

**INTEGRATED RUBBER AGROFORESTRY
FOR THE FUTURE OF
SMALLHOLDER RUBBER IN INDONESIA**

Paper presented to the Rubber National Conference, IRRI, Medan, Indonesia,
November 1994.

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Integrated Rubber Agroforestry for the Future of Smallholder Rubber in Indonesia

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1. INTRODUCTION

Smallholder rubber covers 84% of the total Indonesian rubber area (3.23 million hectares) and contributes 73% of the total rubber production in Indonesia which was 1,405 thousand tons in 1993 (DGE 1994).

So far only 15% of the smallholder rubber area has been assisted by the Government development projects such as PIR, PPKR, PRPTE and now TCSDP and TCSSP. Apart from that, between 10 and 20% of non-project rubber farmers living in the vicinity of the projects are estimated to have gained an indirect profit in terms of cultivation technology and improved planting materials. The undergoing development projects of the Government are carried out in the form of packages of credit and cultivation technology to change smallholder rubber planting scheme known as 'jungle rubber', which is not very productive, into a good planting scheme with good management and high productivity.

Due to the fact that the cost needed for a smallholder rubber development project per hectare is relatively high, the area that can be covered by the projects with limited funds is relatively small compared to the total smallholder rubber plantations. So far the projects cover 128,000 ha of PRPTE (with a low degree of success), 160,000 ha of PIR, and 75,000 ha of UPP, which are totally 363,000 ha, which represents only 15% of smallholder rubber area. Thus 85% smallholder rubber area has not

been touched by the projects. The untouched plantations are like jungles with an annual yield of less than 600 kg per hectare.

The limited development funds provided by the Government, and the difficulties to obtain soft loans from international sources like the World Bank and Asian Development Bank for the expansion of the projects, will be disadvantageous to the expansion of smallholder rubber, which is the backbone of Indonesian rubber, in the future.

From the viewpoint of environmental conservation, a rubber jungle with a planting scheme similar to a secondary forest has a positive value, because its habitat is good for environmental conservation. Its good hydro-ology characteristics will resist erosion and enrich plant biodiversity. It positively supports the 'green movement', which has acquired a lot of interest from big industrial countries (who are the consumers of natural rubber). This is strengthened by the fact that natural rubber is a polymer derived from renewable resources, which is energy efficient because it uses solar energy. When used as automotive tire material it also saves energy because it has low rolling resistance.

Unfortunately 'jungle rubber' has a low productivity so that it does not provide a good income for rubber farmers, especially when the rubber price in international markets is not profitable.

Gapkindo is concerned about the supply prospect of smallholder rubber in the future, both in terms of quantity and quality. The organization is eager to play a role in the betterment of the 'jungle rubber', which in reality has great potentials in sustaining the green era in the future. Therefore Gapkindo initiates cooperation with the Regional Office for Southeast Asia of ICRAF (the International Center for Research in Agroforestry) at the Center for Forestry Research in Bogor. ICRAF is one of the CGIAR centers, with its headquarters in Nairobi, Kenya.

The cooperation will develop ways to manage rubber jungles into an agroforestry system that sustains both environmental conservation and

rubber farmers' livelihood. Pilot projects have been planned in West Kalimantan (Sanggau and Sintang) and Jambi (Muara Bungo). These pilot projects will manage the rubber jungles intensively by planting high yielding clones which are suitable for the 'rubber forest' system. They will also plant hard wood trees in between the rubber trees to improve the farmers' income and the biodiversity of the forests.

Secondary crops that will be suitable for mature rubber jungles are rattan, manau, durian, salak, cempedak, coffee, duku, candle nut trees, etc. as seen in plantations in Malaysia, Thailand and several areas in Indonesia.

The pilot projects are expected to start at the beginning of 1995. Gapkindo intends to set up small scale projects to attract interest from the Government and international organizations, so that later the projects can be developed in a large scale.

Actually agroforestry, which is a cultivation scheme for hard wood/industrial forests, has been a traditional cultivation scheme in the dry lands in Indonesia, namely in Sumatra and Kalimantan. Although in the Government administration agriculture and forestry are managed separately by the Ministry of Agriculture and the Ministry of Forestry, in the field rubber agroforestry is an integrated scheme.

2. NATURAL RUBBER AS A POLYMER FRIENDLY TO ENVIRONMENT

Today around 85% of natural rubber comes from Southeast Asia. In its original habitat in South America, rubber plants are nearly extinct due to a disease called *microcyclus ulei*, known as SALB (South American Leaf Blight).

Rubber is an elastomer, a polymer which is viscoelastic, meaning both resilient and inert. According to its phenomenon, an elastomer can be compared to a combination between a steel spring and bread dough.

Rubber or elastomer has become an absolute need for advanced industries today, and the requirements for its technical specifications have become more tough and sophisticated. In 1993 the total elastomer or rubber consumption was 14.19 million tons, consisting of 8.75 million ton (62%) synthetic rubber and 5.44 million ton (38%) natural rubber.

The various usage of natural rubber and their proportion are as follows:

	<u>percentage</u>
Automotive tires and their components	70 - 72
Industrial machinery components	9 - 10
Latex products	7 - 8
Footwear	4 - 5
Technical products	3 - 4
Adhesives	1 - 2
Others	2 - 3

It is clear that the main use of natural rubber is in automotive tires and their components like inner tubes, bladders, flaps, etc., mostly for heavy duty tires like truck, bus, tractor tires, and very little for passenger car tires, because its skidding tendency on wet roads and its low wear rate are disadvantageous. Industrial machinery components which constitute the second largest user of natural rubber, although its total use is only a seventh of the use for tires, comprises of hundreds of products such as hoses, conveyor belts, gaskets, rubber rollers and others. The third largest user which is using more and more natural rubber and has the potentiality to become the second largest user is latex products, especially gloves, condoms and toy balloons.

From the point of view of the volume of natural rubber usage, the largest user is outworn goods, like automotive tires (abrasion by friction on the road, and replacement with new tires) and rubber gloves (disposable). A condom is actually disposable too, but because of its thinness, a million condoms only require latex equal to one ton of dry rubber. On the other hand a dock fender for instance, requires 100 kg of rubber, but it may not be replaced for twenty years.

Natural rubber has several important advantages compared to synthetic rubber in general, namely resiliency or high elasticity, low hysteresis and low heat built up, good durability and high tear resistance, good adhesive quality and processability, and the ability to incorporate a great amount of fillers. Yet natural rubber also has its disadvantages which are inhibitive in its usage, namely its narrow working temperature range, its bad wear rate, its tendency to oxidize from contacts with oxygen, ozone and solar heat, its tendency to decompose by copper compounds, manganese and iron, its sensitivity towards strong acids, oil, and non-polar solvent, and its low abrasion resistance. The higher technical specifications of rubber nowadays have limited the use of natural rubber to a small number of the various uses of the world elastomer products. One of the significant advantages of natural rubber is that the steric configuration of its molecule chain is very uniform, which is practically 100% *cis*. This takes place because actually the Polyisoprene polymer in natural rubber is not formed through polymerization like in synthetic rubber, but through biosynthesis, from an addition reaction. However perfect the polymerization reaction might be, the synthetic product can not surpass the naturally formed structure. Therefore the main disadvantages of synthetic rubber compared to natural rubber are inadequate resiliency, high hysteresis, and low tear resistance. The advantage of natural rubber as a result of the uniform structure is the ability to crystallize when the rubber is stretched, so that its strength increases in a stretched condition. The drawback of synthetic

rubber can be overcome partly by the addition of carbon black, which when mixed with rubber will form pseudo-bonds to increase the rubber strength.

Because of the unique technical properties, natural rubber becomes a polymer that is most suitable for modern automotive tires, especially in radial tires. The drawback of natural rubber properties like low wear rate, low skid resistance and low oxidation resistance needs to be balanced by mixing it with suitable synthetic rubber, especially *cis*-Polibutadiene and SBR synthetic rubbers. Therefore the existence of synthetic rubber in a tire is supportive to natural rubber. Without the existence of synthetic rubber, the rate of natural rubber usage in tires would not have reached the proportion it has nowadays.

Natural rubber has proven to be very economically produced using plantation cultivation techniques and modern processing which are very friendly to environment, because rubber is obtained from perennial plants which absorb carbon dioxide and release oxygen. Apart from those, rubber trees' hydro-ecological value is close to that of forest trees, so it positively contributes to the sustainability of lands.

From the point of view of social-economy, 84 % of Indonesian rubber has been produced by smallholders. It means providing a livelihood for the rural societies in Sumatera and Kalimantan, and reducing urbanization to Java.

The prospects of natural rubber as an export commodity is good. But economic recession in the world economy has resulted in the apathy and pessimism the rubber industry, especially in the smallholder sector. What is actually the beneficial technical property of natural rubber in line with environmental conservation? Rubber has the ability to conserve energy. This means saving energy, and in connection with transportation, will reduce the need for oil as fuel. Natural rubber as an energy preserver can be produced using solar energy, which is abundant and free, through the process of photosynthesis,.

Due to the stereo-regular structure, rubber has an elasticity that can be used to store energy. Another feature resulted by the regular structure is that natural rubber has low hysteresis (energy loss), so that the heat built up in the heavy duty airplane or truck tires is low. Because of the low hysteresis, a tire made of natural rubber has a low rolling resistance.

The low rolling resistance in turn saves oil fuel and reduces exhaust gas emission from motor vehicles, which means reducing the concentration of carbon-monoxide and carbon-dioxide, which are the main causes of air pollution and green house effects. Economizing oil fuel also means the reduction of the rate of ozone, nitrogen-oxide and sulfur derivatives in the air.

