Farming system characterization and the adoption of innovations in West Kalimantan

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Key Words: rice, jungle rubber, budwood garden, rubber clone

Introduction

Smallholder rubber plantations of 1 to 4 ha per farm produce 73% of Indonesia's natural rubber production, and approximately 1.3 million farm households rely on rubber production for their income (DGE 1996). More than two-thirds of these households still grow unselected rubber seedlings in an extensive complex agroforestry system called jungle rubber or 'hutan karet', which covers more than 2.5 million hectares (Gouyon 1995; Michon and de Foresta 1992). The advantages of jungle rubber are now quite clear: no cost, no labour required for maintenance during the immature period and income diversification with fruits, rattan, timber and other NTFPs (non-timber forest products) harvested from the agroforest. There are also indirect environmental benefits, such as soil conservation and rehabilitation of degraded lands (Penot 1997).

Originally, the adoption of this system did not require a large change in farmers practices (Dove 1993; Penot 1995) as they continued to slash-and-burn new plots every year for 'ladang' cultivation. At that stage, one can still consider jungle rubber as an "enriched fallow with rubber". However, the productivity of this jungle rubber system is low (500 kg/ha/year of rubber) compared to that of estate clonal plantations (1200 to 1800 kg/ha/year). The 35-year lifespan of rubber is the same as the traditional fallow period necessary to restore soil fertility and to eliminate problem weeds. The 'Kantu' Dayaks considered rubber gardens as 'managed swidden fallows' (Cromb 1988 in (Dove 1993a)). *"Swidden cultivators use simple land and labour resources within the swidden system to cultivate rubber"* as clearly explained by Dove (1993). Jungle rubber and shifting cultivation are complementary, as the two systems can easily be combined in local farming systems. The concept of a "composite system" has been developed by Dove (1993) who states that *"there has been little analysis of the relationship between the two systems (rubber and swidden agriculture with rice) and thus little understanding of why this combination historically proved to be so successful".*

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Different projects have been implemented to increase rubber productivity at the beginning of the 1970s, with a partial approach (ARP[1]) or a full-package approach based on monoculture (SRDP, TCSDP[2]). The results of these different projects have been highly variable, except for the SRDP/TCSDP projects which implemented more than 75,000 ha of monocultural clonal rubber plantations, and also introduced external technical innovations (grafting, fertilization, etc) to the smallholder sector.

In this context, the Smallholder Rubber Agroforestry Project (SRAP) was developed by ICRAF, CIRAD-CP and GAPKINDO, using a participatory approach for on-farm experimentation with three main types of Rubber Agroforestry Systems (RAS). The main objective of this project is to minimize the amounts of inputs and labour to levels that are acceptable to farmers, but still allow clonal rubber to grow in a forest-like environment (Penot 1996). Research in agroforestry has recently focused on how to integrate farmers knowledge of jungle rubber with external innovations in order to raise productivity, while conserving the advantages of agroforestry practices in terms of environmental benefits and biodiversity (Penot 1997).

Objectives of the Rubber Agroforestry Systems (RAS) programme

So far, all rubber development schemes have been based on rubber monoculture with high levels of inputs and labour force. The current situation in Indonesia is characterized by relatively poor farmers who cannot afford the cost of the complete monoculture technological package (Penot 1997). However, the farmers are more interested in low to medium intensity cropping patterns (in particular for labour in immature period). The constraints to smallholders improving their local rubber agroforestry systems are the scarcity of improved planting material and its poor quality, the inefficiency of extension (and the poor planting material distributed to farmers), and the lack of information.

To address this, several clonal Rubber Agroforestry Systems have been established in pioneer and buffer zones, in degraded zones such as *Imperata* savannah, as well as in zones where replanting is required (old jungle rubber). The SRAP project is using a participatory approach to implement on-farm trials with three main types of rubber agroforestry systems (RAS). These aim to combine low to medium input requirements with agroforestry practices in order to determine the best level of intensification. One of the main objectives of RAS is to provide a low labour requirement during immature period, income diversification and environmental benefits through the combination of endogenous and external innovations. The adoption of technical innovations (especially improved rubber planting material) is easier when RAS do not require a radical change in the current cultural practices.

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[1] ARP : Assisted Replanting Programme

[2] SRDP : Smallholder Rubber Development Project
TCSDP : Tree Crop Smallholder Development Project

The main technical innovations in RAS are:

- The use of improved rubber planting material, such as the clone PB 260, BPM1, RRIC 100, RRIM 600. These clones are adapted to the local agro-ecological conditions and they have proven to be the best in terms of yields and secondary characteristics (resistance to leaf diseases and exploitation methods).
- The combination of rubber with annual crops during the first three to four years, and also with perennial crops.
- The introduction of different levels of manual and/or chemical weedings, lower than that of monoculture.
- The use of fertilizers during the first three years to improve rubber growth and maintain the yield of annual intercrops.

Budwood gardens and nurseries managed by farmer groups have been set up in the villages to help farmers to produce clonal rubber planting material themselves, as this represents more than 50% of the total cost of establishment of RAS (Penot 1996). The main constraints for farmers are budwood availability and quality (clonal purity) as well as a lack of technical information and grafting training.

Brief description of RAS trials

The first trial (RAS 1) is similar to the current jungle rubber system, in which unselected rubber seedlings are replaced by adapted clones. The main objectives are to determine if clonal rubber germplasm can thrive in a jungle rubber environment, to double yields, and to assess the required minimum management level. A secondary objective is to assess the level of biodiversity conservation in the jungle rubber system. In effect, RAS 1 is aimed for planting in pioneer or very remote areas or replanting in old jungle rubber or secondary forest areas. RAS 1 is not suitable in *Imperata* grasslands (Penot 1995; de Foresta 1997).

The second trial (RAS 2) is a complex agroforestry system in which rubber and perennial timber and fruit trees are established after slashing and burning, at a density of 550 rubber trees and a range of 90 to 250 other perennial trees per hectare (with various planting densities and species combinations). It is very intensive with annual crops being intercropped during the first three to four years, with emphasis on improved upland varieties of rice with various levels of fertilization.

The third system (RAS 3) is also a complex agroforestry system with rubber and other trees planted at the same density as that of RAS 2, but with intercrops only in the first year. These are followed by a combination of covercrops, Multi-Purpose Trees (MPT) and Fast Growing Pulp Trees (FGT). RAS 3 is established on degraded lands covered by *Imperata cylindrica* (alang-alang grass) (Penot 1994).

This network of farmer-managed trials is underway in West Kalimantan, Jambi and West-Sumatra provinces. These experiments take into account the limited resources of smallholders; labour is one the main factors being considered in assessment of a system's suitability.

Methodology:

Type of surveys

Four surveys have been conducted in eight villages (Sanjan, Embaong, Trimulia, Sukamulia, Pariban Baru, Kopar, Engkayu and Bali) in the subdistricts (kabupaten) of Sanggau and Sintang in West Kalimantan. Respondents were from Dayak and Javanese transmigrant populations. The four surveys were as follows:

- Farming systems characterization survey (FSS) (Survey 1),
- RAS innovation adoption process (Survey 2),
- Improved Genetic Planting Material (IGPM) use and production (Survey 3),
- Innovations in rubber cropping systems and cultural practices (Survey 4).

The main outputs are the characterization of the farming systems based on rubber and a constraints/opportunities analysis on innovations in RAS systems as an alternative to existing rubber cropping systems (jungle rubber, monoculture). To take into account the expansion of oil palm plantations in the Sanggau area, the village of Bali and other non-SRAP villages were chosen to investigate the advantages and the constraints of adopting oil palm compared to rubber agroforestry systems.

There are a number of objectives of these surveys as follows:

- characterize the advantages and disadvantages of adoption of improved rubber planting material in Rubber Agroforestry Systems;
- identify which rubber cropping system based on clonal rubber seems the most adapted for the farmers in terms of labour requirements and productivity, in addition to providing income diversification and environmental benefits;
- understand the reasons why clonal rubber can not grow in the traditional rubber agroforestry system, called jungle rubber or 'hutan karet;
- identify the main constraints for the farmers to produce rubber planting material themselves;
- identify the socio-economic constraints (capital, lack of communication, etc) to the adoption of external innovations (clonal rubber).

The objective of the farming system characterization survey (Survey 1) was to characterize farms involved in the SRAP network of on-farm trials and to compare them with non-SRAP farmers, based on identification of the main constraints.

The RAS innovation adoption process survey (Survey 2) aimed to test the hypothesis that farmer organization, according to traditional customary laws ('adat') and social coherence in the village community, is the key factor contributing to the successful integration of external innovations. Surveys 3 and 4 focused on innovation adoption processes and the identification of farmers' strategies according to existing opportunities in the selected areas.

In West Kalimantan province, several governmental and private oil palm projects are currently being developed and will transform the traditional landscape (jungle rubber) into monoculture plantations. The implementation of either a rubber project (SRDP, SRAP) or an oil palm project in a specific village appears to depend on social organization in the village and social links between groups.

The area of West Kalimantan has been partially documented through surveys conducted by SFDP/GTZ in the Sanggau area by Clauss (1991), Momberg (1993), Jong (1994), Sundawati (1993), and Werner (1993). The local Dayak agroforestry systems have been well characterized with emphasis on tembawang (a fruit/timber-based agroforestry system). Village monographs have been prepared in transmigration areas (Sanggau/Trimulia and Sintang/Pariban Baru) by the transmigration department. Dayak farming systems have been characterized by Dove (1993) for the Kantu Dayaks in the eastern part of the province, for the Maloh Dayaks in the same area by V King in the 1980s' and by Salafsky (1994) for the Gunung Palu area (Ketapang district).

Two types of surveys involving four questionnaires were implemented:

- FSS questionnaire: for characterizing farming systems of all farmers through a formal and relatively detailed questionnaire;
- Inno A & B questionnaire: for reviewing the innovation adoption process for SRAP farmers with questions on various innovations of RAS;
- IGPM questionnaire: for assessing IGPM use and production;
- Inno-C questionnaire: for assessing other innovations concerning RAS, such as the innovation adoption process for non-SRAP farmers. This is a limited version of the IGPM questionnaire with emphasis on improved planting material, use of herbicide, and fertilization.

Data were collected between June and November 1997. The software selected for data processing was WINSTAT, which was developed by Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement (CIRAD-TERA).

Sampling scheme for sites and farmers

The benchmark areas of SRAP were selected to cover a wide range of situations in terms of:

- ethnic groups (Dayak, Melayu, Minang, Javanese transmigrants, other spontaneous transmigrants);
- agro-ecological zones (traditional jungle rubber, farmers in forest environment on flat land with good or poor soils, hilly areas in forest margins with low population density, remote hilly areas with poor soils and *Imperata*, *Imperata* savannah and transmigration areas); and

- socio-economic environment (remoteness, access to market, other off-farm or crop opportunities).

Table 1 summarizes the benchmark areas that are representative of almost all rubber growing areas in Indonesia.

***Table 1.* Benchmark site characterization in West Kalimantan**

Factors	*Forest margins with poor soils: traditionaI jungle rubber*	*Forest margins with* poor *soils: jungle rubber + SRDP*	West-Kalimantan *transmigration areas.*
Villages	Kopar, Engkayu	Embaong, Sanjan	a) Pariban Baru (Sintang) b) Trimulia c) Sukamulia
Type of population	Dayak (Christians)	Dayak (Christians)	a) Dayak (Christians) b) Javanese transmigrant (muslim)
Population density	Low with plenty of land	Medium: land is becoming scarce	High with limited land (2.5 ha/household)
Ecological environment	Secondary forest, jungle rubber and tembawang[3], poor soils	Secondary forest, jungle rubber and tembawang, poor soils	Degraded sheet *Imperata* land, poor soils risk of fire
Farmers' behaviour and strategies	Extensive systems, S&B for local upland rice for wine rice only. Accept a low level of intensification.	Extensive and intensive systems (rubber monoculture), S&B for local upland rice Accept a medium level of intensification.	Intensive on sawah; extensive on rubber on uplands. Do not accept intensification on upland.
Main constraints	Low productivity of jungle rubber	Low productivity of jungle rubber. Wrong choice of rubber clone in SRDP: leaf disease limiting the production.	Very degraded land with *Imperata* on a very limited cropping area (2 ha). Risk of fire. Remoteness.
Opportunities	Land is plentiful. Oil palm & pulp. Existing old complex agroforestry practices.	Presence of SRDP/TCSDP project: rubber monoculture in the 1980's. Oil palm & pulp. Existing old complex agroforestry practices.	Sawah off-farm activities.
On-farm trials priority	RAS I and 2	RAS I and 2	RAS 2 and RAS 3

[3] Tembawang are indigenous fruit and timber-based complex agroforestry systems where the main tree may be illipe nut tree.

