Introduction to SRAP methodology and RAS concepts: summary of the preliminary results

by Eric Penot

INTRODUCTION

Rubber as a trigger for complex agroforestry development in Indonesia

Rubber was introduced to Indonesia at the turn of the century in North Sumatra, and was originally cropped in private estates, but was very rapidly adopted by local farmers in the central plains of Sumatra and Kalimantan through an extensive complex agroforestry system "jungle rubber". Local farmers, as well as spontaneous migrants, developed their own system according to their limited resources of cash and labour. Rubber trees were planted with rice after traditional slash and burn and then the rubber trees were left to grow with the regenerating secondary forest. A higher planting density than that of estates was used, in order to compensate for tree losses due to competition and depredation. The rubber tree is basically a forest species in its natural habitat in the Amazon Basin in Brazil, so rubber proved to be as adaptable to this "new" environment, as to monoculture planting in estates.

Farmers profit from a no-input/very low labour rubber cropping system with a certain amount of income diversification, as jungle rubber produces also fruits, nuts, timber for housing as well as other products such as rattan and NTFP[1]. Such a system has been described and defined, from a botanical point of view, as a "complex agroforestry system" (H de Foresta, G Michon 1992). Production per ha from unselected rubber seedlings is very similar in both monoculture and jungle rubber systems, with a yield close to 500 kg/ha/year. In the case of jungle rubber, the advantages are quite clear: there is no cost for establishment (unselected seeds with no value and no fertilizers are used), labour investment is low (only a few days for rubber planting as the land has been already cleared for upland rice) and there is no maintenance during the immature period. Other benefits are biodiversity conservation as biodiversity is close to that of primary forest or old secondary forest for old jungle rubber (de Foresta & Michon, 1992, 1995) and environmental benefits in terms of soil conservation and water management are due to its forest-like structure.

The constraints have also been well identified (A Gouyon, 1995): there is a delay in production as rubber trees are being tapped 8 to 10 years after planting[2], compared to 5 or 6 years in estates, and the productivity is relatively low (compared to plantations planted with clones). Rubber based farming systems have been well characterized in North Sumatra (Barlow *et al*, 1995), in South-Sumatra (A Gouyon, 1995) and partially characterized in Jambi (Levang, 1990 and ASB: van Noordwijk *et al*, 1995) and West-Sumatra (M Gruninger, 1996). Therefore, it was necessary to conduct a complete farming system characterization in the selected areas in West Kalimantan, West Sumatra and Jambi (completed by PH Courbet in West-Kalimantan, Iwan K in West-Sumatra and A Kelfoun in Jambi in 1997, with the direct collaboration of SRAP local staff).

Farmers are still relying on unselected rubber seedlings for jungle rubber, whereas estates have all now adopted improved planting material. Amongst these, rubber clones have proven to be the best in terms of yields and secondary characteristics (resistance to diseases and exploitation methods etc.). Yields of clonal rubber in Indonesia are between 1400 and 1800 kg/ha in estates, or with the best farmers in the SRDP rubber scheme (in South-Sumatra, Prabumulih, D Boutin, pers comm.). Other improved rubber planting material such as clonal seedlings (seeds from plots planted with one clone) and polyclonal seedlings (seeds from an isolated garden planted with several selected clones. In Indonesia,

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[1]NTFP = Non Timber Forest Products : such as medicinal plants, gaharu, resins, local vegetables....

[2] At least in Sumatra, in Kalimantan, our survey indicates more 10 to 15 years of immature period.

there is only one estate (Lonsum) able to produce polyclonal seedlings (BLIG)[3]. Polyclonal seedlings, which were used in the 1950's and 1960's in estates, have generally been abandoned in favour of clones, which are more profitable, more homogeneous, adapted to a high level of production and with good secondary characteristics (resistance to diseases etc.), in particular the third generation of clones which have been available since the 1970's. Clonal rubber is therefore the first and most important innovation to be adopted by farmers (as improved varieties generally are for other systems). However rubber planting material can be scarce or even unavailable in some areas, of very poor quality and purity, and there is very little information on clones available to farmers. Many planting material programmes have been developed in Indonesia; most of them being unsuccessful (in particular the village budwood garden programme). It was necessary to study the current situation of Improved Genetic Planting material (IGPM) availability and use, and this was done in West Kalimantan by W Shueller/Sunario and in Jambi/West Sumatra by Iwan/E Penot.

In the 1970's, the Indonesian government began to seriously consider supporting the smallholder rubber sector. It must be noted that the model chosen by the government for smallholders is directly derived from the estate model: rubber monoculture with high levels of labour and inputs and no intercropping during the immature rubber period (but use of cover crops). The objectives were to maximize return to capital and return to labour as well as developing a simple rubber monocropping system that could be extended over large areas without much adaptation to local conditions (this adaptation was generally limited to the choice of clone and the level of fertilization). This model has proven efficient but costly. So far, only 15 % of Indonesian farmers have been reached by projects and only a proportion of these actually developed fully productive plantations (around 10 % of the smallholding area) .

In Indonesia, several partial approach projects (such as ARP[4] and GCC) and full approach projects (such as NSSDP and WSSDP[5]) were initiated between 1975 and 1980. Then in 1979-80, the government decided to launch two new types of projects: the NES/PIR[6] projects aimed for transmigration areas with the settlement of migrants in virgin areas (similar to FELDA and FELCRA schemes in Malaysia), and the PMU[7] projects such as SRDP/TCSDP[8], for existing local farmers. Previous projects, as well as SRDP-like schemes funded directly by the Indonesian government, were regrouped in the PRPTE (Project for Rehabilitation and Replanting of export crops).
Table 1 displays rubber planting distribution among the various projects (up to 1994):

Table 1. Areas of rubber planted in various projects in Indonesia

	TCSDP	SRDP	NES	PRPTE	GCC/ ARP	NSSDP WSSDP	TOTAL
Périod	1990-->98	1980–>90	1978–>90	1980–>90	1974–>80	1973–>79	
Area	69 000	101 149	168 571	15 697	112 600	20 019	487 036

[3]BLIG = Bah Lias Isolated Garden, London Sumatra, North Sumatra.

[4]ARP = Assisted Replanting Project
GCC = Group Coagulating Center.

[5]NSSDP = North Sumatra Smallholder Development project
WSSDP = West Sumatra Smallholder Development project

[6]NES = Nucleus Estate Project (PIR in Indonesian) funded by World bank (NES) or directly by the Indonesian government (PIR).

[7]PMU = Project Management Unit.

[8]SRDP = Smallholder Rubber Development Project. From 1980 to 1990
TCSDP : Tree Crop Smallholder Rubber Development Project : continuation of SRDP since 1990, funded by World Bank. A similar project TCSSP is funded by ADB.

%of total	14,2 %	20,8 %	34,6 %	3,2 %	23,1 %	4,1 %	
Class A & B	80 % estimated	89 %	60 %	39 %	< 25 %	80 % estimated	

Source AG, 1995 et Penot , 1999
Classe 1 & B indicates that plantations are correcte and productive.

All rubber development schemes have been based on rubber monoculture with high levels of inputs and labour. Only 15 % of the total rubber farmers' area has been reached directly by projects. It is now necessary to review why the monoculture model has not been adopted on a large scale by all smallholders as is the case in Malaysia and Thailand, and also to see if other rubber cropping alternatives are possible.

One of the main reasons why farmers did not adopt the rubber monoculture package is its cost. In Malaysia and Thailand, this was greatly subsidized by the government, allowing farmers to shift from extensive jungle rubber to intensive monoculture. The current situation in Indonesia is characterized by relatively poor farmers who cannot afford the cost of the monoculture technological package, farmers that are more interested in low to medium intensive cropping patterns (in particular for labour in immature period), 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 and credit.

