Rubber agroforestry systems (RAS) : improvement of productivity, rubber based systems sustainability and biodiversity .

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EXECUTIVE SUMMARY

The rubber smallholder sector contributes to 84 % of the total rubber area and 73 % of the total production in Indonesia. So far, only 13 % of farmers have been reached by rubber smallholder development projects based on a rubber monospecific cropping technological package, comparable to that of estates, and this has been at a relatively high cost (PRPTE, NES, SRDP and then TCSDP/TCSSP projects). 10 to 20 % of non-project farmers close to these projects may have taken indirect benefit in terms of technical information, credit and, mainly, improved planting material, IGPM[1], from these existing projects. 70 % of the rubber farmers still do not have access to technical innovations and are growing rubber under "jungle rubber" management, an extensive rubber based agroforestry systems that covers more than 2 million hectares in Indonesia. Most of these farmers rely on rubber as their main source of income from jungle rubber. This is a low input agroforestry system, where rubber competes with the regrowth of the natural forest, very low establishment cost and with very low labour input, almost no maintenance. However, it has a low level of productivity due to the use of poor planting material (rubber seedlings).

On the other hand, such jungle rubber maintains a forest-like environment which is favourable to soil conservation, water conservation in watersheds and a certain level of biodiversity. Basically, jungle rubber is a sustainable rubber-based cropping system installed by farmers after the slashing and burning of the existing vegetation, primary or secondary forest, old jungle rubber or bush, for one upland rice crop. The creation and development of a demand for natural rubber in the beginning of the 20th century lead to a wide development of the smallholder rubber sector, and to the stabilization of the former swidden agriculture. The increase of productivity of rubber cropping patterns is considered to be linked also with the improvement of quality of rubber raw material.
The main issue is to assess the feasibility of growing IGPM, and in particular clones, in an agroforestry system, competing with natural secondary forest regrowth (RAS 1) or other perennial (RAS 2 and 3) an to known to which extend competition or association with other trees may affect the production level of both rubber and associated trees (fruit or nut trees, timber trees, rattan...). Basically, the key question is wether high yielding IGPM, and in particular the clones, can be cultivated in RAS or do require monoculture conditions.

Implementation of OFT (On-Farm-Trial), with participatory approach with farmers, will permit to identify the components of several improved rubber based agroforestry

[1] IGPM : Improved Planting Material is divided in two different types : the "clones", that have been selected by cross-breeding or from one remarkable tree and multiplied by grafting from one unique selected tree, and the improved "seedlings" : the clonal seedlings (CS) are trees obtained from seeds collected under clonal rubber trees, and polyclonal seedlings (PCS)are seeds collected in specific clonal garden with a mix-up of several selected clones. A clone is a very homogeneous high yielding planting material that requires grafting and nursery management, therefore it is costly (400 to 700 rp/plant in 1994). CS and PCS are heteronegeous medium yielding planting materials. CS/PCS are generally cheap due to the use of seeds (prices between 20 to 80 rp/seed), however their production potential is limited.

systems (RAS), with various level of intensification, without destroying the very nature of such systems, regarding to the farmers' possibilities, but also to biodiversity and environmental concerns. RAS is a source of diversification of income, with low to medium input, and high productivity through the use of IGPM and associated perennial crops (for timber, fruits, rattan production...). The identification of such RAS through adaptive on-farm research (OFT, demo-plots and farming system surveys) may enable the development of further technical RAS recommendations and a farmers' typology for intermediate medium input rubber based agroforestry systems that fit the non-project farmers' situations. Rubber smallholder development strategies might be developed later as alternatives for development projects complementary to the current rubber development approach (TCSDP/TCSSP type projects) .

Keywords :

Rubber, Rubber Agroforestry Systems (RAS), non-project and self-reliant farmers sector, rubber productivity, rubber commodity system, rubber based farming systems typology, jungle-rubber, participatory approach, on-farm-trials, GAPKINDO, ICRAF, CIRAD, Indonesia.