The selected transects ranged from the traditional forest/jungle rubber environment to severally degraded transmigration areas covered by sheet *Imperata* grassland. *Imperata* and *Mikania* are major weeds that limit the growth of crops.

SRAP used a participatory approach in the identification and implementation of on-farm trials. The criteria for farmer selection for on-farm experimentation ('SRAP farmers') were as follows:

- motivation;
- mutual interest in participatory research;
- willingness to retain agroforestry practices;
- adoption of improved planting material; and

mutual agreement on a trial protocol to be followed for the duration of the experimentation (five years for immature period).

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

- when possible, an initial FSS survey was conducted in order to obtain baseline information and to be able to compare the evolution of farming systems ,
- the presence of existing farmer groups to address the methodology, and
- representativeness of the site.

FSS was conducted with two populations: SRAP farmers and non-SRAP farmers. 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 made, then a random sample taken from these. For each village, the same number of SRAP and non-SRAP farmers was taken.

In villages where no on-farm trials were implemented, but where SRAP had some activities (budwood gardens and rootstock nurseries), farmers were selected from those belonging to a SRAP budwood garden group (village of Sanjan) or those having nursery activities (Sukamulia).

As emphasis is put not only on characterization, but also on the innovation adoption process, the farmers' sampling method is based on an initially selected population (SRAP farmers) with additional non-SRAP farmers (with no access through SRAP to inputs or information) as a control.

It is hypothesised that the characterization of farming systems will improve understanding of the farmers' strategies regarding either the adoption of external innovations or the maintenance of traditional cropping systems for each village.

Farming systems characterization (Survey 1)

The survey of the farming systems practised by Dayak farmers and Javanese transmigrants aimed to identify the different resources used by the farmers (land, labour force, capital) in order to compare the different cropping systems (rubber and rice) in terms of labour and land productivity (See Figures 1 and 2). This was used to develop a classification of village situations. The characteristics of the farming systems are based on rubber and on subsistence cultivation in low-land (sawah), upland (ladang), tembawang (associated fruit and timber trees) and home garden (pekarangan).

Figure 1. **Ethnic group**

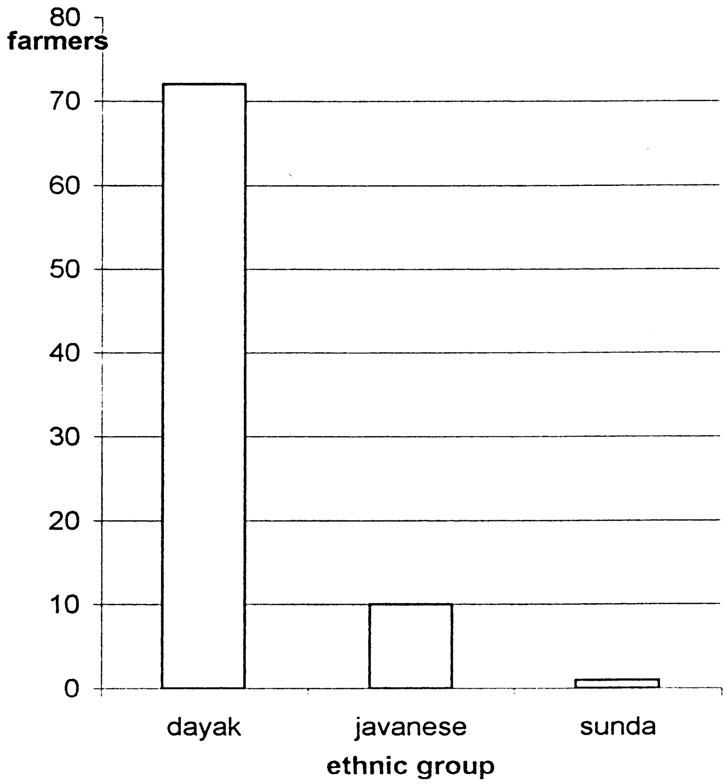
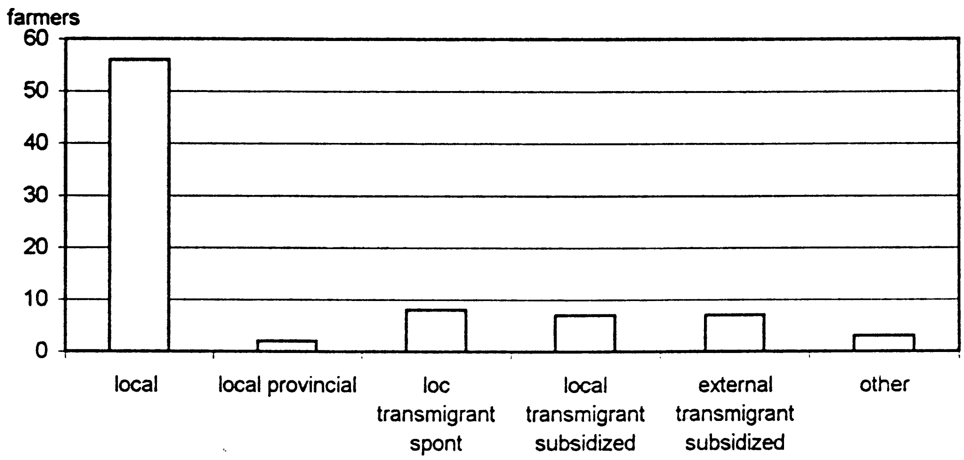


Figure 2. Origin of the family



The main factors which influence farmers' strategies for land use are social interactions in the village, availability of inputs, and the presence of clonal rubber projects in the area. The main criteria which explain the farming practices are: 1) ethnic group, 2) total area of cultivable land, 3) access to customary land, 4) lack of capital, 5) lack of technical information on IGPM production, and 6) off-farm activities.

Traditionally, Dayak farmers practice an extensive system due to the abundance of land, whereas Javanese transmigrants practice an intensive system, especially on sawah, due to the scarcity of land (only two hectares are provided to transmigrants). The Javanese also compensate for this with off-farm employment.

In Sanjan village, one farmer said, "The last time I used my plots of sawah and ladang was three years ago. Now, working in sawah and ladang is considered a minor farming activity". The farmers here prefer to use their labour for tapping clonal rubber, which generates a far higher return to labour (Penot 1996). This evolution has a constraint: farmers now have to buy rice.

Rubber cropping systems

Traditional jungle rubber is dominant in Dayak villages: 90% of the rubber area in Engkayu and 65% in Sanjan. The average area is two ha per farmer (Table 2). At the present time, many farmers think that they have a sufficient area of jungle rubber for their available labour. Embaong and Sanjan villages have clonal rubber from SRDP/TCSDP monoculture projects, with clones GT1, PR261 and AVROS 2037. The main problem is that clone GT1 is susceptible to the leaf disease *Colletotrichum*. This causes leaf fall, which reduces the tree's latex yield. In addition, the amount of shade cast by the tree is reduced, so weeds such as *Imperata cylindrica* can become a serious problem. The average yield of GT1 in SRDP/TCSDP plots is around 1200 kg/ha compared to that of jungle rubber (500 kg/ha) (see Table 3).

***Table 2.* Average area of rubber cropping systems per village**

Average area/farmer per village (ha)	Engkayu	Suka-mulia	Pariban Baru	Sanjan	Embaong	Kopar	Trimulia	Bali
Local rubber	3.96	1.83	1.62	3.02	0.69	2.58	0.85	3.35
Clonal rubber	0.5	-	1.64	2.43	2.12	0.5	0.5	-
Productive area (%)	40	27	36	42	53	49	25	47

***Table 3.* Average latex yield (kg/ha) per cropping system**

Village	Engkayu	Sukamulia	Pariban Baru	Sanjan	Embaong	Kopar	Trimulia	Bali
Local rubber	485	444	452	534	567	465	420	479
Clonal rubber				1160	1128			

The choice of RAS trial by farmers differed between villages according to farmers' available labour and farming strategies. In Embaong village, all SRAP farmers have chosen the RAS 1 system, which is similar to jungle rubber with limited inputs and labour, but where the unselected rubber seedlings are replaced by adapted clones. On the other hand, in Engkayu, the RAS 1 system is most popular, but some farmers have chosen the other systems RAS 2 and RAS 3. RAS 2 is largely dominant in the Javanese transmigrant villages, because it is based on annual intercropping during the first two to three years and also offers income production during the immature rubber period. RAS 3 has no intercrops except during the first year, during which time a combination of covercrops and pulp trees are used.

No inputs are used in the jungle rubber system. Fertilizers (Urea, KCL, TSP 36, Dolomite), herbicides (Round Up) and pesticides are provided by projects. With income from rubber, farmers invest in herbicides (Round Up). Fertilizers are usually reserved for the immature period.

Sixty-five percent of the farmers tap on average one hectare of rubber per day. The fishbone ('V'-shaped) tapping system is the most commonly used in the jungle rubber; the 1/2 S is used for clonal rubber. Most of the farmers tap 200 to 300 rubber trees per day (Figure 3). Share-tapping is not popular as these workers generally do not use very sustainable tapping practices. In general, tapping quality is rather low in jungle rubber, partly explained by: 1) lack of information on suitable tapping systems, and 2) large variation in yield per tree due to the characteristics of the seedling population. The requirement for resting the trees results in farmers adopting the tapping system of D2/6/7 (Figure 4).

***Figure 3.* Number of rubber trees tapped per worker per day**

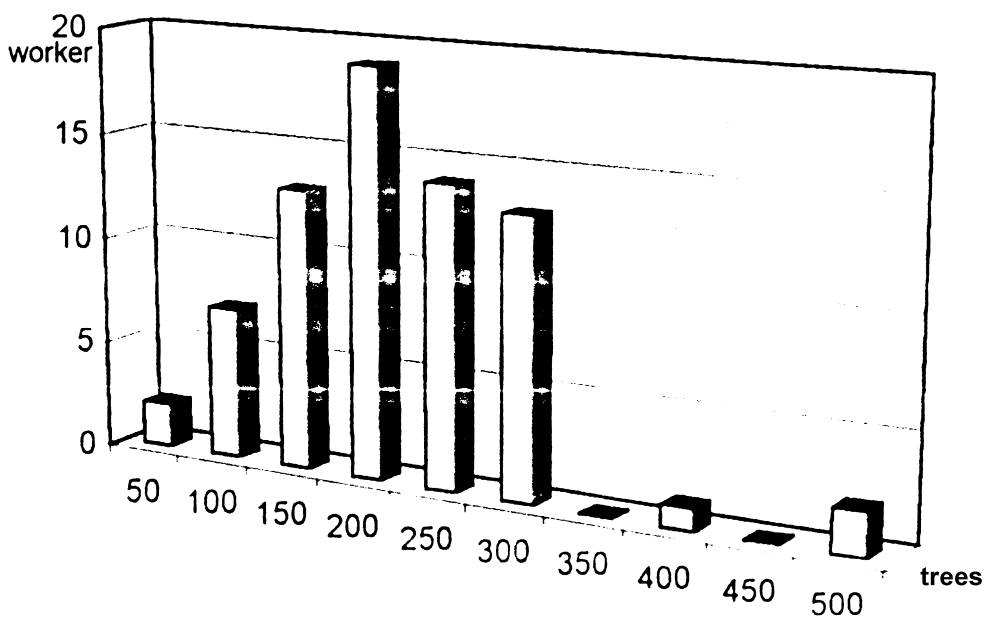
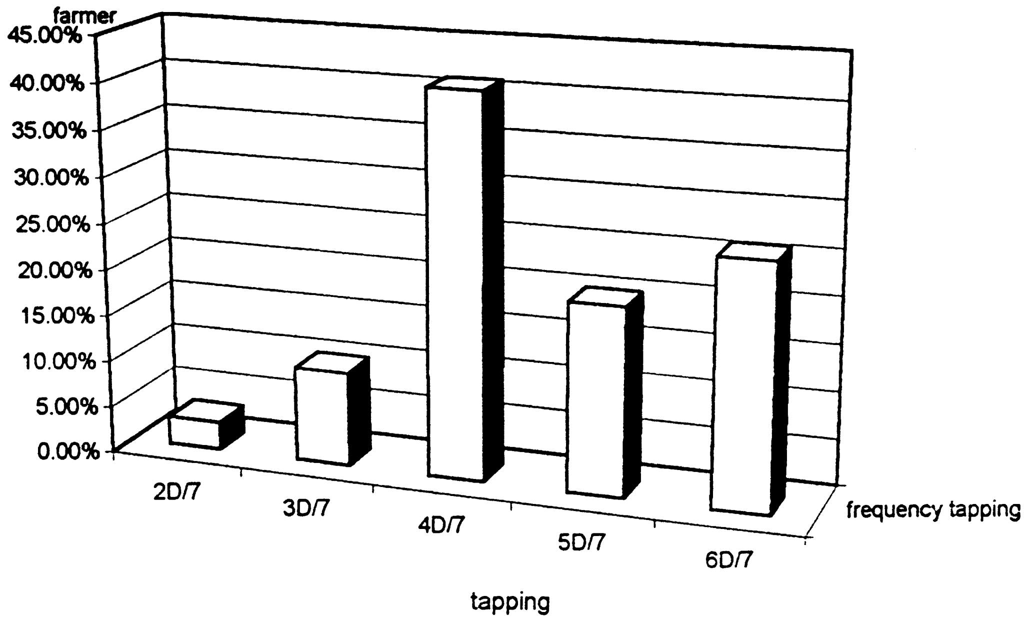