For passenger cars, the reduction of 5 - 7% of rolling resistance can save 1% of oil fuel consumption. For heavy duty vehicles like truck, the saving of 1% oil fuel can be reached by the reduction of only 2 - 4% of rolling resistance.

The rolling resistance of automotive tires depends greatly on the tire tread and the carcass in the tire, which is normally 75% of the total tire. Therefore the choice of elastomer for this component very important.

Table 1.
Energy Balance
ENERGY CONTENTS IN A TON OF POLYMER

POLYMER	Energy contents, GJ
Natural rubber	13 - 16 (15)
Synthetic rubber SBR	156
Butyl	209
EPDM	170
Polyurethane	209
Plastic Polyethylene	100 - 150
Polystyrene	95

The energy contents of oil(petroleum) = 50 GJ/ton
 1 GJ = 10^9 Joule = 239 000 Kcal = 278 KWH

Table 1 shows the energy content of 1 ton of polymer material by comparing natural rubber to synthetic rubber and several kinds of plastic.

If we calculate the energy content, namely the energy which is needed to process raw material into finished goods in GJ units (1 GJ = 10^9 Joule = 278 KWH) we will see that natural rubber only needs 13 - 16 GJ or an average of 15 GJ to produce, while synthetic SBR needs 156 GJ. Butyl synthetic rubber which is generally used as material for inner tubes and a lining in a tubeless tire, requires the most energy, namely 209 GJ. EPDM (Ethylene-Propylene rubber) as General Purpose Rubber which may potentially replace natural rubber in many non-tire

usage, requires 170 GJ. Polyfoam or Polyurethane foam, which are known as the competitor of natural latex foam, requires 209 GJ, and plastic polyethylene used as household wrapping material requires 100 - 150 GJ. Polystyrene which we use to make coasters requires the least energy, i.e. 95 GJ, because it is made using emulsion polymerization process.

Synthetic rubber and plastic require higher energy because they are generally made from oil, while the energy content of oil is already 50 GJ/ton. So, if 9 million ton of synthetic rubber were replaced by natural rubber, it would save 500 000 barrels of oil/day. The idea is certainly unrealistic, it is hypothetical.

P.W. Allen (1979) made an energy calculation and came to a conclusion that in 1 ton of natural rubber there was an energy content of 13 - 16 GJ. If analyzed, some of the energy comes from fertilizer, pesticides and other chemicals amounting to 5 GJ. To process the rubber only 3 GJ of energy is required, the greater part of energy is required for the transportation of rubber by sea, because natural rubber is produced mainly in Southeast Asia, far from the consuming countries, namely the industrial countries in America, Europe and Japan.

From the 3 GJ/ton energy needed for rubber processing, 0.75 GJ is for electrical power and 2.25 GJ/ton for drying. So, now we see which area needs efficiency improvement.

For transportation by land 0.25 GJ/ton/km is needed, while 5 - 8 GJ/ton is required for transportation by sea.

The awareness of environmental conservation has become stronger, especially after the Earth Summit Conference in Rio de Janeiro in 1992, particularly in West Europe and North America and environment conservation has become a decisive factor in policy making.

In line with the above development, the biggest world tire industries, namely Michelin, Bridgestone and Goodyear have introduced a kind of automotive tire which is more friendly to environment, called "Green Tire" or

"Environmental Tire". Goodyear, for instance, has recently produced *Invicta GFE (Greater Fuel Efficiency)* which is said to economize oil fuel as much as 4 %. It has also been said that if all motor vehicles in the world use this kind of "Green Tire", it will save oil consumption of up to 200 million barrels a year, and furthermore it will reduce pollution from the mufflers and also it will save the energy used to process the oil into fuel.

It is forecast that natural rubber, which is an energy efficient elastomer with low rolling resistance, because it is synthesized from carbon-dioxide and water by solar energy, will play an important role in the making of "Green Tire".

Several experts in tire industries said that the environmental consideration and the development of "green tire" will increase the proportion of natural rubber in the polymer for tires, i.e. up to 60% for the tires of passenger cars, and up to 80% for radial tires for medium trucks. Now the proportion of natural rubber in the tire polymer amounts to 30-40%, so it is expected to increase doubly.

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3 Introduction

In the rural areas in temperate zones, forests and agricultural lands have become two separate entities for quite some time. Human beings have snatched the best lands from natural forests and have turned them into farms, and trees are not grown in agricultural lands except in the form of specific cultivation (fruit trees), which is monoculture using sophisticated technology and high cost.

Now the forestry world has reclaimed its rights by developing silviculture and creating forest preserve areas which have forced farmers to leave. The exclusive modus vivendi between forestry and agriculture and between forest management and farmers is more historical than natural, and has been so established that it looks natural and reasonable. And, of course, the system was applied in tropical regions by the colonial government. Here the Western agronomy has neglected the existence of trees, and the extension of tropical agricultural lands has literally eliminated the forests.

Western silviculture has overlooked the farmers; forest exploitation and management have clashed with the needs of the farmers, who are considered as enemies or thieves. And there have been no previous efforts to learn whether it is right, naturally and traditionally, that agriculture and forestry should clash and invade each other, or just the contrary, they can exist harmoniously in a region that is so different from Europe or North America.

Farmers in tropical regions are naturally land clearer. Yet all their activities, which try to benefit from seasonal plants, are generally not limited to deliberate deforestation which result in the complete destruction of forests. In the agricultural system in the tropics, whether in dry or humid areas, there is a close relationship between trees and seasonal plants, between agricultural and forestry plots.

The mutual symbiosis is evident in areas covered with jungles. Because of the environmental condition, and also because of the abundance of natural resources and their significance to the livelihood of the farmers, agriculture in these areas is gradually constructed from the plants and structures taken from the surrounding forests. Except for the land clearing at the beginning, which is unavoidable, specific efforts of reconstruction have been carried out, which rehabilitate the trees and forest environment in the agricultural areas.

Secondary forests have emerged, enriched with useful wood trees, which have been planted for the purpose of hunting or exploitation; pastures and greenery are managed to raise cattle, diversified plantations or man-made multipurpose forests can be spotted in agricultural lands, and various gardens can be seen in villages and yards. All of them supplement the open cultivated fields and reflect the basic and essential ties between the forestry world and agricultural activities.

To overcome the increasing problems resulting from the change of tropical environments (the continuing decrease of forest areas and soil fertility, the increase of erosion, the disappearance of plant and animal genetic resources, the enlargement of desert lands), a new branch of science has emerged which admits the existence of and works towards the reapplication of the symbiotic agroforestry system, which has actually never been abandoned by the farmers in the tropics. Agroforestry offers the combination of efforts initiated in forestry and those carried out in agronomy, combining the efforts of the forestry services and those of rural development agencies, to create a harmony between agricultural intensification and the conservation of natural forests and their resources (Bene et al. 1977, King 1978, 1979).

Agroforestry is expected to be beneficial for the wet and dry areas in the tropics, in the effort to prevent the expansion of desert lands or soil desolation and to maintain the sustainability of tropical forests. It is

expected that agroforestry will be useful to improve traditional agricultural qualities and the intensification and diversification of commercial silviculture.

The numerous researches that have then been carried out in Indonesia, based on simple criteria but having high operational values, have made it possible to draw a demarcation line between the agroforestry systems, both the ones under investigation and the ones already widely applied in the tropical rainforests (de Foresta and Michon 1991, 1993).

Apparently the countless agroforestry facets found on the islands in Indonesia can be grouped into two large categories, namely "simple agroforestry" and "complex agroforestry", which derive from two different concepts and require different approaches.

Simple Agroforestry: trees and agriculture

A simple agroforestry is a conventional diversification of several small components, which is now called a classical agroforestry scheme and is considered important both in the viewpoint of research and the numerous institutions who manage agroforestry (Nair, 1989, Stepler and Nair, 1987). Generally the diversification narrows into a tree component, which may have an important role in economy (coconut, rubber, clove, teak) or a trivial role (dadap, lamtoro), and a component of seasonal plants (rice, corn, vegetables, pastures...) or small trees (bananas, cocoa, coffee) which are still important from the economic viewpoint.

In Indonesia, the form of agroforestry that can be described in details must be "tumpangsari" (Bratamihardja, 1989), a "taungya" system in Indonesian version, which is an obligation in the teak forest in Java and has become more common in the rural reforestation program. Thus the simple system now has been applied in large scales in commercial plantations (PTP and smallholders) (Siregar et al. 1990): coffee has been diversified with dadap, which provides shades and firewood, for quite a long time.

Diversification of coffee plants and coconut trees has been **more and more** practiced, and lately we observe the efforts to diversify rubber jungles with cocoa, which is still in the experimental phase. Only oil palm is still not affected by the diversification trend in commercial plantations.

Diversification in a simple agroforestry is also evident in traditional agriculture. The diversification often reflects improvement of production systems in connection with natural drawbacks, like the diversification between coconut trees and ricefields in swampy lands on the coast of Sumatra. The diversification is also common in densely populated regions, for instance kapok trees have been planted for centuries on ricefield dikes in Central Java. A similar case can be observed on irrigated ricefields in South Garut: due to the shortage of agricultural lands, people plant tangerine and clove on the dikes.

Complex agroforestry system: forest and agriculture.

A complex agroforestry system is a system which includes several components of trees, shrubs, perennial plants or pastures. The physiognomy and work method are similar to those of natural forest ecosystems, whether primary or secondary. It is necessary to note that a complex agroforestry system is not the same as forests deriving from gradual natural ecosystem transformation; it is actually "a garden" resulting from a simple traditional shifting agricultural system. Actually the gardens are built from newly opened agricultural lands, which have been cultivated and later on enriched in a natural process. It is the characteristics of many regions in Indonesia that forest lands are limited, not only because of the increase of population, but also because of the extension of forest concessions, transmigration centers, and industrial crop forests. Thus the

opening of a new land for a farmer practicing shifting agriculture is often only a reason to build an agroforestry garden. (Sevin 1983, Scholz 1983, Pelzer 1978).

