Farming system characterization and the adoption of innovations in Jambi

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Key Words: cropping systems, jungle rubber, income, projects, credit

Introduction

In this study rubber based farming systems were characterised, and surveys conducted to investigate the processes by which farmers adopt innovations such as clonal rubber. The study area was in the west of Jambi Province, Sumatra. Previous studies in the area included a partial characterisation through surveys conducted by the ICRAF ASB project in 1995 (ICRAF/CASER, 1995; Hadi et al, 1996), and surveys for the World Bank recently conducted in Kabupaten Bungo Tebo (Gouyon, 1997). Results from the characterization of jungle rubber based farming systems in South Sumatra (Gouyon, 1995) are also generally applicable to the province of Jambi.

Methodology

Two surveys were conducted. The objective of the farming system survey (FSS) was the characterization of farmers participating in the SRAP network of on-farm trials, and also to compare these with non-SRAP farmers. The main constraints in the farming systems were identified. The second survey was based on an analysis of the innovation adoption process and identification of farmers' strategies with respect to existing opportunities in the area.

Sampling scheme for sites and farmers

The benchmark areas of SRAP were selected to cover a wide range of situations. A number of ethnic groups were included, namely Melayu, Minang, Javanese transmigrants and other spontaneous transmigrants. Agro-ecological zones were chosen to include traditional jungle rubber farmers in forest environments on flat land with either good or poor soils; hilly areas in the forest margins with low population density, and also transmigration areas. Other economic factors considered were remoteness, access to markets and other off-farm or cropping opportunities. Table 1 summarizes these benchmark areas that are representative of almost all rubber growing areas in Indonesia, and include a wide range of constraints.

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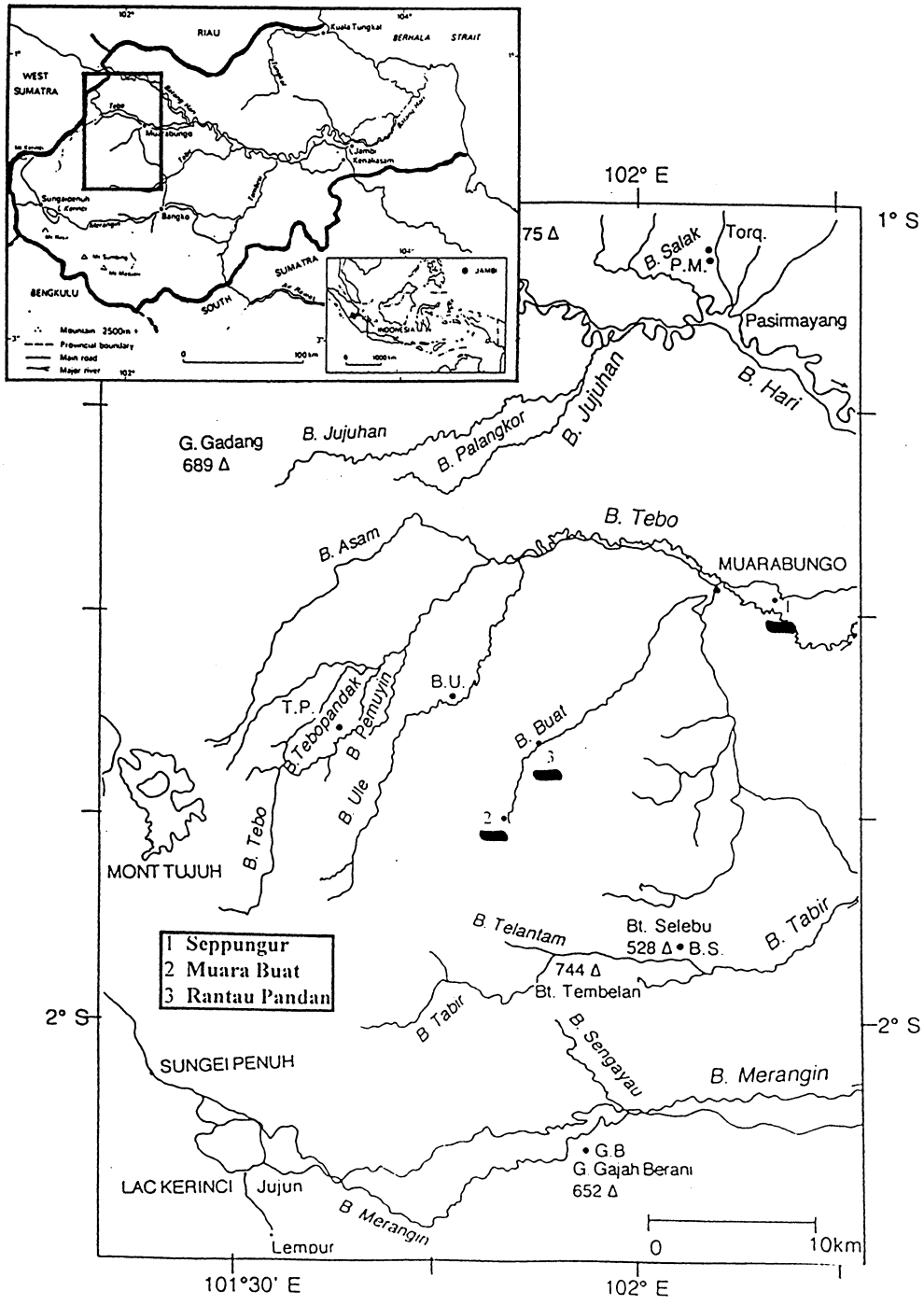
Figure 1. **SRAP sites in Jambi**



The selected transects ranged from hilly forest margins to the traditional forest/jungle rubber environment in the central plains of Sumatra, where soils were relatively good for rubber growth.

Table 1. Site characterization in Jambi

Factors	**Central peneplain: flat areas**	**Forest margins: hilly areas**	**Transmigration areas**
Villages	Sepunggur	Muara Buat Rantau Pandan	Rimbo Bujang Unit 9 (Sukadamai): transmigration TSM Unit 7 (Saptamulia): transmigration INTI
Type of population	Melayu (Muslim) Local farmers or Spontaneous migrants		Javanese transmigrants (Muslim)
Population density	Medium	Low	High
Land availability	No available land left (since 1992)	Plenty of land	Limited land 2 ha/household TSM 5 ha INTI
Ecological environment	Secondary forest Old jungle rubber on flat areas (peneplains)	Secondary and primary forest Old jungle rubber on steep slopes (piedmont of the Barisan mountains)	Old secondary forest before implementation of NES/TCSDP projects. Clonal rubber plantations
Farmers' behaviour and strategies	Extensive S&B for rice and palawija production Accept a certain level of intensification	Extensive Irrigated rice, no upland rice, S&B for cinnamon planting Reluctant to intensify labour use	Intensive but destructive Improved rubber in monoculture.
Main constraints	Low productivity of jungle rubber	Low productivity of jungle rubber Pig and monkey damage in new rubber plantations, Mikania sp. (weed)	No land title given if credit is not repaid Land tenure not secure
Opportunities	Close to the main road and to Muara Bungo	Land is available, Existing complex agroforestry practices Good access to markets Sawah and livestock	IGPM & inputs supplied by transmigration project
On Farm trial priorities	RAS 1, RAS 2.2, RAS 2.5 (Cinnamon)		No RAS NES/TCSDP only

The primary objective of SRAP is to develop a complete set of on-farm trials using a participatory approach, in order to release technical recommendations on RAS technologies. The criteria for the initial selection of farmers to implement on-farm trials ('SRAP farmers') were the following: motivation, mutual interest in participatory research, willingness to retain agroforestry practices, adoption of improved planting material, and mutual agreement on a trial protocol.

The selection of villages within the benchmark areas was based on the previous criteria, through preliminary discussions with existing farmers groups, plus the following:

- if possible an initial FSS survey to obtain baseline information and to be able to compare farming systems evolution,
- the presence of existing and effective farmer groups to address the methodology,
- Assessment of how representative the village was of the locality.

Here, two main ecosystems were studied: central flat plains, and piedmont of the Barisan mountains.