***Figure 4.* Frequency of tapping (days per week)**



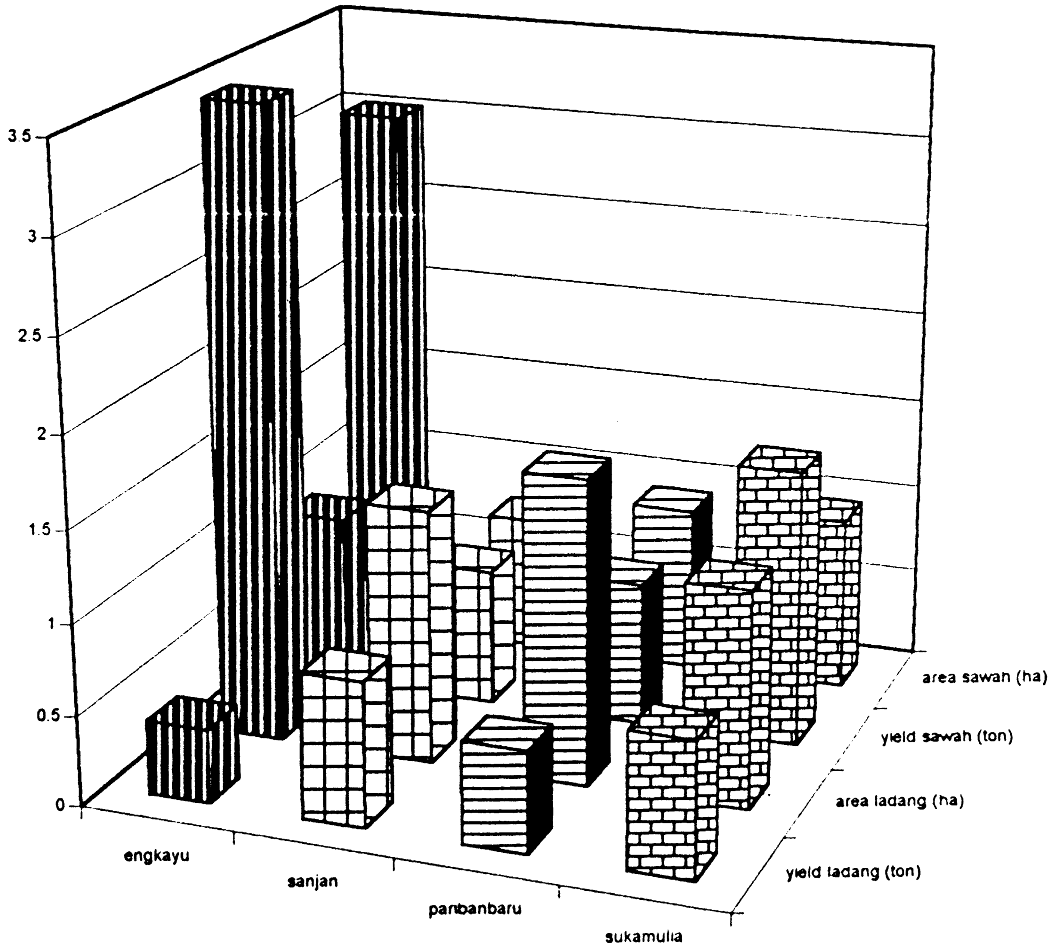
The annual cropping system in Dayak and Javanese villages: Sawah and Ladang

Dayak farmers traditionally produce rice on both sawah and ladang, whereas Javanese farmers prefer to concentrate their labour on sawah. Upland rice is generally considered by Javanese farmers to be too risky. If we compare the cropping calendar of sawah and ladang, Dayak farmers had to manage their time and their labour force to produce rice in both systems. The tradition of using 'gotong royong' (communal labour groups) allows farmers to manage both sawah and ladang labour requirements.

Average rice yield in sawah	Average rice yield in ladang
Local varieties: 756 kg/ha/yr Improved varieties: 1560 kg/ha/yr	Local varieties: 396 kg/ha/yr

If we compare sawah rice yields in a Javanese transmigrant village to those in a traditional Dayak village, the average yield for Javanese is about twice that of the Dayak farmers (Figure 5). Dayak farmers do not use any inputs in sawah and use a limited number of local irrigated rice varieties. They say the input costs are too high and are not compensated by a sufficient rice yield. For Javanese farmers, their first priority is to produce rice in sawah. The high yields however do not seem to offset the investment in labour, fertilisers, chemical treatments, and hiring draught power for ploughing (Rp 7000/day).

***Figure 5.* Average area and yield of rice fields in sawah and ladang**



The rice yield in ladang is low because of the presence of insects 'walang sangit' (*Leptocorisa acusa*), 'ulat grayak' (*Spodoptera letera*), and rodents. The production of rice in ladang by the Dayak farmers is essentially reserved for the production of local wine ('tuak').

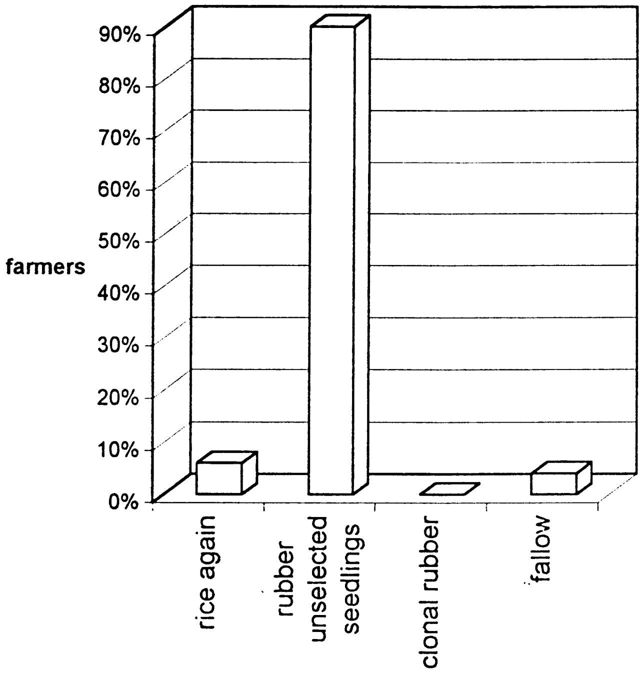
In 1997, the main constraint in ladang was the severe dry season because farmers usually plant rice at the beginning of September. The erratic rainfall is a major constraint and there was shortage of rice. Meanwhile, rubber production was also low due to the drought, which led to a dramatically reduced income for that year.

Outside transmigration areas, lack of land does not seem to be a constraint, especially for Dayak farmers. However, the current implementation of oil palm projects will reduce the total cultivable area in the very near future.

The cropping system after rice harvest in ladang

After harvesting rice in ladang, 85% of Dayak farmers generally plant unselected rubber seedlings as a means of land appropriation. Only 12% continue to grow rice in ladang in the second year (Figure 6). Continued upland rice production is not favourable in terms of return to labour, especially taking into account the risk of crop failure, compared to jungle rubber establishment. Jungle rubber requires no establishment cost (unselected seeds with no value and no fertilizers used), a low labour investment, and low maintenance during the immature period (Penot 1997).

Figure 6. **The cropping system after harvesting paddy in ladang**



<u>"Round Up": an alternative to reduce weeding on sawah and ladang and the constraints of gotong royong and 'bakti' systems</u>

Dayak farmers use the gotong royong or bakti system to prepare or weed a plot of sawah or ladang. These systems involve communal labour for farming activities. Gotong royong is flexible but expensive. For one group, the number of members is not fixed. The price of gotong royong depends on the number of persons and might take into account farmers cash flow at a particular moment. The bakti system is not flexible and is more expensive. There is a fixed number of members and farmers have to work a specific number of days. If one member can not work one day, he must pay for a replacement or send a member of his family. The price of one day in this work group depends on the price of rice and rice wine (tuak) on which basis people are paid. In 1997, the average price was around Rp 5000/man-day, whereas five and ten years ago, the average price was Rp 2500 and Rp 1000/man-day respectively. The opportunity cost for labour has increased, and in the future, with increased opportunities for off-farm work in oil palm plantations, the price of gotong royong is likely to increase further.

With the income from rubber, a farmer can buy herbicide (Round Up, Spark) and pesticide (Dharmabas). The weeding cost is lower using Round Up than using communal labour. For one hectare of sawah, a farmer uses four liters of Round

Up and needs two days. The total cost is around (Rp 90,000). If a farmer uses the gotong royong group for weeding one hectare of sawah, he needs to employ 20 men over three days. The total cost is around Rp 120,000 (Kopar village). By using herbicide, there is a greater return to labour and also the treatment is more effective against weeds than manual weeding.

Return to labour and productivity

Now that the main cropping systems have been described, the next step is to compare these cropping systems in terms of return to labour and productivity per unit area of land. This analysis will allow us to understand the different cropping strategies adopted by different farmers.

With the development of oil palm projects in Kalimantan province, a new opportunity for income diversification has arisen with the added benefit of credit provision for this new technical package. Oil palm is becoming a significant competitor with rubber. That is why an oil palm village was included as part of the survey to compare the incomes of oil palm smallholders with rubber smallholders.

Land resource management

The average total land area cultivated by Dayak farmers is around 14 to 18 ha (including fallow) compared with Javanese farmers who have only two hectares. The strategy of land resource management is therefore very different for Dayak and Javanese farmers. In Javanese villages, the limited land encourages Javanese farmers to concentrate their labour to rice production in sawah (2 crops/year). Usually, the 'lahan satu' and 'lahan dua' are used for rubber nurseries and for producing vegetables for their own consumption and for sale. The Javanese farmers do not cultivate rice on their upland fields.

The survey of the Dayak villages shows different management of land resources. For example, Engkayu village is a traditional Dayak village where farmers do not concentrate their labour force on one cropping system. There it is a custom to plant rice every year in the ladang. On average, farmers own 2.5 ha of sawah, 3 ha of ladang, and 4.5 ha of rubber, mainly jungle rubber. Farmers have owned a small area of clonal rubber (0.5 ha) as part of the SRAP project since 1995.

In contrast, Sanjan village is a progressive Dayak village, where farmers concentrate their labour force on one cropping system: rubber plantation (monoculture and RAS). This village shows the evolution of the traditional farming system after the adoption of clonal rubber. The average area of rubber plantations is 4.5 hectares, including both monoculture plantation and jungle rubber. In this case, the income from rubber allows farmers to reduce the area of ladang and sawah, because they can buy rice. Since 1982, the SRDP project has planted 20 hectares with GT1 clone. The success of the rubber project is due to social factors. The village leader had enough influence to promote rubber planting instead of oil palm. The leader of Sanjan village explained that the motivation for choosing rubber instead of oil palm was that farmers will lack land for their annual crops with the oil palm plantation. In addition, farmers who mix trees with rubber will also benefit from fruit and seed production (Table 4).

Table 4. Average area per cropping system per village

Village/ Cropping system	Eng-kayu	Sanjan	Pariban-Baru	Suka-mulia	Kopar	Trimulia	Embaong	Bali
Sawah	3.02	0.75	0.92	0.96	2.9	0.72	0.57	0.7
Ladang	3.47	0.75	1.66	0.75	2.46	0.29	0.83	0.85
Clonal rubber	0.5	2	1	0	0.52	0.31	2.12	0
Jungle rubber	4.71	3.45	2.32	1.49	3.96	0.85	0.69	3.35
Tem-bawang	1.2	2.37	1.05	0	0.53	0	0.74	0.92
Fallow	4.08	4.6	1.41	0	1.53	1.31	3.15	9.7
Home garden	0.01	0.01	0.48	0.25	0.12	0.2	0.1	0.27
Oil palm	0	0	0	0	0	0	0.38	2
Total	16.99	13.93	8.84	3.45	12.02	3.68	8.58	17.79

Land tenure and rights

All Dayak households have equal rights and access to communal land. Forest and communal land belong to the community. Farmers can borrow communal land for making ladang. The Dayak people have no problem in accessing communal land. However, the Javanese people are limited to only 2 ha of cultivable land, this given as part of the transmigration programme (0.25 ha pekarangan, 0.75 ha lahan satu, 1 ha lahan dua). Not all Javanese farmers received the lahan dua and in exchange received a cow.