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Introduction

After a review of the rubber smallholder sector situation, it will be presented the potential to develop other technical alternatives between jungle rubber currently cropped by the majority of farmers and current rubber development projects in Indonesia. The Rubber Agroforestry Systems (RAS) in a global perspective including the search of sustainable cropping systems, alternative to slash and burn process and reliable, increased and diversified source of income for rubber farmers.

1 ***Indonesia's rubber sector : The importance of the smallholder sector***

Natural rubber is the Indonesia's second largest non-oil agricultural export after plywood. Indonesia is the second larger rubber producer behind Thailand and just before Malaysia. These 3 countries contribute to more than 80 % of the total natural rubber produced in the world. It is considered that around 12,5 million people are involved in rubber production, processing and marketing in Indonesia. Rubber is the main income source for smallholder in all the low altitude and poor soils plains of Sumatra and Kalimantan.

The smallholder sector accounts for 84 % of the country's rubber area and 73 % of the total rubber production. In that respect, the situation in Indonesia is intermediate between Thailand (95 % smallholder, 5 % estates) and Malaysia (60 % smallholder, 40 % estates). There are approximately 1,3 million of farmers' households relying on rubber production producing 925 million tons on 2,658 million of hectares, compared to around 650 000 ha for the estate sector. Farmers' average yield[2] is low, 593 kg/ha compared to that of the private estates (1065 kg/ha) or the governmental estates (1311 kg/ha) (Statistik karet, DGE, 1992).

So far, approximately 15 % of farmers have been reached by governmental rubber development projets. We can estimate that maybe 10 or 20 % of farmers may have enough cash, or have access to credit and access to information and planting material due to the fact that they are located close to these projects and can take an indirect benefit. generally, they may be able to shift from their old jungle rubber to Rubber Monospecific Plot (RMP). RPM is an intensive rubber cropping system similar to that of the commercial estates, which involves the use of clones (from various and sometime controversial sources, and of varying

[2]Rubber yield is calculated on areas with mature trees. The total rubber cropped area includes also immature trees. Yield and areas statistics at the national level are subject to incertainty.

quality).

However, 65 to 75 % of the smallholder sector, representing more than 50 % of the total rubber production of Indonesia, still do not have access to IGPM, information and credit, and still grow rubber in an extensive system, defined as jungle rubber (see A Gouyon[3], C Nancy[4], C Barlow[5] for jungle rubber definition and analysis....). A first typology, table 1, display the distribution and the characteristics of 4 classes of farmers, depending their access to technology. The recommendations domains of the RAS research programme is class III farmers : the non-project farmers that want to improve the productivity of their current rubber cropping pattern without a deep change , in term of management, of their extensive cropping practices based on agroforestry where rubber is the main cash crop.

Description of the jungle rubber system

The jungle rubber system is basically derived from the encountering between 1) a swidden agriculture in Sumatra and Kalimantan where land was plentiful, 2) a new crop opportunity (the growing demand for rubber since the beginning of the century) adapted to the agro-ecological conditions, 3) a growing number of spontaneous migrants and 4) the Indonesian custom of mixing trees in a extensive agroforestry system with few labour input and limited cash.

After slashing and burning the primary or secondary forest, upland rice is cropped for one year, followed sometimes by a palawija[6] crop the second year. Then the plot returns to fallow, secondary forest, or Imperata savannah, depending on local conditions. Rubber has been introduced as an alternative to this unproductive fallow. Rubber seedlings are planted the very first year with the upland rice. Then, the plot is abandoned for several years and rubber competes with the natural regrowth of the forest to give a jungle rubber. The competition with the forest implies a delay in term of growth for rubber and opening (first tapping, the beginning of latex production) occurs generally 6 to 10 years after plantation versus 5 years in normal condition. The yield is very low due to poor planting

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[3]Socio-economist of CIRAD-CP, Tree crop Department, based in South Sumatra from 1988 to 1991, see publications in anex.