The surveys were conducted with two types of farmers: 'SRAP' and 'non-SRAP' farmers who had no access to inputs or information through the SRAP project. For the selection of non-SRAP farmers (the "control" population), a list of farmers having farming as their main activity, and living permanently in the village was compiled in each village, then a random sample taken from the list. For each village, approximately the same number of SRAP and non-SRAP farmers has been taken. The total numbers of respondents per village can be seen in Table 2.

Table 2. **Number of survey respondents**

Village	SRAP/ OFT Farmers	Type of SRAP activity	Date OFT planted	Non SRAP Farmers	Total Per village
Sepunggur	12	OFT RAS 1.1 RAS 1.2 RAS 2.2 RAS 2.5	 Oct/Nov 95 Oct 96 Dec 95 – Feb 96 Oct 96	17	29
Muara Buat	5	OFT RAS 1.1 RAS 1.2 RAS 2.5	 Dec 95 Oct 96 Dec 95 – Feb 96	4	9
Rantau Pandan	7	OFT RAS 1.1 RAS 1.2 RAS 1.3 RAS 2.2	 Dec 95 Oct 96 Oct 96 Dec 95 – Feb 96	6	13
Rimbo Bujang Unit 9 Unit 7	0	None	-	10 7	17
Total	24 SRAP			44 non SRAP	68

Type of surveys

3 types of surveys with 4 questionnaires were implemented:

- FSS questionnaire: Farming system characterization has been implemented for all farmers through a formal and relatively detailed questionnaire (called FSS);
- SRAP Innovations questionnaire: concerning all aspects of various innovations and cultural practices on SRAP trial plots (called inno_A);
- Other innovations in general concerning rubber agroforestry systems: the innovation adoption process for non-SRAP farmers. A complete set of questions with emphasis on improved planting material, cultural practices, use of herbicide and fertilization (called inno_B & C).

All questionnaires are summarised in Tables 4 & 5 in annex. These questionnaires were tested on a small scale then reviewed and finalized. Data was collected between June and September 1997.

Data processing

The software used for data processing was WINSTAT, developed by CIRAD. WINSTAT is a survey oriented data management package, which includes full statistical analysis tools and a good graphics module. The database enables the

selection of populations and various types of variables as well as multivariate factorial analysis (AFC). A preliminary analysis with simple statistics is presented in this paper.

Main outputs from the FSS in Jambi

Surveyed farmers

Number of respondents

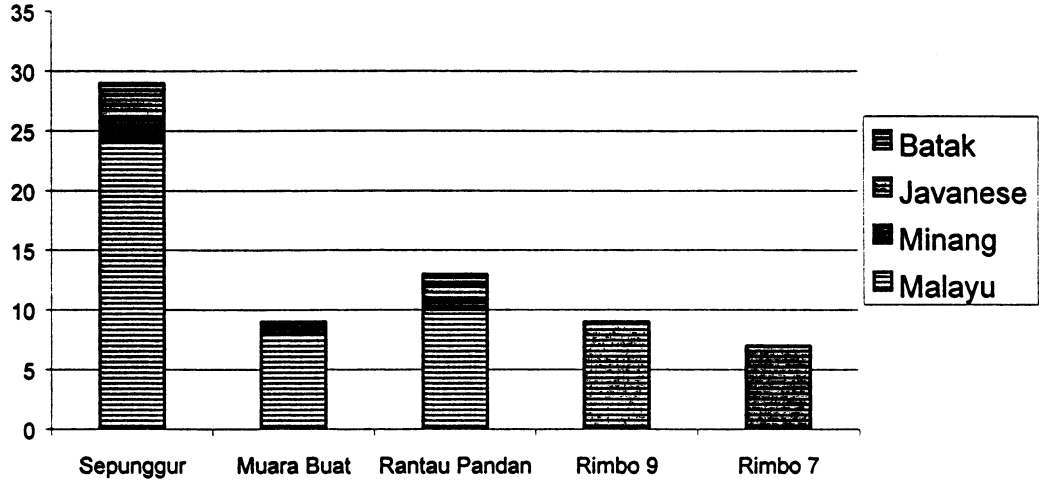
In total, 68 farmers were surveyed. The distribution between villages and between SRAP and non-SRAP farmers can be found in the following:

Sepunggur	:	29
Muara Buat	:	9
Rantau Pandan	:	13
Rimbo Bujang, unit 9	:	10
Rimbo Bujang, unit 7	:	7
Total	:	68 respondents

Ethnic group

Original inhabitants in Jambi province are Melayu. They are in the majority in the non-transmigration area. In Rimbo Bujang, all the farmers are Javanese (most of them from central Java). The Melayu are the original inhabitants of Sumatra with the Kubu ('Orang Asli'), a very small group of 3,000 people who still live in the primary forests. The Melayu have been partly mixed with spontaneous Javanese migrants as well as Minangkabau migrants from W.Sumatra province, in particular in the piedmont of the Barisan mountains.

Figure 2. **Ethnic Group Distribution**



Origin of the families

In the piedmont area (Muara Buat and Rantau Pandan), there is a large majority of local farmers, with some spontaneous migrants from North- and West-Sumatra. There has never been any transmigration program here.

In Sepunggur, except for 5 spontaneous external migrants, all farmers are native to the province. However, there are two types of inhabitants: 'real' local farmers, and local transmigrants (a *translokal* transmigration program was implemented in Sepunggur between 1977 and 1979 for 144 households). In Rimbo Bujang, all farmers are Javanese, either official transmigrants (TSM and INTI) or spontaneous migrants *(Merantau)*.

Farm resources

Household

Household size:

Considered here are all the people who live permanently in the house, and are dependent on the head of household.

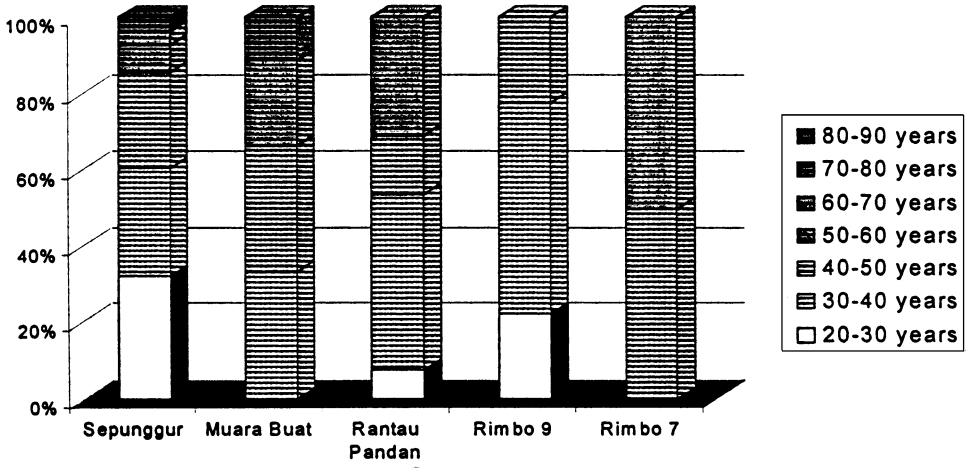
Village	Average Size	Standard Deviation	Minimum	Maximum
Sepunggur	5.52	1.96	2	10
Muara Buat	5.33	1.63	3	9
Rantau Pandan	4.92	1.90	3	10
Rimbo 9	4.40	1.56	3	8
Rimbo 7	6.00	2.88	2	11
Total sample	5.26	2.03	2	11

These values are similar in all sites. For most of the households, it includes the head, his wife and their children (average of 3 children at home), with sometimes a grandfather/ grandmother, a grandchild or daughter/ son-in-law.

Age of the head of household

The population in the transmigration area is more homogeneous than in other villages in terms of age range. Most of the farmers applied for transmigration between 20 and 30 years old: in Rimbo 9, where the TSM program *(Transmigrasi Suakarsa Mandiri)* was implemented 5 to 10 years ago, the average is about 36, whereas in Rimbo 7 (INTI program 15-20 years ago), it is 48. In other villages, all age classes are represented, with the youngest sample in Sepunggur and the oldest in Muara Buat. However this difference may be due to sampling.