The period for seasonal plants here, namely non-irrigated rice, is only one or two harvests; thus categorizing the agroforestry system into a diversification between seasonal plants and trees. The formation of the complex agroforestry is similar to that of taungya, but the resemblance stops there. In taungya the phase for the trees is managed by forestry services, it does not include any agricultural components, and mostly consists of wood trees. On the contrary the tree phase in the complex agroforestry, which can be called forest gardens or agroforests, remains in the hands of the farmers and is still a close diversification of various useful plants, and during its life span the system serves as a transition from agriculture to forestry.

The structural and physiognomic resemblance between an "agroforest" and a natural forest shows the advantage of an agroforest from the viewpoint of environmental conservation; just like in other simple agroforestry systems, water and soil resources are efficiently conserved, moreover the biodiversity common in natural forests is sustainably managed, and that is the characteristics of an agroforestry system which distinguish it from various other agricultural systems (Bompard and Michon 1985, Michon and Bompard 1987, Michon and de Foresta 1990, Seibert 1988).

A traditional agroforest is often considered as an addition to dry ricefield, it is useful but not fundamental for the economy of the farmers. This is not true. Actually the determining factor for the expansion of complex agroforestry systems is not the issue of staple food, but commercial reasons (Mary 1986, Mary 1987, Mary and Michon 1987). The "gardens" are set up to ensure income for the farmers and are often the only income source in the family work system. Evidently the systems contribute to the economy of the family, because the components are

important from economic viewpoints (rubber, coffee, clove, fruit, cinnamon, nutmeg, etc...) and they are basically important for the success of agribusiness in Indonesia: remember 70% rubber latex exported by this country is produced in the complex agroforestry systems which look more like jungles than conventional plantations and cover over two million hectares of land (Gouyon et al. 1990).

Apart from the commercial significance, it is necessary to mention the simplicity in the development and management of the flexible systems (de Foresta and Michon 1991, Michon and Bompard 1987, Mary and Michon 1987, Gouyon et al. 1990, Michon et al. 1989, Mathias-Mundy et al. 1990). Since the agroforestry systems are developed and managed by the farmers, the upkeep or production of the systems do not need any sophisticated technology nor enormous investment in the form of capitals or work force. The diversity of their products which may not trigger fast capital gain, is somehow an important guarantee for the farmers to face various inherent risks in the development of the production index. Another flexibility feature is observed in the possible change of the production status in an "agroforest", which can achieve a new commercial value in line with the market development: for example fruit or wood for furniture. The above flexibility may become the key to the success of the systems in the future (de Foresta and Michon 1991).

Rubber Jungle as an agroforest (Examples from Sumatra).

In South Sumatra rubber seeds were introduced by traders from Malay at the beginning of 1910 and farmers were interested in the expectation to obtain a good income when rubber price reached its culmination. The farmers learned to cultivate this new plant in their fields quite fast. They developed a new cultivation system which is still applied nowadays with little changes: rubber is planted right after rice and grow

together with food plants and forest regrowth. (Picture 1). After an average of 10 years, the farmers can tap their rubber trees for over 30 years.

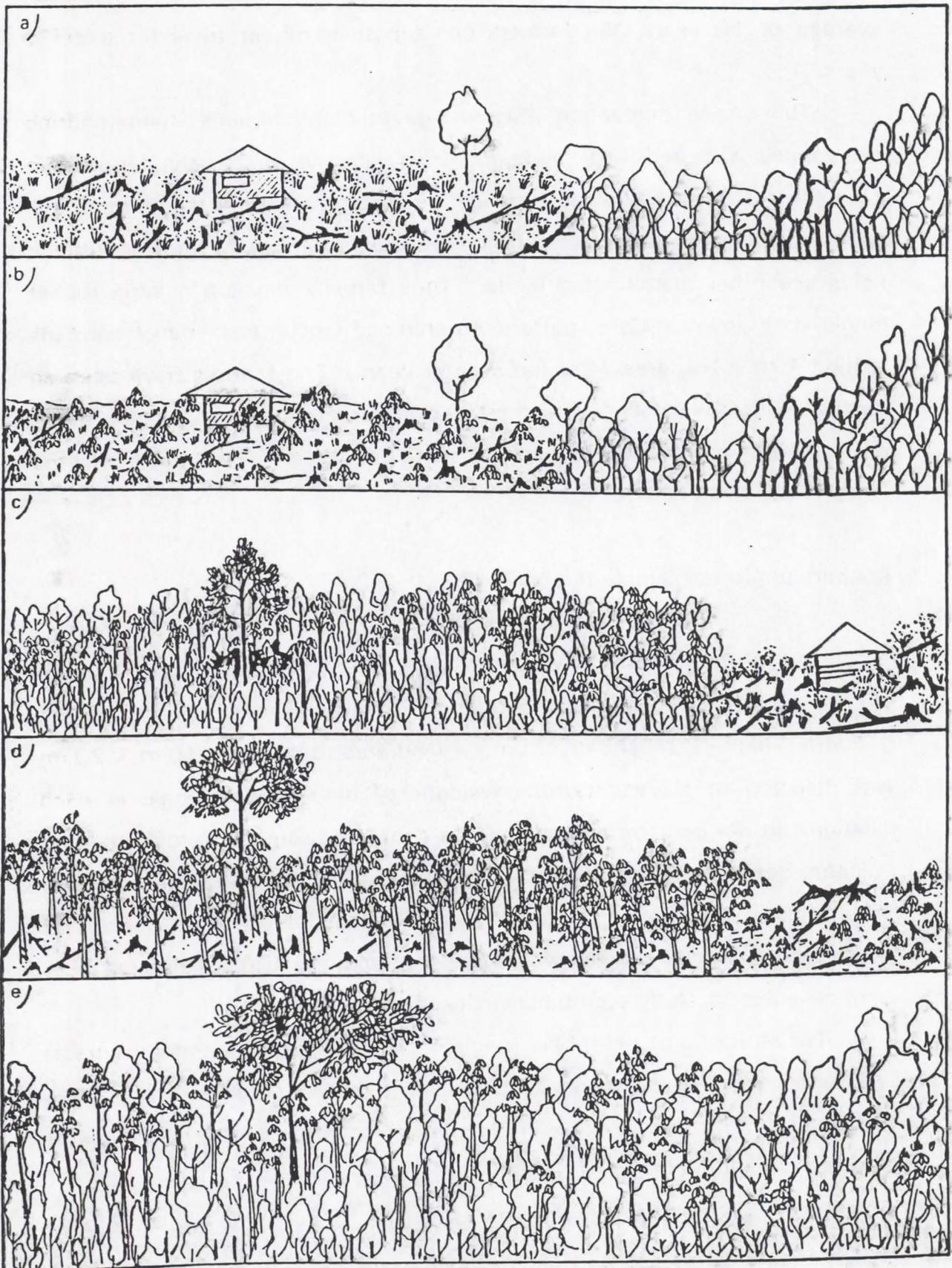
This new cultivation system gave higher yields than shifting cultivation, with very little additional cost, and no risk to the farmers: in case the rubber trees fail to produce satisfactory income, the farmers still have a secondary rubber based forest which can be cleared for non-irrigated fields like other uncultivated lands. Thus farmers develop a large rubber jungle area following the pattern of shifting agriculture, which spreads around 1 to 3 hectares after the second year. The farmers have been so familiar with the rubber agroforestry system, that except for the minor ethnic tribes like Kubu, they have all grown rubber in their non-irrigated fields (Laumonier, 1991).

Rubber Jungle - or Jungle Rubber?

The structure and distribution of species in rubber jungles were studied in two locations, in Jambi (Rantau Pandan, Muara Bungo) and South Sumatra (Sukaraja, Musi Banyuasin). A land area of 100 m² (50 m X 20 m) was selected to represent the physiognomy of a rubber jungle in each location. In the plot the vegetation was analyzed using the profile method (Michon, Bompard et al. 1983) to obtain a picture of the space arrangement, the structure and floristic data. Apart from that, all the plant species of which the projected canopies would intersect with the 100 m surveyed lane, were collected to study their biodiversity (Rantau Pandan).

The structure of the rubber jungle is close to that of secondary forest, with rubber trees taking the place of pioneer trees like *Macaranga spp.* The structure can be categorized in two main grades like the example in Sukaraja profile (Picture 2):

Figure 1 : GENERAL SCHEME OF JUNGLE RUBBER ESTABLISHMENT



Picture 1: General Scheme of the establishment of "a rubber jungle"

- a) On the left of the scheme, the vegetation is cut down and burned, then the field is cultivated (mainly rice and rubber)
- b) Rubber trees receive the benefit of husbandry of the non-irrigated field until rice harvest time.
- c) Rubber trees grow along with bushes
- d) After 8 to 10 years the rubber trees are ready for tapping; the land is cleared and useful species are preserved.
- e) Natural plants regenerate during the lifetime of the agroforest (35 - 40 years), with the development of the physiognomy and function of the rubber jungle.

