200 tappings/year so 130 mandays including other activities). Labour is converted into total mandays in our calculation. It is assumed that rubber is tapped by the owner.

Production patterns have been carefully adjusted to account for the normal evolution of production including losses of trees. In RAS 1, 2.2 and 3 ; rubber yield has been slightly reduced (10 %) due to possible competition with associated trees compared to that of a TCSDP monoclonal rubber plot (this is an assumption). RAS 2.5 rubber production is assumed to be similar to that of TCSDP as cinnamon is harvested the 8th year with no further competition.
Production and prices for fruit and cinnamon have been assessed from interviews with farmers and ENSO/West-kalimantan for pulp trees production.
TCSDP system may be adopted by farmers on their own or though projects. A line in table 2 shows the actual cost of TCSDP system in project, including project costs (evaluated at 1,5 millions rp in 5 years).
The table in appendix displays the main financial results of each system.

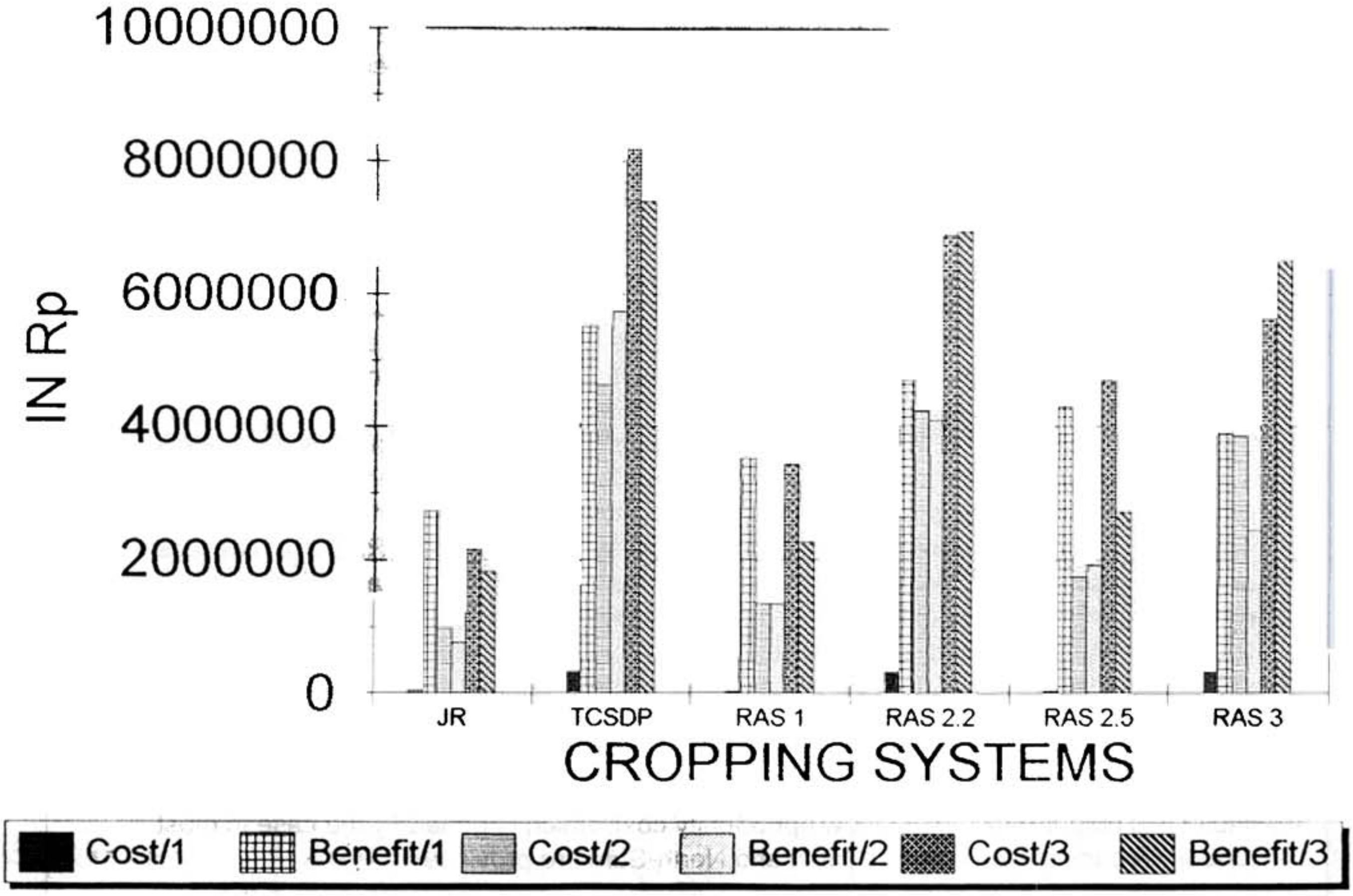
COST-BENEFIT ANALYSIS

The analysis is based on incremental benefit related to the jungle rubber system (table 1). The analysis has been made with 3 levels of labour daily cost. The first one, 2000 rp/day, is equivalent to the output of upland rice farming in shifting cultivation. The second one, 3500 rp/day, is the wage offered by local estates (that can be considered as the 'real regional opportunity cost'). The last one, 5000 rp/day, represents the cost of bagi-dua system (share-cropping using external labor for rubber tapping).

The incremental benefit of RAS systems is in the same range as that of TCSDP for RAS 1 and significantly superior for RAS 2.2, 2.5 and 3 due to the non-rubber components production such as fruits cinnamon or FGT production. The most intensive systems, TCSDP and RAS 2.2 are very sensitive to labour cost, in particular for RAS 2.2. The less sensitive systems are , of course, the jungle rubber system with clonal seedlings (very extensive) and, to a less extend, RAS 1 and 3 (intermediate level of intensification).
RAS incremental benefit is far higher than that of jungle rubber, even using clonal seedlings, mainly due to the fact that the bulk of total income comes from rubber and rubber productivity with clones is multiplied by 3, in addition to other sources of income. Incremental benefit is still very atracting at high labour cost, but then systems are in the same range. RAS systems are aimed to decrease labour requirement and gives a very interesting output in the case of low opportunity cost, which is generally the case in most rubber producing areas except South and North-Sumatra provinces.