[4]Socio-economist from Sembawa Research Station (IRRI).

[5]Socio-economist from the National Australian University.

[6]The palawija are the non-rice secondary crops such as groundnut, corn, soybean, cassave....

material. Maintenance is very low, sometimes unexisting. Cost of establishment is very low. Labour is limited to planting during the immature period. Jungle rubber is a sustainable "forest-like" system where rubber is the main cash-crop. The farmer generally collects also fruits and nuts, firewood, timber.....

***Improve planting material ; a challenge*.**

75 % of farmers are still currently growing rubber under jungle rubber conditions with a very poor productivity and rubber raw material quality, with very poor planting material such as unselected seedlings, due partly to the lack of financial and technical means, but mainly due to the lack of IGPM availability (in particular the clones) to improve their rubber cropping patterns. The productivity of such farmers has not significantly change since the beginning of the century with the boom on rubber in Sumatra. *The main target is to enable to them to shift from an extensive system to a more productive system, and sometimes more intensive*. *The very first issue is to increase the productivity from the current rubber yield of 300/600 kg/ha in jungle rubber to a yield of 1300 to 1800 kg/ha (with clones), with a good quality of rubber raw material, through the adoption by farmers of low cost RAS patterns close to their current cropping patterns.*

This increase of productivity implies the adoption of IGPM, mainly clonal rubber, but also CS/PCS for specific situations. A lot of research has been done to improve rubber production in estate conditions, leading to the release of a well identified improved technological package for rubber. So far, basically, a similar to estate technological package has been adapted to smallholder. The best example is the one used by SRDP in the 80's in Indonesia (and still used by current projects). This package is based on the use of clonal rubber, in a rubber monospecific cropping system, with a high level of maintenance for the immature period and an adapted exploitation system for tapping[7]. It is a well-tried and well known package, but it is an expensive one, that does not fit the farmers capacities without technical and financial help from governmental projects[8].

So far, no adaptive research has been done to improve the productivity of such systems without destroying their very nature

[7]The rubber exploitation system includes the tapping patterns (frequency...), the panels management (downward and upward), the use of stimulation....

[8]The average cost for a plot of 1 ha for SRDP project was 2 000 US $.

: an agroforestry system based on rubber, where rubber is the main cash-crop, but not the only source of income, beside other advantages. Basically, the key question is wether high yielding IGPM, and in particular the clones, can be cultivated in RAS or do require monoculture conditions. RAS patterns will be tested through OFT keeping in mind that RAS are only "open" models. Through participatory approach, farmers will have the final decision for some RAS components such as the type of perennial associates with rubber or the level of maintenance, depending on local factors, both ecologic or economic.

IGPM availability is still limited in most provinces (except South and North-Sumatra). There is a high level of planting in some zones since 15 years ago (Jambi, Riau, West-Sumatra, Bengkulu in Sumatra, and West, Central and South-Kalimantan in Kalimantan, and more recently Ceram/Maluku and Irian Jaya at a very small scale), and also replanting (South-Sumatra is a good example). In each province where rubber is cropped, pioneer zones (extension of jungle rubber) and replanting zones (adoption of improved systems) are both present.

Adapted rubber cropping patterns for a correct land-use as an alternative to the slash and burn process is an issue for developers in these zones.

The situation may be summarized in the following points :

- 1 - planting rubber is a land acquisition process from a formerly "undivision land tenure" (where land is belonging to the community) to a full "individual property" by the fact of tree planting. *Land status is an important factor in the strategy of the farmer. Planting rubber is a land acquisition process.* This explains also why the system has been so extensive in locations where land was plentiful and originally population density was very low (central plains of Sumatra and Kalimantan).