Each Dayak child usually inherits equal amounts of land from his parents, Usually, the child who will care for the parents when they retire will receive a little more land, often the tembawang. The Dayak farmer may borrow land from the community or from the family. A farmer who wants to cultivate a piece of communal land only has to ask for permission from the village head or the owner. Farmers may borrow communal land if they do not possess enough land to complete the duration of fallow on the ladang. The average duration of fallow is 6 years in Engkayu, 4.5 years in Sanjan and 5 years in Pariban Baru. Sometimes, the village head has difficulty in allocating land because fruit trees or rubber may have been planted by some families on the communal land. Planting trees around or inside a plot is a land acquisition process for the farmer. If a farmer of Engkayu village clears a piece of communal land without permission, he must pay a fine of 2 pigs, 25 kg rice and 96 pieces of china crockery. The standard ‘fee’ for using communal land depends on the community. The system is often based on a sharing of the harvest (‘bagi hasil’), where for every 10 jarai of rice harvested, 1 jarai is given to the community. Profit from the sale of this rice is used for the maintenance of communal equipment. Farmers can also borrow land from other farmers and will share the rice production with the owner (30% for the owner).

Price of land

The price of land depends on the type of land and its location, but also on the availability of land in the area. It is difficult for farmers to evaluate the price of land on a per hectare basis as they consider each plot individually. They assess land value in terms of ecological characteistics. Two types of land are usually bought by farmers: sawah and upland fields for rubber planting. Farmers buy land to increase their production of rice and their income from latex production, but also as an investment for their children. In Engkayu, farmers prefer the acquisition of sawah, while in other villages farmers buy both sawah and land for rubber planting. With the arrival of oil palm plantations in the Sanggau area, the land price has increased. For 7.5 ha of land given to the oil palm project, farmers receive only two hectares of oil palm. With the establishment of an oil palm plantation, shortage of land will be a problem in the next few years because farmers will not have enough land to pass on to their children. This could lead to some children being forced to leave the village.

The investment cost for an oil palm plantation is higher than for a rubber plantation (SRDP 1982) as one hectare of rubber costs Rp 1.4 million compared to Rp 4.5 million for 2 ha of oil palm, plus the 'loss' of 5 ha of land which has to be given to the project (Table 5).

***Table 5.* Price of land**

Ethnic group	Village	Cropping system	Area	Price (Rp) + year
Dayak	Engkayu	Jungle rubber immature	1 ha	170,000
Dayak	Engkayu	Jungle rubber	1 ha	250,000
Dayak	Engkayu	Fallow	1.5 ha	25,000
Dayak	Lape	Sawah	0.25 ha	300,000
Dayak	Bali	Jungle rubber	2 ha	300,000 (1976)
Dayak	Bali	Oil palm	2 ha	12,000,000 (1992)
Javanese	Trimulia	Ladang	1 ha	800,000
Javanese	Trimulia	Jungle rubber	1 ha	400,000
Javanese	Trimulia	Sawah	1 ha	950,000
Javanese	Trimulia	Sawah	1 ha	2,000,000 (1990)
Javanese	Pariban baru	Jungle rubber	1 ha	500,000 (70 trees)

Annual income from land

In the village of Kopar where there is a lack of land due to an oil palm plantation, farmers' perception of the value of land has increased. Land is now considered a very precious resource.

In terms of the income per unit area of land, the clonal rubber plantation yields more than the jungle rubber system (Table 6). Differences in latex yield in jungle rubber depend on the age of the plot, the tapping method used, and the latex price. In Engkayu village, the latex price is Rp 1200 per kilo compared with Rp 1900 per kilo in Embaong village. The higher price is due to farmers belonging to a cooperative and selling their production directly to the factory in Pontianak. The revenue from monoculture rubber plantations is limited due to the susceptibility of GT1 clone to leaf disease (*Colletotrichum*). Average annual yield of GT1 in SRDP/TCSDP plots is around 1200 kg/ha compared to that of jungle rubber (500 kg/ha). When comparing revenue from monocultural rubber plantations in Embaong village (Rp 2,285,000) and clonal rubber agroforestry systems in Sanjan village (Rp 2,021,000), there is only a very small difference between the two systems. The agroforestry system is almost as profitable as monoculture and has the added advantage of production of fruit and timber, which can provide extra income.

***Table 6.* Comparison of different cropping systems in terms of income per unit area**

Cropping system	Net income (Rp/ha/year)
Jungle rubber	**820,000**
Agroforestry and Monocultural Clonal rubber plantation	2,124,000
Sawah: improved varieties	460,000
Sawah: local varieties	248,000
Ladang	289,000

The comparison of income between ladang and sawah (with improved varieties) is clearly in favour of the later**.** However, the amount of labour and inputs is much higher in sawah than ladang. In both cases, jungle rubber's income is higher than rice cropping? It seems, therefore, more profitable for the farmer to invest his labour in tapping mature jungle rubber than in cropping rice which is far more risky dur to climatic events. It also shows that the improved technological package for sawah does not work, or is not adapted, or is misused by farmers.

The land remuneration in ladang is low due to the low yield because farmers use only local rice varieties and no inputs. Rice cultivation in ladang is expensive due to the traditional custom of work groups (gotong royong: Rp 100 to 300,000) and its cost (in particular the cost of an important component: rice wine or 'tuak').

Annual labour requirement per cropping system

Rubber cropping systems

In general, farmers who own clonal rubber plantations invest three times more work in weeding than those having jungle rubber (six man-days/year against two). The immature period for clonal rubber is around five years, compared with around 10 to 12 years for jungle rubber. In clonal monoculture, pernicious weeds like *Imperata* are more likely to become a problem than in jungle rubber, especially if the clones suffer from leaf disease and leaf fall. Communal work groups can be used for the annual weeding programme for the rubber plantation.

Time spent tapping is reduced in the monocultural system (58 man-days/year) compared to jungle rubber (man-days/year). As rubber is planted in lines in the monocultural system, tapping and weeding are easier. If the rubber plantation is far from the house, it can be difficult to carry the rubber sheets and also to increase the frequency of tapping. Around 70% of the farmers tap their rubber plantation the whole year. The tapping systems most commonly used are D2 (tapping every two days), or D2 6D/7 (tapping every two days with a Sunday rest) (Table 7).

***Table 7.* Comparison of annual labour requirements in rubber cropping systems**

Cropping system	Weeding	Tapping	Collecting latex	Total (man-days/year)
Jungle rubber	2	72	8	82
Monoculture	6	58	6	71

Sawah

The annual labour requirements are higher in sawah with improved rice varieties because farmers spend more time weeding (Table 8). This ensures an efficient use of inputs and increases the potential yield. In some villages, herbicides are used (Round Up) for weeding sawah in order to save labour and also to avoid use of community work groups which are considered to be too expensive. Dayak farmers take longer to harvest the rice as they harvest it stem by stem with an ‘ani-ani’ tool (razor blade), whereas Javanese farmers use a sickle.

***Table 8.* Comparison of annual labour in sawah for different rice varieties (man-days)**

Type of rice varieties	Ploughing	Transplanting	Weeding	Harvest	Total
Improved	28	27	69	27	151
Local	22	26	50	36	134

Ladang

The annual labour requirements of ladang are higher than those of sawah with improved rice varieties (Table 9). This is because in sawah the farmer has only to weed and burn, compared with ladang where he has to cut trees and slash weeds before burning. It seems more efficient for the farmer to invest his labour in sawah as there is a greater income per unit land and also a higher rice yield (1560 kg/ha/year compared to 396 kg/ha/year in ladang) due to use of local varieties and no use of inputs. However, sowing rice in ladang is a tradition for Dayak farmers because they can use it to produce the local alcohol (tuak). Several factors affect the annual labour requirements for ladang: the fallow age (28% between two and five years) and the use of community groups or family labour. Risks of crop failure are high due to erratic rainfall, and the low soil fertility leads to low yields. The main reason that Javanese farmers do not want to grow upland rice is the risk involved.

***Table 9.* Annual labour requirements for activities in ladang (man-days)**

Cropping system	Land preparation	Sowing	Weeding	Harvesting	Total
Ladang	39	26	59	29	153

Returns to labour for different cropping systems

Productivity per unit of labour is very important to farmers. In areas where land is abundant, extensive cropping systems are used as a source of "income from forest products" and are synonymous with "low risk" of crop failure. Analysis of returns to labour for different cropping systems will allow us to understand the farmers' land use strategies.

***Table 10.* Comparison of returns to labour for different cropping systems**

Cropping system	Revenue per man-day (Rp)
Jungle rubber	9600
Clonal rubber	27200
Sawah: improved rice varieties	8100
Sawah: local rice varieties	4000
Ladang	2100

The labour investment (for tapping) in mature clonal rubber is less than that for jungle rubber and returns to labour are Rp 27,000/day and Rp 9,600/day respectively (Table 10). Thus once the trees are mature, the advantages of clonal rubber in terms of return to labour are clear. However, the main constraints of clonal rubber are the high level of maintenance in the immature period, the cost of improved rubber planting material and inputs, and lack of income during the first five years. In contrast, the jungle rubber system is a low-input agroforestry system that requires little investment and little labour during the immature period, and also provides diverse products, such as fruit, timber and NTFPs.

The surveys in Sanjan and Embaong villages showed that with the adoption of improved planting material, trees could be tapped at five to six years of age compared to 13 to 15 years for jungle rubber. With more weeding (e.g., once per year) in jungle rubber, farmers could tap rubber at around 10 years of age. A local seedling rubber plantation with high maintenance like that of clonal rubber, could be tapped at around six to seven years of age, however, the labour investment would not be recovered as latex yields are very low (500 kg/ha/yr.).

Javanese farmers have chosen the RAS 2 because they can grow rice during the first two to three years of the immature period as an intercrop. They focus on the maximization of land use due to the fact that their land area is very limited. Another strategy is to choose RAS 3 for the farmers who do not want to invest a lot of labour in the rubber plot during the immature period and who want to grow only one crop of rice, considering that the risk of crop failure is too high for the second or the third year.

The return to labour in sawah with improved rice varieties is twice that if local rice varieties are used, mainly due to the rice yield. However, to make up for the extra cost of improved rice varieties, inputs and labour, the rice yield would have to be at least two to three times higher than the yield of local rice.

The low return to labour in ladang is mainly due to low yields caused by natural risks like rodents, insects, diseases, erratic rainfall and weeds. These low yields do not offset the time spent in cutting trees and the expense of group weeding.

The difference in returns to labour for different cropping systems explains the progressive decrease of upland rice cultivation in favour of rubber plantations. Farmers reason in economic terms, especially with respect to labour, and they have prioritised investment in perennial crops (in particular rubber) because they get more income with less work and the risk of crop failure is lower, especially compared to upland rice. The income from latex allows the farmer to buy rice to meet his farmily's annual requirement. But this expense limits the farmer from investing in inputs during the immature rubber period or for food crops.

The superiority of rubber cropping systems in terms of income generated

In Indonesia, the farm gate prices are not based on latex quality. The price of rubber sheet is based only on the weight. Forty-four percent of farmers sell sheets in the village and 56% sell outside the village. There is no contract with the trader. Farmers can sell their production to whoever offers the best price. However, selling sheets in the village allows farmers to negotiate credit during the period that they need to buy rice. The price of one kilogram of sheet goes down during this period (October to December). Selling their production in the village can provide farmers an income every day, whereas sale in the town involves waiting until the end of week, and also the additional cost of transport. The average price in the Sanggau district was around Rp 1100/kg (1997). The cost of inputs is low in jungle rubber, comprising only acid for coagulation (Rp 25,000 to Rp 30,000/year). The cost of inputs in clonal rubber plantations is higher because of purchase of herbicide for *Imperata* and due to the leaf disease of GT1 clone. However, this cost is largely recovered from the high income generated by clonal rubber plantation.

The analysis of income from the different rubber cropping systems shows the superiority of clonal rubber cropping systems from the perspective of maximisation of land productivity and return to labour.

