided bulldozers. Where logs and stumps were numerous, farmers were paid Rp. 110,000 for clearing and burning.

For the first year, the government provides each transmigrant family with a free subsidy of food, seeds, basic farm implements, lime, fertilizer and pesticides. A quantitative list of items obtained by farmers in Sitiung V is given below:

50 kg rice per month for 1 year	1 hoe, machette, sickle
35 kg rice seed	6 coconut seedlings
5 kg peanut seed	2 rambutan seedlings
5 kg soybean seed	2 citrus seedlings
3.5 tonnes lime	1 cow (not yet received as of August, 1986)
600 kg rock phosphate	
100 kg urea	
100 kg TSP	

After the first year, farmers can buy fertilizers and lime at highly subsidized prices, although difficulties in coordinating an efficient distribution often result in unavailability. The current subsidized price of fertilizers and lime to farmers is Rp. 125,000 (US $ 112) per tonne (Ray Diamond, IRDC pers. comm.). This implies a government subsidy of about US $ 66 and 260 per tonne for urea and TSP respectively. These values have been estimated from a case study by Louis Berger International Inc. (1983) and include a 25% increase in farmer purchase price for lime and fertilizer which became effective in April 1986.

Government recommended rates for fertilizer and lime **per crop** and the cost implications for the farmers are as follows:

Application rate	Cost (Rp.)*
Lime 2.5 t per ha	332,500
TSP 100 kg per ha	12,500
Urea 100 kg per ha	12,500
KCl 100 kg per ha	12,500
	370,000

Sitiung I has irrigation water supplied to about 50% of the fields, which are used for flooded rice production (sawah) . An irrigation scheme is also being developed for Sitiung II. All the other settlements have rainfed upland fields (ladang) and a few swamps which are used for flooded rice culture.Transmigrants usually plant rice on their upland fields at the begining of the rains in September and October. Sometimes, maize is planted at wide spacings with the upland rice. Occasionally, soybeans or peanuts are planted instead of rice. Upland rice may be followed by peanuts, soybeans, mung beans or cow peas in February - March. Farmers usually do not plant a third crop to grow in the dry season. Sometimes only one crop of upland rice is grown per year and the land left fallow after harvest. Two crops of irrigated rice are often grown in Sitiung I and the Minang communities with transplanting occurring in October - November and March - April.

*** 1 US $ = Rp. 1120 (August, 1986)**
(The post devaluation exchange rate in Dec. 1986: 1 US $ = Rp. 1644)

In general, the homegardens (pekarangan) comprise a complex multistoried mixture of perennials, annuals and livestock. Their proximity to the house facilitates intensive management including the application of manure, ashes and kitchen waste and are an important source of both food and income (Colfer et al., 1986). These homegardens are a classic example of the agroforestry approach to homegardens in the tropics (Fernandes and Nair, 1986). An inventory of plant species in the homegardens of 10 interviewed farm families identified 36 woody perennials and 19 herbaceous species (Table 2). Although mature homegardens (8-10 years) are characterized by a predominance of perennials and fewer species of intercropped annuals, large sections of younger homegardens may be planted to upland rice, peanuts, cow peas and cassava.

The indigenous Minang farms in the Sitiung area follow a similar pattern of a homegarden around the house associated with various outlying fields. Where the topography and drainage is suitable, these fields are planted to flooded rice. Alternatively, upland rice is cultivated for 2 or 3 years and followed by tree crops such as rubber, coffee and fruit trees (duku, durian, jackfruit). In addition, semi-wild rubber trees are tapped on communal land. In recent years, rubber tapping has been quite profitable. Woods (1984) showed that it accounted for up to 62% of the total income of Minang farmers cultivating rubber as described above. The strategy is to use the tree crops to provide stable, low-risk income while also protecting the soil.

6. DIAGNOSIS OF THE FARMING SYSTEMS AT SITIUNG

The decision by the Government of Indonesia to adopt both lime and fertilizer inputs to enable transmigrant farmers to grow crops successfully on the infertile, Al saturated soils at Sitiung is likely to have been influenced by the research experiences from the TropSoils program at Yurimaguas, Peru. The initial free allowance that the transmigrant farmers receive and the facilities for purchasing these inputs at heavily subsidized prices has had a dramatic positive effect on crop production at Sitiung. Despite the impact of lime and fertilizers, however, farm families interviewed at Sitiung most often mentioned food and cash as the basic needs not being adequately met.

Table 2. Common plant species in homegardens at Sitiung

(Indonesian names were obtained from Colfer et al., 1986)

Species	English	Indonesian	Uses
(a) Woody perennials:			
Albizia falcataria	albizia	-	green manure, fuel.
Anacardium occidentale	cashew	-	fruit.
Anona muricata	soursop	-	fruit
Areca catechu	beetle nut	-	masticant.
Artocarpus heterophyllus	jackfruit	nangka	fruit, vegetable, boundary demarcation.
Averhoa bilimbi	bilimbi	bilimbi	fruit, vegetable.
Averhoa carambola	carambola	-	fruit.
Bambusa spp.	bamboo	-	building material.
Cajanus cajan	pigeon pea	-	food seed.
Calliandra calothyrsus	calliandra	-	green manure, fuel.
Camellia sinensis	tea	the	beverage.
Carica papaya	papaya	papaya	fruit.
Ceiba pentandra	kapok	kapok	fibre, fuelwood, boundary demarcation.
Citrus spp.	citrus	jeruk	fruit, cash crop.
Cocos nucifera	coconut	kelapa	food nut, fibre.
Coffea robusta	coffee	kopi	cash crop, beverage.
Crotalaria sp.	crotalaria	-	green manure.
Durio zibethinus	durian	duren	fruit.
Elettaria cardamomum	cardamom	kepulaga	spice, cash crop.
Erythrina spp.	erythrina	-	live fence, local medicines.
Eugenia aquea	water apple	-	fruit.
Eugenia caryophyllus	clove	cengke	cash crop, spice.
Garcinia mangostana	mangosteen	mangis	fruit.
Gliricidia sepium	gliricidia	-	live fence, fodder green manure.
Gnetum gnemon	-	-	food seed, vegetable
Jatropa curcas	jatropa	jarak pagar	live fence, local medicines.
Lansium domesticum	duku	duku	fruit.