- 2 - rubber is still seen as a long term income source, with a certain flexibility of the cropping pattern (possibility of stopping the tapping without damaging the trees), without a lot of risk under the current system. In that respect, rubber trees may be considered as a "bank". *Risk management is seen also as a major issue for those poor farmers.*

- 3 - rubber increase the value of poor lands with no other sustainable crop alternatives, at least no sustainable annual foodcrop systems. Rubber is the only sustainable crop to be grown by smallholder on large areas of Sumatra, Kalimantan and Irian Jaya. *Rubber is then the main component of agricultural development in these areas* (probably up to 5 millions ha). Oil palm and coconut tree may be alternative crops depending on agro-ecological zones (in the central plain of West-Kalimantan and South and North of Sumatra for oil palm, mainly for estates, coastal zones for coconut). In mountainous areas of western Sumatra, crop alternatives may be coffee and cocoa (West-Sumatra and Bengkulu provinces). An other alternative might be timber production.

- 4 - Rubber cropping systems are the only reliable and sustainable alternative to slash-and-burn and to shifting cultivation in these areas that give a reliable and permanent source of income to farmers. Sustainability of such systems is not only environmental, but also financial. The current system of jungle rubber maintains a high level of biodiversity (De Foresta, 1990), and a good level of soil and water protection through a forest-like ecosystem. Soil fertility is improving under rubber as latex tapping does not export significant nutrients. *The evolution of the current jungle rubber into RAS (Rubber agroforestry system) is a major issue for soil conservation, conservation of a forest-like environment and biodiversity.*

The potential for improving the jungle rubber is clear from the information that have been collected. Also the quality of rubber raw material rubber produced by a very heterogeneous smallholders sector is linked to a general increase of productivity of the sector[9], as it has been previously identified by economists (A. Gouyon and C. Nancy, Colin Barlow, M Dove). The price incentive increase if the production is significant.

2 the features and constraints of jungle rubber.

2.1 the constraints on jungle rubber

Jungle rubber systems are now well known (A Gouyon, C Nancy, C Barlow). After having seen the origin and the extent of jungle rubber in Indonesia, the constraints and shortcomings of jungle rubber may be summarized in the following :

- 1 - a very low productivity due to poor planting material (seedlings). There is not a sufficient supply of IGPM, in particular certified clonal plants. Farmers may have not cash or credit to afford the cost of clones for planting. The quality of planting material is most of the time not assured. The available credit from the middlemen (most of time there is no other source of credit) is at very high interest rates and does not fit the farmer's need for long term investment for a new plantation (or

[9] See the publications of Anne Gouyon, economist of CIRAD.

replanting). *Low cost RAS patterns are an important issue to fit the needs of farmers according to the cost of intensification. The level of cost of improvement of jungle rubber or shift to RAS is considered as low to medium.*

- 2 - a poor quality of tapping (overtapping, V-tapping, full spiral taping, overconsumption of bark, many wounding up to bark destruction...) results in the reduction of yield and, in the long term, of the tree's lifespan, therefore of its production potential. Little information on good exploitation system is available for farmers and current behaviour should be understood in term of short-term strategy of the farmers (in term of production, not in term of "tree-banking"). That is linked with the need of immediate cash availability.

- 3 - poor soils, sometimes with a water ground table as close as 50 cm deep (in Kalimantan), leaf diseases with strong attacks (West-Kalimantan), wind damage (North-Sumatra : various agro-ecological factors, resulting in the necessity to refer to an agro-ecological typology and zoning, may affect rubber production. Geographically, this means that it will lead to various different situations to take into account, with different strategies of farmers to cope with these local problems.

- 4 - a poor quality of rubber raw material. The under-use of rubber processing facilities (70 %) lead to a situation of permanent competition between processors for rubber availability and a permanent demand for any kind of rubber, leading to a very low raw material quality purchase policy. Nevertheless, in some areas, a quality pricing policy may exist, practically nearby SRDP projects (the case of West-Kalimantan).