For the rubber cropping systems, we can describe two types of situations:

- Villages where income generated by the jungle rubber system is low and actually lower than the income generated by oil palm plantations (Kopar, Engkayu and Bali) (Table 11). This fact shows that for rubber to compete, farmers have to improve their rubber cropping system by adopting technical innovations (improved planting material). The adoption of rubber agroforestry systems (RAS) is an opportunity for farmers to improve their income. The length of the immature period depends on the quantity and quality of work invested by the farmer to maintain their RAS. Despite the small area of RAS (0.5 ha), these trial plots should be the first step in helping the farmer to change from jungle rubber to clonal rubber agroforestry.
- Villages where the income generated by clonal rubber is 2.5 times higher than jungle rubber. This income can be further improved by 30% if farmer uses the D/3 tapping system. Also, the new clonal rubber agroforestry systems will produce more latex due to the use of new clones which have a faster growth and better leaf disease resistance than GT1 (e.g. PB260, RRIM 600, BPM1, RRIC 100). This situation show the relative difficulty for farmers to change their rubber cropping systems from a very extensive to a semi-intensive cropping system due to labour investment requirements during the immature period.

***Table 11.* Comparison of income generated by different cropping systems (Rp/year)**

Village/ Cropping system	Engkayu	Suka-mulia	Pariban Baru	Sanjan	Embaong	Kopar	Trimulia	Bali
Rubber	837,000	596,000	807,000	2,263,000	2 ,177,000	574,000	750,000	990,000
Sawah	387,000	437,000	489,000	302,000	278,000	272,000	332,000	212,000
Ladang	146,000	206,000	367,000	272,000	129,000	283,000	112,000	396,000

The integration of some improved rubber (‘karet lambau’) to the Sejiram area (Sintang area) by a priest (from the order of Capuchins) in the 1920s greatly changed the local farming systems. Appreciation of the income generated from latex and the high risks of annual crop failure in upland fields have progressively modified farmers' strategies. For the majority of the farmers in 1997, the income from rubber constituted between 70% and 100% of farming incomes and more than 50% of the total annual income. However, an evolution of this farming system is now necessary. The income provided by clonal rubber shows that the rubber income can be increased by a factor of 2.5, however, this evolution includes three constraints: need for capital, use of improved technology, and a lot of work during the immature period. The implementation of RAS can be limited by two constraints: capital and labour.

Analysis of total annual revenue per village

The total annual income includes both farming and non-farming income (Table 12). Non-farming income is more important in the transmigration villages like Sukamulia or Trimulia, where 80% of farmers are involved in this type of activity. The off-farm income can be as much as 75% of total annual income. For the SRAP farmers of Sukamulia, when the clonal rubber agroforestry will begin to produce latex, farmers will be able to compare the regular income provided by latex to the irregular income from outside work. Some farmers in Trimulia have understood the advantages in investing their capital in clonal rubber agroforestry systems by establishing these on their upland fields. The development of clonal rubber agroforestry systems is an opportunity for the young people to get an income and to stay in the village. The establishment of a clonal rubber plantation does not require a prohibitive amount of capital. Although farmers have to invest in inputs and work during the immature period, the establishment cost of one hectare in RAS 1 is around Rp 500,000 and the future income generated constitutes a sufficient asset.

***Table 12.* Total annual revenue per village**

Village	Bali without oil palm credit	Bali with oil palm credit repaid	Embaong	Engkayu	Kopar	Pariban Baru	Sanjan	Suka-mulia	Trimulia
Annual income (,000 Rp/year)	4405	1714	2007	1173	1079	2147	1954	2783	1345
Main source of income	Oil palm	Oil palm	Clonal rubber	Jungle rubber	Jungle rubber	Jungle rubber + off-farm	Clonal rubber	Off-farm + clonal stumps pur-chase	Off-farm + rice sawah

The annual income for Bali farmers is twice that of Embaong farmers because of income from two main sources: oil palm in its high production phase (planted in 1983) and jungle rubber. However, when the oil palm credit installments for the Bali farmers are annually taken into account, (for a total credit of Rp 11.5 million to be repaid in seven years), the net annual income is lower than the income from clonal rubber plantation. This shows that oil palm credit seems to be difficult to repay during the first years of production (year 3 to 7), due to the fixed rate (30% of the monthly production) taking into account the fact that farmers expectations are rather high. However, oil palm income per hectare is far more attractive that that of jungle rubber. Although their income can be high, oil palm smallholders are obliged to sell their production to a specific factory and cannot negotiate the price. A major drawback for oil palm smallholders is their lack of independence and freedom. Another problem for farmers in oil palm schemes is the need to replant oil palm after 20 or 25 years of production.

For the local Dayak farmers, who do not have a rubber project like TCSDP or SRDP, the annual income is modest due to the low latex production in old jungle rubber. For the progressive villages, like Sanjan or Embaong, farmers have understood the advantages of clonal rubber compared to local rubber (better yield), although the choice of clone (GT1) was not the best. With the development of budwood gardens, choice of clones more resistant to leaf disease (e.g., PB260), and social cohesion, the establishment of new clonal rubber agroforestry systems in ladang began in Sanjan village.

For the transmigrant villages, off-farm employment constitutes a short-term strategy, as in Sukamulia. These farmers have chosen to invest in production of clonal stumps for sale, which requires an annual investment of Rp 579,347, similar to RAS 1. The profit from the sale of stumps is higher than the annual income from clonal rubber plantations in Sanjan or Embaong village (Rp 3,714,402) (Schueller 1997). However, this short-term strategy does not allow the farmer to invest in land for his children.

A typology of Dayak and Javanese farming systems (see Table 13)

We can describe three types of farming system according to the following criteria:

- Ethnic group: adoption of innovations will not be for the same reasons for Dayak and Javanese transmigrant farmers.
- Total cultivable area of land: a strategy of Javanese transmigrants is investing capital in land purchase as a way to increase their incomes and also for their children.
- Access to customary land.
- The lack of capital: the difficulty of obtaining credit at low interest rates. Dayak societies traditionally distribute capital amongst members by organizing feasts.
- The lack of technical information on IGPM production: access to technical information, lack of communication between farmers.
- Off-farm activity (oil palm).

***Table 13.* Classification of farming systems in Sanggau and Sintang area**

Farming Systems	Ethnic group	Population density	Ecological	Access to communal land	Cropping systems	Off-farm	Constraints	Innovations
Intensive system on sawah	Javanese	High	Low land degraded, poor soils	Difficult	Sawah (0.75 ha): 2 crops paddy/year+fertilizer+herbicide Yield=1.5t/ha Lahan satu + dua (1 ha): Vegetables + rubber nursery Pekarangan (0.25 ha): high density fruit trees (>70) + budwood garden	Oil farm	Limited land area (2 ha) Problem of *Imperata cylindrica*	Rent draught labour for sawah IGPM production for sales
Extensive system traditional	Dayak	Low	Upland, secondary forest, poor soils	Easy	Sawah (3 ha)+ 1 crop paddy per year, no fertilizer+herbicide Yield = 0.95t/ha Ladang (3ha): 1 crop paddy per year (rice wine) no fertilizer + herbicide Yield = 0.5 t/ha Jungle rubber (4.7ha): yield = 0.5t/ha fallow (4 ha) tembawang customary land or private: (1 ha) access to wood and timber	Oil palm Cut wood and limited harvest	Social: lack of communication 3 social groups: - RAS adoption - kelapa sawit adop tion - traditional Absence of fertilizer in sawah and ladang Gotong royong Lack of capital for	Jungle rubber to RAS 1/2/3 Oil palm private plantation Production of vegetables with chicken fertiliser

Farming Systems	Ethnic group	Population density	Ecological	Access to communal land	Cropping systems	Off-farm	Constraints	Innovations
							buying clonal stump + fertilizer No prod budwood	
Extensive Intensive system based on rubber	Dayak	low	Upland, secondary forest, poor soils (sandy)	easy	Sawah (0.75 ha): 1 crop per year + herbicide Yield=0.75t/ha Ladang (1.5 ha): 1 crop per year Yield = 0.8 t/ha Jungle nibber (3.5 ha Yield = 0.5 Out Monoculture (SRDP) (2 ha) Yield= 1.6 t/ha Tembawang (2.4 ha) Fallow (4 ha)	Trading wood and timber harvest	Lack of capital to buy fertiliser Leaf disease (colletotrichum) limiting production rubber on GTI clone	Monoculture to RAS (no oil palm project) Herbicide to sawah and ladang Diminution area+sawah: concentration labour force on tapping rubber (mono culture) IGPM prod in private and collective nursery for replanting Several mutual group (budwood gardcn)

Traditional Dayak extensive system (villages of Kopar and Engkayu)

Traditionally, Dayak farmers practice an extensive agricultural system based on rubber, due to the abundance of land and easy access to customary land. The traditional cropping systems are based on cash crops (jungle rubber) and subsistence crops (rice) in sawah and ladang. After harvesting rice in ladang, 90% of farmers establish jungle rubber with unselected seeds as a means of land acquisition. Despite this, farmers still have a limited area of jungle rubber, generally corresponding to an area that can be tapped by the available labour of the household.

Because of a lack of communication between farmers and the social pressure for equity, only a small proportion of farmers are interested in investing their labour in different types of rubber agroforestry systems. The other farmers are either still undecided on whether to invest in RAS or oil palm projects or to keep their traditional jungle rubber. Risk avoidance is also a major component of their strategy. Although they know that they have to adopt some innovations to increase their overall productivity, any introduction of innovations potentially increases risks. A general observation on farmers' attitudes in these villages is that farmers are not thinking of the future and are not investing in the next generation. The situation in Bali village is typical of traditional Dayak farmers who have adopted oil palm, and where the system of group labour has become a social constraint, compared with rubber smallholders who can manage their time freely.

Intensive system using clonal rubber: Dayak people (villages of Embaong, Paribanbaru and Sanjan)

The villages of Embaong, Paribanbaru, and Sanjan have successfully adopted innovations. The introduction of clonal rubber planting material in combination with the progressive attitudes of the farmers has led to a replacement of the extensive agricultural system with an intensive system based on clonal rubber. In Sanjan village, this process has been in operation for 15 years. Farmers consider ladang and sawah cultivation as secondary farm activities. Farmers prefer to concentrate their labour force on their rubber monoculture, an agroforestry clonal rubber plantation. Clonal rubber stump production is seen as a means to increase clonal rubber area. Farmers use community group labour (gotong royong) to produce rice and rubber. The cost is increasing due to increasing off-farm opportunities (oil palm plantations). With the income from rubber, the use of herbicide (Round Up) is becoming an alternative to reduce costs for gotong royong weeding in sawah, ladang, and rubber.

Intensive Javanese system based on sawah and IGPM production (Sukamulia and Trimulia)

The Javanese transmigrants practice an intensive system for sawah due to their limited cultivable area (two hectares from transmigration scheme). This land constraint encourages the Javanese farmers to intensify their rice production in sawah by using improved seeds, natural and chemical fertilizers, and herbicides.

With the introduction of clonal rubber planting material, Javanese transmigrants have developed rubber rootstock nurseries on their upland fields as a source of income. Upland cropping systems are generally not intensive due to higher risk of crop failure. The village of Sukamulia is typically representative of such system. In Trimulia, farmers were primarily interested in land rehabilitation with clonal rubber. IGPM production is seen as an opportunity but not yet really developed, however, there is obviously a great interest in that activity.

Conclusion on farming systems characterization

The adoption of innovations is essentially due to social processes. The classification of farming systems shows that with different agroecological situations (forest area and *Imperata cylindrica* area), the strategies for improving returns to labour are different between villages.

The Dayak farmers complain about too many farm activities because they do not concentrate their labour on intensive farming systems, which give a high return to labour. In contrast, Javanese transmigrants have developed an intensive strategy to compensate for their lack of land. This is based on rice crops with improved varieties and on rubber rootstock nurseries in upland fields.

Regarding the main constraints (i.e., lack of capital, lack of social cohesion), one could question if capital is a real constraint, especially if one compares the cost of the investment in one plot of a clonal rubber agroforestry like RAS 1 (Rp 500,000) with the credit needed to buy a « parabola ». In fact, it is possible for many farmers to invest in a rubber agroforestry system, step by step (half hectare every 3 or 4 years for instance). But on the other hand , there is an immediate and legitimate demand for consumer goods. The trade-off is invest now or profit now!

Most farmers do not know which clones are adapted to the agroecological situations in West Kalimantan. The lack of information is essentially due to the lack of communication between farmers and also the lack of information from official plantation service authorities (Dinas Perkebunan or DISBUN). Also, the lack of technical information constitutes a constraint to the production of improved rubber planting material. The establishment of budwood gardens by the SRAP project is a good opportunity for the farmers to learn how to produce improved rubber planting material. However the choice of rubber cropping system essentially is the farmer's own decision and depends on his perceptions of the advantages and disadvantages of monocultural or agroforestry systems.