Table 2 shows that rubber contributes to around 80 % of total income and to 95 % in RAS 1, but the use of Net Present Value of production increase the importance of rice during the immature period and decrease the final value of the wood at the end of lifetime. In fact, clonal rubber wood and timber output is expected to be high enough to able the farmer to further invest in whatever improved cropping system (mospecific plantation of rubber or oil palm or agroforestry systems).
Jungle rubber produces not only rubber but also fruits, timber for local use, medicinal plants, rattan and firewood which are generally for self-consumption. Production for self-consuption is not taken into account in this calculation, but is considered as a general

INC REMENTAL COST BENEFIT ANALYSIS
FOR RUBBER BASED CROPPING SYSTEMS



Cost/1 and Benefits 1 : labour cost = 2 000 rp/day
Cost/2 and Benefits 2 : labour cost = 3 500 rp/day
Cost/3 and Benefits 3 : labour cost = 5 000 rp/day

benefit for the farmer that is comparable for all systems except TCSDP[11] which is monoculture.

The return to labour : a sensitive argument for farmers in selecting a cropping system.

An important factor for the farmer is to maintain a good return to labour or to imporove it. The evolution from an imput extensive system such as jungle rubber into an intensive system such as RAS 2.2 or TCSDP is generally limited by cash availability and labour. Two conditions must prevail for adoption of new technology : limited risks and high return to labour, or at least conservation of return to labour comparable than that of a jungle rubber. Figures in table 3 show rubber return to labour is definitely improved with TCSDP and RAS (around 50 000 rp/manday compared to 9 000 rp for jungle rubber at the year 15 in full potential production). A better estimation of the return to labour in the long term may be done using the labour cost that leads to Net Present Value equal to zero (table 1). One can see that this opportunity cost (OC/zero) for jungle rubber is close to the bagi-dua labour cost giving little room for extension. OC/0 of TCSDP is similar to that of RAS 2.2 and lower than that of more extensive system (RAS 1) of intermediate (RAS 2.5 and 3). The interest of these intermediate systems is that they are still afordable for farmers (investment cost is limited) with limited labour requirement and a good optimization of labour. RAS 1 is typical of that situation.