- 5 - a lack of information on technical innovations : no or few extension services outside rubber projects are dealing with farmers (in particular in pioneer zones). The efficiency of the extension services is limited by the lack of adapted technologies for the farmer, and very limited, practically, to the supply of clones (by DISBUN[10] or local small scale projects).

- 6 - whereas there are for some provinces other crop opportunities, like coffee and cocoa in West-Sumatra and Bengkulu, or oil palm in Lampung and central parts of West-Kalimantan, there is usually no other crop alternatives for rubber farmers in most of rubber growing areas, leading to a very rubber-specialized farming system. Increasing the productivity of rubber systems as a whole (including agroforestry systems) is generally the only solution to improve

[10]DISBUN = Dinas Perkebunan : extension service for tree crops.

farmer's income through agricultural production at the moment, beside possible income opportunities with industrial development.

2.2 The advantages of jungle rubber as a rubber based agroforestry system

The establishment of jungle rubber is made at a very low cost if any, in fact, as land is already cleared for upland rice cropping and as rubber seeds do cost nothing if collected in near-by jungle rubber plots. Labour input is limited to seeds planting or to a little nursery with the transportation of seedlings plants to the near-by plot. Maintenance of rubber the first year is limited to that of upland rice, if any. Then the farmer lets rubber to compete with the secondary forest regrowth. First tapping occurs 8 to 10 years later. Jungle rubber is composed by rubber and other trees, some of them multiple-purposes : fruit or nut production, timber, rattan...and some secondary species, depending on biodiversity, without specific use. The system provides income diversification. The secondary forest associated with rubber maintains a certain level of biodiversity and a forest like environment with a good soil conservation and an increase of soil fertility, and a better water management in watershed.

In a whole, jungle rubber, and RAS systems derived from it, are sustainable alternatives to the original slash and burn process, with a higher productivity in the case of RAS, that fit the farmers constraints in term of labour and limited financial input. RAS 1[11] pattern will have the advantage of a very high level of adoptability by farmers as RAS 1 is very close, in term of management, to the current jungle rubber system and as farmers express a strong demand for a clonal planting material adapted to these conditions.

The issue is to assess the possibilities for improving rubber patterns productivity, therefore of their income. Sustainability and productivity increase of jungle rubber, encountered in various locations of Indonesia through adoption of adapted innovations (RAS) and alternatives are the principle immediate objectives for the development of applied technical support. In order to maintain or increase their competitivity and their income, the Indonesian non-project smallholders have to cope both with an increase of the raw material quality, an increase of rubber yield and an improvement of the rubber cropping patterns productivity.

[11]RAS 1 pattern is a system similar to jungle rubber where the rubber seedlings have been replaced by IGPM, in particular clones (see the paper SRAP project proposals).

Albeit a great effort from various rubber development project, and in particular SRDP/TCSDP since the 80's, most of the farmers still do not have access to any improved rubber cropping system, due to the high cost of the SRDP/TCSDP package rubber cropping pattern, currently adopted in smallholders projects (TCSDP[12] and TCSSP[13]), showing the need to an intermediate low cost but with high productivity rubber cropping system based on agroforestry.

3 The SRAP : Rubber Agroforestry project.

The rubber farmers may be divided in 4 types as presented in the table 1. A methodology of analysis has to be identified[14] in order to deal with the variability of situations of the smallholders

The key question for developers, and therefore for researchers, is the following : to which extend the jungle rubber system may contribute in the future to these multiple objectives : a) the increase of the farmer's income, b) the increase of the farmer's productivity, c) the increase of quality of the preprocessed rubber raw material and d) the preservation of forestry environment and biodiversity.
Regarding the productivity of an improved rubber agroforesty system (RAS) : what are the main components of the evolution of jungle rubber for a better productivity ? How to valorize this biodiversity ? which crops may be suitable with rubber in RAS ? What are the importance and the future of secondary use of rubber such as wood....?
Two basic problematic have to be taken into account :

- *the pioneer zones* : how to improve the jungle rubber pioneer system, within the available means to the farmers, or to which extend, and at which cost, it is possible to improve it, in order to give to the farmers the opportunity to have a better productivity for the new planting ?
- and *the replanting zones* : how to create the favourable conditions to the shift from an ancient jungle rubber plot, into an improved system : RMP (TCSDP policy) or RAS, at a low cost, with a partial approach ?.