1 Rubber Agroforestry Systems (RAS) : research for a new alternative

Rubber Agroforestry Systems (RAS) take into account these constraints, and try to combine low to medium input requirements with agroforestry practices. These practices are a combination of endogenous and external innovations, and involve a lower labour requirement in the immature period, income diversification and also have environmental benefits. An analysis of the innovation adoption process has been done (E Penot, 1997) in the three following areas:

A) endogenous[9] innovations in the jungle rubber system by non project farmers
B) endogenous innovations in the rubber monoculture "estate-like" system by former project farmers and
C) C) Rubber Agroforestry Systems (RAS) developed by research project farmers with a combination of endogenous innovations and exogenous innovations from SRAP/CIRAD/ICRAF[10].

Several hypotheses concerning rubber and associated trees are behind the concept of RAS, and these are discussed below.

- 1 - *" There is no significant decrease (no more than 20 %) in rubber tree yield when planted in RAS i.e. competition for light, water and nutrients from associated trees does not significantly affect rubber yields".*

There is evidence for this from Dijkman (1951), where the yields of unselected seedlings averaged 500 kg/ha when planted either in weeded monoculture or in jungle rubber. We can assume that this is also the case with clonal planting material.

This hypothesis would probably hold for RAS 2 and 3 due to the limited number of trees /ha (<250/ha) and it is expected that the associated trees will only compete seriously when the canopy is above or mixed with that of rubber, which will be between 10 and 25 years after planting, depending on the species. Overall, competition from other species may probably not be significant for rubber (at planting density of 550 trees/ha). It may be questionable for RAS 1 where associated tree density is higher (secondary forest regeneration). This can be quantified later by dividing the RAS 1 field into 2 plots : with and without selective cutting of non-economic trees in the inter-row in order to compare yields with and without canopy competition. Of course, technically, this can only be only

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[9]We understand by ''endogenous'': innovations that came from farmers themselves, not from external projects.

[10]SRAP = Smallholder Rubber Agroforestry Project: a research programme based on farm experimentation using participatory approach with :
CIRAD = Centre de coopération Internationale en Recherche Agronomique pour le Developpement, FRANCE.
ICRAF = International Centre for Research in Agroforestry/

demonstrated after 25 years of yield recording. However, it seems important to study above and below-ground competition in RAS 1.

For pulp trees which are expected to be harvested 8 years after planting, and whose role is to provide shade to overcome Imperata, the question of competition is highly relevant, in particular for trees like *Acacia mangium*. In this case; pulp trees are not considered as permanent associated trees but as part of the temporary combination of cover crops/fast growing trees for shade in RAS 3. Therefore the problem of competition from pulp trees in RAS 3 can be considered similar to the situation with intercrops.

- 2 - *In RAS 2 : rubber can profit directly from associated intercrops or cover crops (and the weeding done on these).*
Evidence confirming this has been obtained from STDIII/EEC/CIRAD/BP Sembawa research on competition between rubber and annual intercrops.

- 3 - *In RAS 3 : a relevant combination of non-viny cover crops and fast growing pulp trees can overcome Imperata and significantly decrease the labour requirement for weeding during the immature period.*
This hypothesis has not previously been rigorously tested, and RAS 3 experimentation should provide much needed information on the effectiveness of this combination.

The concepts of RAS and detailed methodologies have been defined (Penot, 1994), and a comprehensive network of OFT (On-farm-Trials) has been established in 1995 and 1996.
The 4 main activities of SRAP are the following :

- 1 : The implementation of a network of On-Farm-Trials in 3 provinces, covering a wide range of situations using different types of RAS in order to fulfill local farmers' requirements and overcome local constraints (1994-1997)
- 2 : The development of village budwood gardens to promote high quality planting material production by the farmers themselves, and the study of constraints for such production (1996)
- 3 : Farming system characterization to identify an operational typology of situations and the study of the RAS innovations adoption process (1997).
- 4 : Specific studies on RAS components such as: the biodiversity of jungle rubber and RAS 1, the above and below-ground competition in RAS systems, the economics of ecological components in RAS, the effect of burning on soils in rubber plots (1995-1998).

2 Presentation of RAS trials
SRAP OFT experimentation uses improved rubber planting material (clones) to improve productivity of rubber agroforestry systems, which can be established in pioneer and buffer zones, in degraded zones such as *Imperata* grassland as well as in zones where replanting is required (old jungle rubber). The objective is to identify the components of RAS which will minimize inputs (capital of investment) and optimize labour (in particular during immature period of rubber). SRAP is using a participatory approach to do on-farm experimentation with three main kinds of rubber agroforestry systems (RAS) . Each is being tested for its suitability for local agro-ecological conditions, for labour and cash requirements, and to determine the best level of intensification.

RAS have been described (Penot, 1995b and 1996b) and some preliminary results were presented at IRRDB in 1996 (Penot & Wibawa, 1996). A complete economic analysis was done in 1996 (Penot, 1996a) to compare the expected profitability of RAS with monoculture and some other rubber cropping patterns.

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 suitable 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. The rubber clones must be able to compete with the natural secondary forest growth. Various weeding protocols are being tested. Two planting density has been originally chosen for the first year of experimentation in Kalimantan : 550 and 750 rubber trees/ha. Finally, the selected planting density for RAS 1 (as well as RAS 2 and 3) is 550 trees/ha.

This will identify the minimum amount of management needed for the system, a key factor for farmers whose strategies depend on labour and cash availability. RAS 1 requires a certain level of existing biodiversity in the surrounding area (old jungle rubber, Tembawang or other types of timber/fruit agroforestry systems, home gardens, secondary or primary forest) for establishment. In effect, RAS 1 is aimed for pioneer or remote areas, for replanting in old jungle rubber or secondary forest areas as well as for poor farmers. RAS 1 is not suitable in Imperata grasslands (Penot, 1995a, de Foresta, 1994).

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 90-250 other perennial trees per hectare (with various planting densities and selected species according to a typology). It is very intensive, with annual crops being intercropped during the first 3-4 years, with emphasis on improved upland varieties of rice, with various levels of fertilization. RAS 2 aims to answer the following questions: how is total system productivity and income generation affected by a combination of rubber, associated trees and intercrops? What are the dynamics of species interactions? And what are the crop alternatives during rubber immature period ?
Intercrops are annual (predominantly upland rice or a rotation of rice/leguminous crops such as groundnut) or perennial (cinnamon), during the initial years of establishment. Previous experimentation has shown the positive effect of annual intercropping on rubber growth (Wibawa, 1995, 1996, STD3/EEC reports). The range of trees that can be grown in association with rubber in agroforestry associations and the market potential of their products are being examined *e.g.* tekam, meranti and sungkai trees for timber; durian, rambutan, duku, langsat, cempedak, petai and jengkol for fruit; tengkawang and kemiri for nuts (see Annex 1 for Latin names).

The third system, RAS 3, is also a complex agroforestry system with rubber and other trees planted at the same density as that in RAS 2, but with intercrops only in the first year, only. Subsequently a combination of covercrops, MPT's[11] and Fast Growing Pulp Trees (FGT) are planted. It is established on degraded lands covered by *Imperata cylindrica (*alang-alang grass) (Penot, 1995). The grass precludes the growth of annual crops, so selected cover crops *(Mucuna, Flemingia congesta., Crotalaria spp, Setaria, Chromolaena odorata*) or MPT's (*Calliandra*, Wingbean, *Gliricidia sepium.*) and FGT (*Gmelina arborea., Paraserianthes falcataria., Acacia mangium or crassicarpa)* are established. The objective here is to eliminate the weeding requirement by providing a favourable environment for rubber and the associated trees to grow and quickly establish a canopy which shades out *Imperata*.

All these trials are documented in SRAP methodology project documents (SRAP 1995, 1996). The 3 main kinds of trials have been divided into several types (3 RAS 1, 3 RAS 2 and 4 RAS 3) in order to test 1 or 2 components at a time.
A network of farmer-managed trials is underway in Jambi and West-Sumatra provinces in Sumatra, and in West Kalimantan province, Borneo. 27 trials, with an average of 3 to 5 farm/replications per trial, covering 50 hectares and involving 100 farmers have been established (Tables 2). Each farmer's field is considered as a replication with 1 or 2 simple treatments such as rubber weeding level, rubber fertilization, rice variety x fertilization, type of associated trees, type of covercrops/MPT/FGT combinations. 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. This experimentation is well documented in SRAP progress reports for each province, and in the methodology documents.