A possible constraint is in the distribution of required labour, in particular during the immature period. TCSDP and RAS require labour prior to production systems (respectively 300 to 500 mandays for RAS and 600 for TCSDP) in contrasting with jungle rubber (54 mandays). In RAS, labour required during immature period is less than TCSDP. In RAS 2.2, the required labour for weeding rubber is diminished due to rice cropping where rubber profit from crop weeding. The main constraint for adoption of a clonal rubber based system is the necessary minimum level of maintenance during the immature period. The first 2 years are critical as rubber clones require a minimum level of weeding (probably around 6 weeding/year compared to 12 for TCSDP but that is still under experimentation with farmers). Labour requirement in RAS systems is 50 to 75 % that of TCSDP monoculture system leading to a better adoption of clones by farmers as far as labour during immature period is concerned .
After opening, the low tapping frequency of clones leads to a significantly improved return to labour. For these reasons, the use of clonal seedlings do not yield a real significant impact on return to labour as well as income. Exploitation system and tapping frequency are key issues in improving return to labour during production period.
Return to labour is optimized in the RAS 1 system and is especially suitable for farmers in remote or pioneer zones as well as those with poor cash availability. The immature period investment is half that of TCSDP and may be within the range of possibility for some farmers without any access to credit. RAS 1 is aimed to decrease the labour requirements by 30 % during immature period.
For RAS 2.2, rice intercropping has significant benefits for rubber growth however rice production does not have a great economic value compared to that of rubber. Nevertheless, it is important for some farmers to grow rice during the immature period in order to valorize labour investment, in particular for those with limited access to land such

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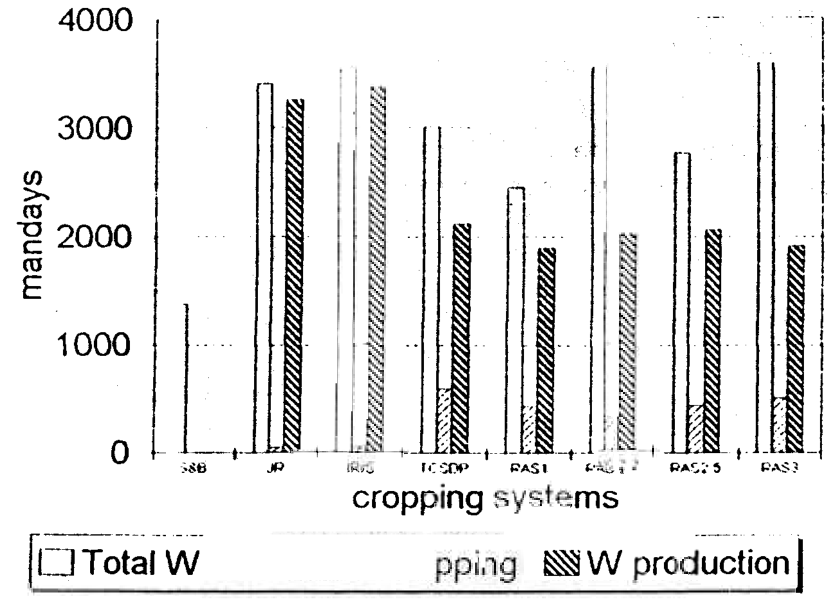
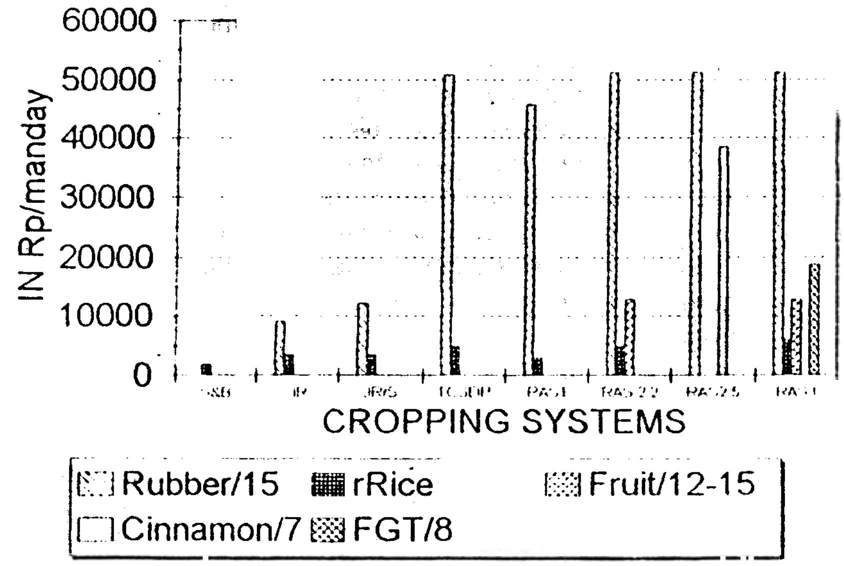
[11] TCSDP like monoclonal rubber plot is the only system without non-rubber products but it is also not an agroforestry system.