For most of the farmers with little capital, their strategies are oriented to extensive cultural practices as long as land is abundant. This situation will change with the establishment of oil palm plantations in Sanggau and Sintang areas. If farmers have not achieved their perceived minimum standard of living (e.g., with respect to their children's education, housing and health), then they are likely to favour opportunities which will let them attain that standard of living as quickly as possible. These opportunities may be off-farm work or planting oil palm. The interest of many farmers in adopting oil palm is explained by the fact that credit is included in an oil palm project. These projects are an opportunity for farmers without capital or with a short-term strategy (i.e., salaried employee).

With the adoption of innovations, social differentiation between villages and farmers is likely to occur. Access to land, which was the main criteria of social differentiation, will be replaced by another factor: access to innovations and development of innovations by the farmers themselves. Therefore, it will be interesting to analyse the constraints and the perceptions of innovations in relation to the adoption of improved rubber planting material by farmers.

Innovation Adoption Process (Survey 2)

Adoption of improved rubber planting material: Advantages and constraints

Before SRDP or SRAP projects were implemented in the provinces, farmers already knew about clonal rubber. Generally, this knowledge was limited to its high yielding characteristics. Requirements of clonal rubber in terms of labour for weeding, fertilization, and exploitation systems were not well known. Therefore, most farmers were not able to assess the labour and cost requirement, the consequences of shifting from jungle rubber to clonal rubber, or the necessary changes in management of resources at the farm level. The main objective of the SRAP project was to introduce systems that required as little management as possible, while still ensuring a good growth of clonal rubber.

There is a real demand from the farmers to transform their local rubber agroforestry systems by including external innovations, such as clones, fertilization, and good tapping systems. However, innovation can be considered as a risk, particularly in terms of capital and labour investment. The adoption of innovations by a village depends on the social structure, as can be seen by the success in Sanjan and failure in Kopar.

Some farmers in Sanjan who had access to clonal rubber in monoculture also began to develop innovations, such as intercropping during the immature period and planting fruit and timber trees (or selecting these from the natural regeneration). They therefore created a complex agroforestry system based on improved rubber, where the original aim of improving the fallow has been replaced by the establishment of a more intensive cropping system. These practices were forbidden in rubber development projects until as recently as five years ago. Population increase, land scarcity in some areas and other more productive crop opportunities have forced farmers to move to a more productive rubber agroforestry system. Farmers now want to improve their income by increasing latex production (Gouyon 1993).

Fifteen years after the SRDP project and two to three years into the SRAP project, what are the farmers' perceptions of the clonal rubber compared to the local seedlings? What are the contraints for clonal rubber adoption compared to local seedlings? Which rubber cropping systems would farmers favour using clonal rubber? These questions are addressed below.

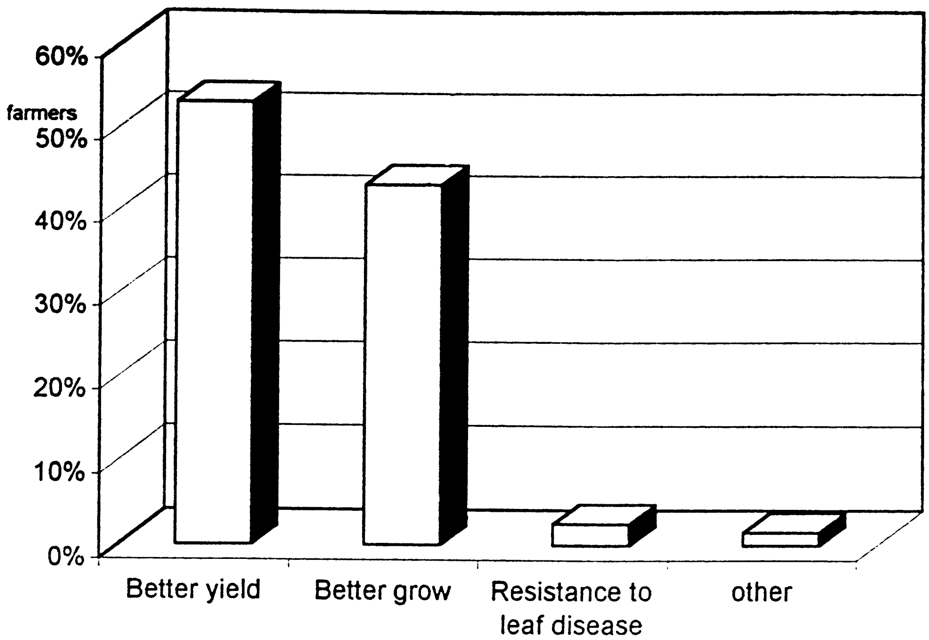
'Karet Lambau': a first experience with improved rubber

The introduction of rubber by private Dutch estates in the 1910s triggered a radical change in the landscape, but not in farmers' practices, at least in the beginning. In 1920 in the Semitau district, a Dutch priest imported an improved rubber variety from Medan, Sumatra, called 'karet lambau'. Lambau in the Dayak language means "something new which came from outside", a definition of an external innovation. The rubber tree had a straight trunk, rough bark, long leaves and produced a yellow concentrated latex (productivity similar to AVROS 2037). After five to six years, the rubber started to produce latex and continued for 25 years. This rubber was very susceptible to disease (root, bark and leaf disease) and not robust in withstanding tapping by inexperienced farmers. The average yield per tree per tapping was superior to that of jungle rubber. Despite being forbidden by the Dutch authorities to plant karet lambau in fallows, farmers stole seeds to develop the jungle rubber system. In fact, rubber plantations were established widely during the Japanese occupation.

Characteristics of improved rubber planting material: high yield, better growth and good secondary characteristics.

The farmers' perceptions of clonal rubber are that the main qualities are a high yield (50 %) and a better growth (40 %) (Figure 7).

***Figure 7.* Advantages of clones compared to seedlings**



Only two villages (Sanjan, Embaong) have clonal rubber trees (GT1) actually in production, these being from the SRDP and TCSDP projects. Farmers can compare the age of opening between the clonal and local rubber. The farmer begins to tap the clonal rubber after six to seven years, whereas the average age of opening local rubber is 13 to 15 years. So the first advantage of using clonal rubber is the early opening for production. In Sanjan, when the same number of rubber trees are tapped (200 to 300), the production of clonal and local rubber is 15 kg and 5 kg per day respectively. The average yield of GT1 in SRDP or TCSDP plots is 1200 kg/ha (TCSDP, pers. comm.) compared to 500 to 600 kg/ha for jungle rubber.

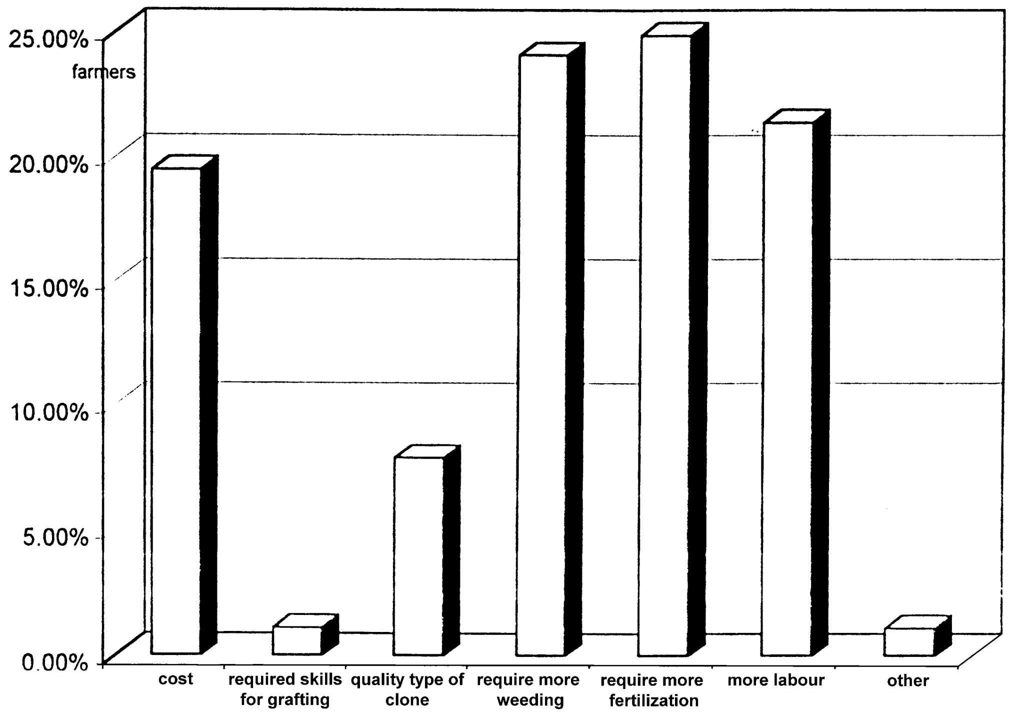
Farmers believe that the lifetime of local rubber (40 years) is longer than clonal rubber (only 25 years). However, the economic lifetime of clonal rubber is about 30 to 35 years; it is poor tapping practices by the farmer that reduce the lifetime to 20 years. However, the shorter productive life is compensated for by the early start of tapping.

Production of GT1 is limited due to the attacks of leaf disease. Therefore, recommendations for specific clones that are suitable for the agroecological conditions are very important. In this area, clones such as PB 260, RRIC 100, BPM 1 and RRIM 600 are the most suitable. PB 260 is more resistant to disease than RRIC 100 and BPM 1 (and incidentally is also relatively high yielding, producing on average 1600 to 1800 kg/ha/yr in South Sumatra in similar conditions). The main problem of some clones such as GT1 is suceptibility to disease (*Colleteotrichum*, root disease). Because this is the only clone they know, only 3% of farmers interviewed believe that clonal rubber is more resistant to disease than local rubber. As there is a lack of information about the price of the treatments for these diseases, farmers assume the prices are high and this could be a disadvantage of clonal rubber.

Disadvantages of clonal rubber compared to local seedlings?

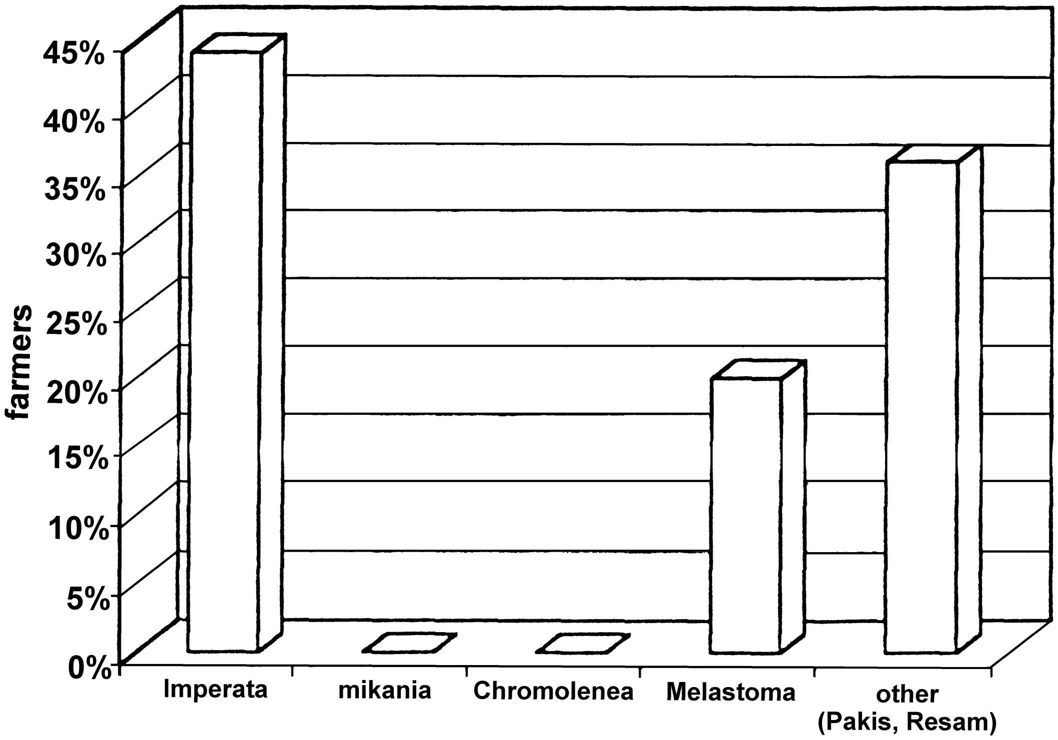
Farmers believe that the main constraints to adoption are that clonal rubber requires more fertilization (20%) and more weeding (20%) than local ruber (Figure 8). Farmers fertilize their clonal rubber plantation only when projects provide inputs, because farmers lack the capital to invest in fertilizers. Fifty percent of the farmers believe that the most suitable number of weedings for the growth of clonal rubber is three to four times per year. However, the constraints for the farmers are the lack of time and the lack of labour force to carry out this weeding. Twenty-five percent of the farmers can carry out only two weedings per year due to other farming activities (gotong royong) or off-farm activities (oil palm). This reflects the fact that most farmers are still following an extensive strategy and do not currently assess the gains in labour and land productivity of clonal rubber.