Table 2. FARMERS AND AGRICULTURAL SCHOOLS INVOLVED IN RAS ON FARM EXPERIMENTATION

Province	Village	Trial	Farmers/experimental fields	Agricultural schools
West-Kalimantan	5	15	63	1
Jambi	3	7	25	1
West-Sumatra	1	3	8	-
Total	9	25	96	2

[11]MPT's = Multi Purpose Trees

3 Farmers strategies in various environments : the necessity for an operational typology of situations

Three provinces have been selected in Indonesia to cover a wide range of conditions in terms of ecological and socio-cultural and economic factors under which farmers have developed a range of strategies for adoption of innovations and cropping pattern intensification. All sites are located in an equatorial climate, with rainfall between 2 000 and 3 000 mm/year, and are suitable for rubber production which is the main driving force of RAS systems.. Soils are red/yellow podzolic soils, very acid, with a low fertility status (low nutrient content and high Aluminium toxicity), in particular in West-Sumatra and West-Kalimantan. Continuous annual food cropping is generally not possible on such acid soils. Farmers recently re-oriented their strategies to tree crops : rubber and oil palm being the main cash crops which are complemented by timber, fruits and NTFP (Non Timber Forest products).

Various groups of people with different behaviour related to forest environment, cropping strategies and resource allocation are taken into account in order to cover a wide range of socio-economic situations. Table 3 gives a summary of these different situations in the selected provinces and shows some selected constraints and opportunities of the benchmark areas directly related to farmers strategies.

This typology takes into account the socio-economic environment (remoteness, pioneer zones, access to credit, inputs, information etc) and the ethnic group (Dayak, Malayu, Javanese and Minang) which is essential for understanding the farmers strategies, and their ability to adopt "new" technologies according to their cash and labour availability, as well as their willingness to intensify or not (see table in annex 2).

TABLE 3 : SITE CHARACTERIZATION

Factors	**West-Kalimantan** ***Forest margins with poor soils and transmigration areas.***	**Jambi (Sumatra)** ***Forest margins***	**West-Sumatra** ***Very degraded land***
Ethnic groups	a) Dayak (Christians) b) Javanese transmigrant (Muslim)	Malayu (Muslim)	Minang (Muslim)
Population density	a) low with plenty of land b) high with limited land (2 ha)	low with plenty of land	Low with limited land (marginal lands)
Ecological environment	a) 2nd forest, jungle rubber and tembawang (*1), poor soils. b)degraded sheet Imperata land (*2), poor soils	a) forest and jungle rubber on steep slopes (foothills of the Barisan mountains b) forest and jungle rubber on flat areas (peneplains)	Imperata infested land with steep slopes, poor soils, erosion and maximum altitude for rubber (500-600 meters
Farmers' behavior and strategies	a) extensive systems, S&B (*3)for local upland rice, willing to accept a low level of intensification b) intensive with sawah and rubber on uplands. Not willing to accept intensification on upland	a) extensive systems, limited upland rice, S&B for cinnamon planting Reluctant to accept labour intensification b) extensive, S&B for rice and palawija production Willing to accept a certain level of intensification	very intensive with continuous food intercropping in tree based systems (rubber) Very keen to intensify
Main constraints	a) low productivity of jungle rubber, Imperata b) very degraded land with Imperata on a very limited cropping area (2 ha) High pressure of Colletotrichum (a rubber leaf disease)	a) low productivity of jungle rubber, vertebrate pests on new rubber plantations, b) low productivity of jungle rubber *Mikania* Pigs and Monkeys	no sustainable continuous foodcrop systems, Imperata, erosion on very steep slopes, erratic rainfall, Remote area, Altitude : maximum for rubber. Rubber leaf disease Low availability of inputs. Pigs damage
Opportunities	a) available land Presence of SRDP/TCSDP (*4) Existing old complex agroforestry practices b) farmers motivated	land available previous and existing complex agroforestry practices very good access to markets	very good motivation for intensification
On Farm trials priority	a) RAS 1 and RAS 2 b) RAS 2 and RAS 3	RAS 1 RAS 2	RAS 2

*1 Tembawang are indigenous fruit and timber based complex agroforestry systems where the main tree is often Illipe nut tree.
*2 S&B: slash and burn practices.
*3 Imperata and Mikania are major weeds which limit growth of crops
*4 SRDP and TCSDP are rubber development projects funded by World Bank based on clonal rubber monoculture.

On farm experimentation was started after a careful selection of zones representative of various constraints, both technical and environmental (*e.g.* forest vs Imperata grasslands) and socio-economic (including ethnic groups). Villages were selected on the following criteria: easy access for easy monitoring, no current rubber project (but old projects may have been implemented), and the presence of farmers motivated to adapt or change their systems. Meetings were organized in the selected villages to inform farmers about RAS technologies. Some RAS types were selected according to local constraints and suitability, such as RAS 2 and 3 for Imperata grasslands, RAS 1 in forest or jungle rubber environment. Farmers were selected on the following criteria: suitability of plots according to selected RAS type, accessibility and farmer motivation.

4 The village budwood garden programme

After one year of experimentation with RAS in selected villages, discussions with farmers revealed their interest in producing clonal rubber planting material themselves, because this represents more than 50 % of the total cost of establishment of RAS (see economical analysis of RAS, Penot, 1996a). Basic information on clones, grafting and nursery and budwood garden techniques was provided to farmers who were interested in this production. The main constraint for farmers is budwood availability and quality (clonal purity) as well as a lack of technical information and basic technical training in grafting techniques. The main idea was to provide farmers with the external components (innovations) that are out of their reach without external help: basically budwood gardens and training. All other components were provided by farmers themselves.

Farmers organized themselves into budwood garden groups as "group of interest" (10-15 farmers) in order to manage the community budwood garden and share the budwood production. Nurseries were established on a private, individual basis. Each farmer was trained in grafting techniques. SRAP provided information, training and the budwood garden (generally 400 plants, which after 3 years would theorically produce 5000 stumps per year *i.e.* enough to plant 8 hectares per year). Farmers provided the rootstock nurseries, labour, grafting and all other inputs (fertilizers for nursery, polybags etc). The idea was not to show that farmers are able to produce clones (this is already known) but to identify the constraints (generally not technical but social constraints) that prevent farmers from developing such activity themselves. In light of the many budwood garden projects that have been developed and failed, in particular in the Jambi province (for instance the Disbun Bandes programme), failure is generally due to social factors (poor farmers organization, cultural reasons, disagreement within the communities..). These factors should be explored in order to identify the conditions in which it would be best for farmers to produce their own rubber planting material, or where this should be produced by specialized nurseries (as is already the case in South and North Sumatra). Replanting is largely dependent on clonal planting material availability and cost. In many provinces, and in particular West -Kalimantan, West-Sumatra and Jambi, availability is very poor and quality is not guaranteed.

In West Kalimantan, the majority of farmers wish to have community based village budwood gardens and 7 have been implemented. In Jambi, due to lower interest and motivation, private budwood gardens have been developed in 2 villages. Four budwood gardens were also established in agricultural schools or projects as collection budwood gardens. Preliminary studies on the establishment and use of budwood gardens and planting material production were done by W Shueller and Sunario in West-Kalimantan, and by Iwan Komardiwan and E Penot in Jambi and West Sumatra.

5 From SRAP to the Rubber Agroforestry initiative.

The implementation of the SRAP has opened a "Pandora's box" with many research topics to be studied. The core team and project has focused on the OFT network, the farming system characterization, the adoption innovation process and the rubber planting material study. Other research topics have been covered by associated scientists within ICRAF, as follows:

- *Biophysical interactions (above and below ground) between components of rubber agroforestry systems in Indonesia* with Sandy Williams (ICRAF/SRAP/University of Wales, Bangor, UK), from 1995 to 1997 (PhD to be presented in 2000). A study on rubber shoot and root growth in response to competition from secondary forest regrowth (RAS 1-type environment) with clones and unselected seedlings.
- *Biodiversity in rubber agroforests* with Hendrien Beukema, Fred Stolle and Isron Wah Yudhi (ICRAF/UNESCO/ASB) from 1995 to 1998. The biodiversity of jungle rubber is compared with existing local primary forests, using ferns as an indicator group. PhD to be presented in 2000.
- *What are the direct effects of the burn on soil fertility (chemical/physical/biological properties) and what does slash and burn as land clearing method for establishing new rubber gardens mean to the smallholder rubber farmer?* with Quirine Ketterings, Yakub Ambigau, Djunaedy, Titus Tri Wibowo, Meine van Noordwijk and Iswandi Anas (PhD for Q. Ketterings to be presented in 1999) from 1996 to 1998 (Ohio State University/ICRAF/ASB/SRAP).