Figure 3. **Age of the respondents per village**



Education level of the head of household

According to this sample, farmers from Muara Buat & Rantau Pandan seem to have a higher education level than other places. However we cannot conclude that this is true for the whole population. There is a bias from the 'SRAP' farmers who are not only farmers but have off-farm jobs as their main activity, among them many teachers. They are not representative of the whole population. However, with their strategy based on adoption of innovations, they play an important leading role in the community as 'progressive' farmers.

Labour units (LU)

For most of the households, only the head and his wife work in the fields. Children who stay at home are usually still at school and can't help.

Village	Average LU	Standard deviation	Minimum	Maximum
Sepunggur	1.94	0.49	1.00	3.13
Muara Buat	1.95	0.81	0.48	3.06
Rantau Pandan	1.83	0.64	1.00	3.00
Rimbo 9	1.77	0.54	1.00	2.67
Rimbo 7	1.93	0.77	1.00	3.00
Total	1.89	0.62	0.48	3.13

Note:

Definition of labour units (LU), based on BAPPEDA, BPS and Departemen Tenaga Kerja:

- 0-9 years old : 0 LU
- 10-14 years old : 0.14 LU
- 15-19 years old : 0.53 LU
- 20-54 years old : 1.00 LU
- 55-64 years old : 0.93 LU
- > 64 years old : 0.48 LU

Land resources by type of land use

The main trends in each village are the following:

Village	Sawah	Ladang	Rubber	Non rubber tree crop	Private fallow
Sepunggur		Only 3 farmers: approx. I ha	2-7 ha	Only 2 farmers: immature oilpalm	1-7 ha
Muara Buat	0.5-1.5 ha	< 1.5 ha	14 ha	Approx. I ha (cinnamon)	1-3 ha
Rantau Pandan	0.5-1	< 1.5 ha	1-10 ha	< I ha (cinnamon)	1-5 ha
Rimbo 9	Only 3 farmers: 0.2-0.7 ha	-	Approx 2ha	-	-
Rimbo 7	-	-	4-6 ha	1-2 ha (oilpalm)	-

A complete statistical description of the area for each type of land use is presented in Table 3.

Figure 4. **Average land resources per village**

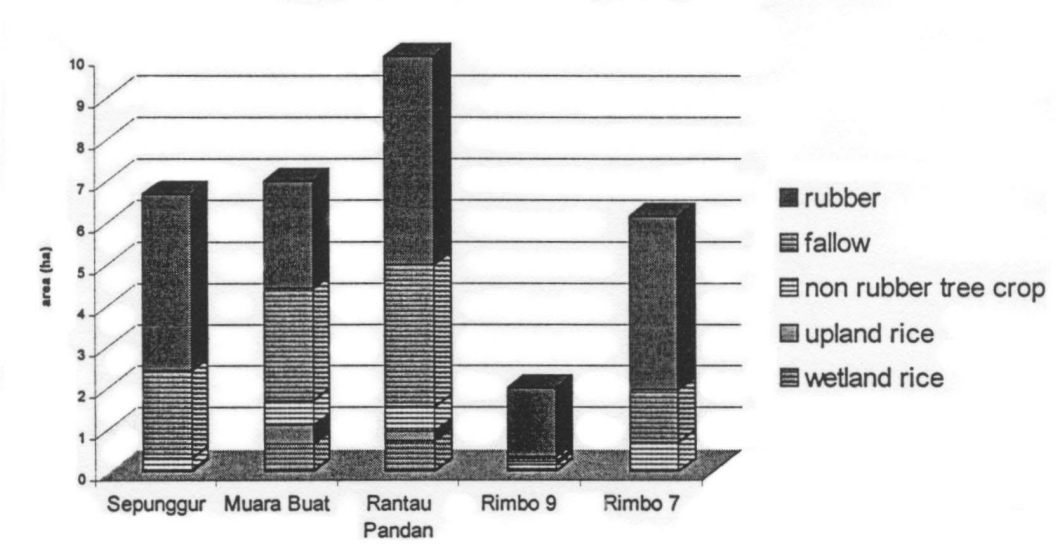


Table 3. **Area per type of land use and per village**

Sepunggur

	Average area	Standard deviation	Minimum	Maximum
Total area	7.03	5.40	2.50	26.50
Irrigated rice	0	0	0	0
Upland rice	0.04	0.19	0	1.00
Rubber	4.25	3.77	1.00	20.00
Home-garden	0.28	0.38	0	1.50
Non rubber tree crop	0.27	0.98	0	5.00
Bush/fallow	2.13	2.20	0	8.00

Muara Buat

	Average area	Standard deviation	Minimum	Maximum
Total area	7.00	4.94	1.50	18.00
Irrigated rice	0.66	0.33	0	1.00
Upland rice	0.44	0.58	0	1.50
Rubber	2.56	2.13	1.00	8.00
Home-garden	0	0.01	0	0.02
Non rubber tree crop	0.59	0.47	0	1.00
Bush/fallow	2.75	3.96	0	13.00

Rantau Pandan

	Average area	Standard deviation	Minimum	Maximum
Total area	9.84	9.88	1.00	32.50
Irrigated rice	0.75	1.29	0	5.00
Upland rice	0.23	0.46	0	1.50
Rubber	5.00	5.53	1.00	21.00
Home-garden	0.21	0.52	0	2.00
Non rubber tree crop	0.56	0.78	0	3.00
Bush/fallow	3.46	4.25	0	14.00

Rimbo 9

	Average area	Standard deviation	Minimum	Maximum
Total area	2.57	1.05	1.50	5.00
Irrigated rice	0.14	0.27	0	0.75
Upland rice	0.11	0.31	0	1.00
Rubber	1.64	0.95	0.50	4.00
Home-garden	0.37	0.25	0.12	1.00
Non rubber tree crop	0	0	0	0
Bush/fallow	0.11	0.21	0	0.50

Rimbo 7

	Average area	Standard deviation	Minimum	Maximum
Total area	6.51	3.35	2.00	13.00
Irrigated rice	0	0	0	0
Upland rice	0	0	0	0
Rubber	4.19	1.61	1.25	6.10
Home-garden	0.14	0.08	0	0.25
Non rubber tree crop	0.68	0.66	0	2.00
Bush/fallow	1.30	2.42	0	7.00

Land availability and land tenure

In the piedmont area (Muara Buat and Rantau Pandan), land is apparently still plentiful with both primary and secondary forests. The village is located close to the boundary of the Kerinci-Seblat National Park. Traditionally, customary land

belongs to families/clans in the village community and the members cultivate it in turn. Some farmers try to buy land: this is considered private property, but has no official land certificate. The land market is developing, but further information needs to be collected. Land availability is expected to be dramatically reduced in the near future and land use potentially severely affected by new plantations (mainly oil palm) on land re-appropriated by the government[1].

In Sepunggur, although some secondary forest still remains, there has not been any free land available since 1992. There is no 'lineage land' like in the piedmont area, however there is a kind of community land along the river which can be farmed in turn by the farmers in specific years (annual crops only). Only local transmigrants from the "Lokal Transmigrasi Proyek" have got an official land certificate.

In Rimbo Bujang, another official transmigration area, there is no forest, and hardly any old jungle rubber left amongst the monoculture plots. The land is limited to 2.5 hectares per household. Every transmigrant received a land certificate some years after settlement. This certificate is used as collateral if the fanner joins a development project such as TCSDP or NES, and returned to the farmer when he has repaid the credit loaned by the project

Main farming activities

Rubber

Rubber cropping systems

In Sepunggur, Muara Buat and Rantau Pandan, the traditional jungle rubber system is largely dominant. Some recent innovations appear in the cultural practices: more and more young local rubber plantations have been planted as monoculture plots; and clonal seedlings from surrounding estate plantations are replacing traditional unselected seedlings to a certain extent. Apart from clonal. planting material provided by the SRAP project, only three farmers in our sample owned clonal rubber; these had lucrative off-farm activities, and so maybe could not be considered 'true' farmers.