LABOUR REQUIREMENT PER SYSTEM



RETURN TO LABOUR OF CROPS



as transmigrants. Then rice intercropping is not only a choice but also a necessity, explaining why rice intercropping is always attractive for farmers (at least for the first year) when rubber is not yet producing. The investment during the immature period is not so heavy as the figure includes the inputs cost for rice which are to be paid off within 4 months.

For RAS 2.5, cinnamon is definitely a very interesting associated crop with rubber as it fits well with the strategy of local farmers in the Muara Bungo area, a hilly area where rice is not often cropped. This extensive system fits also local farmers' strategies focused on low labour investment.

For RAS 3, FGT's are an important source of additional income. This may help the farmer to reimburse credit if any.

Initial investment is also an important component of farmers strategies. RAS systems are low to medium inputs systems. Table 4 shows the importance of initial investment in NPV related to that of TCSDP with respectively 30 %, 55 % and 78 % for RAS 1and 2.5, RAS 3 and RAS 2.2 of that of TCSDP (if adopted by farmers on their own without projects cost). If we had the TCSDP project cost, estimated at 1.5 millions rp/ha, then it is clear that RAS technology is more affordable for farmers and constitute a very interesting alternative to the current rubber development policy.

Conclusion

This preliminary simple cost-benefit analysis of various rubber based cropping systems (based partly on technical assumptions that should be confirmed by experimentation) gives an idea of the improved economic output resulting from the choice of using rubber clones compared to unselected seedlings in jungle rubber. Both NPV and return to labour are significantly improved in RAS and TCSDP systems with advantages to RAS in terms of income diversification, environmental benefits and return to labour as well as investment during immature period compared to TCSDP.

Further in-depth investigation is required, including the results of the current on-farm experimentation on RAS systems giving step by step more accurate information about labour requirements, cost and production. This hypothetical financial calculation enables us to see the scope of such systems and their potential economical performance compared to current existing systems and show clearly that RAS systems may be interesting alternatives to jungle rubber and TCSDP like system. RAS systems are low to medium labour and input systems with valuable economical outputs, compared to TCSDP, and , of course, compared to jungle rubber. By providing a good return to labour for a limited initial investment, the RAS systems are especially suitable for farmers with limited cash availability.

The current on-farm experimentation and the farming system surveys wil enable us to obtain accurate data on labour and production as well as information on technology adoption by farmers currently practicing these RAS systems.