Table 2. (cont.)

Species	English	Indonesian	Uses
Leucaena leucocephala	leucaena	lamtoro	green manure, boundary demarcation, fodder.
Mangifera foetida	mango	-	fruit, condiment.
Nephelium lappaceum	rambutan	rambutan	fruit.
Parkia javanica	parkia	-	vegetable pods, fodder, green manure.
Pithecellobium jiringa	stinkbean	jengkol	vegetable seeds.
Psidium guajava	guava	-	fruit.
Sesbania grandiflora	-	-	vegetable flower, green manure, fuel.
Peronema canescens	-	sungkai	live fence, poles.
Tamarindus indica	tamarind	-	condiment.
(b) **Herbaceous annuals and perennials**			
Ananas comosus	pineapple	nenas	fruit.
Arachis hypogeae	peanut	kacang tanah	food seed, cash crop.
Capsicum spp.	chilli	cabe	spice, vegetable.
Colocasia esculenta	taro	talas	food root.
Cucurma domestica	turmeric	kunyit	spice
Glycine max	soybean	kacang kedelai	food seed, cash crop.
Ipomea aquatica	swamp cabbage	kangkung	vegetable
Ipomea batatas	sweet potato	ubi jalar	food root
Manihot esculenta	cassava	ubi kayu	food root
Musa spp.	banana	pisang	fruit
Oryza sativa	paddy rice	padi sawah	food seed
	upland rice	padi gogo	food seed
Pachyrrizus erosus	yam bean	bengkuang	vegetable
Phaseolus aureus	mung bean	kacang hijau	vegetable
Piper betel	betel leaf	-	chewed with Areca.
Saccharum officinarum	sugar cane	tebu	food
Solanum melongena	egg plant	terung	vegetable
Vigna sesquipedalis	long bean	kacan panjang	vegetable
Vigna unguiculata	cowpea	kacang tunggak	food seed
Zea mays	maize	jagung	food seed

All the transmigrant farmers at Sitiung have spontaneously developed agroforestry - based homegardens involving multistoried mixtures of trees, annual crops and stall-fed livestock. This diversity in the homegardens not only supplements the production from the cropland but also minimizes risk of crop failure. Recent studies have shown that homegardens account for 44% of total agricultural products (Colfer et al., 1986; Chapman, 1984) and provide between 28% and 60% of the total cash value of agricultural produce in the various communities in Sitiung. It is important to note that the development of these homegardens has been based mainly on the previous experiences of the farmers. The fact that many were landless prior to their arrival at Sitiung and the lack of adequate germplasm would indicate that most of the homegardens are currently producing well below their potential.

The food problem involves primarily an inadequate production of rice (especially rainfed) to meet year round family needs, resulting in an annual requirement to purchase rice. This causes competition for scarce cash resources that are also required for the purchase of lime, fertilizers and pesticides in order to ensure adequate production in the next season.

Low soil nutrient levels are reflected by low unfertilized crop yields and good response to fertilizers for most crops. In particular, Sitiung soils are particularly low in exchangeable Ca, Mg, and K, very low in available P and possibly also low in Mo, Mn, Zn, B and Cu. High levels of extractable Al, combined with low CEC, results in Al levels greater than 60%. All these can, however, be corrected by lime and fertilizer. Farmers differentiate between "dark" (good) soils and red or yellow (poor) soils and tend to concentrate inputs on the poor soils.

Moisture stress is a major problem for crop production due to shallow rooting of many crops (probably related to high Al saturation and/or low supply of bases in the subsoil) and the high permeability of most Sitiung soils. Failure of rains in certain years increases the problem. The implications of the transmigrants' practice of thoroughly digging the soil before planting are serious. In contrast, the indigenous Minang are aware that moisture stress is most severe when the topsoil is disturbed by tillage, and thus undertake no-till planting methods (Evensen et al.,1986).

None of the farmers interviewed mentioned lack of labor as a constraint. This is probably due to the availability of cooperative labor ("gotong royong"). This system involves groups of 20 - 25 farmers working in rotation on each other's fields. The farmer whose land is being worked pays for this labor by providing meals for the group. Despite this system, however, some

bottlenecks are likely to occur especially at planting and harvesting when all the farmers are involved at approximately the same time. The relatively high wages of off-farm labor (lumber camps, road construction) make it difficult for farmers to neglect wage labor at any time of the year.

Soil erosion is severe on some transmigrant farmers' fields because they were allocated steeply sloping land for production of their food crops. Erosion control practices currently used by some transmigrants at Sitiung include bench terracing (very labor intensive) and contour planting.