In the transmigration area, all farmers own clonal rubber in monoculture from the plantation project (NES or TCSDP). In addition, some farmers had bought clonal rubber themselves from private nurseries, and planted it on land they had purchased or rehabilitated. Clonal stumps were sold for around 300 Rp each. In Rimbo Bujang (Unit 7) a farmer from Medan is trading in PB 260 stumps; these were bought at private nurseries in Medan and sold to other farmers in Rimbo Bujang.

Rubber tapping

Rubber is traditionally tapped in a *fishbone* ('V'-shaped) pattern in jungle rubber, at 1 to 3 different places on the same tree. The first tapping usually occurs

[1] Officially, 74 % of the total land in Indonesia is supposed to be "forest" and belongs to the state.

around 8 years after planting. Since the yield per tree drops during the period of leaf fall in the dry season ('wintering effect'), some farmers stop tapping at this time (for approximately two months), but only if they can afford it. When there is no source of income other than rubber sales, trees are tapped throughout the year. Due to the higher rainfall in Jambi, the "wintering" period, is not as pronounced as it is in South Sumatra, and the trees can survive without cessation of tapping at this time.

Clonal rubber is tapped in a spiral pattern (half the circumference of the tree), from the left to the right. Although there are some farms (3) with clonal. rubber in Sepunggur, Muara Buat and Rantau Pandan, these trees are still immature, which shows that the introduction of clonal rubber to these villages was very recent. Farmers who already have experience in tapping clonal rubber are all from Rimbo Bujang, and they learned this way of tapping from project officials (NES) or by having worked as wage-tapper in clonal estate plantations. The first tapping usually occurs around 5 years after planting. Some PB260 trees have been opened at 3 1/2 years, however the trees had a very low girth at opening. In practice, trees are often opened before they have reached the technically recommended girth of 50 cm.

Weeding

Weeding is very infrequent in jungle rubber with one or two weedings per year during the immature period. Farmers do not use herbicide, but simply hoe the main weeds. After an average of 5 years, jungle rubber fields are not weeded at all, however farmers may periodically clear the rubber rows to make tapping easier.

In clonal monoculture, fields are usually weeded three to four times a year, always using herbicides, mainly ‘Round Up’. In transmigration areas, 'Polaris' and 'Bimastar' are used (similar chemicals to ‘Round Up’ but at different concentrations).

Other inputs

In Rimbo Bujang, all inputs (fertilisers, pesticides and herbicides) are or were provided by projects (credit to be repaid between 5 and 13 years after planting). For NES farmers in Rimbo 7, farmers have already repaid the credit, and they now have enough income from rubber sales to buy their own inputs.

In all other locations, farmers don’t use any inputs for local rubber. The main reason given for this was lack of money to buy inputs. Another reason was that they don’t really need inputs and have never used them in the traditional jungle rubber system. For those growing clonal rubber, inputs were either given by the SRAP project (for SRAP trials) or bought by farmers themselves (for other fields). There was a clear preference for ‘Round Up’ as the main herbicide used.

Rubber production

Farmers from Sepunggur, Muara Buat and Rantau Pandan all use formic acid (cuka) to coagulate latex and they sell slabs, whereas farmers from Rimbo Bujang use TSP *(triple super-phosphate)* and directly sell cup-lumps. Although these farmers are aware that using TSP lowers rubber quality, they still prefer it because latex coagulation is faster. Farmers are paid by traders according to rubber weight only, so it is common practice to add wood shavings to the latex in the collecting cup, or to coagulate it with TSP, without any consideration for rubber quality. In fact, there is no financial incentive for production of high quality rubber.

Average production of rubber fields:

	Jungle rubber			Clonal monoculture	
	Sepunggur	Muara Buat	Rantau Pandan	Rimbo 9 GT 1. AVROS, PR 261, BPM 1	Rimbo 7 GT1,AVROS, PR 261, PB260
Slabs/cup-lumps 50 % D.R.C. (kg/ha/year)	1341	1279	1144	3080	3393
Dry rubber production (kg/ha/year)	670	640	572	1540	1696

Here we found confirmation of the potential production of jungle rubber: around 600 kg/ha/year. The use of clonal rubber (clone GT1) increases the production per hectare by a factor of three. The production potential is higher with clone PB 260 (between 1800 and 2000 kg/ha/year as observed in SRDP-Prabumulih plots in South Sumatra).

Estimation of the Value of the Land

Cost of land for 1 hectare in 1996 (Rp/ha)

Village	Sepunggur	Muara Buat	Rantau Pandan	Rimbo Bujang Transmigration
Bushland	320000	120000		750000
Jungle rubber	780000	315000		900000
Clonal rubber plantation				10000000 (credit included)

Source: From interviews with local farmers.

We assume that the majority of farmers will not buy land in traditional areas. This is the opposite in transmigration areas.

Irrigated rice production

Almost all households surveyed in the piedmont area have a plot of, cropped once a year, whereas rice plots are very rare on the central plain (like Sepunggur) because of unsuitable soils. According to farmers, some swampy soils in Rimbo Bujang 9 could be used for irrigated rice production, but in reality they are rarely cultivated as such.

Farmers from Muara Buat only use local varieties. Some improved varieties from the BIMAS program are used in Rantau Pandan, however, there is no significant yield difference in production, between these and the local varieties, probably because of the lack of fertilizers on improved varieties. Average production is around 950-1000 kg/ha. There is very little upland rice production in the area.

Non rubber tree crops

Cinnamon is cultivated in piedmont areas, either in monoculture or mixed with rubber. Bark is usually harvested at about 7 years, after felling the whole tree. Traditionally, cinnamon is cropped in a different way in the Kerinci area with partial removal of the bark, and no destruction of the trees at the 7th year. There is no information about the quality of cinnamon produced under the altitude of 600 meters asl.

In addition to rubber and cinnamon, most of the farmers in Rimbo 7 and two farmers in Sepunggur also cultivate oil palm on their own initiative (maximum one hectare). This seems to be a very recent trend, since all these plots are still young (less than 2 years old). The area of oil palm plantations is expected to increase greatly in the coming years, due to the many projects planned for the area.

Coffee is also frequently cultivated in Sepunggur, usually left to grow in jungle rubber or fallow, and is usually grown for self consumption. Many kinds of fruit trees are also grown.

Off-farm activities

Related to agricultural sector

Wage labour

Three main types of off-farm activity can be observed

- Rubber tapping in other farmer's fields. Share-tapping occurs both in transmigration and non-transmigration villages, although division of the harvest is slightly different in these areas. The most common division is a three-way split *(bagi* 3). In Sepunggur, Muara Buat and Rantau Pandan, 1 part goes to the owner of the field and 2 parts to the tapper, whereas in Rimbo Bujang 2 parts go to the owner (who has to pay for all inputs) and I to the tapper. The divisions differ according to labour demand, rubber prices and other existing opportunity costs. The "bagi" may vary from 2 to 5.

- Rubber tapping in estate plantations. This is based on wage-tapping. An advantage of working in these plantations, farmers learn about clonal rubber and improved tapping practices.
- Other wage labour. This includes any kind of agricultural work in other farmer's fields (e.g. planting, weeding, harvesting) and timber harvesting in the secondary forest.

Fishing

Many farmers, especially in Sepunggur, fish in the river for self-consumption or to sell. Only one farmer (in Rantau Pandan) owns a fish pond.

Rubber trade

Two farmers in Muara Buat & Rantau Pandan buy rubber in the village and sell it in Muara Bungo.

Non-agricultural sector

Trade

There is one big trader in Rantau Pandan, who owns a grocery shop, leases minibuses and sells rubber. Most commonly, some farmers have small shops *(warung)* near the house, where they sell food and cigarettes.

Government officers

Our sample includes 9 teachers, especially among SRAP farmers, as well as a policeman and a soldier in Rantau Pandan. It seems clear that our sample in Muara Buat and Rantau Pandan is biased. Most of the "SRAP farmers" do not in fact have farming as their main activity.

Other

- 1 village head *(Kepala desa)* in Muara Buat
- 1 customary head *(Kepala adat)* in Sepunggur
- 2 group heads *(Kepala kelompok)* in Rimbo 9. These types of activities are usually not waged, but give these people an important institutional and social status compared to other farmers.