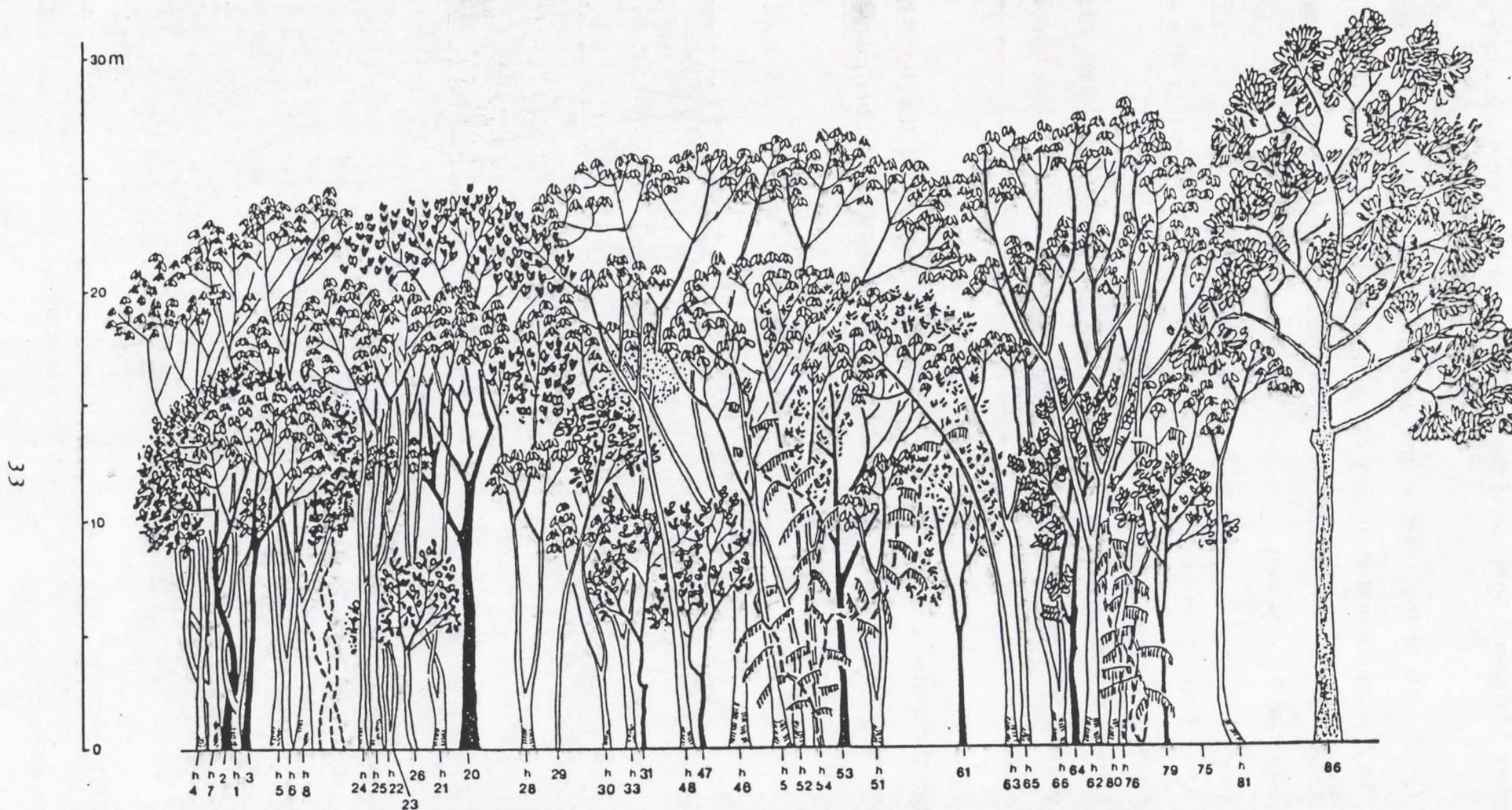
Note: the same process with several years delay is on the right of the scheme. Arrangement of the small plots can form a large rubber jungle.

In the rubber jungle



In lowland areas (≤ 200 m a. p. l.) in Sumatera, "a rubber jungle" can now be considered as the largest and richest reserve of forest plant and animal genetic resources.

Figure 2 : ARCHITECTURAL PROFILE OF A JUNGLE RUBBER



Desa Sukaraja, Musi Banyuasin, Sumatera Selatan. Plot 50 x 10 m; umur kebun: 35-40 tahun
 Hanya pohon-pohon yang berdiameter lebih dari 10cm sudah digambar; h = pohon karet

**Table 1: Jenis tumbuh-tumbuhan yang terutama di dalam "hutan karet"
(Sumatra bagian selatan)**

Variaty	Family	use	area	local name
Mangifera spp.	Anacardiaceae	fruit, timber	M.B/S.	Mangga hutan
Alstonia Angustiloba	Apocynaceae	timber, resin	M.B/S.	Pulai, Pelai
Durio zibethinus	Bombacaceae	fruit, timber	M.B/S.	Durian
Flacourtia rukam	Flacourtiaceae	fruit, timber	M.B/S.	Rukem
Garcinia spp.	Guttiferae	medicinal, timber	M.B/S.	Kandis
Lauraceae spp.	Lauraceae	timber	M.B/S.	Medang
Archidendron pauciflorum	Mimosaceae	vegetable, timber	M.B/S.	Jengkol, Jiring
Parkia speciosa	Mimosaceae	vegetable, timber	M.B/S.	Petai
Artocarpus integer	Moraceae	fruit, timber	M.B/S.	Cempedak
Artocarpus elasticus	Moraceae	fibre material, timber	M.B/S.	Terap
Eugenia spp.	Nyrtaceae	timber	M.B/S.	Klat
Calamus spp,	Palmae	handicraft	M.B/S.	rotan
Arenga pinnata	Palmae	fruit, sugar	M.B/S.	Enau, Anau, Aren....
Areca catechu	Palmae	pasionate, medicine	M.B/S.	Pinang
Milletia atropurpurea	Papilionaceae	timber	M.B/S.	Mibung, meribungan
Vitex cf. pubescens	Verbenaceae	timber, medicine	M.B/S.	Leban
Peronema canescens	Verbenaceae	timber, fench	M.B/S.	Sungkai
Dyere costulata	Apocynaceae	resin, timber	M.B.	Jelutung
Baccaurea cf reticulata	Euphorbiaceae	timber, estates material	M.B.	Lempaung
Pangium edule	Flacourtiaceae	medicine, timber	M.B.	Kepayang
Sonerilla sp.	Melastomaceae	garden species	M.B.	?
Bulbophyllum lepidum	Orchidaceae	garden species	M.B.	?
Salacca spp.	Palmae	fruit	M.B.	Salak hutan
Coffea canephora	Rubiaceae	pasionate, fire wood	M.B.	kopi
Dimocarpus longan	Sapindaceae	fruit, timber	M.B.	Mata Kucing
Styrax benzoi	Styracaceae	resin, timber	M.B.	Komenyan, Kemenyan
Dillenia obovata	Dilleniaceae	timber	S.	Simpuh
Lithocarpus cf. elegans	Fagaceae	timber	S.	Lampening
Bellucia sp.	Melastomaceae	fruit	S.	Jambu amerika
Helicia robusta	Proteaceae	timber, vegetable	S.	Seranto tua
Nephelium lappaceum	Sapindaceae	fruit	S.	Rambutan
Schima eallichii	Theaceae	timber, fish poison	S.	Seru, puspa

Daerah: M.B. = Muara Bungo, Jambi / S. = Sembawa, Sumatra Selatan

- with dense canopy trees of 20 - 25 m high, dominated by rubber trees (490 trees/ha), 260 non-rubber trees/ha consisting of 10 species with a diameter more than 10 cm, and 50 rattan bushes/ha.
- with dense lower plants of 0.5 to 10 m high, dominated by lots of bush and small tree species , including seedlings and shoots of the canopy species.

The biodiversity study in Rantau Pandan shows that there are 268 species of plants besides rubber, all of them originally came from a natural forest, classified into 91 wood trees, 27 bushes, 97 vines, 23 herb, 28 epiphyte species and 2 parasites. The biodiversity of the studied area is comparable to that of secondary old forests. Compared to commercial plantations which include very few species other than rubber, the importance of a rubber jungle for the sustainability of the biodiversity of forest plants must be underlined.

As a whole a "rubber jungle" pictures a secondary rubber based forest which may last for 40 years or more before it is replanted, while the regrowth of a secondary forest in the shifting agriculture rarely reaches 20 years. The considerable length of time gives more opportunities to non-pioneer primary forest species to develop. An abandoned rubber jungle will develop into a mature forest with fewer and fewer rubber trees per hectare.

The Extensive Economic Functions

The information below has been collected through a socio-economic survey in South Sumatra, involving more than 350 farmers in 31 villages,

and an agronomic survey of more than 280 rubber gardens. (Gouyon and Nancy 1989; Gouyon, Nancy et al. 1990). Additional data on household expenses have been recorded based on an interview with 20 farmers in 2 villages, the financial flow of the families have been monitored weekly for a year using 9 respondents in 2 villages. The data of the jungle rubber in Jambi have been obtained by interviewing respondents in 90 villages (Gouyon, Nancy et al. 1991).

Most of the literature on smallholder rubber outside Government projects in Southeast Sumatra (Thomas 1957; Barlow and Muharminto 1982; Cottrell 1990) has been focused on rubber trees and their secondary plants during the early phases. The perennial non-rubber plants have been overlooked because the yield has been non-commercial, and because most of the agronomists and economists do not have the necessary background to identify forest species with economical values.

Thus botanical contributions (de Foresta 1992) have been important to identify the components.¹

Source of income: rubber and others.

If we observe a "rubber jungle" for its economic value, we will notice that rubber yields up to 85% of the average income per ha per annum. A rubber tree is tapped from 3 to 5 days a week. The product is sold to a local broker weekly and provides some cash throughout the year.

Food crops and commercial crops growing along with young rubber trees (for instance rice, bananas, pineapples, vegetables, etc.) may become an important source of income from one until three years. Afterwards, erosion, weeds and the shade of the rubber trees will prevent further cultivation. Although only temporarily, the crops have an important role as

¹ Yet the quantitative data concerning the contribution of non-rubber perennial plants presented here must be considered as a rough estimate.

the source of income for the farmers during the first years. The crops function as cover crops to prevent weed growth and produce a fast income to pay for weed control, which needs to be done to protect young rubber plants. The crops yield various products either for self-consumption or for commercial purposes when rubber price drops. (Thomas 1965). "Producing their own rice" for the farmers also means earning respect from other people in their village.