The research topics developed by students in SRAP in 1997-1998 are the following :

- *Farming system characterization and RAS innovations adoption process in Jambi province in Indonesia* by A. Kelfoun, CIRAD/ICRAF-SRAP/ENSAM Rennes (France), in 1997 (MSc).
- *Farming system characterization and RAS innovations adoption process in the West-Kalimantan province in Indonesia* by Phillipe Courbet, CIRAD/ICRAF-SRAP/CNEARC-ENGREF Montpellier (France), in 1997 (MSc).
- *IGPM (Improved Genetic Planting Material) availability and use in Rubber Agroforestry Systems : constraints of production in West-Kalimantan province*, Indonesia by Wilfried Shueller, CIRAD/ICRAF-SRAP/ENITA Bordeaux, France, (MSc)
- *The economic value of ecology in complex rubber agroforestry systems in Indonesia* : with Franz Gaeztwiller, (PhD), Humboldt University of Berlin/ICRAF/SRAP, from 1997 to 1999. The economical value of ecological components of RAS are evaluated through a matrix analysis.
- *Peasant strategy and plantation projects in Indonesia*, with Benedicte Chambon, 1998-1999 (CIRAD/SRAP/ICRAF). A study on how rubber farmers react to various types of extension systems (from NES to partial approach) and what is the place and role of agroforestry in these strategies.

6 Main results and preliminary recommendations

6.1 RAS technology : preliminary results from on farm experimentation

In terms of RAS establishment, the main factors being evaluated are rubber planting material (clonal rubber), weeding level, fertilization level (in particular phosphate (Penot, Fairhurst *et al*, 1996), the association with timber and fruit trees (in RAS 2&3), the association with pulp trees and covercrops (in RAS 3) and intercropping (in RAS 2).

The most critical period for RAS establishment during immature period is the first 2 years where competition with weeds (in particular *Imperata*) and/or secondary forest (in RAS 1) is the most aggressive. RAS phases can be described as follows :

- A immature phase (5 to 7 years) with:
  - A1: critical establishment phase, years 1 & 2
  - A2: intermediate immature period,years 3 to 5/7

- B production phase (year 5-7 to 25-35)with
  - B1: increasing yield phase from year 5-7 to 10
  - B2: stabilized yield phase from year 10 to 20-25
  - B3 : decreasing yield phase from year 25 to 35

So far, trials planted in 1994-1996 being between 1.5 and 3 years old, the present analysis concerns only the A1 phase with emphasis on rubber growth performance and survival, and intercrop performance and interactions with rubber.

In Jambi

Trials have been developed in 2 different situations :

- In Seppungur: representative of the central plain of Sumatra where rubber is the main crop, on flat land with relatively good soils not requiring high amount of fertilizers for rubber. Emphasis is put on replanting of old jungle rubber. Marketing is easy due to the close proximity to the main road. RAS 1 is very successful in this area due to control of pigs and low monkey populations. As farmers still rely on an extensive strategy for agriculture, RAS 1 seems to fit quite well with their preferences in terms of rubber cropping patterns. Some farmers however are interested in RAS 2.2, with more intensification through intercropping in the immature rubber period. Strategies vary from no management at all (plots invaded by Imperata which is not actually a widespread problem in this area) to a fully weeded field very close to monoculture. The most successful fields are those where farmers live close to their field and grow a wide range of palawijas and associated trees (including cinnamon and coffee), consequently with a good level of weeding and remarkable growth of rubber and associated trees.

- In Muara Buat and Rantau Pandan : representative of hilly areas (piedmont of the Barisan mountains) with severe slopes. Rubber, cinnamon, timber extraction and irrigated rice (sawah) are the main activities. Farmers are looking for very extensive rubber systems requiring little labour. RAS 1 and RAS 2.5 (rubber + cinnamon) have been established in this area. Most of the farmers spent relatively little time in their rubber fields during the immature period and are apparently still not ready to increase the level of labour and inputs to rubber systems. Depredation from pigs and monkeys leads to severe rubber growth limitations in RAS 1 and 2.5. We suppose that we have found the limit of RAS systems in remote areas where farmers presence in their fields is very limited. In this case pest damage is high, and management levels very low. Some farmers have been successful, even if not exactly following the weeding recommendations. It seems that 3 to 4 weedings per year in RAS 1 is sufficient for RAS 1 establishment. *Mikania sp*., a very aggressive climbing weed considered dangerous for rubber, does not seem to be really a problem. Mikenia is relatively well controled on the rubber lines and disappears very rapidly in the inter-rows due to the shade provided by the vegetation regrowth. Steep slopes can lead to landslides, a common feature in the landscape. It is very important that rubber rows are planted along contours, and woody vegetation allowed to grow in the inter-row areas. A preliminary conclusion might be that RAS 1 development in such areas should be limited to very motivated farmers who are fully informed about the labour and guarding requirements.

Only three replications of RAS 2.5 have been established and all failed by lack of maintenance. Farmers do not seem to be very interested in combining cinnamon with rubber, as land is still plentiful for both crops, at least in this village.

In West-Kalimantan

In all cases, early planting of rubber stumps with 1 whorl of leaves in polybags at the very beginning of the rainy season in October is an absolute necessity. This enables rubber to compete efficiently with secondary forest regrowth in RAS 1, profit from weeding of intercrops in RAS 2, and to compete with *Imperata* in RAS 3. The direct planting of bare rooted stumps has not been a failure (like in West Sumatra), but has led to losses and severe delay in growth (estimated at approximately 1 year). This was due to poor quality of planting material supplied by a local development project in early 1995 (though this may reflect the quality of planting material to which farmers would usually have access), and the fact that plants were not sufficiently developed before the onset of the dry season. The stumps in polybags have already developed a root system necessary for rapid growth, and can be sufficiently developed by the dry season (March-September in all sites). The availability of good quality stumps with sufficient girth is also a significant criteria. In West-Kalimantan, stumps are traditionally produced with a small diameter due to poor growth of rootstocks in nurseries. Another result is that if competition with weeds is important, and in particular *Imperata*, water is probably the main constraint in the dry season (when growth may actually possible stop) as shown also in experimentation in South-Sumatra (Wibawa, 1995). Further experimentation may be necessary to gain a better understanding of water competition during the dry season

between rubber, intercrops, covercrops and associated trees (in particular fast growing pulp trees) and its effect on rubber growth.

It is very important to target a suitable type of RAS to specific classes of farmers. An operational typology of farmers is needed, taking into account socio-economic and environmental factors, so that farmers' needs can be met.

RAS 1 is obviously suitable for most farmers who are still relying on relatively extensive rubber cropping systems. It can also be considered as a transition system, enabling farmers to shift from fully extensive jungle rubber to semi intensive RAS, and then, later, to more intensive systems such as monoculture. Although most farmers tend to grow clonal rubber in monoculture due to pressure from projects or extension, they are also very interested in agroforestry systems. In that respect, it seems that Dayak farmers are more concerned with diversification and the maintaining agroforestry practices than Malayu farmers in Jambi for instance. But it is clear that RAS 1 is not a "backward" system as it may appear to uninformed persons, and is intended to dramatically increase labour and land productivity while being more suited to farmers' resources in terms of labour and capital. The main problem is to maintain a minimum level of weeding of the rubber row during the critical first 2 years. 4 to 6 weedings/year seems to be necessary, only 4 if Roundup is correctly used. The use of Roundup to control Imperata is the most efficient way, both technically and economically, as it saves numerous days of manual weeding. Farmers themselves are using increasing amounts of Roundup, even if not provided by projects, and the comparison of costs between manual and chemical weeding is largely in favour of the use of Roundup.