Farmers' current knowledge about some innovations

About clonal and local rubber

Farmers' knowledge about clonal rubber is clearly dependent on the presence of a rubber project (TCSDP, NES, SRAP) or clonal rubber estate plantations in the area (e.g. those only few km from Muara Bungo).

In the transmigration area, where almost all the farmers are participating in a TCSDP/NES project, all people surveyed have been well informed about clonal

rubber, its characteristics and the cultural practices required for a number of years. In other villages, about 50 % of the farmers already had information on clonal rubber before SRAP came into the region, and most through discussion with PTP (estate) workers. Consequently, the best known clones are those provided by these projects or growing in the PT? (especially GT1) but also PB260, which is said to be resistant to wind damage, high yielding and a fast starter. Many farmers in Rimbo Bujang bought PB260 stumps from another fanner who trades in clonal stumps from Medan.

According to the surveyed farmers, the main advantage of clonal rubber is clearly its higher yield compared to local rubber, and sometimes its faster growth too. Its main drawbacks are the shorter productive life and its supposedly higher susceptibility to wind damage (many farmers in Rimbo Bujang added this weakness was due to the fact that clonal rubber's tap root had been cut). PB260 is not particularly sensitive to wind damage. Of the clones selected by SRAP, only RRIM 600 is susceptible. It seems that wind damage is a constraint in Rimbo Bujang.

About rubber cropping systems

Most farmers put forward the lack of money as the main reason for continuing with the local rubber system. Some farmers recently improved their productivity by using clonal seedlings from seeds collected in the PTP. However we will see that capital is probably not the main constraint to adoption of clonal rubber.

Regarding specific features of the different cropping systems, most farmers are aware that weeding and fencing (protection) can improve rubber growth even for local rubber. However many of them still continue with jungle rubber system due to the following advantages: lower risks, no capital needed, low labour requirement and income diversification through fruit and wood production. Rubber seedlings which do not grow or are eaten by wild pigs are easily replaced with no cost in jungle rubber. In the case of clonal rubber, farmers feel they can't take the risk of poor management regarding their investment of capital.

Most farmers see monoculture as the best cropping system in terms of rubber growth, especially for clones. It is clear that, except for the RAS experiments, they do not have any knowledge or experience of agroforestry systems using clones. Monoculture is clearly the dominant model, as projects have promoted this, with no possible alternatives suggested.

However, rubber is often mixed with annual crops e.g. upland rice and vegetables during the first two years after planting to optimise land use. This provides food crops during the immature period of rubber and reduces weeding at the same time. After three years, shading from rubber trees makes further intercropping almost impossible, except for shade tolerant species, for instance ginger. In jungle rubber, rubber is mixed with fruit trees (durian, jengkol, petai etc) with coffee, and sometimes associated with cinnamon in the piedmont area. In the transmigration area, clones are never mixed with perennials because it is prohibited by the project until credit is repaid in full. According to farmers, only rattan

can grow with rubber without disturbing it. This perception reflects the strong influence of extension on farmers in the NES project.

Economic Analysis of Cropping Systems

Net Income for cropping systems per year and per ha

Rubber

The net income per year and per ha for rubber is the following

Rubber cropping system

	Rubber system	No. of farmers	Net income (.000 Rp/ha/year)
Sepunggur	Jungle rubber	24	1480
Muara Buat	Old Jungle rubber	6	1078
Rantau Pandan	Old Jungle rubber	9	1146
Sukadamai	Clonal rubber monoculture	2	2552
Saptamulia	Clonal rubber monoculture	7	3046

Average net income from rubber plots per hectare and per year

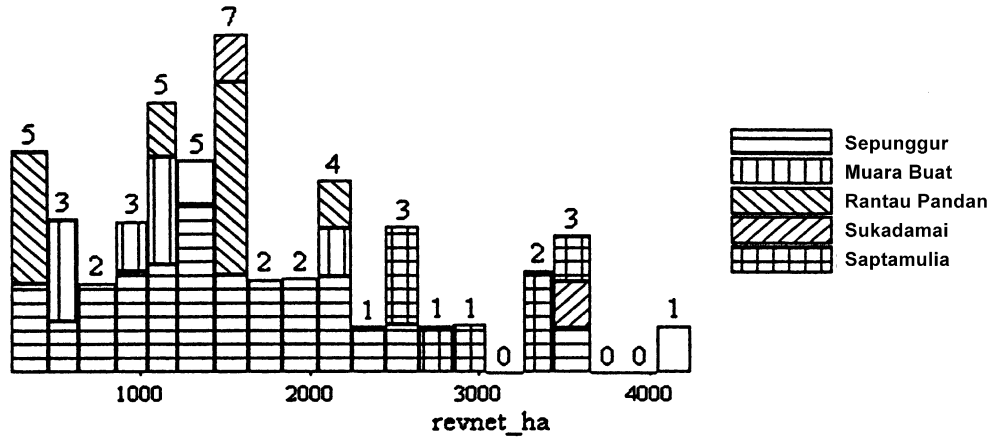
- Jungle rubber : 1341000 Rp/ha/year
- Clonal monoculture : 2 937 000 Rp/ha/year rubber

These tables show clearly the advantages of clonal rubber, compared with jungle rubber based on unselected seedlings, in terms of net annual income. The figures for clonal rubber production are based on clone GT1, although the production of clones like PB 260 and RRIC 100 are expected to be superior to GT 1. One hectare of rubber in production should enable farmers to repay a small amount of credit (e.g. 250 000 or 500 000 Rp) on an annual basis. The problem is more one of cash flow availability at a particular time (planting) rather than the total cost.

Farmers with more than 1 hectare of clonal rubber definitely have the capacity to repay credit which would cover the cost of establishment of a small plot (1/2 hectare) of clonal rubber, for example 250 000-500 000 Rp every 2 years.

The following figure shows the distribution of the net revenue/ha of rubber cropping systems in different villages.

Figure 5. **Distribution of net revenue/ha rubber. Survey. 1997, A Kelfoun**



Rice cropping systems

Sawah/irrigated rice

	Type of seeds	No. of farmers	Net income (.000 Rp/ha/year)
Muara Buat	Local varieties	6	756
	Improved varieties	1	1094
Rantau Pandan	Local varieties	1	345
	Improved varieties	4	1126

Average net income from sawah rice plots per hectare and per year

- Local varieties : 697 000 Rp/ha/year
- Improved varieties : 1120 000 Rp/ha/year

Price of rice: 1200 Rp/kg

Ladang

Average from 5 farmers with local varieties

	Number of farmers	Yield in kg/ha	Net income (.000 Rp/ha/year)
Sepunggur	1	480	346
Muara Buat	2	908	654
Rantau Pandan	1	1080	777
Sukadamai	1	300	216

Average net income from upland rice/ladang plots per hectare and per year: 529 000 Rp/ha/year

Income from rice production, either from sawah or ladang, does not seem to be sufficient to enable repayment of credit or investment in the establishment of new plantations. Rice is cropped mainly for subsistence and family food security.

Cinnamon

Harvested at the 7th year

Average net income from cinnamon plots per hectare: 2 000 000 Rp/ha/year

Income from cinnamon might enable a farmer to establish I to 2 hectares of clonal rubber (2 ha of RAS 1 or 1 hectare of RAS 2 or monoculture)

Conclusions regarding incomes from various cropping systems

Comparison of systems:

Cropping systems	Net income (.000 Rp/ha/year)
Rubber jungle rubber	1341
clonal monoculture	2937
Sawah local varieties	697
improved varieties	1 120
Ladang (upland rice)	529
Cinnamon	2000

Jungle rubber still provides most of the farm income in these areas. Cinnamon appears to be a good opportunity, but production only starts after a 7 year immature period.

Labour Requirements and Return to Labour for Different Cropping Systems

Labour Requirements Per Cropping System in man-days (man-day is equivalent to 8 hours of work/day)

This data will be used for the calculations of return to labour. This is presented for the following cropping systems: Rubber, Rice/sawah, Rice/ladang, cinnamon

Rubber already in Production: labour requirement in man-days

	Weeding	Tapping	Latex collection	Total
Sepunggur	3	60	9	72
Muara Buat	2	53	9	64
Rantau Pandan	2	69	7	78
Sukadamai	5	43	8	56
Saptamulia	7	38	8	53
Jungle rubber	2	61	8	71
Clonal Monoculture	7	40	8	55

Rice/Sawah: Annual labour requirement per year, transport not included.