The non-rubber components in a rubber jungle provide various products with economical values (de Foresta and Michon 1993). Various kinds of fruit trees grow spontaneously because their seeds have been distributed by some kinds of animals, and because there are many varieties of plants in the rubber jungle. (*Table 1*). The fruit helps to balance the farmer's family diet, especially their children's, and increases the nutrition values. Species for furniture wood are well taken care of - especially in areas where wood from natural forests have become very rare, like in South Sumatra. The farmers also obtain their firewood from the jungle for household consumption. And when the land is going to be replanted, the rubber jungle will provide all the wood needed for fencing, thus the farmers do not need to purchase iron wires for the purpose. Wood and firewood have become very important to the farmers, because logging activities have caused the farmers to lose other kinds of resources. Farmers also mention the use of some species for traditional medication. More inventory needs to be carried out to evaluate the potentials of the medical plants for use in a large scale.

Contribution to the family's property.

Just like in other perennial tree cultivation systems, a rubber jungle will prosper the farmers by providing them with a property and an income. The traditional land principles consider a family land as a personal property

as long as the land is exploited. Thus the rubber jungle can become a personal property which can be sold or passed on to the children or mortgaged. The existence of rubber trees which are potentially productive adds to the value of the land.

Owning a rubber jungle means that the farmer can sell the property for the purpose of supplying the need for a big amount of money, for instance for wedding celebrations, and for a credit guarantee in inland markets. But most of the farmers have been unable to obtain a certificate for their lands, because of the complicated procedure and high cost of acquiring one. This will lead to fights among the villagers or with outside parties for the property, and limit the use of lands for a bank loan security.

Minimal input by using bushes to control weeds and mammals.

Agronomists often consider the rubber jungles as poorly maintained, because they are covered with dense bushes, which impede the rubber growth (ready for tapping after 8 to 12 years) compared to weed free plantations (ready for tapping after 5 to 7 years).

But the farmers consider the bush species as cover plants to control highly competitive weeds like *alang-alang*, which otherwise requires the use of expensive herbicides. The farmers show that compared to the bush cover, *alang-alang* will postpone tapping readiness to 2 or 3 more years, and will also cause the probable destruction of one third of the rubber trees by fire, during their early years. Moreover, according to the farmers the bushes protect the rubber plants from tapir, deer or boars, which will feed the barks of young rubber plants or rubber shoots.² The wood fence constructed by the farmers can only last for two or three years. Without the protection of the bushes afterwards, the farmers have to maintain the

² It is unclear how the bushes protect the rubber plants from mammals. Maybe they function as impediments or deviation of the mammals' attention to young rubber plants.

fence along with the rubber growth at high cost. A rough estimate shows that the bush cover has saved the farmers Rp. 500 000 for material, herbicides and workers for rubber plant protection before the tapping phase - a considerable amount compared to the income of the farmers.

Economic life value with spontaneous regeneration.

Rubber trees in well managed plantations can hardly be tapped for more than 28 years because of the decay of the barks. Likewise the trees in a jungle rubber are often poorly tapped, because of the use of unskilled tappers that belong to the family, for instance children. The speed of tapping has also been more important than the quality, to save energy. Therefore each tree can hardly be tapped after 20 years. Surprisingly a rubber jungle can be exploited for more than 30 years: if the first planted tree decays, often the farmers replace it with a shoot which grows spontaneously in between the trees. Yet, because rubber growth is not optimal under shades, this regeneration can not prevent the decrease of the tree population from 500 trees/ha to 200 trees/ha after 40 years. Thus the method is not profitable anymore, and the farmers have to do a complete replanting if they still need to cultivate the land.

A rubber jungle ... what is its contribution to biodiversity?

As a land use system where tree crops are deliberately planted in the same land management unit with agricultural plants and /or livestock in a space arrangement or temporary arrangement, with ecological and economical interactions between various components (Lundgren and Raintree 1982, in (Nair 1989)), a rubber jungle definitely belongs to an agroforestry system.

Besides, as an agricultural system which sustains forest ecosystem characteristics, with large ecological and economical diversity, a rubber jungle belongs to "the complex agroforestry system or agroforest" - like the smallholder resin garden in Lampung (Torquebiau 1984; Michon 1985; Mary and Michon 1987, Michon 1991) or the durian based mixed gardens in West Sumatra (Michon, Mary et al. 1986). This type of agroforestry is very common in areas where the population is relatively low (fewer than 200 persons/km²) in Indonesia, and where the natural forest is near in terms of distance and time (de Foresta and Michon 1993).

Preserving biological diversity may actually be important for human beings as a whole - natural forest and agroforests are considered as a natural reserve for species that will prove to be useful in the future. But long term goals often clash with pressing income needs in line with the increase of population in developing regions.

The complex agroforestry system may become an example of an agricultural system where biodiversity produces financial income quickly. In the case of "a rubber jungle", the biodiversity of plants has been performing two economical functions;

- increasing the farmers' income with cash or food for their own consumption, so that they can reduce their dependence on rubber;
- enabling the farmers to enlarge the cultivated lands with minimum capital and work power input.

Yet can the low-input/low-yield system be maintained, considering the changing economic conditions, especially the threat of increasing population?

Note: This contribution is a summary of three published articles:

1/ de Foresta, H. and G. Michon (1991). **Agroforesteries Indonésiennes: systèmes et approches.** Communication à l'Atelier "Quelles agroforesteries pour l'Orstom?", Paris, Octobre 1991.

2/ Michon G. et Bompard, J.M. (1987): "Agroforesteries Indonésiennes: Contributions paysannes à la conservation des forêts naturelles et de leurs ressources. " Revue d'Ecologie (La Terre et la Vie) 42: 3 - 37.

3/ Gouyon, A., H. de Foresta and P. Levang (1993). "Does 'jungle rubber' deserve its name? An analysis of rubber agroforestry systems in Southeast Sumatra." *Agroforestry Systems* 22:182 - 206.

¹ ORSTOM-ICRAF S.E. Asia, Bogor, Indonesia

² CIRAD-CP, Paris, France

¹ ORSTOM-ICRAF S.E. Asia, Bogor, Indonesia

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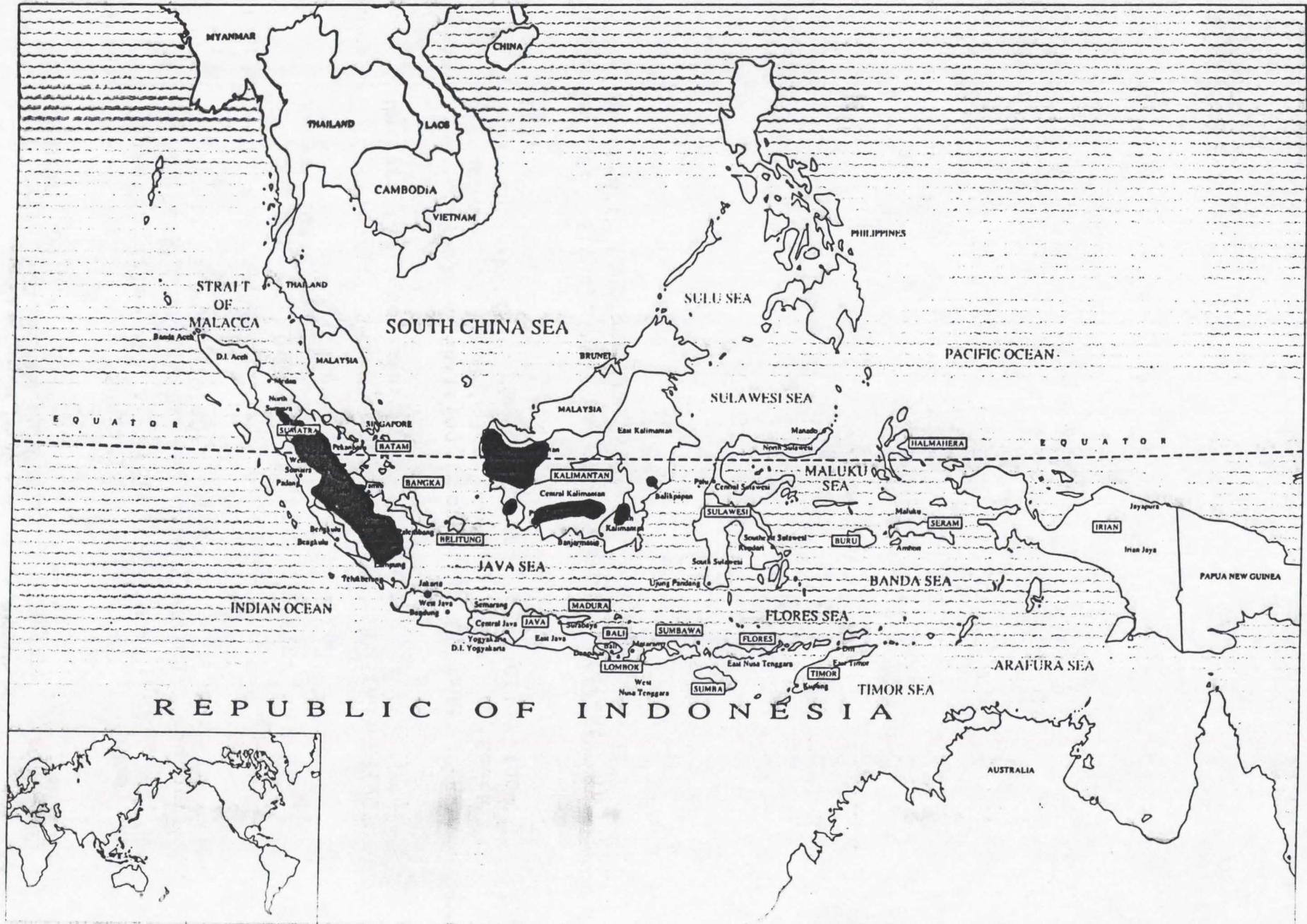
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Jungle Rubber areas in Indonesia



MAP OF INDONESIA

4. Indonesian smallholder rubber in the agroforestry system

4.1 The importance of the smallholder sector

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% smallholders, 5% estates) and Malaysia (60% smallholders, 40% estates). There are approximately 1,3 million 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. Various government programmes since the 70's have reached only about 15% of the farmers (see § 6). So far, the hectarage included in these programmes is only 362 000 ha out 2,65 million ha in the smallholder sector.