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[12] TCSDP is funded by World bank and developed in the following provinces : Bengkulu, West-Sumatra, Riau, South-Sumatra, Jambi, Maluku and West-Sumatra.

[13] TCSSP is funded by ADB and developed in the following provinces : Aceh, North-Sumatra, Lampung, South and East-Kalimantan. Both projects TSCDP and TCSSP are based on the same technological package for rubber.

[14] The research done by Anne Gouyon and C Nancy in South-Sumatra (1988-1991) can be used for that purpose.

In both cases, the need for technical innovation, information and training, level of cost and credit and development policy priorities should be assessed.

Possible evolution of jungle rubber.

Jungle rubber may have different patterns of evolution, depending on farmer's situation and on ecological features :

- 1- The shift from rubber-forest to Rubber Monospecific Plot (RMP) : the existing recommendations are clearly identified now in what could be considered as the "TCSDP package"[15]. The main component of this package is the clonal planting material. Projects (TCSDP, NES, GAPKINDO, DISBUN.....) and private nurseries operators have widespread a certain number of clones in some provinces since several years to class II farmers, however the purity of clones is not always guarantied.

- 2 - The shift from rubber-forest to an improved Rubber based Agroforestry System (RAS) .The objective is to increase the global productivity of this complex agroforestry system, without destroying their very nature. This is clearly a priority objective that concerns the very majority of farmers. Environment aspects and biodiversity have to be taken into account. The different level of biodiversity (from the secondary forest to the introduction of associated crops, such as fruit and timber tress, firewood trees etc..) of such systems should be assessed and valorized. The use of clones (and also clonal seedlings/CS and polyclonal seedlings/PCS to identify their real level of adaptability and production in such environment) is the first component to be tried. The introduction of improved planting material is not the innovation in itself, but the innovation is in its use in improved RAS where the problem is the ability of clones to compete with secondary forest or the balance with other associated perennial crops. Different levels of intensification should be studied

The IGPM unavailability (in particular the clones), limited cash availability for IGPM, the lack of credit, the lack of information force a vast majority of farmers to stick to the current jungle rubber system, without any improvement. The introduction of IGPM into this sector may enable a consequent increase in production. The shift from jungle rubber to RAS and identification of such suitable RAS systems adapted to local ecological and economic situation is the main objective. The sustainability and the productivity of RAS should offers an alternative to slash and burn in deforestation and pioneer

[15]Full technological package for rubber, considered as the "estate" package transplanted for farmers.

zones, or in remote areas.

The level of intensification in RAS should fit the farmers possibilities in term of labour and financial input (therefore inferior to those required for a TCSDP plot for instance) and reach a level of RAS productivity that generates sufficient income to permit farmers to rely on cash from rubber and by-products such as fruits, timber, firewood, rattan, etc...The adoption of an rubber based agroforestry system (RAS) enables the diversification of income sources as well as some different alternatives of evolution at the end of the RAS lifespan (or rubber plantation lifespan) : to remove the old RAS by a new RAS, the shift from RAS to a monospecific rubber plot, like in TSCDP, or to conserve a fruit and timber oriented agroforest (such as tengbawang system in West-Kalimantan).

4 RAS research topics

4.1 Main features

The constraints and opportunities to enable such increase of productivity have to be fully identified and resolved through the followings research themes :

- 1- the acquisition of a good knowledge of the smallholders sector, through the analysis of the existing bibliography and the implementation of surveys in not well known production zones (mainly Central and West-Sumatra and Kalimantan). This should enable the identification of an operational typology of situations and farmers (see table 2). Some topics still have to be well identified such as : the definition of a rubber grower, land tenure and property, labour relation and contracts between farmers, owners and labourers, credit schemes by middlemen, the risk management depending ecology and economic situation...