	Type of seeds	No. of farmers	Ploughing	Sowing	Weeding	Harvest	Total
Muara Buat	Local	6	54	33	45	57	189
	Improved	1	80	20	42	40	182
Rantau Pandan	Local	1	60	30	60	80	230
	Improved	4	41	37	71	39	188
Average for local varieties		7	55	33	47	60	195
Average for Improved varieties		5	49	34	65	39	187

Rice/Ladang: labour requirement in man-days

	Number of farmers	Ploughing	Sowing	Weeding	Harvest	Total
Sepunggur	1	24	6	10	12	52
Muara Buat	2	8	13	8	29	58
Rantau Pandan	1	40	30	40	60	170
Sukadamai	1	60	30	30	10	130
Average	5	28	19	19		94

Note: On average, these figures are slightly lower than those obtained by *P* Levang in *1989 (110* to *120* man-days/ha).

Return to Labour for Various Cropping Systems

These data are presented per type of cropping systems: Rubber, Rice/sawah, Rice/ladang, cinnamon.

Rubber

	Rubber system	Number of farmers	Return to labour (.000 Rp/manday)
Sepunggur	Jungle rubber	24	25.3
Muara Buat	Old Jungle rubber	6	18.8
Rantau Pandan	Old Jungle rubber	9	16.5
Sukadamai	Clonal rubber monoculture Young plantations	2	27.4
Saptamulia	Clonal rubber monoculture Mature plantation	7	61.8

Average return to labour for various rubber cropping systems:

- Jungle rubber : 22 300 Rp/man-day
- Clonal rubber monoculture : 54 200 Rp/man-day

Sawah

	Type of seeds	Number of farmers	Return to labour (.000 Rp/man-day)
Muara Buat	Local varieties	6	5,4
	Improved varieties	1	6,0
Rantau Pandan	Local varierties	1	1,5
	Improved varieties	4	8,7

Average return to labour for various sawah cropping systems:

- Local varieties : 4 800 Rp/man-day
- Improved varieties : 8 200 Rp/man-day

Ladang: 8 000 Rp/manday.

Comparison between different cropping systems in terms of return to labour

Cropping Systems		Net income (.000 Rp/manday)
Rubber	Jungle rubber	22300
	Clonal monoculture	54200
Sawah	Local varieties	4800
	Improved varieties	8200
Ladang		8000

The return to labour of clonal rubber system is far more attractive than the returns from other cropping systems, and this confirms the high interest of farmers in clonal rubber. These figures are very similar to the values used in the prospective economic analysis of RAS (Penot, 1996).

Economic Analysis at tbe Farming System Level

These calculations take into account the average area per cropping system per farm as observed in the surveys.

Rubber

Area and Average Production Per Farm

	Jungle rubber			Clonal Monoculture	
	Sepunggur	Muara Buat	Rantau Pandan	Sukadamai	Saptamulia
Average area of rubber per farm (ha)	4,02	2,72	5,00	1,72	4,19
Productive area per farm (ha)	2,76	1,47	1,62	0,31	2,54
% of total area	68,6%	54,0%	32,4%	18,0%	60,6%
Average production of slabs/cup-lump (kg/ha/year)	1341	1144	1279	2960	3393

Rubber Yields

	Sepunggur	Muara Buat	Rantau Pandan	Sukadamai	Saptamulia	Local	Clones
Rubber yield (kg/ha/ year)	670	640	572	1480	1696	648	1649

N.B. A slab contains 40-60 % (average 50 %) DRC (Dry Rubber Content).

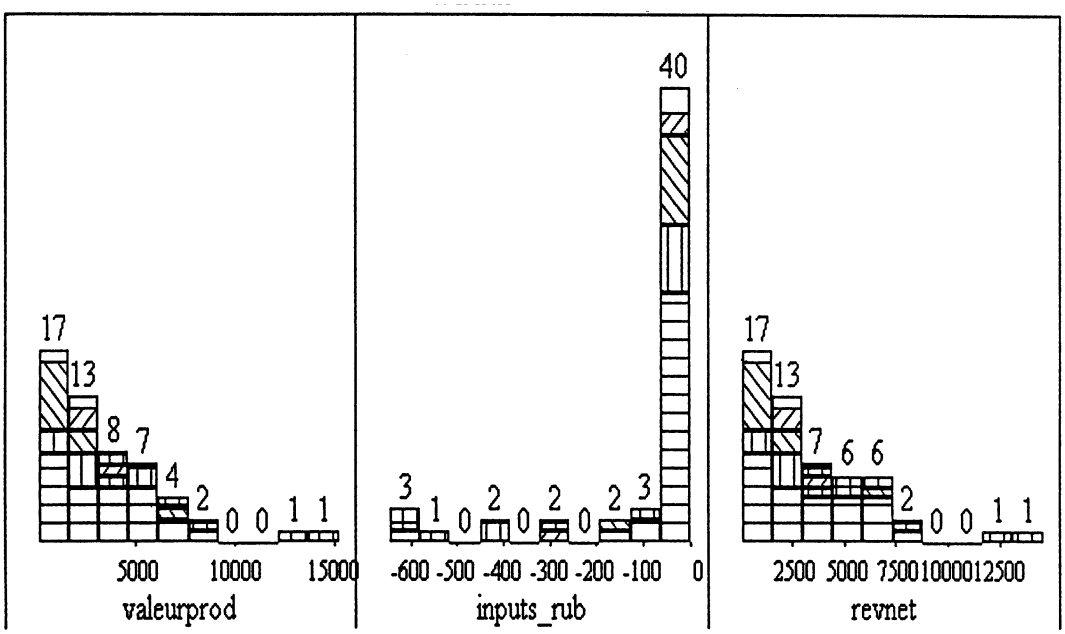
Average price of rubber in July 1997: Sepunggur village- 1150 Rp/kg of slab, therefore 2300 Rp/kg of dry rubber (100 % DRC). Transmigration area (Rimbo Bujang)- 950 Rp/kg of slab, therefore 1900 Rp/kg of dry rubber (100 % DRC). The price had increased to 4 000 Rp/kg of dry rubber (100 % DRC) in March 1998.

Net Income from Rubber Per Farm Per Village

	Sepunggur	Muara Buat	Rantau Pandan	Sukadamai	Saptamulia
Average Pro-duction per farm (kg/year)	3651	2140	2206	2920	8824
Value of the production (.000 Rp/year)	3459	2033	2041	2392	8383
Net income from hevea[2]	3411	2015	2003	2283	7951

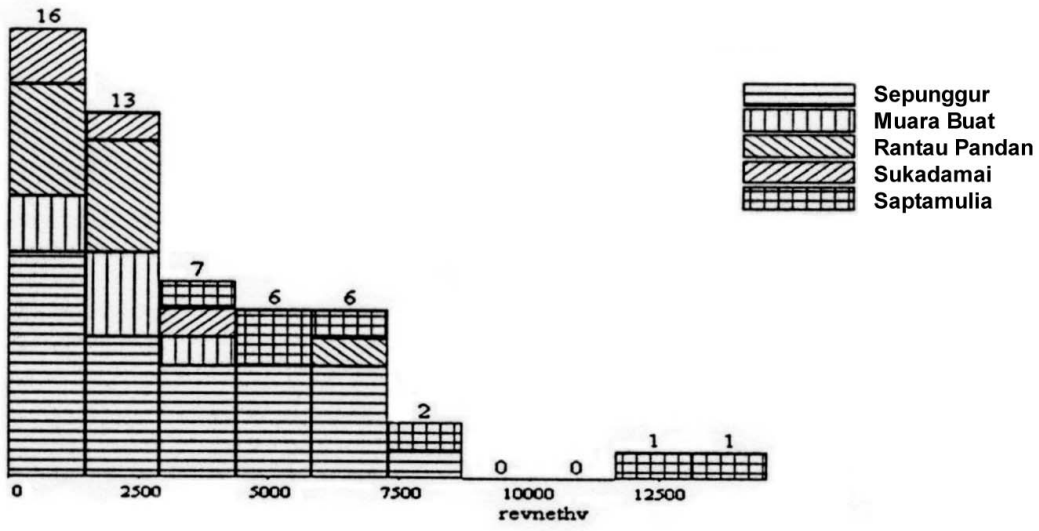
[2] NB: Income is calculated with production value minus inputs costs (labour not included)