4.2 "Jungle rubber", a rubber - based agroforestry system

"Jungle rubber" systems are now well known (A Gouyon, C Nancy, C Barlow). Jungle rubber can be established at very low cost. Maintenance of rubber in the first year is limited to that required by upland rice. Then farmers usually let rubber compete with secondary forest regrowth. First tapping occurs 8 to 10 years later. Jungle rubber is composed of rubber and other trees, many of them with multiple purposes: for example, fruit or nut production, timber, rattan. The system provides diverse sources of income.

The secondary forest associated with rubber maintains biodiversity and a forest-like environment. It also contributes to soil conservation and water management. Furthermore, jungle rubber systems are fire resistant. Overall, jungle rubber is a sustainable land use system that fits farmers' household labour supply and financial constraints.

Low productivity: the key shortcoming of "jungle rubber" systems

Jungle rubber systems are characterized by very low productivity due to poor planting material (unselected seedlings). Farmers' average yield¹ 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). There is not an adequate supply of higher yielding planting material (HYPM), in particular certified clones. Even if there were such a supply, farmers may not have cash or credit to afford the cost of clones. Furthermore, much planting material is of uncertain quality. *Low cost techniques to raise productivity are an important requirement to fit the constraints of farmers.*

Lack of information on technical innovations is another major constraint. There is little extension outside rubber projects and almost none for farmers in pioneer zones. The efficiency of the

¹Rubber yield is based on area with mature trees. The total rubber cropped area also includes immature trees. Yield and area statistics at the national level are subject to uncertainty.

extension services is limited by the lack of appropriate technologies for the farmer.

Poor soils and other agronomic problems also contribute to low productivity. Sometimes the water table is only 50 cm deep (in Kalimantan). Leaf diseases make strong attacks especially in West-Kalimantan. Wind damage is a severe problem in North Sumatra. These local factors mean that rubber varieties and techniques must be adapted to help farmers to cope with these local problems.

Despite low productivity, there are few alternatives for farmers that are as profitable as rubber in large areas of Sumatra and Kalimantan. Increasing the productivity of rubber (including rubber agroforestry systems) is still the most important way to improve farmer's income.

4.3 Smallholder rubber planting is expanding

HYPM availability is still limited in most provinces, except South and North Sumatra. However, there is a high level of planting and replanting in many areas, including Jambi, Riau, West Sumatra, and Bengkulu in Sumatra as well as West, Central and South Kalimantan, and, more recently Ceram/Maluku and Irian Jaya at a very small scale. Replanting also is significant (South-Sumatra is a good example). There is in fact a large pioneer zone in many provinces. This is happening for various reasons :

- 1 - Planting rubber is a means of land acquisition in areas, where land is still plentiful. There is still considerable scope for further rubber expansion of production in Indonesia, in particular in Central Sumatra (Riau and Jambi), Central and South-Kalimantan, and Irian Jaya. These are locations suitable for rubber but not for most other crops, (especially foodcrops) due to poor soils. Rubber agroforestry is a sustainable alternative to shifting cultivation of foodcrops in many areas.

- 2 - Planting rubber helps established claims to land. *Land status is an important factor in the investment strategy of the farmer. Planting rubber is part of the land acquisition process.*

- 3- Rubber still is seen as a profitable, long term income source, with flexibility in the management of production. The possibility of stopping the tapping without damaging the trees gives the farmers flexibility and reduces risk. In that respect, rubber trees may be considered as a "bank" . *Risk management is also a major objective for these low-income farmers.*

- 4 - Rubber planting is one way to increase the value of degraded lands (Oil palm and coconut may be alternative crops depending on agro-ecological zones. Another alternative might be timber production).

- 5 - Rubber is a sustainable alternative to shifting cultivation of foodcrops in these areas and gives a reliable source of income to farmers. Sustainability of such systems is not only financially feasible, but also environmentally sound. The current system of jungle rubber maintains a high level of biodiversity (De Foresta,

1990). The forest-like ecosystem also protects soil and water resources. Soil fertility is conserved under rubber as latex tapping does not export significant nutrients. The evolution of the current jungle rubber into RAS higher-yielding (rubber agroforestry systems) can raise productivity and help conserve Indonesia's natural resources, including soil, water, and the forest-like environments necessary to sustain biodiversity.

5. Towards sustainable and integrated rubber agroforestry

5.1 The necessary increase of productivity of rubber farmers.

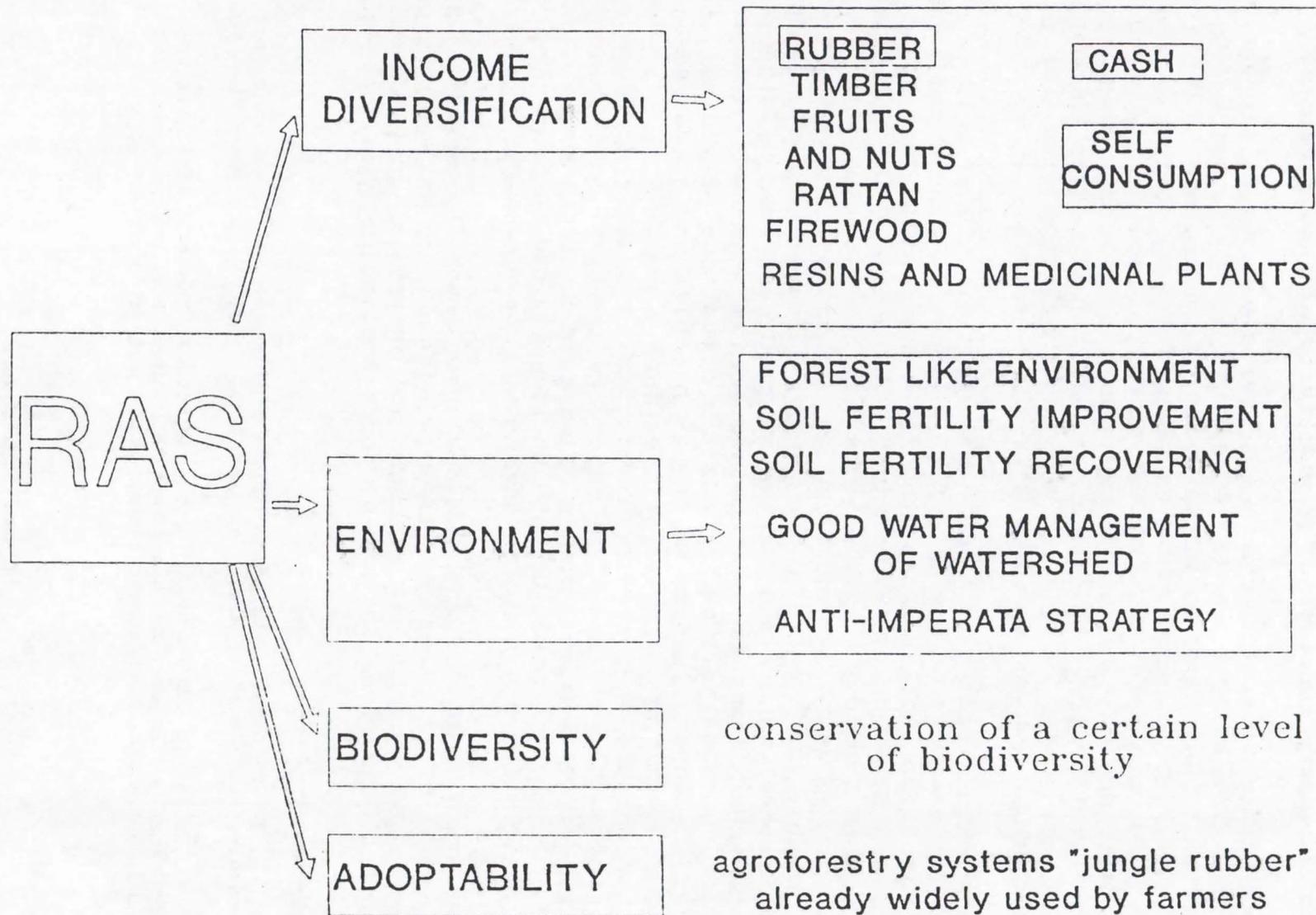
Albeit a great effort from various rubber development project, and in particular SRDP/TCSDP since the 80's, most of the farmers still do not have access to any improved rubber cropping system, due to the high cost of the SRDP/TCSDP package rubber cropping pattern, currently adopted in smallholders projects (TCSDP⁶ and TCSSP⁷), showing the need to an intermediate low cost but with high productivity rubber cropping system based on agroforestry. 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.

⁶TCSDP is funded by World bank and developed in the following provinces : Bengkulu, West-Sumatra, Riau, South-Sumatra, Jambi, Maluku and West-Sumatra.