RAS 2 suits some farmers who require higher productivity from their investment of labour and land during the immature period, or for those in transmigration schemes. This is the case in Pariban Baru/Sintang with Dayak farmers, but it is not the case with traditional Javanese transmigrants in Trimulia village. A priori, it was expected that this group (supposedly the most experienced in intensive agriculture) would have been most likely to adopt RAS 2 system, which is relatively labour intensive. However in reality, priority is given to irrigated rice, their traditional crop, and to income generating activities off farm. Rubber is considered as a way to rehabilitate the 2 ha of land provided to transmigrants, which is generally covered with Imperata and unsuitable for sustained foodcrop production. However rubber planting is only carried out if this does not require too much labour. This explains why RAS 2, has not been widely adopted here. This pattern may change when the clonal rubber fields begin to produce, and will provide a sustainable income.

RAS 2.1 aims to compare rubber growth when planted with or without associated fruit/timber trees. It is not expected that there will be differences due to competition between treatments (if any) until 10 to 15 years after planting. It is a long-term trial.

RAS 2.2 shows that growing upland rice as an intercrop is still very risky. Dayak farmers wish to plant local rice (Pulut and Merunggup varieties..) to be used for rice wine production. Improved rice varieties such as Wayararem and Jatilihur did not prove to be very suitable. For good production they required the complete package of fertilizers and plant protection against insects ('walang sangit in particular). Because of their shorter cycle (100 days), farmers planted these improved varieties 2 months later than the local traditional varieties, so they would mature at the same time. Therefore both varieties could be protected from depredation by birds and harvested simultaneously, which is a more efficient use of labour. However as a result of the 2 month delay, fields were often invaded by *Imperata* that severely jeopardised the crop.

It seems unrealistic to continue to grow rice the third year for the following reasons: weed pressure is too high, soil fertility is decreasing, soil compaction is increasing, there is an increase in pests (insects) and , finally, the shade from rubber tree canopies becomes too great. Intercrop diversification with groundnuts, other pulses, pineapple and chilli is highly recommended. Apparently cassava cropping does not increase root disease if it is harvested before 12 months old, but is still not recommended as it might increase root disease occurrence if it stays in the fields more than one year. Incidence of white root disease is mainly due to the quality of burning (the fungus in the soil is not destroyed if temperatures are too low), and the number of big trunks still in place after planting as these will rot and become a reservoir for fungus. *Colletotrichum* in the nursery and possibly within 6 months of planting as well as pink disease are the most common leaf diseases, but these can be easily treated with low cost chemicals (Dithane 56 and Bayfidan).

For RAS 3, it is too early to produce any recommendations, as there is obviously a problem with establishment of covercrops. The selected covercrops are non viny species which do not require too much labour for control in the rubber row (*Mucuna* is an exception). Establishment in farmers conditions is generally not successful, as it requires a very specific time table to be followed between the slash of Imperata, the use of Round-up 3 weeks after slashing on young alang² shoots, and then the planting of covercrops 2 of 3 weeks after Round-up. Any delay between these phases will jeopardize covercrop establishment in favour of the return of Imperata. It is also too early to see if fast growing pulp trees will generate sufficient shade to overcome Imperata.
The test field with 1 replication only, called RAS 3.1 shows that the best covercrop to overcome Imperata is *Chromolena odorata*, followed by *Mucuna*, but that last diseapear very soon. 5 replications of RAS 3.2, with covercrops and pulp trees were established in November 1996 where covercrops have been totally overcome by Imperata. Pulp trees are growing relatively well, in particular *Acacia mangium* and *Gmelina arborea*. The difficulty in establishing *Chromolena* is that brown sticks should be used and planted immediately after harvest and this requires a certain amount of labour. Eventually, *Flemingia congesta* is the best alternative. RAS 3, with various treatments (with and without pulp trees or associated trees, different types of combination of covercrops and/or pulp trees), still needs 1 or 2 years of experimentation before recommendations can be released.

In West Sumatra : village of Bangkok.
RAS 2.2 with rice and palawija intercropping has been implemented in this remote village in the hills covered by *Imperata* where soils are very poor. It is very successful due to the high management intensity and good care that Minang farmers provide to their fields. The first planting suffered severely from drought in early 1996, but all dead plants have been replaced. The direct planting of bare-rooted stumps was a failure in West Sumatra due to very poor soils and steep slopes, but mainly due to erratic rainfall. However since then farmers have shown that good intercropping associated with good weeding have given both good rice yields and good growth of rubber and associated trees in a difficult environment. *Imperata* has totally disappeared from the fields. As plots are located in a small watershed, it is impressive to see how farmers have rehabilitated their land which was previously covered by *Imperata*. Fires and vertebrate pests (pigs) still pose a great risk, but farmers live close to their plots, and their constant presence limits these risks and explains the success of the trials.

Originally developed in 2 villages : Bangkok and Lubuk Gadang, the RAS methodology was explained to farmers in both locations, however the project was not continued in Lubuk Gadang due to limited resources and difficult access. Farmers here were initially provided with clonal rubber in early 1996, but no further activity or monitoring was done since that time. On a visit in April 1997, we were very surprised to see that RAS has actually been successfully developed (and adopted) by local farmers, without any incentive or support from us. This shows the obvious suitability and adoptability of RAS to the local situation.

Contour planting with well weeded intercrops and strips of *Flemingia congesta* to limit erosion seems to be very efficient for soil protection. In a remote area where farmers have relatively few opportunities for crops other than rubber (only cinnamon), the Bangkok situation is the exact opposite of the situation in the village of Muara Buat in Jambi, showing that a preliminary analysis and a typology of situations is definitely required before producing recommendations for a particular rubber system.

RAS recommendation domains
In all cases, rubber is the main economic driving force of each system. Income diversification enables farmers to profit from market opportunities for fruits, timber, rattan and other non-timber products. RAS 1 is designed for farmers in remote or pioneer areas with low cash availability, without land shortage and who are still keen on extensive systems. RAS 2.2 is the most intensive system aimed at farmers with severe land limitation such as transmigrants if indeed they still focus their activities on farming. Farmers in degraded areas with Imperata (in West-Kalimantan and West-Sumatra for instance where the risk is high) are targeted for RAS 3.

6.2 The village budwood garden programme and the production of improved rubber planting material by farmers

Summary of the main results from the surveys on "IGPM availability and use by smallholders in West Kalimantan"

Introduction

Between June and September 1997 three surveys were conducted in the West Kalimantan Province by W. Schueller (ENITA/SRAP student) and Ir Sunaryo (SRAP[12]). The aim was to identify the technical and socio economical constraints faced by farmers concerning IGPM[13] availability and its use in rubber cropping patterns.
The first survey addresses the technical constraints linked to IGPM production in private nurseries in the villages of Sukamulia, Pusat Damai, Sosok and Tanjung in the Sanggau area. The second one addresses the social and technical constraints faced by farmers who produce their own planting material through village budwood garden programmes. The third survey deals with the use of IGPM, particularly through the evolution of the SRDP-TCSDP[14] plots in the village of Sanjan (combinations of clonal rubber + associated trees), and the reasons for such evolution.

Presentation of the main results
Survey I - IGPM availability in private nurseries of the Sanggau area

From producers to users (farmers), through official institutions (in particular Disbun), it seems that there is obviously insufficient care and attention given to the quality and clonal purity of rubber planting material. Some farmers have developed IGPM production activities in order to have additional sources of income beside farming activities. However, most of them still ignore the quality requirements for such production. For many farmers, the important word is "unggul" which means "improved" , in that case "clonal". They are not sensitive to the importance of quality in the production process. Clones are mixed in the nurseries during the grafting period and there is no guarantee for the final user of the type of clone which is provided. Due to budwood shortage, some farmers even graft rootstocks with buds from local non clonal rubber. There is no easy way for the final user to recognize a clone. Clones in budwood gardens can be identified by a good specialist, but there is always still a certain possibility of error.