Production and inputs cost, net revenue for rubber. Distribution, survey 1997



Valeurprod = total value of the rubber production
Inputs_rub = costs of all inputs
Revnet = total net income from rubber

Distribution of revenue from rubber per village



Income in x1000 rupiah

Rice/Sawah

Yield of sawah

	Type of seeds	Number of farmers	Yield In kg/ha/year
Muara Buat	Local varieties	6	1118
	Improved varieties	1	1800
Rantau Pandan	Local varieties	1	480
	Improved varieties	4	1565

Average yields from sawah:

- Local varieties : 1027 kg/ha/yr
- Improved varieties : 1612 kg/ha/yr

Income from Sawah Per Farm Per Village

	Sepunggur	Muara Buat	Rantau Pandan	Sukadamai	Saptamulia
Average production of rice in kg/year	0	1085	1132	0	0
Value of the production (.000 Rp/year	0	782	815	0	0
Net income (.000 Rp/year)	0	730	803	0	

Only some villages have sawah plots

Rice/Ladang

- Average Yield : 735 *kg/ha/year*
- Average production of paddy per farm : 938 *kg/year*
- Net income per farm : 675 000 *Rp/year*

NB: data from 5 farmers only.

Ladang income cannot be considered as a source of cash for credit repayment

Average Farm Income from Farming and Off-Farm Activities

Farming Activities

	Sepunggur	Muara Buat	Rantau Pandan	Sukadamai	Saptamulia
Net farm income (.000 Rp/year) from farming activities	3321	2285	1704	688	8271

Off-Farm Activities: from rubber share-tapping: system *bagi tiga* (2/3 for the tapper)

	Value of the production (.000 Rp/ha/year)	Input costs (.000 Rp/ha/year)	Share to the tapper	Net income for the tapper	Net income for the owner
Sepunggur	1496	16	2/3	996	483
Muara Buat	932	8	2/3	621	303
Rantau Pandan	1164	18	2/3	775	370
Rimbo Bujang (clonal plantation)	3099	162	1/3	1023	1904

Average income from off-farm activities

	Sepunggur	Muara Buat	Rantau Pandan	Sukadamai	Saptamulia
Number of farmers with non-farming source of income	10/29	5/9	12/13	9/10	3/7
Type of work	Timber Trade Fishing Warung Civil servant	Timber Trade Fishing Civil servant	Trade Civil servant (9 out of 12)	Labourer	Trade Warung Nursery
Non fuming net income per farm (.000 Rp)	2712	4224	5369	1101	3640

The village of Rantau Pandan with 9 out 12 "farmers" being civil servants cannot be considered representative. Off farm activities are relatively important, and could be used to repay loans.

Total Farm Income

Total farm income includes incomes from agricultural activities (Type A) as well as incomes from off-farm activities (Type B).

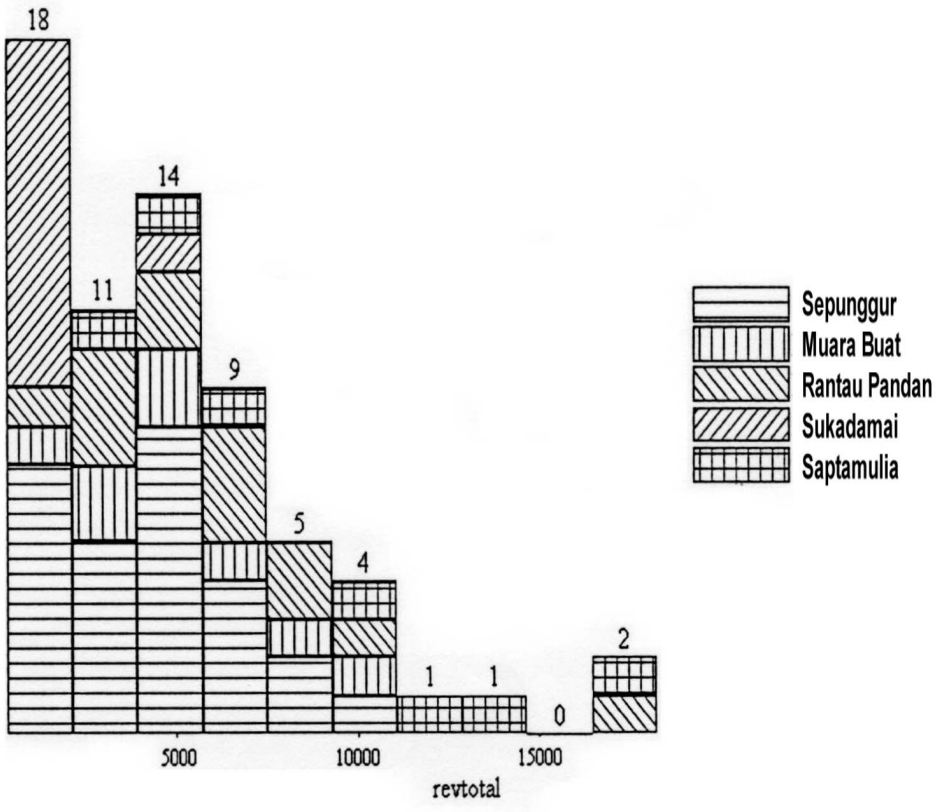
	Type	No. of farms	Incomes from % of Agriculture total (.000Rp/year)	% of total	Income from % off farm activities (.000 Rp/year)	% of total	Total income (.000 Rp/year)
Sepunggur	A	19	3,546	100%	0		3546
	B	10	2,938	52.0%	2,712	48.0%	5650
Muara Buat	A	4	3,184	100%	0		3 184
	B	5	1,745	29.2%	4,224	70.8%	5969
Rantau Pandan	A	1	979	100%	0		979
	B	12	1,764	24.7%	5,369	75.3%	7 133
Sukadamai	A	1	1,660	100%	0		1660
	B	9	366	24.9%	1,101	75.1 %	1467
Saptamulia	A	4	6,954	100%	0		6954
	B	3	10,026	73.4%	3,640	26.6%	13666

Total average farm income per village

	Sepunggur	Muara Buat	Rantau Pandan	Sukadamai	Saptamulia
Total average farm income (.000 Rp/yr	4325	4925	6660 non representative sample	1679 young plantation	9831 mature plantation

These figures for annual income show that capital might not be the first problem for rubber farmers, at least in this representative sample of 68 farmers in Kabupaten Bungo Tebo even for farmers still relying on jungle rubber. However cash availability at one specific time in a lump sum (for instance for setting up a polybag nursery, planting and fertilizing) might be the real constraint.

Distribution of Farm Total Revenue Per Village, survey 1997 A Kelfoun



Capital accumulation at the farm level

Average per farm	Sepunggur	Muara Buat	Rantau Pandan Non-representative sample	Suka-damai	Saptamulia
Value of land	3701	2052	4391	12305	35131
Value of animals	626	125	1054	487	551
Value of tools	280	198	171	62	141
Value of the house	3309	5262	12193	2461	9429
Total accumulated Capital	7916	7637	17809	14115	45252

Farmers' strategies

The Opportunities

The following external factors have to be taken into account in the definition of farmers strategies:

The Presence of neighbouring rubber estate plantations (PTP)

Information about clones (yield, advantages and constraints...) is available for all farmers of the area from PTP workers or officials. In addition, some farmers have also worked in PT? And could learn tapping practices, as well as about the use of inputs.