⁷TCSSP is funded by ADB and developed in the following provinces : Aceh, North-Sumatra, Lampung, South and East-Kalimantan. Both projects TCSDP and TCSSP are based on the same technological package for rubber.

table 1 ADVANTAGES OF RUBBER AGROFORESTRY SYSTEMS



Rationale for a RAS concept definition

RAS patterns are linked with the hypothesis of work which consists in the fact that the general increase of the productivity of the rubber based cropping systems, including rubber in itself as the driving force cashcrop but also side-products (fruits, timber, rattan....), and quality of rubber raw material are linked in a spin of intensification and necessary for rubber based systems sustainability. The various possible levels of intensification of RAS systems, should fit the farmers strategies and limited cash possibilities, with a low to medium level of input and labor in order to give an intermediate RAS patterns as an alternative to the current jungle rubber and the "estate like" technological package for rubber monospecific plot such as SRDP/TCDP. As farmers already implement complex agroforestry systems such as jungle rubber, RAS patterns which management patterns are close to the current systems, are expected to have a high level of adoptability by farmers. Rubber based agroforestry systems have the advantages of being a source of income diversification as well as respecting environment and biodiversity.

Consequently, improving the current jungle rubber through conserving the very nature of an agroforestry system, that fits the farmers strategies and the local environment, appears as the very solution for a particular type of farmers, the class III farmers (see farmers typology), those who have a limited access to information, innovations, improved planting material and cash and credit, but have a strategy of intensification through the increase of their production, therefore of their income ; not only rubber, but also side-products from jungle rubber or improved agroforestry system.

RAS enable a certain flexibility and fit a strategy of farmer's income diversification through various level of production, outside rubber, in time during the RAS lifespan and in side-products (fruits, timber, rattan.....). RAS also may conserve a certain level of biodiversity and fits environmental concerns such as soil fertility and water conservation, forest-like environment and a sustainable and productive alternative to slash and burn process.

Two main situations have been so far identified leading to two main types of On-Farm-Trials (OFT)

- a) the improvement of jungle rubber where IPM, improved planting material, clones or CS/PCS, replace seedlings : a very basic level of intensification (with RAS 1), and
- b) the establishment of a complete complex agroforestry system,

This increase of productivity implies the adoption of rubber IPM (Improved Planting Material), mainly clones, but also CS/PCS for specific situations. A lot of research has been done (IRCA-CIRAD-CP/France, RRIM/Malaysia, IRRI/Indonesia, RRIC/Sri Lanka.....) 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. 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.

So far, no adaptive research has been done to improve the productivity of such systems without destroying their very nature : 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 whether high yielding IPM, 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 perennials associates with rubber or the level of maintenance, depending on local factors, both ecologic or economic. RAS 1 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. RAS 2 and 3 patterns are complex agroforestry systems where rubber is the main driving force in term of income and also the main component, established just after a ladang with various level of intensification and adaptation to degraded lands.

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

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

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

The key question for developers, and therefore for researchers, is the following : to which extent 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 agroforestry 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....?

5.2 The need of intermediate rubber agroforestry systems (RAS) with various level of intensification.

Two basic problematics have to be taken into account :

- *the pionner zones* : how to improve the jungle rubber pionner system, within the available means of farmers, or to which extent, 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 favorable 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 ?. In both cases, the need for technical innovation, information and training, level of cost and credit and development policy priorities should be assessed.

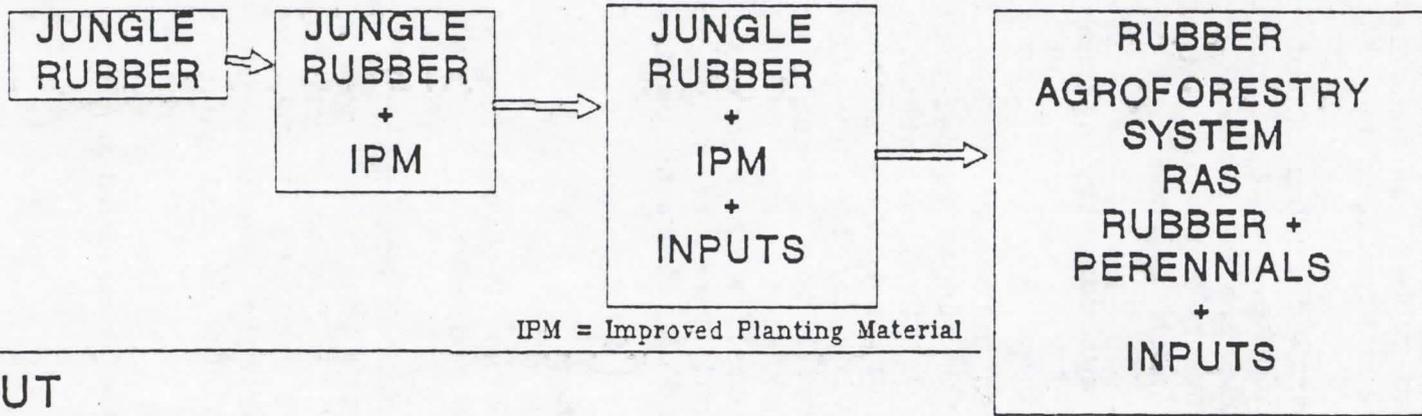
Possible evolution of jungle rubber.

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"¹³. 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

¹³Full technological package for rubber, considered as the "estate" package transplanted for farmers.

RAS PATTERNS LEVEL OF INTENSIFICATION



INPUT FERTILIZER
Growth booster fertilization

no

yes

yes

LABOUR
level of weeding

no

no

minimum weeding

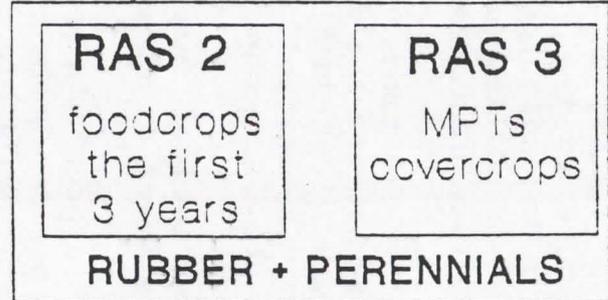
1
minimum weeding

1
minimum weeding

CROPS

selection in natural regrowth

selection in natural regrowth



yes

yes

PERENNIALS

farmers, however the purity of clones is not always guaranteed.

- 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 trees, firewood trees etc..) of such systems should be assessed and valorized. The use of IPM 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 IPM unavailability (in particular the clones), limited cash availability for IPM, 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 IPM 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 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 TSCDP 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).

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 labor 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 behavior and their real potential. Previous surveys of smallholders and estates show a great demand and interest in IPM, 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 IPM 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 IPM.

Historically, the presence in the very early beginning of the rubber planting boom in Sumatra, of active Research Centers (AVROS in Indonesia) enabled Indonesia, in particular the estate sector, to profit from the release of famous clones¹⁴. The adoption of IPM is the very first step to improve productivity. But the smallholder sector still did not do this "varietal revolution", as adoption of IPM has 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 IPM with a low cost of production for the farmers, and probably, by the farmers themselves. Adaptive research has to be done in order to identify the IPM component of RAS package and 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 material¹⁵ to smallholders is a major issue.*

¹⁴Such 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.

¹⁵These 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).

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 od 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. Other crops, naturally grown (wood species) or introduced (rattan...) have to be tried under farmers conditions¹⁶. This experimentation is clearly very new as there is no 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 (pionner 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...). Firedwoods 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.

¹⁶Some interesting results came out from experimentation done in Sungei Putih (North-Sumatra).

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 keywords 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.

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 terms 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.

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6. Smallholder rubber development policy in the future

Indonesia is poised to take the lead in natural rubber production. Rising wages already have reduced the competitiveness of producers in Malaysia and Thailand. Malaysia's production levelled off as a consequence; even Thailand's output seems about to reach its peak. But production costs on Indonesian estates are almost as high as Malaysia's estates and Thailand's smallholders, while production costs for Indonesian smallholders are much lower than all of these (Barlow, Jayasuriya, and Tan, 1994). So, in the future, Indonesia's competitive advantage in natural rubber production will derive mainly from its smallholders.

Increasing exports. Raising smallholder productivity is Indonesia's best hope for expanding natural rubber exports for two reasons. First, as noted above, smallholders produce almost 3/4 of Indonesia's natural rubber. Second, and more importantly, Indonesian smallholders are not only the lowest-cost producers of natural rubber in Southeast Asia--they probably are the lowest-cost producers in the world.

Economic development. Besides being the key to Indonesia's future competitive advantage in natural rubber, a workable strategy to raise productivity of rubber smallholders also would serve the three pillars of economic development in Indonesia: growth, equity, and stability. Despite development in other sectors, increases in smallholder rubber productivity still can be an important engine of economic growth and poverty alleviation

in regions of Sumatra and Kalimantan. The supply of workers continues to grow in these rubber-producing regions, while new land is getting scarce. Under these conditions, farmers will be eager to raise productivity if they have profitable options. If such intensification is achieved, the resulting expansion of income and employment would, among other benefits, help inhibit migration to Java.

Environmental conservation. The environmental benefits of complex agroforests discussed above in section 3 give rubber agroforestry systems (RAS) a special place among smallholder rubber development options. Rubber agroforests provide a means of rehabilitating degraded forest land and, thereby, conserving Indonesia's soil and water resources. Moreover, planting trees may help alleviate global climate change stemming from "the greenhouse effect." Similar benefits from trees can be achieved through development of large-scale plantations of forest species or oil palms as well as smallholder rubber. But among tree-planting options, only complex agroforests (including rubber agroforests) compare to natural forests regarding conservation of biodiversity.