There is no control and no certification of IGPM, by either private nurseries or government nurseries. Nursery farmers do not keep records of clonal stump production. Many sell their production to intermediates who are in charge of selling it outside the village. Therefore, they do not know what type of purchasers buy their production, and for what use (monoculture or agroforestry systems) . For nursery farmers, production/quantity is more important than quality. This current situation seems to be the result of a lack of technical information or quality policy from official institutions. The importance of clonal purity, and the differences between all these types of rubber planting material has never been adequately explained or stressed. It also seems that Disbun[15] is not especially attentive to these criteria. Productivity often prevails over clonal purity. We must also admit that Disbun resources are very limited, and far from being able to fulfill the demand for planting material. This situation leads Disbun and other projects to sub-contract private nurseries to produce the required planting material without any quality control. On one hand, this creates a demand and an opportunity for private nurseries to develop their activities, and therefore decreases the shortage of improved planting material. On the other hand, as there is no planting material quality policy implemented by Disbun, projects and final users, this has led to the distribution of

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[12] SRAP = Smallholder Rubber Agroforestry Project
[13] IGPM = Improved Genetic Planting Material
[14] SRDP = Smallholder Rubber Development Project (World Bank scheme from 1980 to 1990)
TCSDP = Tree Crop Smallholder Development Project (from 1990 to 1998)
[15] Disbun = Dinas Perkebunan = tree crop extension service.

all kinds of planting material, from the best to the worst. Thus there will be a significant negative impact in the mid term on rubber production and farmers income.

Survey II - Constraints for IGPM self-production by farmers' group through the SRAP community budwood gardens programme in the area of Sanggau-Sintang

Farmers of Sanjan and Sungei Kosak villages were first provided with budwood gardens by the SRAP project in 1995, followed by Engkayu, Kopar, Embaong, Trimulia, Pariban Baru and Sukamulia villages in 1996. Due to social, economic, or cultural criteria, the results of adoption are quite different between villages. The objective of this survey is to understand the constraints that prevent farmers from producing their own high quality IGPM at low cost..

Sanjan and Pariban Baru village budwood gardens may be considered a success. Farmers in Sanjan have already used clonal rubber for more than 15 years, and 5 farmer groups (kelompok) have been created. These groups all have the same opinions regarding the development of the village, and this enables a high level of adoption of innovations. This shows the importance of social balance between groups within a village, social equity, development sustainability and consensus within the community in the process of adoption of IGPM production. Furthermore, all the farmers in Sanjan do not want to join the oil palm projects in the surrounding area that have approached them. Rubber plantations have always been their top priority. Among all the SRAP budwood gardens, only Sanjan's is ready for use now in 1997, because it was planted in 1995.

In the village of Pariban Baru (Sintang area), a few Dayaks, among Javanese transmigrants in a foodcrop based transmigration scheme, joined the PKR-GK[16] rubber project in 1993. There is no real communication between the two groups . PKR-GK Dayaks farmers live in the Dusun II village area, and joined SRAP in 1994. In 1996, they were provided with a budwood garden after discussions with local farmers revealed a strong demand for IGPM. Due to their partial isolation, the Dayak farmers of Pariban Baru have developed a strong solidarity under the authority of the group's leader. They therefore put great hopes in their clonal rubber plantations to improve their income. A group rootstock nursery has been established and grafted. In this case, the strong social cohesion of the farmers group was a key factor in self-production of IGPM.

In Trimulia, a Javanese transmigration village, farmers were originally reluctant to initiate IGPM production activities. They put emphasis and priority on sawah production (irrigated rice). But rapidly they began to understand the advantages they could gain from this new activity, and are about to follow the example of Sukamulia village in developing a trading policy for IGPM. In 1997 many farmers established their own nursery, and intend to increase this activity next year. However they still lack technical information. In the next few years this production activity should greatly increase.

In Embaong, Kopar and Engkayu, traditional Dayak villages, social problems occur due to disagreements between farm groups (social imbalance),and labour and organizational constraints. In Embaong, farmers also consider that they earn enough income from their plantations (clonal rubber /SRDP), and their strategy is to buy clonal stumps rather than produce them. Most of them joined oil palm projects two years ago. Labour is now the main constraint for the development and use of budwood gardens. However the situation seems to have recently changed. Considering the success of the budwood garden programme in Sanjan, farmers in Embaong are reconsidering their position by putting more effort into the community budwood garden.

In Sukamulia, there is no real demand or incentive for good quality budwood for planting material from the final users (mainly Disbun).

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[16] PKR-GK = GAPKINDO funded project, operated by Disbun, the objective of which was to supply 2000 farmers in West Kalimantan with improved planting material and some other inputs through a 'partial' approach .

In Sungei Kosak, the project was a total failure. Indeed, they put more effort into their sawah because rice production is annual. Rootstocks that should have been grafted in 1996 were used to replant dead trees in the plantations.

Conclusion

In the case of the 2 Javanese villages, Sukamulia and Trimulia, IGPM production is oriented to trade and not to plantation establishment. We see here the beginning of a process of specialization (nursery activity) and it shows that one activity, IGPM production may lead to 2 different strategies: self-production for further planting or nursery specialisation for trade. In traditional Dayak villages, the success of the village budwood garden programme does not depend on technical or economic constraints, but on the social cohesion in the community, in particular regarding equity, balance and agreements between farmer groups and consensus on the village level development strategy.

Survey III - Evolution of SRDP-TCSDP plots in Sanjan : introduction of associated trees with clonal rubber in former monoculture plots. The use of IGPM.

This survey shows that farmers still developed innovations after being forced to follow a specific technical package (monoculture). In Sanjan village, farmers were provided with clonal rubber plantations through the SRDP-TCSDP project. Many of these monoculture plots have been transformed by planting associated trees, despite this being forbidden by the official institutions. Farmers still consider monoculture as the best system for clonal rubber, but also think that it does not suit their particular conditions, and that monoculture should be reserved for estates only. Indeed, farmers need other sources of income and look for opportunities to diversify. Almost all the farmers still have experience with jungle rubber, and are familiar with this complex agroforestry system. They think agroforestry practices suit their farming policy, and would like to develop a similar system in their clonal rubber plantations, although on a smaller scale. Therefore, most of them have already planted fruit and timber trees or allowed naturally regenerated trees to grow, and some are ready to grow pulp trees if this activity is going to be developed in the area.

This agroforestry system, already developed in Sanjan and to a lesser extent, in other villages, will probably spread throughout the area in the next few years. To be effective and efficient, this system should be recognised and approved by the official institutions, which still advocate monoculture, and are still reluctant to advise the planting of associated trees. Although most farmers choose rubber monoculture at the beginning when they have access to IGPM, It is still questionable to what extent they will later move to agroforestry practices and what triggers that evolution.

6.3 Farming system characterization In Jambi and West-Kalimantan

6.3.1 West Kalimantan Province

Four surveys have been conducted in the area of Sanggau and Sintang in West Kalimantan: 1- farming systems characterization (FSS), 2- RAS innovations adoption process, 3- IGPM use and production and 4- innovations of rubber cropping systems and cultural practices. The preliminary outputs are the characterization of the farming systems based on rubber, and the analysis of the constraints and opportunities for farmers to adopt rubber improved planting material in agroforestry systems, as an alternative to their rubber cropping systems (jungle rubber, monoculture). The main factors which influence farmer's strategies for land use are the social dynamics in each village. The implementation of rubber projects (SRDP, SRAP) or oil palm projects in each village depends mainly on social organization and social links between each group.

<u>The first draft of an operational typology</u>

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

- ethnic group
- total cultivated area
- access to land and land-use

- capital
- access to rubber improved material rubber (budwood garden)
- off farm activity (oil palm)

A first draft typology would be the following :

1) *Traditional extensive system (Dayak people)*

Traditionally, Dayak farmers practice an extensive agricultural system based on jungle rubber, due to the abundance of land and easy access to communal land. The traditional cropping systems are based on subsistence crops, irrigated and upland rice, and cash crops (jungle rubber). After harvesting rice from upland fields, 90 % of farmers establish jungle rubber with unselected seeds (at least on a small part of each field), as a means of land acquisition.. Because of a lack of communication between farmers and extension agencies on the requirements for clones, only a few l of them are interested in investing their labour in clonal rubber agroforestry systems and still rely on relatively extensive tree crop systems.