The Plantation projects :

NES in Rimbo 7 and TCSDP in Rimbo 9 have allowed all transmigrants to have access to clonal rubber, with provision of stumps, all necessary inputs (with credit), technical advice and sometimes practical training (tapping, grafting...). 2 out of 17 farmers in the area chose not to join these programmes in order to avoid dependence on a project. Clone availability is not a constraint in Rimbo Bujang, allowing farmers to have access to IGPM outside official projects.

The SRAP project:

When the SRAP project came to the 3 villages of Sepunggur, Muara Buat and Rantau Pandan, only some farmers showed their interest for RAS technology. There might have been some misunderstanding from some farmers about ownership and the rights to future rubber production. Now that the project is well established and its aims quite clear to farmers, there is a real demand from other farmers. Since clones are not available, and economically out of reach for most farmers, sometimes feelings of frustration and jealousy have been directed toward farmers who had access to improved planting material through SRAP. This is already a source of social rivalry between project and non-project farmers, reflecting the importance of social factors, especially equity in adoption of innovations.

Overcoming the constraints

In the transmigration area, the main constraint is the **lack of land,** so that farmers have to optimize their land use, firstly through intensification of the rubber cropping system (clonal rubber in monoculture with large use of chemical inputs), secondly by intercropping with food crops in their rubber plots. An important step has been made by the TCSDP project in allowing farmers to cultivate annual crops during the first few years, however cropping perennials on these plots is still forbidden.

In all other villages, the main constraint is the lack of capital. Since most of the farmers are not limited by land, they rely on extensive farming systems without any inputs. In the piedmont area, in order to optimize labour productivity and reduce risks, farmers also rely on crops other than rubber, such as cinnamon or irrigated rice production.

In view of the need and demand for clones to improve productivity, a first step towards rubber yield improvement could be the use of clonal seedlings (from clonal estate plantations) in extensive systems. However, yield improvement

would be very limited. Indeed, this is a step that many farmers are already taking.

Preliminary classification of situations

According to these preliminary outputs from the farming system survey, some important variables can be set out to identify an operational typology. Two main criteria are used:

- Access to land
- Access to capital

A four-class typology can be identified:

	No capital	Capital
Access to land	Class 1	Class 2
No access to land	Class 3	Class 4

Class 1: Access to Land/ no capital

This is the case of most of the farmers in the non-transmigration areas. They still have access to land which is not cultivated yet, either customary land in the piedmont area, or farmers' private fallows in the peneplain area. Incomes, mainly coming from rubber sales, are usually sufficient for the household subsistence, but don't allow farmers to generate capital. Extensive systems with low productivity have reached their limit: income cannot generate sufficient capital to invest in the improvement of the system. As off-farm opportunities and the necessity of improving income increase, farmers are beginning to look for alternative fanning systems which combine high productivity and low cost with labour optimization.

Class 2: Access to land and capital

Only a few farmers (from Rantau Pandan and Muara Buat) belong to this second class. They are usually the richest farmers in the villages, with lucrative off-farm activities and a high standard of living. They can give priority either to these off-farm activities (usually trading) or to improving their cropping systems. Some of them have already invested in clones and inputs as a result of their off-farm incomes. They still have access to land, and an important constraint for them is a lack of technical information about clonal rubber requirements.

Class 3: No access to land/no capital

This is the situation for most of the young TSM transmigrants in Rimbo 9. They are limited to a maximum of 2 ha of land per household and own clonal rubber from TCSDP which was still immature in 1997. They do not yet get any income from rubber, so depend on temporary jobs such as share-tapping, labouring or

house building. The main constraint for these farmers is their dependence on the project for 10-15 years. Land certificates are given to farmers after repayment of credit.

Class 4 No access to land/ capital

This is the situation of the older transmigrants in Rimbo 7, and which is expected to be the situation for farmers in Rimbo 9 in about ten years. It appears that most farmers have successfully repaid their credit, and they already benefit from incomes from high yielding rubber plantations. They now have sufficient capital to buy all necessary inputs without credit. Their cropping pattern is largely based on clonal monoculture, with the recent trend of planting oil palm as well as rubber. The main constraint for them is obviously the lack of land: most of the farmers got 5 ha from transmigration when they arrived. Some of them bought more land later. Currently, there is no more available land. Their average standard of living is quite high, far higher than most of the local farmers in non-transmigration areas.

Conclusions

The innovation adoption process can be considered as a social process. Farmer organisation and social coherence within the village community are key factors which enable farmers to integrate innovations into their farming systems.

Factors which facilitate adoption of innovations are the presence of projects (NES, TCSDP, SRAP), presence of neighbouring clonal plantations and development of oil palm projects in the area. We observed that the influence of Disbun (government extension service) is extremely limited for rubber smallholders. The main constraints are obviously the lack of land, especially in transmigration areas, and/or the lack of capital.

According to these two constraints, a four-class typology was identified: farmers with or without capital, in or out of transmigration areas. RAS adoption is clearly possible in nontransmigration areas with traditional extensive systems. RAS I seems to be suitable both for piedmont and peneplain areas due to its low to medium labour requirement. Many farmers already crop upland rice or palawija in the interrow in the first year of rubber growth, sometimes during the second, but never during the third year. Cinnamon grows well in hilly areas (Muara Buat, Rantau Pandan), allowing further extension of RAS 2.5 in these areas.

Farmers in transmigration areas now crop clonal rubber in monoculture. Apparently, they want to continue with such a system and dont seem to be interested in any kind of RAS.

The objective of these two surveys was to identify an operational classification of farmers linked with recommendation domains for RAS systems. It is obviously a difficult task to assign the relevance of a RAS type to a particular target group of farmers. The most difficult feature will be to obtain from farmers a

good understanding of the advantages and disadvantages from their perspective, as well as the technical requirements for each RAS system.

Land scarcity leads to intensification of rubber systems, firstly with the use of IGPM (on condition that capital is available). Therefore, good quality IGPM at low cost through production by fanner groups, with the parallel development of private nurseries, seems to be a priority. However, a lack of technical information and practical training has led to abandonment of existing BANDES[3] budwood gardens and limits the use and dissemination of clones. Thus these issues must be specifically addressed.

Clonal rubber adoption in the Jambi province is not only a technical problem (lack of grafting training) but also an economic problem, especially the lack of capital necessary to buy IGPM and required inputs, as well as the lack of available credit.

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[3] BANDES = Penembangan Desa Village development program

Table 4. **Main Features of the Farming Systems Survey Questionnaire**

Section	Number of variables	Unit of analysis	Type of information
Identification	5	Village/person	
Household members	16	Person	number, status, ethnic origin
Household assets	9	Household	houses, tools, animals, farming area
Gotong-royong system	9	Village	description and cost
Sawah	6	Cropping system	number, inputs
Sawah	is	Plot	practices
Ladang	18	Cropping system	number, inputs
Ladang	27	Plot	practices
Rubber	21	Cropping pattern	number, inputs
Rubber	20	Plot	practices
Rubber	5	farm level: total production	production
Herbicide	7	Cropping system	inputs
Fertilization	3	Cropping system	inputs
Pekarangan (home garden)	18	Plot	practices
Non rubber tree crop	20	Plot	practices and production
Fallow	3	Plot	practices and production
Grazing land	2	Farm	practices and production
Fish pond	5	Farm	practices and production
Access to forest reserve and timber use	22	Farm	practices and production

***Table 5*. Main features of the questionnaire on the innovation adoption process**

inno-A: RAS innovations SRAP farmers		inno-B: improved planting material all farmers		inno-C: practices, innovations, all farmers	
Section	Number of variables	Section RAS innovations	Number of variables	Section RAS innovations	Number of variables
Identification	5	identification	5	identification	5
Weeding	I I	IGPM; clones	22	practices	7
Herbicides	5	clonal seedlings	5	Associated trees	27
RAS	5	Polyclonal seedlings	4	weeding	9
Intercrops	6	budwood garden	22	fertilization	4
Fertilization of intercrops	9	next rubber plant-ing	9	covercrops	2
Rice	4	clonal rubber polybag nursery	17	annual crops	5
Pest and diseases	6			timber trees	6
Associated trees	15			fruit trees	6
Cover-crops	I			pulp trees	8
Fast growing pulp trees	9				
Nursery: pests	7				
Pest in rubber fields	11				