Figure 8. **Disadvantages of clones compared to seedlings**



Before the SRAP project, 65 % of the farmers were aware that clonal rubber required more weeding than local rubber, due to root competition with the weeds. For 45 % of farmers, the main weed is *Imperata cylindrica*, especially during the five years of the immature period (Figure 9). Without weeding, *Imperata cylindrica* retards the growth of clonal rubber. Local rubber can grow without weeding compared to clonal rubber which requires a minimum of four weedings per year during the first two to three years. One of the reasons why some farmers have chosen the improved agroforestry system RAS 2.2 (in participatory Research with SRAP project) is to address the weed problem. Intercropping with rice requires weeding of the intercrop; this directly benefits the trees and the farmer gets a higher return to his labour in the form of the rice crop.

Figure 9. **The main weed in clonal rubber field**

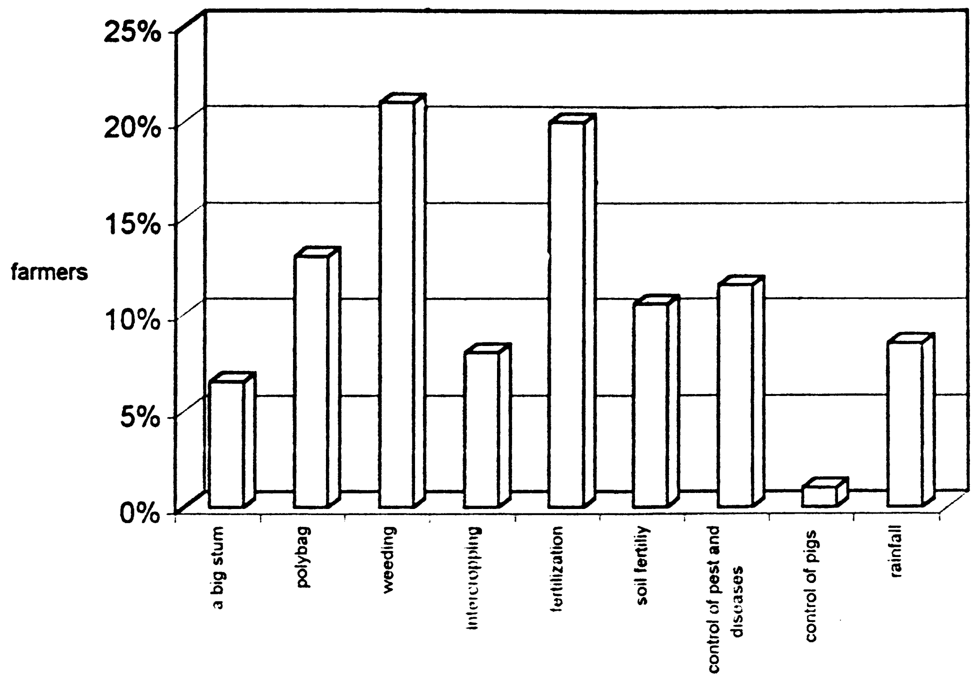


The use of herbicide (Round Up) is more efficient than manual weeding. Farmers save labour and money because one day is sufficient for weeding one hectare with herbicide, whereas nine man-days are necessary with a machete (this method is also less effective). RAS 1, the system similar to the current jungle rubber system, seems a suitable alternative as the regenerating secondary forest (belukar) shades out the weeds at least in the inter-row. One farmer in Engkayu said, "If I have no money to buy herbicides, I will go back to the jungle rubber system".

Twenty percent (or two) of the farmers stated that another constraint of clonal rubber is the cost. The farmer has to obtain a credit for the adoption of the improved planting material, especially with the SRDP projects. The average price of a clonal stump is between Rp 250 to Rp 400. The investment for one hectare of clonal stumps (500 stumps) is estimated to be between Rp 125,000 and Rp 200,000. In Sanjan, 20 farmers who had obtained credit for the project in 1980-83, repaid it after five or six years of production. For one hectare, the credit amounted to Rp 1.450 million in total, with a contract of 13 years duration. Three types of clonal stumps were planted: GT1, AVROS 2037 and PR 261. In Sanjan, a farmer said that before buying clonal rubber, one must first know the yield of each type of clone.

Only 8 % of the farmers consider that the quality/purity of the clone is important for rubber growth (Figure 10). A farmer in Sanjan said, "When I grow rice in ladang, if rainfall is normal, I know approximately what the yield will be. But with the different rubber clones, I do not know what the difference in yields will be."

Figure 10. **The most important criteria for ensuring good rubber growth**

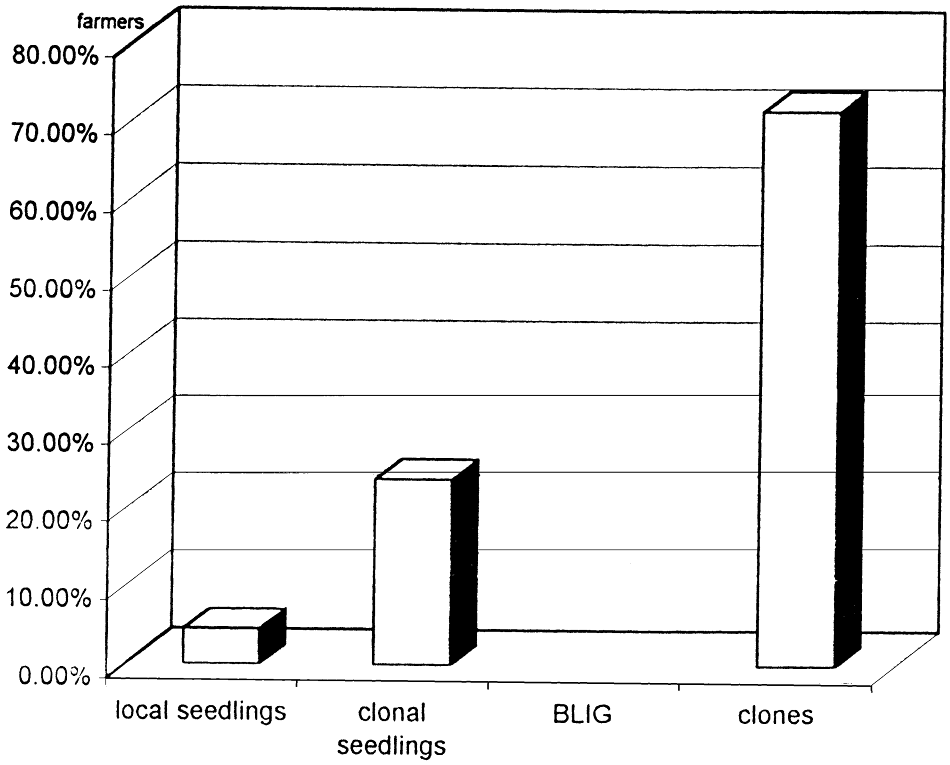


One reason for this statement could be that only Sanjan farmers actually have experience with different clones. They know that different plots of rubber monoculture planted at the same period do not produce the same amount of latex. However, clonal rubber production is very homogenous (all rubber trees produce more or less the same quantity of latex) this reflects different type of soils, exploitation systems and different effects of leaf disease on production. Good technical information on clones is demanded by farmers, as well as adapted and reliable clonal recommendations. Recognition of different clones by farmers is a problem.

The preference for improved rubber planting material

Generally, farmers have a preference for grafted clones (70%) over clonal seedlings (20%) (Figure 11). Clonal seedlings are grown from seeds collected from plantations of grafted clones. They have a slightly better yield than unsellected seedlings, but this is still much lower than grafted clones. In the study area, farmers will choose improved planting material that they know. Farmers who prefer to plant clonal seedlings believe that clonal seedling growth is faster than grafted clones and production of planting material is easier (no grafting).

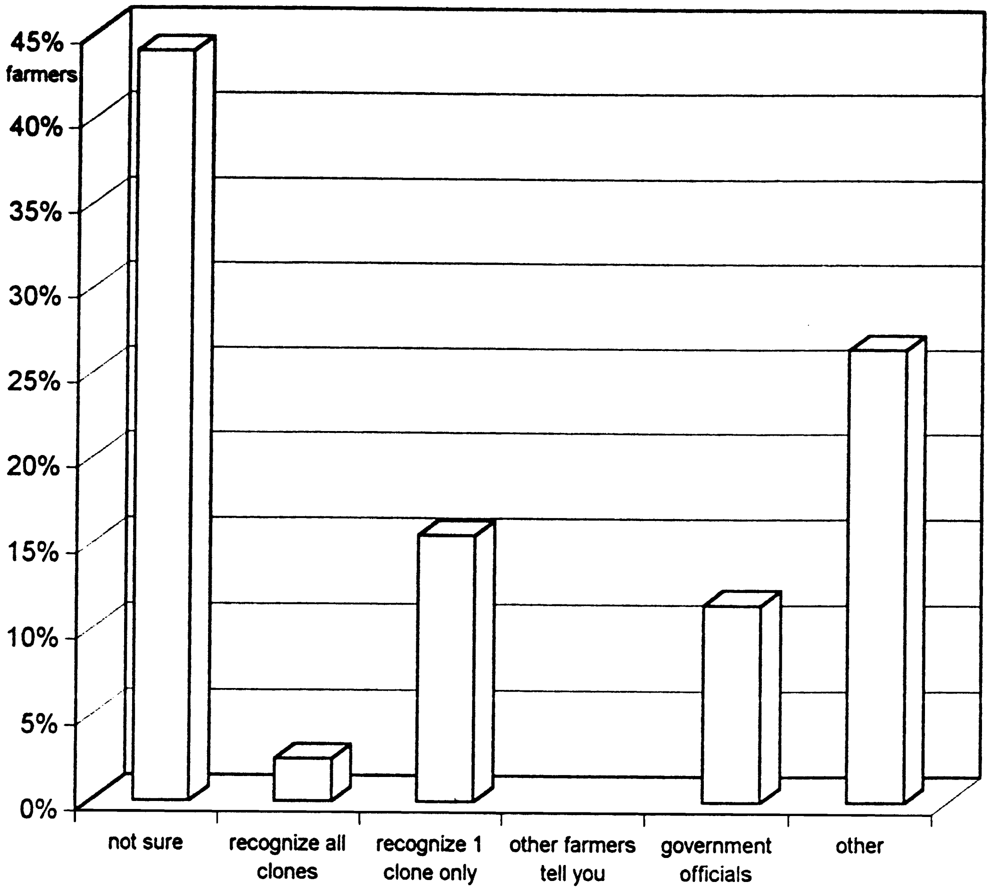
***Figure 11.* Preference of planting material**



Recognition of clonal rubber

Forty-five percent of the farmers are not able to recognize a clonal stump from a local rubber stump, reflecting the lack of information on grafting (Figure 12). Each village has a budwood garden with different clones. In Sanjan, four types of clonal stumps have been introduced (PB 260, RRIM 600, RRIC 100, PBM 1) by the SRAP project. Many farmers (25%) can not distinguish between these four clones, but they can see differences between clones and local seedlings, especially through observation of leaves, roots and trunk. A clone has thick leaves and a smooth trunk compared to the local seedling, which has thin leaves and a rough trunk (local criterias of identification). Some farmers (15%) can recognize only one clonal stump, RRIC100 with large leaves, or PB 260 with round leaves. Ten percent of farmers believe what government officials (DISBUN) say about clonal rubber.