Pests and diseases are big constraints to crop production in Sitiung. The main pest of peanut, maize and cassava is the wild pig which is capable of totally destroying unprotected fields. Rice blast (Pyricularia oryzae), seedling fly (Atherigona exiqua), brown planthopper (Nilaparvata lugens) and stem borer (Chilo sp.) are major pests of upland rice. Soybeans are attacked by seedling fly (Agromyza sp.) soon after germination and a pod borer (Etiella zinckenella) at the pod filling stage. The weed Imperata cylindrica (alang-alang) was also mentioned as a problem. Most farmers lack cash resources to purchase pesticides and adopt avoidance strategies. Thus, upland rice is planted early in the rainy season, when the incidence of blast is low. Maize and peanuts are not planted in areas prone to pig damage i.e. close to forest margins.

Poor supply of agricultural inputs is often a problem throughout Sitiung. Both inadequate supplies and untimely delivery of fertilizers and pesticides were cited as problems by farmers in Sitiung II and III (Perry, 1983). In newer settlements such as Sitiung V there was a long period between the end of government fertilizer allocations in 1984 and the establishment of a local distributor. Heavy rains sometimes make the roads from the Trans - Sumatran Highway into the settlements impassable thereby limiting the supply of inputs at critical periods like planting time. Even when adequate supplies exist, however, farmers lack cash to purchase inputs and are reluctant to participate in credit programs.

Cash income is limited by low yields and/or prices of cash crops. The low yields of soybean, peanuts and maize are due primarily to the acid, infertile soils which require adequate liming and fertilizer inputs, pests (pigs, insects, rats, monkeys) and drought (once in 3 or 4 years). Current low income from tree crops (cloves, coconut, coffee, rambutan) is due mainly to the low prices of these crops in the local markets (Table 3). Farmers are unable to transport their produce to the large markets at Padang and fall victim to the problem of oversupply and exploitation by middlemen. Most farmers are reluctant to participate in government credit programs because of fears of crop failure resulting in their inability to repay loans.

Although most farmers in Sitiung I have cattle, farmers in recent settlements (Sitiung V) are yet to receive their cattle from the Government. The current scheme involves each farmer being given a cow with the condition that two calves are returned to the Government within five years. The advantages of livestock over food and cash crops include lower production costs in terms of labor and inputs and reduced risks since livestock production is less affected by rainfall variability and timely inputs.

Farmers in Sitiung I appreciate the advantages of their cattle which are used for land preparartion and as an investment. In addition, most farmers use the manure on their homegardens and crop lands. Animals are sold to generate cash as needed (for school fees, medical expenses, purchase of inputs and food). It is interesting to note that of the ten farmers interviewed, the only farmer who did not mention lack of cash and fertilizers as constraints to productivity, had a small herd of five cows. He used manure to supplement fertilizer inputs and over the years had sold several animals from his gradually expanding herd. In order to ameliorate the problem of fodder scarcity, improved fodder grasses had been planted within and on the boundaries of the homegarden.

Although disease is apparently not a problem, most cows in Sitiung appeared in poor condition. This is not surprising considering the scarcity of fodder resources which consist mainly of grasses and weeds harvested from the roadsides and croplands. Even assuming an adequate nutrient content of these species, their high moisture contents probably implies an inadequate daily dry matter intake resulting in reduced productivity (poor weight gain, low reproductive rates).

Table: 3 Price data for cash crops

Herbaceous crops	Price (Rp. per kg)*
Soybean	300 - 500
Peanut	350 - 400
Rice	150 - 300
Maize	100 - 150
Cow pea	75 - 100
Cassava	10 - 20
Perennial crops	
Clove	5,000 - 11,000
Coffee	1,500 - 3,000
Rubber	500 - 600
Rambutan	250 - 400
Coconut	75 - 100 (each)

* Prices in Sitiung markets are often at the lower end of the quoted range.

1 US $ = Rp. 1644 (December,1986)

7. CAUSAL DIAGRAM

The identified production constraints or problems and their underlying causes have been summarized in a causal diagram (Figure 1). The diagram highlights the linkages between the production subsystems and facilitates a systems analysis approach to expose the "leverage points" of the system as a whole. These leverage points (hatched in Fig. 1) indicate where interventions of the right kind will have the most effect on improving the system.

Thus, in Fig. 1, improving the fodder situation could improve livestock productivity which in turn has direct, positive implications for food supply, cash generation and indirect feedback effects on manure supply, labor (freeing the farmer for potentially lucrative off-farm employment) and the use of increased income for purchase of inputs.

8. AGROFORESTRY ALTERNATIVES

Although the usual D&D approach is to utilize a stepwise modification of existing technologies in order to enhance adoptability and minimize risk to the farmer, the case of transmigrants at Sitiung offers scope for the introduction of completely new technologies. The reasons for this include:

(1) most of the Javanese transmigrants (with the exception of those in Sitiung I and II) are unable to grow paddy due to lack of adequate water resources and are having to adopt new and unfamiliar cropping practices which are better suited to the area

(2) cropping systems are still at an early stage of development and farmers are exceptionally receptive to new ideas and technologies.

In each case, however, on-farm trials will be essential to minimize risks.