2) Intensive system using clonal rubber (Dayak people)

With the introduction of clonal rubber planting material, in combination with a very active social network in the village, the extensive jungle rubber is progressively being replaced by a more intensive rubber system. This foundations for process are already in place because farmers consider that rice is a is secondary in importance to rubber. Rice systems provide only 3 months of food, the rest of the year's requirements being purchased with income from rubber. Farmers prefer to allocate their labour to their monoculture or agroforestry rubber plantations and recently to clonal stumps production. Farmers used community labour groups ('gotong royong') to produce rice and rubber. The cost of such labour is increasing due to off- farm opportunities, in particular in oil palm plantations. With income from rubber, an alternative to reduce the cost of 'gotong royong' labour for weeding in rice and rubber fields is to use a herbicide that is very efficient against *Imperata* : Round up.

3) Intensive sawah and rubber system

The Javanese transmigrants practice an intensive system due to the limited area for cultivation (2 hectares given in the transmigration scheme). This constraint encourages the Javanese farmers to give priority to intensive irrigated rice production on sawah, with high inputs. With the introduction of clonal rubber planting material, some Javanese transmigrants in Sukamulia village have developed rubber nurseries on their upland field (Lahan I) for IGPM production as an additional source of income, as there is a sustained demand from Disbun and rubber projects. Other transmigrants developed new clonal rubber plantations, as was the case in the Sintang transmigration area, and Trimulia (SRAP project).

Adoption of improved rubber planting material: Advantages and constraints

After the establishment of SRDP and SRAP projects, farmers now have perceptions of the pros and cons of clonal rubber planting material. They also know which rubber cropping systems seem to be more adapted to their social-economic situation and which external innovations may suit their needs. The main benefits of clonal rubber planting material are the better yield (50 % of farmers' answers) and a better growth (40 % of farmers). With clonal rubber, farmer can tap trees between 5 and 6 years after planting, compared to local rubber (13-15 years). However, the main problem of some clones is their susceptibility to leaf diseases (in particular Colletotrichum). This shows the extreme importance of good clonal recommendations at the local level to take into account the various risks (leaf diseases, wind damage etc)

70 % of farmers prefer to use clonal rubber compared to clonal seedlings, but there is a serious lack of technical information on the various types of improved planting material. 45 % of farmers have difficulties in recognising a clonal stump from a seedling. Farmers have doubts about the competence of governmental officials, and about the quality of clonal stumps provided by various sources. However, only 8 % farmers consider that the quality of clonal rubber is an important criteria, because they are not able to recognize a clonal stump. We are here at the heart of the problem of IGPM certification.

The main technical constraints in using clonal rubber lie in fertilization during the immature period, and more weeding and labour required than the local rubber. Farmers are aware that only one weeding per year in the jungle rubber affects rubber growth and delays production. 50 % of farmers consider that 3 or 4 weedings per year is the most suitable weeding frequency. Due to limited labour, other farming activities, and a strategy oriented to extensive agriculture, farmers can not follow the SRAP weeding programme, in particular in RAS 1. 25 % farmers can only carry out 2 manual weedings per year, which is obviously not sufficient when there is a high pressure of Imperata, which is the case in the whole province. Most of the farmers are ready to use herbicide (Round up) to save labour with clonal rubber.

IGPM production by farmers (Improved Genetic Planting Material)

For self-production of IGPM, the main constraints mentioned by farmers are the following: limited credit (30 % farmers), lack of technical information and no source of budwood (15 % farmers). The lack of technical information is linked to poor extension, and little farmer to farmer communication. Many farmers do not have any grafting skills, and do not know how to manage a nursery or a budwood garden. However, 60 % of the farmers wish to have an individual nursery. Only one village (Sanjan) has actually produced their own clonal stump from their SRAP budwood garden (planted in 1995). For other villages, grafting will take place in the second half of 1997. In villages without budwood gardens, because of IGPM unavailability, farmers are obliged to buy clonal stumps at a higher cost than if they produced them themselves. The average price of clonal rubber estimated by the farmers is 300-400 Rp/stump.

Innovations in rubber cropping systems

If farmers have access to land for new plantations, 95 % declare they would prefer RAS systems, compared to monoculture. After several years of SRAP activities in each village, farmers seem to know which rubber agroforestry system is more adapted to their labour and capital capacity. In Sanjan village, many farmers have transformed their SRDP rubber monoculture to their own type of Rubber Agroforestry System. According to the farmers, 90 % are interested in planting fruit trees and 70 % are interested in associating timber trees associated with clonal rubber. Through their indigenous knowledge of jungle rubber, farmers have already identified the suitable trees to be mixed with the clonal rubber: *rambutan (Nephelium lappaceum*), duku (*Lansium domesticum*), mango (*Mangifera indica*) etc. The lack of fruit or timber seeds in jungle rubber or in home-gardens (pekarangan) force farmers to buy seedlings of these plants. Another opportunity of RAS (2) is that farmer can produce rice in the inter-row, and reduce the number of weedings.

Adoption of rubber or oil palm projects: a choice

The establishment of oil palm projects has led to speculation for land, and an increase in land value. Several villages like Engkayu or Kopar were undecided in 1997 on which cash crop they will invest their labour in[17]. The future opportunities for developing improved rubber agroforestry systems will depend on village level social dynamics, and community decisions..

6.3.2 JAMBI PROVINCE

Similar surveys were conducted in four villages in Jambi province between June and September 1997. The main characteristics of the selected sites are the following:

- Sepunggur: central peneplain area, where secondary forest is still available, old jungle rubber being the main cropping system. Part of the village territory is reserved as community land for annual crops (where tree crops are forbidden). Since 1992 there has been no available land left for further planting, other than old jungle rubber or fallows.. Most of inhabitants are local Malayu farmers, including some local transmigrants *(translok),* and some

[17] They eventually did choose in 1998 and joined oil palm projects. Most of them have now 2 ha of oil palm in addition to their former cropping systems.

spontaneous migrants (Minang, Batak, Javanese ethnic groups). SRAP on-farm trials have been implemented there since October 1995.

- Muara Buat and Rantau Pandan: hilly areas representative of the Barisan mountains piedmont, with both primary and secondary forests, where land is still plentiful, in particular in Muara Buat. Local farmers are in majority Malayu. SRAP on-farm trials have been implemented there since December 1995.

- Rimbo Bujang transmigration area. Two units (unit 9 and 7) were selected: Unit 9 with recent transmigrants (TSM) and Unit 7 much older (INTI). Land is limited to 2.5 hectares per household, where the main cropping system is clonal rubber monoculture .There is no available land for further planting. There is no SRAP on-farm trial, but TCSDP (Unit 9) and NES (Unit 7) rubber projects have been integral to the transmigration programmes. A total of 68 farmers were surveyed in these places.

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Farming systems characterisation

Farming systems in Sepunggur are mainly based on rubber as the source of income, exclusively jungle rubber.. There is no wetland rice and hardly any upland rice production, whereas in the piedmont areas farmers crop extensive wetland rice in addition to rubber (Muara Buat, Rantau Pandan). Cinnamon is a new crop opportunity, sustained by a growing demand and market in the neighbouring province of West-Sumatra. Most of these piedmont farmers still have access to secondary forest or fallow. Traditional jungle rubber is largely dominant. Some recent innovations appear in the cultural practices: more and more monoculture in young local rubber plantations, at least during the immature period; to a certain extent, clonal seedlings from surrounding estate plantations are replacing traditional unselected seedlings, and few farmers buy clones from private nurseries. The average jungle rubber production is around 600 to 650 kg dry rubber/ha/year.

In transmigration areas, almost all the land is covered by clonal rubber provided by the transmigration project (NES), TCSDP (Ministry of Agriculture) or by estate plantations[18].