Thus, rubber agroforestry systems are unique among rubber development options because they offer opportunities to provide a wide range of benefits to smallholders, processors, the nation, and the world. This package includes greater income and employment for smallholders, expanded business opportunities for processors, a focal point for regional development, larger non-oil exports, and environmental benefits, including conservation

of biodiversity for Indonesia and the world.

But these important opportunities are being missed. Although smallholders are planting a lot of rubber on their own, most lack adequate access to higher yielding planting material suited to their conditions. In the places where such planting material is available, farmers need more practical information on how to use it best.

Over time, these missed opportunities will threaten Indonesia's competitive advantage in natural rubber. Just as in Malaysia and Thailand, higher wages will come with Indonesia's successful economic development. If there is no increase in smallholder productivity to offset rising labor costs, the low-cost advantage of Indonesia's smallholders will evaporate and so will its natural rubber industry.

What can be done to support rubber agroforestry development?

Sustained success with agricultural exports requires a long-term commitment to invest in research and development in order to increase yields and reduce production costs.¹ For example, when its share of the rubber market was threatened by synthetics in the 1950s, Malaysia acted to retain its competitive position. At that time, almost half the area of its estates and 2/3 of its smallholdings were planted with trees over 30 years old. An ambitious programme of research, replanting, and rural

¹. Successful agricultural exporting countries also invest heavily in infrastructure, which reduces marketing costs, and maintain foreign exchange rates that provide sufficient incentives to exporters.

development transformed the situation (Barlow 1978). Malaysian natural rubber output grew more than 150% from 1955 to 1988, despite competition from synthetics abroad and rising wages at home. Thailand employed a very different rubber development strategy, suited to its smallholder sector and institutional capabilities, to overtake Malaysia. Now rubber agroforestry presents an opportunity--and challenge--for Indonesia to develop its own strategy suited to its unique conditions.

Research on rubber agroforestry systems. An unfortunate feature of the block planting strategy that Indonesia pursued in the 1970s and 1980s was that almost all of the limited supply of higher yielding planting material available for smallholders was restricted to project participants. Moreover, since much of the funding for rubber research has come from plantations, important scientific questions regarding application of higher yielding technology in smallholder settings have not received adequate attention (Tomich 1991). Indeed, there is little scientific evidence on performance of higher yielding rubber planting material under the conditions faced by Type III and Type IV farmers, accounting for roughly 75% of rubber smallholders in Indonesia.

Filling these research gaps is of crucial practical importance since productivity growth in rubber agroforests depends on adaptation of higher-yielding planting material to these complex agroforestry systems. The trials discussed above in section 5 cover several questions that deserve priority. Answers to these basic agronomic questions can provide the

technical foundation for new smallholder development programmes aimed, for the first time, at rubber agroforestry systems. The methods to design and conduct these trials are well-understood; the main barriers to rubber agroforestry research are institutional. In particular, how will it be funded?

New smallholder development programmes. To date, Indonesia's smallholder rubber development efforts have met with little success. Block-planting projects of the 1970s and 1980s, including project management units (PMUs) like SRDP and PRPTE as well as nucleus estate schemes (NES/PIR), were intended to produce large increases in yields. Achievement of the high yields necessary to justify the costs of block planting depended on application of purchased inputs at levels better-suited to large estates than to smallholders.

By the mid-1980s, it already was apparent that high-cost block-planting projects had proved difficult to implement in Indonesia and had benefited only a small fraction of rubber smallholders. Moreover, Indonesia's economic situation had changed because of declining oil prices, which forced cuts in the development budget. About the same time, agricultural development projects began to fall from favor as international donors shifted their attention to environmental concerns. As a result, rubber development programmes withered.

Indonesia's tight government budget constraints make it more important than ever to develop a feasible alternative to the costly block-planting strategy. Programmes aimed at gradual productivity growth in rubber agroforestry systems seem to hold

potential for productivity gains at a small fraction of the cost of block planting. Furthermore, the environmental benefits of rubber agroforests make projects aimed at development of these systems attractive to international donors. In short, compared to block-planting, rubber agroforestry programmes should put less demand on the government budget while being more likely to attract substantial funding from international donors.

Higher yielding planting materials is a key element.

Improving the supply of higher-yielding planting material and providing farmers with practical information about its use should have key roles in any smallholder rubber development programme, including one aimed at rubber agroforests. Various approaches already have attempted to improve planting material supplies for smallholders on a pilot scale. For example, Dinas Perkebunan offices have established nurseries of two hectares or so in many parts of the major rubber growing areas and in recent year also established village nurseries in South Sumatra and Jambi using APBD budget (provincial budget). Over the last three years, GAPKINDO has involved in increasing supply of higher yielding planting materials. GAPKINDO in collaboration with Disbun has sponsored to distribute of higher yielding planting materials to 2200 farmers in West Kalimantan. In addition, small nurseries established in North Sumatra and Jambi in collaboration with the Center for Policy and Implementation Studies contributed to an increase of the supply of higher yielding planting material in those provinces. Finally, rubber research institutes have been involved in supplying planting material to smallholders.

One of the main lessons from these pilot projects is that planting material programmes need to pay attention to demand as well as supply (Barlow, Quizon, and Suyanto, 1993). Since such a large proportion of smallholder rubber area (perhaps 75%) is still under trees grown from unhigher yielding seedlings, projects have taken for granted that there is a big potential demand for higher-yielding planting material. Indeed, some unassisted farmers have started replanting with higher yielding materials. For instance, in parts of South Sumatra and North Sumatra it is common for farmers to buy higher yielding rubber planting material, usually in small quantities obtained from small private nurseries. Elsewhere, however, smallholders' lack of awareness or lack of information on how to achieve the benefits of planting higher-yielding rubber may mean actual demand falls far short of apparent potential. Social marketing techniques may be a cost-effective means to address lack of awareness of higher yielding material and lack of information on its use (K. Fox, 1990). Social marketing would use mass media and other marketing channels to provide farmers with technical information they need to choose material that is appropriate to their economic circumstances and to help them to put it to its best use.

ACRONYMS

AARD	Agency for Agricultural Research and Development
ANRPC	Association of Natural Rubber Producer Countries
BPS	Balai Penelitian Sembawa, Rubber Research Center of Sembawa
CS	Clonal seedlings planting material
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement
CIRAD-CP	CP = Cultures Pérennes = Tree Crop Department of CIRAD.
DISBUN	DINAS PERKEBUNAN
DGE	Directorate General of Estates
GAPKINDO	Union of Indonesian rubber industry.
IPARD	Indonesian Planters Association for Research and Development
ICRAF	International Center for Research in Agroforestry
IRRDB	International Rubber Research and Development Board
HYPM	Higher Yielding Planting Material
IRRI	Rubber Research Institute of Indonesia, Sungei Putih
or CRIR	Central Research Institute of Rubber
PCS	Polyclonal seedlings planting material
PPK	Pusat Penelitian Karet = IRRI
PPSP	Pusat Penelitian Sungei Putih, Rubber Research Center, Sungei Putih
PRPTE	Project for Replanting, Rehabilitation and Extension of Export Crops
RMP	Rubber Monospecific Plot
RAS	Rubber Agroforestry System
SRDP	Smallholder Rubber Development Project
SNI	Indonesian National System for rubber specifications
SIR	Standard Indonesian Rubber
SFDP	Social Forestry Development project
TCSDP	Tree Crop Smallholder Development Project
TSR	Technically Specified Rubber

CONCLUSION

As concerned toward environment has been globally developed since Rio de Janeiro Summit in 1992, it is hoped that new waves on natural rubber development will also occur, especially on the development of smallholder rubber which are pillar of the rubber industry of the country.

Natural rubber is elastomer that still is very important in the automotive tyre-making, especially the radial one. Due to its molecule characteristics, natural rubber has a low rolling resistance so that it reduce the use of fuel and subsequently pollutant tory, and thus it is good for environmental friendly-tire ("green tire) component. Aside of that, this elastomer results biologically as such energy-saving. To produce the same amount of synthetic-rubber it needs less than other materials since the energy of bio-synthesis natural rubber come from solar energy.

Smallholder rubber, in this case "jungle rubber", which has similar pattern to that of secondary forest posses very positive value from the ecological point of view. It has a good hydro-orology for reducing erosion and enriching bio-diversity.

Due to limited funds available, so far only 15 % of smallholder rubber area have been reached by Government development program. If such condition will continue, Indonesian rubber industry which actually has competitive advantage may miss the good opportunity of natural rubber development in the next future. GAPKINDO (the Indonesia Rubber Association) concern on the future prospect of rubber production, quantity and quality; and therefore willing to take a part to its development. Joint with ICRAF (International Centre for Research in Agroforestry), GAPKINDO will develop an agroforestry system based on the smallholder rubber to increase farmer income and simultaneously keep the ecology sustainable. Accordingly pilot projects of planting better clone of rubber in intensive manner in West Kalimantan (Sanggau and Sintang Districts) and Jambi (Muara Bungo district) provinces was planned. In this case, rubber will be planted intercropp with other perennial as such there will be a diversified income and biodiversity. Intercrop plants which are possible for interplanting (as have been tried in Thailand and Malaysia) area: rattan (Manau variety), durian, salak (*Salaca edulis*), cempedak (*Artocarpus* sp), coffee, lansicum, candle nut, etc.

It is planned that the project will be started in the beginning of 1995. As stimulant it will be done in the small scale, and hopefully will be enlarged both by government and International agency who concerned about the environment sustainability. Agroforestry which involve perennial in its system is not new for most Indonesian farmers. It is a traditional agricultural system for most farmer in Kalimantan and Sumatera. As the system has been practiced for generations, and proved very effective in sustaining ecology; in the limited funds available agriculture and forestry sector should work hand in hand for developing the system.

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