Three leverage points were identified in the causal diagram (Fig. 1):

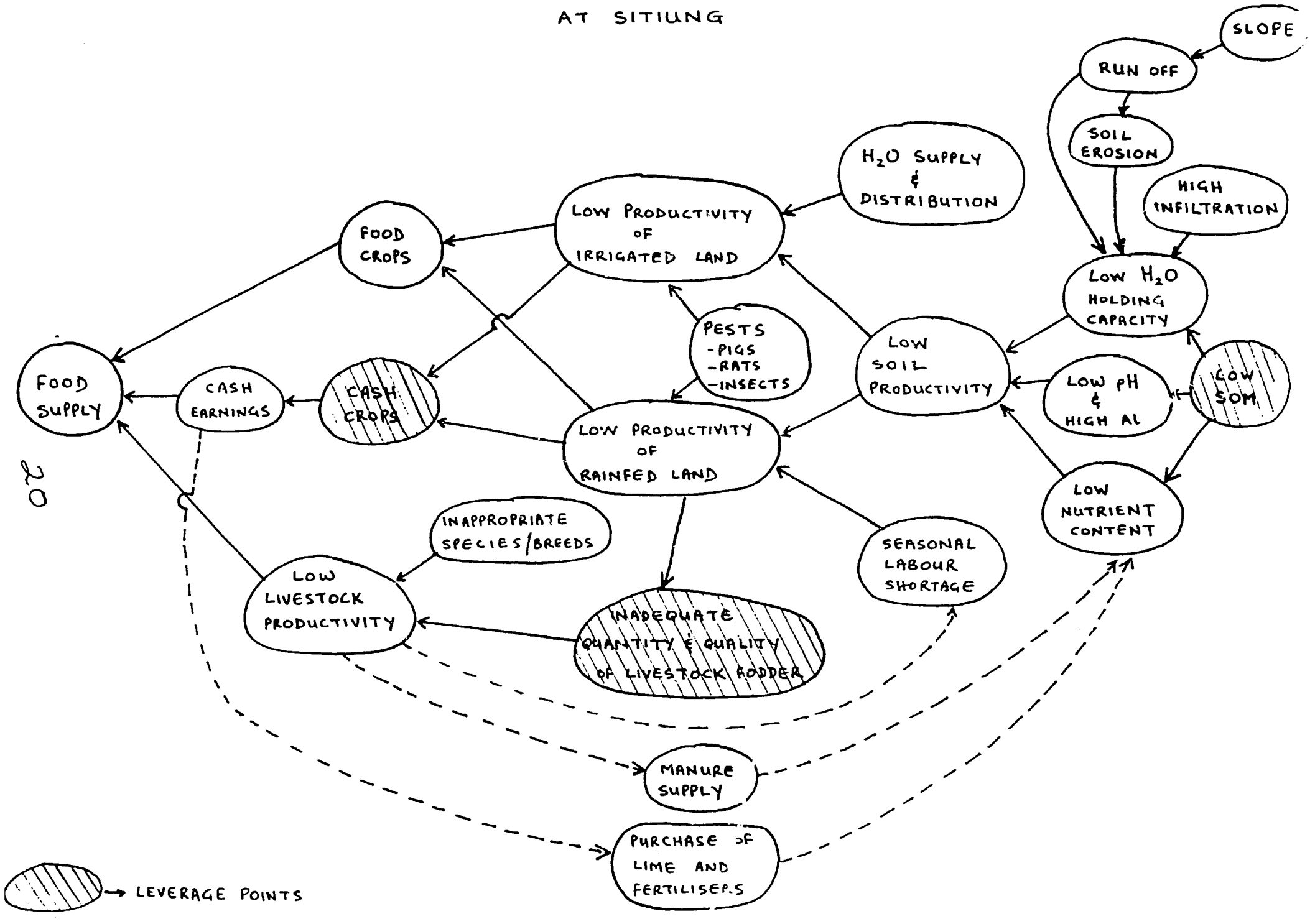
(1) Soil organic matter

(2) Livestock feed

(3) Cash crops (and inadequate marketing infrastructure at the community level)

There is scope to address the above-mentioned leverage points both at the farm and also at community levels.

FIGURE 1: CAUSAL DIAGRAM FOR FARMING SYSTEMS AT SITIUNG



8.1 Farm level

8.1.1 Soil organic matter (SOM)

(a) Current work on soil organic matter indicates that there is more relevance to considering activity of organic matter than total organic matter content *per se*. Parton *et al.*, (1987) define three main fractions: **active** (mainly microbial) with a decay period of 1 to 3 years, **slow** with a decay period of 3 to 25 years and **passive** with a decay period of around 1000 years. From a practical standpoint, one hypothesis that needs immediate investigation is that in order to optimize SOM activity in terms of nutrient release, complexing Al, soil structure and water-holding capacity, it will be necessary to maximize the active and slow pools in the soil.

One method of building up the active and slow pools of SOM would be to add green manures or plant residues to the soil. The incorporation of fast-growing, N-fixing woody perennials in hedgerows along the contours (alley cropping) and the lopping of these hedgerows at regular intervals and incorporating the prunings or using them as mulch would be a potentially promising agroforestry technology. An additional hypothesis is that the use of species with litter that decomposes slowly would facilitate build-up of SOM pools thereby minimizing Al saturation and improving water-holding capacity of the soil. Species such as *Inga edulis*, *Cajanus cajan*, *Cassia siamea*, *Acacia auriculiformis* and *Erythrina* may prove preferable to *Albizia falcataria* and *Calliandra calothyrsus*. It is possible, however, that the high tannin content of *Calliandra* may slow its decomposition relative to *Albizia*.

The above technology also has the potential to simultaneously address the problems of runoff and erosion via the formation of natural terraces and the production of fuelwood. It is essential that researchers look at alley cropping from a multipurpose perspective and not only consider its potential to improve soil properties or recycle nutrients. The labor required to maintain such terraces formed by the hedgerows along the contour would be substantially less than that currently required for terrace maintainance. It is possible that the saving of labor for terrace maintainance will be offset by the labor required to prune the hedgerows. On the other hand, the farmer may be able to engage in paid off-farm labor during the time when terrace maintainance would normally be carried out. This would be in addition to the benefits of green manure, fodder and soil conservation.