- 2 - after an analysis of the various situations of the smallholders sector : the identification of research topics and guidelines for on-farm experimentation, with priorities (see table 3).

- 3 - appropriate on-farm-experimentation in order to produce adapted RAS patterns. The objective is to create the good conditions for the evolution of the current rubber based farming systems (mainly jungle rubber with poor productivity) and to identify the adapted technologies for this evolution depending on environment, geographical and economical situations.

- 4 - an analysis of the Indonesian rubber commodity system to produce recommendations in terms of rubber pricing policy and quality pricing policy to be adopted by rubber professionals in Indonesia and development objectives for non-projects smallholders in Indonesia.

4.2 The improvement of productivity of the rubber cropping patterns : A major issue : the adoption of IGPM and in particular the clones

The principal constraint in Indonesia rubber production has been identified as the quality and the potential of planting material. The clone remains one of the main reliable answer for increased production and productivity, but it requires a minimum of investment (cost of the planting material and labour for maintenance). The use of clones may enable the latex production to be doubled or tripled. Equally, it is recommended also to test clonal, or polyclonal seedlings, such as BLIG (Bah Lias Isolated Garden, North-Sumatra), in order to test their behaviour and their real potential.

POTENTIAL OF DIFFERENT RUBBER PLANTING MATERIAL IN INDONESIA	
PLANTING MATERIAL	YIELD IN KG/HA
non selected seedlings	300 to 500
monoclonal or polyclonal seedlings	500 to 1 000
clones	1000 to 3000

Previous surveys of smallholders and estates show a great demand and interest in IGPM, in particular if they are adapted to their specific local conditions. It is thus necessary to have a better knowledge about the performance potential of these IGPM in various situations, including the rubber-forest situations. This must be based on experimentation in real conditions in non-project farmers (RAS).

The improvement of productivity through the adoption of IGPM.

Historically, the presence in the very early beginning of the rubber planting boom in Sumatra, of active Research Centres (AVROS in Indonesia) enables Indonesia, in particular the estate sector, to profit from the release of famous clone[16]. The adoption of IGPM is the very first step to improve productivity. But the smallholder sector still did not do this "varietal revolution", as adoption of IGPM has

[16]Such as GT 1, PR 107, PR 255, PR 261, AVROS 2037 in the past (and still grown but not all yet recommended), and, more recently : BPM 1, 24, 107, 109, the PR serie : PR 255, 261, 300, 302, 303, 307, 309, 311, 314, and TM series.

been limited to development projects and, in some areas, to wealthy farmers able to buy clonal planting material where nurseries have been developed by the private sector (mainly South and North-Sumatra). Developing and improving RAS systems means the adoption of adapted IGPM with a low cost of production for the farmers, and probably, by the farmers themself. Adaptive research has to be done in order to identify the IGPM component of RAS package at low production cost techniques. *Concerning On-farm-trials (OFT), emphasis should be put on clonal testing and then recommendations adapted to the farmers conditions.*

The availability of clones, or CS/PCS, should be improved in various locations through the implementation farmers nurseries programmes (A Gouyon 1990, C Barlow 1993, C Bennet-Quizon-Mawardi 1991..). Then, it is an important issue to guarantee to the farmers the quality and purity of the improved planting material, in particular in the case of private nurseries. *The supply of certified clonal planting material*[17] *to smallholders is a major issue.*

The cost effectiveness and growth effectiveness of the use of economical doses of fertilizers to boost growth have to be assessed. BLIG planting material has also to be assessed in such conditions.