Rubber here is cultivated in monoculture. All inputs (fertilisers, pesticides and herbicides) are or were provided by projects (credit to be reimbursed between 5 and 13 years after planting, depending on the project). The average rubber production from these clonal plots is about 1600 kg/ha/year. Some farmers have a small oil palm plot in addition to rubber fields. Many farmers also have off-farm activities, both in the agricultural sector (share-cropping/tapping, fishing etc.) or in other sectors such as trading or teaching. These activities can generate additional income to that from rubber. In Rimbo 9 village, off-farm activity is the only source of income during immature period.

Study of the innovations adoption process

The farmers' knowledge about clonal rubber depends on the presence of a rubber project in the area (TCSDP, NES, SRAP) or surrounding estate plantations (PTP). In transmigration areas, where almost all the farmers are following the TCSDP/NES programmes, all surveyed people have for years been well informed about clonal rubber, its characteristics and requirements concerning cultural practices (in particular labour and inputs). In other villages, around 50 % of farmers know about clonal rubber, mainly through discussion with PTP workers.

Capital and IGPM availability are the two main constraints. Most of the farmers cited the lack of capital as the main reason for continuing to cultivate local unimproved rubber varieties. They see monoculture as the best cropping system in terms of rubber growth, especially for clones. However, rubber is mixed with annual crops during the first two or three years for optimal land use. Rubber is often mixed with perennials too; in jungle rubber with fruit trees (durian, jengkol, petai etc) or coffee, and sometimes with cinnamon in the piedmont area. In transmigration areas,

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18 Although most estates use clonal rubber, some of them have planted PCS (PBIG from Malaysia in Rimbo Bujang)

the only perennial allowed by officials is manau rattan (*Calamus manan*), which is not officially considered as disruptive to rubber growth)[19].
Most of the farmers go on tapping jungle rubber in a 'fishbone' pattern (2 cuts in a 'V' shape, and cropping it in traditional way, without any protection or use of fertilizers, herbicides or pesticides. Weeding is almost non-existent, with a maximum of one weeding per year during the immature period.

Land and capital are the two main restricting factors in these systems: lack of land especially for transmigrants and lack of capital for most of the local farmers. So, a preliminary typology of the situations can be made according to these two criteria, and four classes derived. The first class has access to land but no capital (most of the local farmers), the second class has both access to land and to capital (some rich farmers in the non-transmigration areas), the third class has neither available land nor capital (young second generation transmigrants in Rimbo 9), and the last class has no more available land but enough capital to cope with this lack of land (older transmigrants in Rimbo 7).

Conclusions
Farmer organization and social coherence within the village community are key factors which determine whether or not farmers integrate certain innovations into their systems.
Land scarcity leads to intensification of rubber systems, and the first step is the use of IGPM (on condition that capital is available). Therefore, production of good quality IGPM at low cost by farmer groups seems to be a priority. Technical information and practical training are also important, as lack of these has caused existing BANDES[20] budwood gardens to be abandoned.
A technical problem restricting clonal rubber adoption in Jambi province is the lack of grafting training (there is a strong demand for this training from farmers). The main economic constraint is a lack of capital, which is necessary to buy IGPM and required inputs.

6.4 Specific studies

In-depth agronomic studies on the effect of burning on soils, effects of above and below ground competition on rubber growth, as well as land use studies and an assessment of biodiversity have been implemented. Preliminary results are presented and discussed in various papers presented in this workshop.

Final Conclusions

Very promising results have been obtained with RAS experimentation both for technical and social issues. However the technical data were not always easy to process, due to a large variability in farmer management.. Information on RAS 1 and 2 may be used in releasing technical recommendations for the A1 (establishment) phase in the very near future, however some hypotheses, such as "no effect of associated trees on rubber yields (at planting density selected for current RAS)" still need to be confirmed over the next 20 years. Further monitoring is required to improve our knowledge about phase A1 and other future phases. RAS experimentation is a long term research programme.

After being fully analysed, the farming system characterisation and the RAS innovation adoption process studies implemented in 1997 will lead to an operational typology of situations (in 1998) where specific RAS systems will be targeted to farmers according to their resources and strategies. We hope that this operational typology will be a useful tool for development agencies.

The survey on "IGPM availability and use in rubber based cropping systems" has provided useful information on farmers' strategies with respect to indigenous knowledge on and the understanding of IGPM, about self-production

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[19] Rattan harvesting in trials located in North Sumatra (Sungei Putih Rubber Research Station), showed that, on the contrary, rattan is very damaging if planted before rubber reaches 25 years old.
[20] BANDES = Pembangunan Desa. Village development program.

of IGPM by farmers and about the use of IGPM in agroforestry systems. An interesting finding was the way farmers have introduced fruit and timber trees to clonal rubber plots which were formerly pure monoculture.

Specific studies have enabled us to gain a more in-depth agronomic understanding of RAS components. Another important component that has not been yet covered is biodiversity in RAS systems (in particular in RAS 1) and comparison with existing biodiversity in jungle rubber, expanding on the work of de Foresta (1990).

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Annex 1
Local/Latin names of tree species

Local name	Latin name	English name
Aren	Arenga pinnata	Sugar palm
Beringin	Ficus parvolia	Weeping fig
Cempedak	Artocarpus integer	
Cengkeh	Eugenia aromatica	Clove
Coklat	Theobroma cacao	Cocoa
Duku	Lansium domesticum	
Durian	Durio zibenthis	
Jambu air	Syzigium aqueum	Watery rose apple
Jambu bol	Psidium guajava	Guava
Jengkol	Pithecellobium jiringa	
Karet	Hevea brasiliensis	Rubber
Kayu manis	Cassia vera	Cinnamon
Kedondong	Spondias mombin	Hog plum
Kelengkeng/mata kucing	Dimocarpus longan	Longan/cats eyes
Kemiri	Aleurites moluccana	Candle nut
Kepayang	Pangium edule	
Kopi	Coffea robusta	Coffee
Kwini	Mangifera odorata	Kurwini mango
Langsat	Lansium domesticum	
Mangga	Mangifera indica	Mango
Manggis	Garcinia mangostana	Mangosteen
Meranti	Shorea spp.	
Nangka	Artocarpus heterophyllus	Jackfruit
Pepaya	Carica papaya	Papaya
Petai	Parkia speciosa	
Pinang	Areca catechu	Areca nut
Rambutan	Nephelium lappaceum	
Salak	Salacca edulis	
Sengon	Paraserianthes falacataria	
Sirsak	Anona muricata	Soursop
Sungkai	Peronema canescens	
Tekam	Shorea spp.	
Tengkawang	Shorea spp.	Illipe nut
Terap	Artocarpus elasticus	Wild breadfruit

Annex 2
Specific constraints to RAS adoption

Topic	West Kalimantan	Jambi	West Sumatra
Previous and/or current projects, access to information	SRDP/TCSDP	ASB	Pro-RLK
Indigenous knowledge and agroforestry practices	**+++**	**+++**	**+/-**
Clone availability	**+**	**+/-**	**-**
BLIG availability	**-**	**-**	**+++**
Fertilizer use	**+**	**-**	**-**
Upland rice (HYV)* availability	**-**	**---**	**--**
Seed quality	**-**	**-**	**-**
Covercrop seed availability	**-**	**-**	**-**
Pests and diseases	**-**	**--** monkeys, pigs	**-** pigs
Weeds	Imperata	Mikaenia	Imperata
Rubber diseases	*Colletotrichum*		possibly *Colletotrichum*
Land constraints	very low fertility, land scarcity in transmigration areas	steep slopes in pioneer zones	very low fertility and steep slopes, altitude: 550 m - close to upper limit for rubber
Upland rice production	with selected local rice varieties : average potential	may be good in peneplains	excellent weeding, requires soil and water conservation techniques
RAS adoptability potential			
RAS 1	**+++**	**+++**	**0**
RAS 2.2/RICE	**++**	**+**	**+++**
RAS 2.5/cinnamon	**0**	**+++**	**++**
RAS 3	**+++**	**0**	**+**

* HYV: High Yielding Varieties