(b) Woody hedgerows on field boundaries could be managed to form effective pig-proof live fences. Minimising pig damage would have a significant effect on the productivity of crops like maize, peanut and cassava. Apart from the

labor to establish the live fences, little maintainance would be required and the fences could be managed to produce green manure, mulch and/or fodder.

Closely planted, easy to grow species such as Gliricidia sepium, Albizia falcataria and Calliandra calothyrsus would be suitable. Peronema canescens ("sungkai") could be managed to produce good quality poles in addition to being an excellent live fence. Other suitable live fence species include Ceiba pentandra and Jatropa curcas. Like Gliricidia, they can be propagated vegetatively by cuttings although they are not as suitable for green manure production.

(c) On paddy fields, both the organic matter pools and nitrogen level of the soils can be enhanced by growing Sesbania grandiflora on the field bunds and Sesbania rostrata as a green manure crop in rotation with, or intercropped with, the rice.

S. grandiflora , a fast-growing woody perennial, nodulates profusely and its leaves could be harvested for green manure. In addition, its flowers are an excellent and nutritious vegetable. S. rostrata is a woody annual, and has nodules on both roots and stem. Moreover, because of its stem nodulation, it continues to fix nitrogen even when the N content of the soil in which it is growing is high (Dreyfus and Dommergues, 1980). The implication is that it would continue to fix N even when nitrogen fertilizer was used. Farmers in the Mekong delta use a similar species Sesbania bispinosa as green manure in paddy fields. The stem nodules of S. rostrata, however, make it a potentially more valuable species.

8.1.2 Livestock feed

Livestock productivity can be enhanced by improving the quality and quantity of fodder. Improved feeding management offers such potential benefits as better stock health, improved reproductive standards, faster growth, quicker turn-off, increased output of stock per unit area and more efficient labor utilisation. These, in turn, combine to give the prospect of more meat for human consumption, more income for rearers from animal sales and more, stronger animals available for draft power.

(a) There is scope to improve fodder resources both on the homegarden and on the upland fields. Although most homegardens are devoted mainly to woody perennials for food and cash and some annual crops, there is good potential to place greater emphasis on fodder production in currently underutilized boundary and understory areas. As livestock are kept in enclosures on the

homegarden, on-site fodder production would reduce the labor required for herding or the cut and carry system currently practiced. As described earlier, boundaries on upland fields and even the hedgerows along the contours could also be sources of high protein fodder.

Woody legumes like Gliricidia sepium, Codariocalyx gyroides (formerly Desmodium gyroides) and Desmodium rensoni would be suitable. Although species such as Calliandra calothyrsus and Albizia falcataria have relatively high concentrations of N (3.9 and 3.4% DM respectively) they have lower rates of dry matter digestibility (Mahyuddin, 1983) probably resulting from increased levels of tannin (up to 12%) in Calliandra and other anti-nutrients in Albizia. Nevertheless, they can still be used as supplements to low quality roughage diets. There is potential for selection of low tannin varieties of Calliandra for fodder.

8.1.3 Tree cash crops

The cash crop enterprise could be enhanced by intensifying the production of high value tree crops (clove, rambutan, coconut, durian, mangosteen) and other shade tolerant crops like vanilla, black pepper and nutmeg. Although many of these species require fertile soils, there is scope to use fertilizers, manure and residues to enhance the fertility of soils in the homegardens. Vanilla is very labor intensive since it requires hand pollination, but its very high value (up to Rp. 40,000 per kg) would easily justify this input and offer good scope for maximising the returns to labor by women on homegardens.

9.2 Community level

8.2.1 Cash crops and livestock feed

If the farmers in each Sitiung community agreed to pool the 0.75 ha plots that they have been promised, the cash crop and livestock feed leverage points could be addressed by a tree crop/grazing system. A promising option appears to be a community rubber plantation with grazing of the cover crops (Pueraria phaseoloides, Calopogonium muconoides, C. coeroleum, Centrosema pubescens). The possibility of the Government allocating adequate additional land to each community for such a plantation should not be overlooked.

A latex processing plant already exsists near Sitiung and the economic returns from rubber appear promising. Each administrative unit would have their own rubber plantation which would be planted and tapped by women on a

communal basis. This would increase their involvement in cash-generating off-farm labor. A communal herd of goats and/or sheep could be allowed to graze the cover crops on a rotational basis. Rotational grazing coupled with wider than normal spacings of the rubber trees, would be required to ensure adequate persistence of the cover crops.

Small ruminants such as goats are very suitable for such an animal protein enterprise. Goats have the advantage of a high milk producing capability coupled with sturdiness and an ability to thrive under a wide variety of feeds (World Bank, 1983). There are also more animal units per unit of feed, thus spreading risk and increasing sales opportunities relative to milk cow enterprises. The annual demand for goats for the celebration of Rhamadhan by the predominantly Muslim population (equivalent to the demand for Christmas turkeys in the West) offers good scope for an economically profitable goat-rearing enterprise. A high instinct for survival, however, also makes the goats a potential hazard if left unmanaged. Careful management strategies will need to be planned and implemented.

8.2.2 Livestock feed

There is good potential for the development of community-owned, rotationally grazed pastures containing a mixture of woody legumes and pasture grasses by a communal herd of cattle. The Government could allocate a suitable amount of land to each community. Although this would be a new concept to the Javanese farmers who are used to cut and carry systems, the potentially high returns to labor would be a powerful incentive. Some promising low input technologies for oxisols and ultisols in tropical America have been outlined by Sanchez and Salinas (1981) and validated under similar soil and climatic conditions in Yurimaguas, Peru.