The goal, in term of rubber production as the main cash crop, is to reach a yield of 1 000 to 1500 kg/ha (as also maximization of other associated perennial crops) in order to create a real improvement from the existing situation in term of productivity. It is assessed that a slight increase of rubber yield may not be sufficient for the farmers to modify their current practices.

The goal for RAS as a whole is to increase the farmer's income by raising productivity of RAS, including others production as well as rubber.

4.3 Other technical components to be tested for RAS implementation.

Other crops, naturally grown (wood species) or introduced (rattan...) have to be tried under farmers conditions[18]. This experimentation is clearly very new as there is no

[17]These clones may be : RRIC 100, BPM 1, PB 260, PR 261, RRIM 600, and TM 8 or 9....depending on agro-ecological zones (pressure of diseases and wind-damage).

[18]Some interesting results came out from experimentation done in Sungei Putih (North-Sumatra).

experimentation already done in other countries. The objective of these experimentation is to give the possibility to the farmer to stand an agro-forestry system, in suitable locations (pioneer zones, isolated zones, buffer zones .....), with a high level of productivity in term of rubber production.

The sustainability of RAS depends on the best compromise between the required and available labour, the RAS cost and the real cash availability, the technical feasibility of clone introduction, and the increase of productivity in this particular environment. Optimization of other crops depending on situations has to be tried. This experimentation should take into account the limited means of the farmer, so, the limited RAS patterns that will fit both the strategy and the means of the farmer. Labour is one of the main factor to be analyzed, depending on typology. Rattan should be emphasized as there is already some experimentation in research stations that gives a good scope for that crop. The economical outlet of each crop should be assessed under the local conditions (in particular for wood and fruits...). Firewood and fast growing trees with possible side-use (*Leuceana*, *Glyricidia...)* may be tried....like other wood species (*Albizzia Falcata*....) or timber trees.
The biodiversity and forest-like environment of RAS system is also a factor to be taken into account, in particular for RAS type identification.

The use of fertilizers to improve the growth at immature stage (growth booster), the farmers nurseries management (for IGPM supply), crops association (timber species, firewood species, fruits and nuts, rattan, perennial crops.....), annuals intercropping at early stage during immature periods, anti-imperata strategies and side-use of rubber and other crops (wood...) in RAS should be tried in on-farm experimentation. The farmers and situations typology will enable to identify which topic, in which situations, has to be emphasized in experimentation. Other topics taken into account for the set-up of the OFTs may be: the problem of Imperata, the levels of intensification, the economic outlet and opportunities for by-products, the labour use......

Rubber cropping patterns, including associated crops, sustainability and productivity, biodiversity and environment conservation are key-words in this process of shifting from the current non-project smallholders situation, characterized mainly by "jungle rubber system", to improved rubber cropping patterns taking into account the available means of farmers and ecological and economic environment. OFT have to be defined (protocols and methodology...) and implemented in order to give answers regarding the improvement and evolution of such systems.
The identification of suitable evolution of the jungle rubber depends on geographical and economical situations. An operational

typology of both situations and farmers should help us to obtain a zoning, identification of priorities, OFA priorities and, future, development policy recommendations based on technical recommendations.

Conclusion

There is no doubt that RAS systems are one of the possible rubber development policy tool, as an alternative both to the increase of rubber planting almost everywhere in Sumatra and Kalimantan by smallholder with few input capacity that leads to a low productivity for the next 40 years of the newly planted jungle rubber plot, and also to the current rubber development projects, relatively successful in term of implementation, but far too expensive for being able to reach a consequent number of farmers in the mid-term. RAS constitutes an intermediate low input technology, adapted to the farmers current cropping patterns, with a probable high level of adoptability by farmers by conserving the very nature of agroforestry, with a high productivity for rubber and also other associated perennial crops. Emphasis should be put in the identification of RAS components.

RAS technology is not only confined to the Indonesian case as it is a possible alternative to slash and burn agriculture in almost every zones where rubber may be cropped, and in articular in central Africa.