Figure 12. **Recognition of clonal rubber**

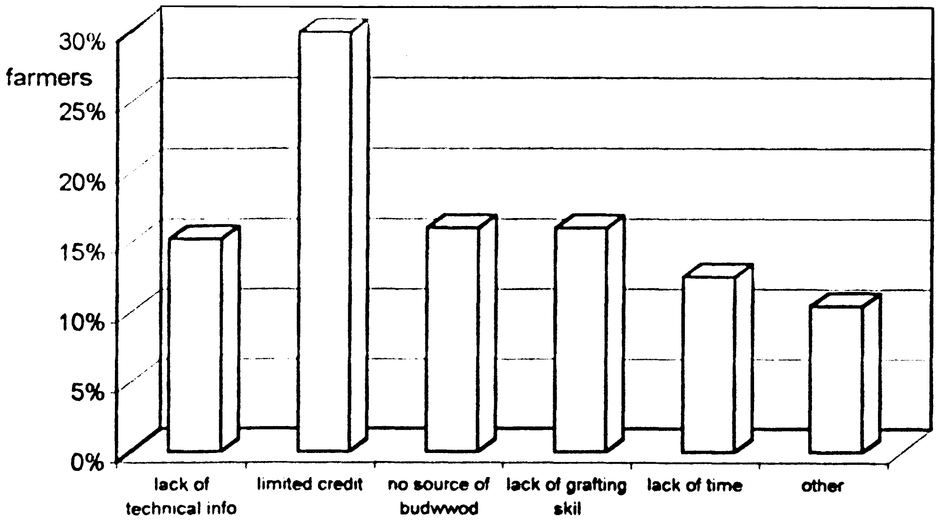


Regarding the characteristics of improved rubber planting material, farmers know only general information (better yield, better growth). In 1989, government officials introduced the concept of clonal rubber to the farmers. While farmers have understood the difference between clonal and local rubber in terms of yield, the difference between clones in terms of yield, growth or susceptibility to disease is not known.

IGPM Production (Survey 3)

Some farmers have developed IGPM production activities to obtain additional sources of income besides farming. The main constraints to producing clonal planting planting material are limited credit (30% farmers), lack of technical information and no source of budwood (15% farmers) (Figure 13).

***Figure 13.* The constraints of producing clonal rubber planting material**



The lack of technical information comes from the lack of communication between farmers. Several farmers do not know anything about the grafting process, rootstock nursery, and the use of a budwood garden.

Ninety-seven to sixty percent of the farmers wish to have a budwood garden and an individual nursery, respectively. With a collective rootstock nursery, the problem is cooperation within the group of farmers. Only one village (Sanjan) has already started producing their own clonal stump from their SRAP budwood garden. Because of the lack of access to budwood gardens, farmers are obliged to buy clonal stumps. The average price of clonal rubber estimated by the farmers is Rp 300 to Rp 400. However, the lack of communication between farmers can be considered a major constraint because farmers do not know the correct price of a clonal stump, a polybag or one metre of clonal budwood. Fifty-two percent of the farmers believe that stumps with two whorls of leaves in polybags are necessary to plant in the field.

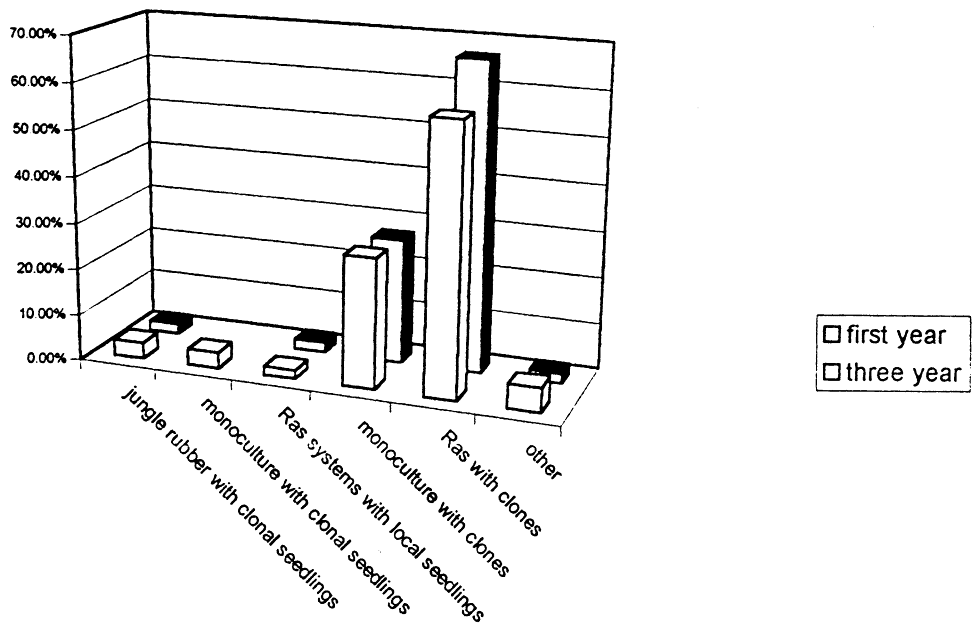
In light of a real demand for improved rubber planting material by farmers, and also the generally low quality of planting material, the establishment of a budwood garden in the village would allow farmers to produce good quality material themselves. Farmers are aware that it would be better if producers could guarantee the quality of improved rubber planting material they sell.

Innovations in rubber cropping systems (Survey 4)

Which rubber cropping system is the most suitable and efficient for clonal rubber?

For future planting, fifty-two percent of the farmers stated that they would choose a RAS with clones, while less than 10% would prefer the monoculture cropping system with clonal rubber (Figure 14). Only 3% of farmers would choose jungle rubber with clonal seedlings.

Figure 14. **Farmers' current preferences for rubber cropping systems**



Reasons why clonal rubber can not replace local rubber in the traditional jungle rubber system

The first reason given was that without fertilizers and sufficient weeding the clonal rubber cannot survive in a jungle rubber environment. The regenerating secondary forest grows faster than rubber without weeding. The root competition between natural trees and clonal rubber is too strong. Soil fertility is a major problem for rubber growth. If a farmer wants to use clonal rubber in the jungle rubber system, he should plant it in a row and weed it well. The concept of RAS1 was based on remarks like these by farmers.

What are the advantages and disadvantages of planting clonal rubber or local rubber in RAS?

Farmers had some difficulty in answering this question as they only had experience with one or two cropping systems (especially farmers who did not have RAS trials). This fact reflects the lack of communication between farmers and the difficulties in introducing innovations when farmers have a long tradition of jungle rubber, which they still consider as a reliable and sustainable source of income. In theory, farmers prefer RAS over monoculture because annual or perennial crops in inter-rows provide income diversification.

Farmers' perceptions of RAS

Several criteria seems to be relevant:

a) the potential production of clones: 1500 to 1800 kg/ha ;

b) income diversification (associated fruit and timber as well as potential annual intercropping);

c) adapted cultural practices on the rubber line.

The reduction of the immature period from eight to fifteen years (with jungle rubber) to five to six years (with clones) is also an important objective. By using fertilizers, clonal rubber growth is boosted. Farmers believe that clonal rubber requires a large amount of fertilisation, whereas local rubber does not require any. If they do not follow the RAS recommendations (fertilizers + weedings), farmers believe that local rubber has better growth than clonal rubber. This fact confirms that the main constraints of using clonal rubber planting material are the labour for weeding and fertilization. Farmers are aware that some clones are susceptible to disease and are looking for resistant planting material. The advantage of RAS lies in the combination of crops: mixing annual (rice) and perennial crops (fruit and timber) with rubber. According to farmers in RAS 2, intercropping is limited to the first two years. In the fourth year, farmers would like to plant pineapple or another intercrop as the weeding of these crops would reduce *Imperata cylindrica*.

RAS: Advantages of associated trees and cover crops with clonal rubber

According to farmers, 90% are interested in planting fruit trees and 70% are interested in planting timber trees with clonal rubber. However, farmers think that it is better to plant trees three years after planting clonal rubber because of competition for nutrients and light. The distance between trees and rubber for suitable rubber growth is three metres. However, for durian trees farmers believe that a wider inter–row of ten metres is better because of light competition. According to some farmers, it is difficult for them to estimate the potential decrease in rubber growth that may result from mixing other trees with rubber. The results of the RAS trials should provide information on this and be a means of comparing farms. Competition from associated trees has not been a problem so far during the immature period.

Farmers believe that fruit trees offer more advantages than timber trees as the former have quicker production (five years for locust bean (petai) and ten years for stink bean (jengkol)) and there is also the opportunity to sell fruit for which there is a more important market than timber (especially for durian fruit).

In theory, planting associated trees and covercrops was a means to reduce the number of weedings per year. Covercrops, particularly *Chromolaena odorata* which can grow in sandy soils, are a good alternative to herbicides. Covercrops can also improve soil fertility and reduce soil erosion. However, for farmers covercrops require a lot of work for no useful, harvestable production. This is the main reason why farmers do not want to plant covercrops.

The perception of the rubber monoculture system differs between farmers. The lack of complementary production (fruits, timber, etc) is the main constraint when compared to the traditional agroforestry practices. Farmers believe that the monoculture system is more suitable for estate plantations than for smallholders (Schueller 1997). An interesting case is found in Sanjan village where 30% of farmers have planted between 90 to 300 fruit and timber trees into their monoculture clonal rubber plots. Also, despite the presence of community forest (tembawang) which contains fruit and timber trees, there is a lack of accessible fruit trees in the village.

Between Embaong and Sanjan villages, the perception of monocultural rubber plantations is different. Sanjan farmers want to develop rubber agroforestry systems, while Embaong farmers prefer to maintain their monoculture rubber plantations and also develop an alternative: oil palm plantations.

Conclusion

In West Kalimantan, the adoption of improved planting material in each village depends mainly on village organization, social interactions between groups, IGPM availability and cost of planting material. Before the adoption of improved rubber planting material, the farmers income was provided mainly by jungle rubber with a low productivity (500 kg/ha). At present, most farmers have opinions about the advantages and disadvantages of adopting improved planting material in agroforestry systems as an alternative to their current rubber cropping systems (jungle rubber, monoculture). The main qualities of clonal rubber are a better yield (1.5-1.8 t/ha), better growth, and a reduced immature period, although there is some susceptibility to disease (leaf disease). For good growth, clonal rubber requires fertilizers (Urea, KCL, TSP, Dolomite) and weeding (in particular for *Imperata cylindrica*). These conditions require farmers to invest more in labour. However, farmers can not always follow the suggested weeding programme for RAS because they have other farm activities (e.g., annual crops, gotong royong work groups). Only two villages decided to invest their labour in rubber plantation as a first priority (Sanjan, Pariban Baru).

The main constraints to IGPM production are the input costs required, the lack of capital, technical information and grafting training. The cost of one clonal stump is still high. Only one village (Sanjan) is currently (1997) producing their own clonal stumps from their SRAP budwood garden, but the other SRAP villages will be ready to produce in the very next future. However, more than 50% of the farmers do not have grafting skills or know about rootstock nursery or budwood garden management. The lack of communication between farmers is one of the constraints to producing improved rubber planting material. There is a real demand for training, however, farmers themselves do not ask other experienced farmers to teach them how to graft.

With the improved rubber planting material, farmers generally prefer RAS over monoculture as long as they know that they can choose their system. The main reasons are that farmers can mix rubber with fruit and timber trees and RAS requires less inputs and labour. In Sanjan village, farmers are changing their monoculture to RAS by allowing regeneration natural vegetation and by planting fruit trees.

Currently, oil palm plantation projects are developping in the Sanggau and Sintang area. The adoption of oil palm in a village depends on the level of social organization and coherence in farming strategies. The great opportunity with oil palm is that credit is provided, however, each farmer loses 5.5 ha of land to the project. For some traditional Dayak villages, like Kopar and Engkayu, moving to oil palm represents a great change in both farming and social activities, but also reflects the confusion of farmers or the community when faced with a choice of various systems and the lack of credit.

In Sanjan, there is a strong community with a solid experience of both monoculture rubber and agroforestry (jungle rubber and tembawang) and good land use management. The community refuses oil palm projects and is orienting further rubber plantations to more agroforestry cropping patterns.

In Pariban Baru, Dayak farmers in a transmigration area are rebuilding agroforestry systems and RAS fits their strategies perfectly. Trimulia village is representative of Javanese transmigrants who put emphasis on sawah and consider annual cropping on upland fields to be too risky and, therefore, are slowly planting clonal rubber. The labour requirement for weeding is the main constraint as off-farm employment is quite important.

Finally, the village of Sukamulia represents another situation where IGPM production for sale has been taken up as a very interesting crop opportunity with almost no risk of crop failure. However, no quality control and no demand for quality by the final users has led to production of very low quality IGPM. Although IGPM production as an innovation in itself has been adopted, quality requirements and clonal purity still need to be improved. This illustrates the need for a well defined IGPM quality policy.

While some farmers favour oil palm plantations, others prefer clonal rubber plantations. This presents a good opportunity to observe the socio-economic evolution and the dynamic of strategies in West Kalimantan province over the next few years to identify a typology of situations. However, local people have always used agroforestry practices and some communities, like Sanjan, are refusing to develop oil palm on their land. There may be room for a compromise between the adoption of new perennial cropping systems (oil palm) and the integration or maintenance of some agroforestry practices in improved rubber agroforestry systems. The main constraint to technical improvement of cropping systems is information. Without sufficient information on risks (crop failure) and technical aspects (monoculture, RAS, other types), the receptivity of local populations to external innovations will be limited.

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