The advantages of having pastures comprising shade-tolerant grasses with an overstory of leguminous trees and shrubs include:

(1) minimizing the possibility of invasion by shade intolerant *Imperata cylindrica* (alang-alang), a noxious weed that colonizes cleared areas including pastures. The tree/shrub component can be harvested for high protein foliage and/or pods thereby allowing adequate light for grasses in the understory. If alang-alang starts to become a problem, a simple solution would be to allow the trees to close canopy and shade it out. It is a lot easier and cheaper to establish pasture grasses than it is to erradicate *Imperata*.

(2) In addition to poor nutrition, heat stress is a major factor reducing the productivity of livestock in the tropics. The shade provided by the leguminous trees and shrubs would not only permit the livestock to graze over a longer period during the day but also minimize heat stress while grazing. Overgrazing under shady areas can be minimized by rotation.

(3) The problems of differential persistence encountered in herbaceous legume/grass pastures due to preferential grazing could be minimized.

TropSoils Indonesia has already undertaken preliminary species trials with acid-tolerant legumes and grasses obtained from Centro International de Agricultura Tropical (CIAT). Andropogon gayanus and the legumes Aeschynomene histrix, Centrosema brasilianum, Stylosanthes guianensis and Centrosema macrocarpum were among the highest yielders. Testing for shade tolerance is the next major step. Tree/shrub legumes with potential include Sesbania sesban, S. formosa, Albizia falcataria, Calliandra calothyrsus, Codariocalyx gyroides, Desmodium rensoni, Gliricidia sepium.

9. RESEARCH REQUIRED

Since its begining in Indonesia, TropSoils has had a highly beneficial collaborative relationship with the Center for Soils Research. There has been considerable investment by CSR in research funds and capable soil scientists. Due to the multidisciplinary nature of agroforestry research, however, it will be necessary to collaborate with additional institutions.

10.1 Farm level

10.1.1 Alley cropping on upland fields

Research objective: to evaluate the effect of intercropping upland rice, maize, peanuts and cowpea with hedges of fast growing, N-fixing woody perennials on crop yields, SOM pools, soil physical and chemical properties and erosion control.

Information required:

- suitability of hedgerow species for:

  - ease of establishment and appropriate growth rate (sufficient to provide adequate green manure/mulch for one or two crops per year without adversely affecting adjacent crops).

  - ability to coppice at low heights

  - biomass production over several seasons (i.e. the effect of coppicing on growth and vigor of the tree)

  - decomposition rates of leaf and twig biomass (for SOM pools, available water capacity, weed control, Al saturation)

  (Carl Evensen's trials on hedgerow intercropping using Albizia falcataria, Calliandra calothyrsus and Gliricidia sepium will provide valuable data for these species)

- appropriate spacings between and within hedgerows (bearing in mind biomass production and soil conservation function of hedgerows)

- cutting height and frequency

- rhizobial and mycorrhizal requirements of the species involved

- labor and capital requirements for establishment and management of hedgerows.

- other inputs (lime, fertilizer) required for sustained production.

Parameters to be monitored:

- crop yields

- litter decomposition rates and SOM pools

- soil physical and chemical characteristics

- erosion control

- weed control

- minimum inputs required for system sustainability.

- hedgerow yields (leaves and wood)

9.1.2 Live fences

Research objective: to evaluate the efficiency of closely planted, fast growing woody species as pig-proof live fences and their productive potential for green manure, fodder or poles.

Information required:

- suitablility of the species identified in 9.1.1 (b) for:

  - ease of establishment and fast growth rate

  - coppicing ability when cut at heights of 1 to 1.5 m at different frequencies

  - persistence of the species over several seasons

- spacing within the live fence

- effect of live fence on crop yields at various distances from it

  - effect of a shallow 10-15 cm furrow or trench 50 cm away from the live fence on the minimization of live fence/ crop competition

- labor and capital requirements for the establishment and subsequent management of the live fences

Parameters to be monitored:

- length of time between establishment of live fence and elimination of pig damage to crops

- effect (due to competition) of live fence on adjacent crop yields.

9.1.3 N-fixing, green manure species for paddy fields

Research objective: To evaluate the effect of *Sesbania grandiflora* and *S. rostrata* as N-fixing and green manure species on paddy rice production.

Information required:

(a) For *S. grandiflora*

- ease of establishment on the bunds of the paddy fields
- growth rate, leaf, flower and wood biomass production
- rhizobial and mycorrhizal requirements

(b) For *S. rostrata*

- ease of establishment in flooded soils
- rhizobial and mycorrhizal requirements
- growth rate and biomass production
- fallow or intercropped system
- timing for seeding and ploughing-in of leaf and stem biomass
- delay between ploughing-in of *S. rostrata* and rice planting
- labor requirements

Parameters to be monitored:

- soil physical and chemical properties
- crop yields
- biomass production of the *Sesbanias*
- nitrogen levels of crop
- minimum inputs (fertilizers, herbicides) for system sustainability.

Potential for collaborative research:

- important to collaborate with the Crops Research Institute , Bogor (section 12, No. 6), since this technology has widespread scope for smallholder rice growers if successful.

9.1.4 Leguminous woody perennials as high protein fodder sources

Research objective: to evaluate the potential of fast growing, leguminous woody perennials as high protein fodder sources.

Information required:

- Suitability of species identified in 9.1.2 for

  . ease of establishment

  . adequate growth rate and biomass production

  . lopping regimes

  . nutrient composition and palatability

- labor requirements for establishment and subsequent management on homegardens

- Should it be decided to maximize fodder production by hedgerows on upland fields in preference to hedgerows for green manure, the same information as required in 10.1.1 will be required for fodder-producing hedgerows.

Parameters to be monitored:

- qualitative and quantitative production of fodder

- effect of feed on livestock productivity

- labor requirements for processing fodder

Potential for collaboration:

Collaboration will be required with the Research Institute for Animal Production (BPT) - see section 12 (4). One possibility is for TropSoils to offer BPT's Forage Research Project an experimental site at Sitiung. In discussions with the Australian scientists at BPT, it emerged that an expansion of the current number of test sites in Indonesia is envisaged for the second five year phase commencing in 1987. None of the current sites are on acid soils. The incentives of Sitiung's established infrastructure and farming communities should be used to influence BPT's choice for a site on acid soils. Getting the BPT/Australian commitment to work at Sitiung would be the first but crucial step for successful collaboration to ensure adequate planning and execution of the livestock research component of this report.

9.1.5 Intensification of high value tree and other crops in homegardens

Research objective: to determine the potential for intensifying production of tree/shrub crops for food or cash in homegardens.

Information required:

- present species composition (as compared with the more established Minang homegardens). Michon *et al.*, (1986) undertook a detailed study of Minang homegardens in Maninjau, West Sumatra. Their methods could be adapted for Sitiung.

- factors influencing choice of species

- additional high value tree/crop species (see 9.1.3)

- germplasmavailability

- optimum spatial distributions of tree/crop species

- production/consumption patterns

Parameters to be monitored:

- production data for the various species

- seasonality of production by species

- consumption pattern (domestic/market)

- nutritional contribution (Stacy Evensen's work will provide valuable information for nutrition and the other parameters identified above)

- labor requirements (time allocation study by Carol Colfer should provide required data)

Potential for collaboration:

It will be important to obtain inputs from the Institute of Ecology (which has extensive and intensive experience in homegarden research), and the Research Institutes for Estate (coffee) and Industrial tree (clove, coconut) crops - see section 12, (1) to (4). It is recommended that Carl and Stacy Evensen visit the Institute of Ecology at Bandung (see Section 12), to establish informal contacts and obtain information on aspects of homegarden research that may be relevant to Sitiung.

9.2 Community level

9.2.1 Improved marketing infrastructure

Research objective: to identify the potential to expand fruit, spice and livestock production in Sitiung beyond the present local market level.

Information required:

Present status of the fruit, spice, coffee and livestock sector

- production by type of fruit, spice, coffee etc.

- seasonality and locations

- marketing systems

- consumption, uses

- processing technologies and capacities

Scope for expanding production:

- required infrastructure for processing and marketing

- national and export market potential

Pre-feasibility study for an agro-industrial fruit, spice, coffee production enterprise.

9.2.2 Community rubber plantation with grazing of cover crops by small ruminants

Research objectives, information required and parameters to be measured should be drawn up after discussions with the Institute for Estate Crops (smallholder production) at Sembawa, Institute for Animal Production (BPT) at Ciawi and the USAID-AARD Small Ruminant Collaborative Support Project based in Bogor. It is important that the management of the latex processing plant at Sitiung are also involved in discussions.

9.2.3 Community pasture lands grazed by communal herds

Consultations with the Institute for Animal Production (BPT), Ciawi and specifically the Australian funded Forage Research Project will be required to determine the extent and scope of research required. An excellent opportunity exists for incorporating TropSoil's experience on pastures obtained at Yurimaguas, Peru. Strong consideration should be given to the possibility of Carlos Castilla (NCSU) developing and coordinating the livestock and pastures program outlined. His long-term experience with the pastures program at CIAT would be especially relevant for the species selection work envisaged.

10. INTEGRATION OF TECHNOLOGIES IN EXISTING SYSTEMS AT SITIUNG

The approach followed in formulating this report, emphasizes a comprehensive analysis of the farm as a whole. Research priorities reflect the most relevant problems as perceived by the farmers or the D&D team. The hypothesis underlying such an approach is that technologies designed to overcome problems perceived by farmers would be more easily adoptable.

It is important to appreciate, however, that the technologies proposed in this report have been designed on the basis of a preliminary diagnosis. Furthermore, the design of agroforestry technologies normally requires the combined input of a multidisciplinary team in order to best incorporate the relevant aspects of the disciplines concerned. Due to the time constraint and the unavailability of key TropSoil personnel (with the exception of Carl and Stacy Evensen), this was not possible.

The diagnosis presented here is of a static type and is useful to indicate the outstanding features of proposed technologies. A more refined design, however, would require an analysis of both the system dynamics and also the farmers' reactions to introduced innovations. It is assumed that a better understanding of both system dynamics and farmers' reactions may lead to modifications in the preliminary designs. This in turn, would lead to an enhanced adoptability of practices by generating more appropriate technologies (i.e. those that address a felt need, can be easily understood, and use resources readily accessible to farmers).

In this context, research on integration of technologies has to do essentially with monitoring of both existing system dynamics and systems' response to introduced innovations. The latter can be accomplished through on-farm experimentation (Fernandes, 1985) which plays a critical role in technology development.

Given that most of the technologies proposed in section 9 are still at the tentative, if not notional stage, two phases are envisaged for research on integration of technologies in this project. The first phase will focus on:

(1) improving the preliminary diagnosis by monitoring the existing systems; and

(2) carry out researcher-managed trials on farms, mainly geared at evaluating the technical performance of proposed technologies (while learning about farmer perceptions of such innovations).

The second phase will concentrate on farmer-managed trials to evaluate:

(1) the technical and economic performance at the enterprise level (livestock, food crops, cash crops) of practices developed in phase one; and

(2) the fit of such practices into the whole system

Research objective: to monitor the bio-physical and socio-economic dynamics of prevailing systems and experimental alternatives for:

- improving the preliminary diagnosis; and

- providing feed-back on the design of both proposed technologies and on-farm/on-station experimentation.

Information required:

- improved description and monitoring of relevant aspects of the system's structure and function.

- monitoring relevant aspects of experimental interventions, including the experimental parameters identified under the various component technologies (see section 10).

- monitoring of farmers' perceptions, evaluations and responses to introduced technologies.

- monitoring of interactions between the improved farming systems and the surrounding environment (physical, economic and social aspects).

- Evaluation of system performance to assess the effects of the experimental technologies through time. Criteria for evaluation will combine farmers' judgements with measured or observed effects on farm management constraints, use of resources and fulfillment of household objectives.

11. INSTITUTIONS INVOLVED IN AGROFORESTRY RELATED RESEARCH IN INDONESIA

Institute	Research focus
(1) Institute of Ecology, (Dr. Otto Soemarwotto, Director) Padjajaran University, Jalan Sekeola, Bandung. (Tel: 021 - 84982; Cable: Ekologi Bandung)	Species composition, spatial distribution and management of homegardens.
(2) Bogor Research Institute for Estate Crops, Jalan Taman Kencana No.1, Bogor 16151. (Tel: 0251 - 24048/27449 Tlx: 48369 AARD IA)	Rubber, coffee, tea cocoa, oil palm, sugar tobacco.
(3) Research Institute for Industrial Tree Crops, Bogor.	Clove, coconut, cashew Clove disease caused by "Rickettsae-Like Bacterium (RLB)"
(4) Research Institute for Animal Production (BPT), P.O. Box 123, Bogor. (Tel: 0251 - 27156; Tlx: PARD 48307 IA)	Livestock production, Forage germplasm evaluation & agronomy, forage nutritive value, smallholder prod. systems.

(5) Forage Research Project, Jl. Dr. Ratulangi 3, Ujung Padang, South Sulawesi, Indonesia. (Tel: 0411 - 83807; Tlx: MAKENCO 71197 UP)	Field research and extension for (4).
(6) Crops Research Institute (Balitan), Bogor.	Cropping systems research
(7) CARE - Indonesia, Jl. Ciniru 1/14, Jakarta (Tel: 771462)	*Leucaena leucocephala* for soil & water conservation; on-farm trials & extension.
(8) World Neighbours, P.O. Box 471, Denpasar, Bali.	*Leucaena* research; on-farm trials.

OTHER ORGANISATIONS WITH COLLABORATIVE AF-RELATED PROJECTS IN INDONESIA

(1) Dept. of Agronomy and Soil Science, Univ. of New England, Armidale, NSW, Australia. (Tel: 067 - 732687; Tlx: AA 66050)	Managing agent of Forage Research Project at (4) above; under funding from Australian Development Assistance Bureau (ADAB). 10 yr. project with 2nd 5 yr phase due to start in 1987. (Dr. G. Blair - Co-ordinator).
(2) TropicalDevelopment and Research Institute, Overseas Devel. Admin. (ODA), 56/62 Grays Inn Rd., London WC1X 8LU (Tel: 01 - 405 7943)	Collaborating with (3) above on clove disease caused by "RLB". ODA funded. Bogor contact: Dr. Piers Poole.
(3) International Council for Research in Agroforestry (ICRAF), P.O. Box 30677, Nairobi, Kenya. (Tel: 332304; Tlx: 22048 ICRAF NBI)	S.E. Asian network aimed at building capacity of institutions to undertake AF research.
(4) Winrock International Institute for Agricultural Development, Route 3, Morrilton, AR 72110 (Tel: 501 - 727 5435: Tlx: 910 - 720 - 6616)	Collaborative research on small ruminants.

12. OTHER RECOMMENDATIONS

1. If successful technologies are to be effectively disseminated, it is essential that the extension service at Sitiung is not only aware of Tropsoil's research, but is also involved as much as possible in the planning and implementation stages. The Government of Indonesia has recently received a substantial grant from the World Bank for unifying all the various extension services (agricultural crops, tree crops and livestock). This has considerable advantages for agroforestry technologies.

2. It is important that TropSoils maintains and extends its activities on the collection and testing of multipurpose tree (MPT) germplasm (the enthusiasm of Dr. K. Rachie (USAID CRSP Review) for these activities is a good indicator). It is recommended that TropSoils undertakes an exchange of promising MPT germplasm between Yurimaguas and Sitiung. Thus, Inga, peach palm and Mauritia flexuosa from Yurimaguas should be exchanged with duku, mangosteen, rambutan and Albizia falcataria from Sitiung.

Such an exchange should be complimented by a visit to Yurimaguas of Carl Evensen (currently at Sitiung). This visit could be used both to effect the transfer of germplas from Sitiung to Yurimaguas and vice-versa and also to gain first hand knowledge of the MPT work at Yurimaguas.

3. TropSoils Indonesia would benefit greatly by the presence of a "co-ordinator type" at CSR, Bogor. The possibility of using Dr. Ray Diamond (IFDC) as a part-time co-ordinator should be explored. Such an arrangement may involve relatively little cost to TropSoils while considerably enhancing liason between Bogor and Sitiung.

4. Agroforestry technologies have particularly good potential for semi-arid regions. It is recommended that TropSoils undertakes a similar D&D analysis for its Niger site.

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14. ACKNOWLEDGEMENTS

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