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APPENDIX

MAIN TABLE ON COST BENEFIT ANALYSIS AND RETURN TO LABOUR FOR VARIOUS RUBBER BASED SYSTEMS

TABLE

COMPARISON BETWEEN RUBBER BASED AGROFORESTRY SYSTEMS

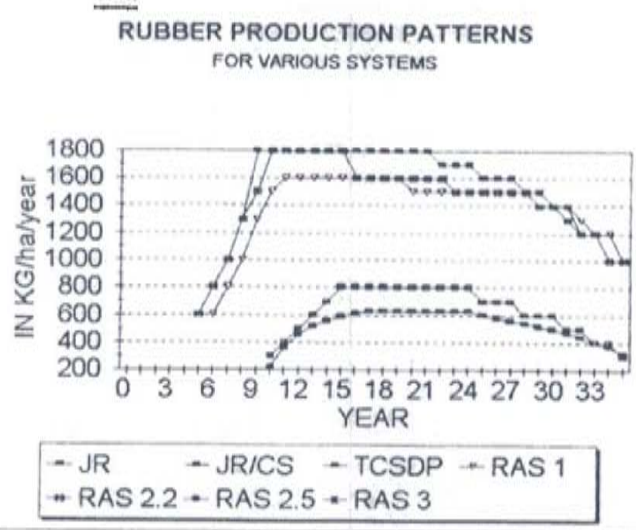
COST NET BENEFIT ANALYSIS (NPV) and RETURN TO LABOUR

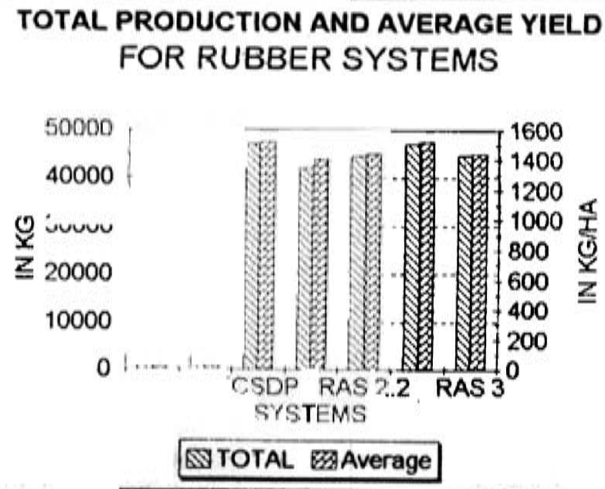
	Upland rice slash and burn system (shifting cultivation)	Jungle rubber unselected seedlings traditionna	Jungle rubber clonal seedlings traditionna close to estates	TCSDP like clonal plantation Developmen projects	RAS 1 Rubber clon traditionnal conditions	RAS 2.2 rice Inter-crop Rubber clone associated tr +rice intercro	RAS 2.5 Cinnamon Inter-cropping Rubber clone + cinnamon	RAS 3 with FGT (*) Rubber clones + associated trees + rice intercrops + FGT
COST BENEFIT ANALYSIS								
TOTAL OUTPUT VALUE OF ALL PRODUCTIONS	724,535	1,859,979	2,226,786	10,070,267	7,464,373	10,837,300	12,197,378	11,075,776
TOTAL COST OF PRODUCTION	0	1,132,451	1,166,120	4,635,898	2,500,064	2,474,836	4,569,125	3,398,891
TCSDP project cost INCLUDED for project farmer				5,596,954				
TOTAL NET BENEFIT	724,535	727,527	1,060,666	5,434,369	4,964,309	8,362,464	7,628,253	7,676,884
LABOUR REQUIREMENT								
TOTAL LABOUR REQUIRED in mandays	1,370	3,414	3,534	3,016	2,454	3,558	2,764	3,588
Labour during immature period for rubber only		54	54	597	434	314	444	514
Labour during mature period for rubber only		3260	3,380	2,119	1,900	2,030	2,070	1,910
RETURN TO LABOUR								
RUBBER return to labour : YEAR 15		8,979	12,210	50,839	45,714	51,246	51,246	51,246
Average RICE return to labour (1 or 3 years)	1,992	3,500	3,500	5,000	2,917	5,000		6,000
FRUIT return to labour : YEAR 15						12,861		12,861
CINNAMON return to labour (year 7)							38,400	
FGT return to labour (year 8)								18,667
LEVEL OF INTENSIFICATION		---	--	+++	+	+++	++	++
INITIAL INVESTMENT during immature period	0	0	34,783	1,470,116	482,359	1,143,293	474,261	817,304
% of TCSDP cost	0%	0%	2%	100%	33%	78%	32%	56%
Number of days of work for initial investment (*1)		0	10	420	138	327	136	234
INITIAL INVESTMENT during immature period with TCSDP project cost included				2,344,706				
				Rice included		Rice included		
RUBBER SYSTEMS CHARACTERISTICS								
RUBBER PLANTING MATERIAL	local rice + no fertilization	seedlings		Clone PB 260	Clone PB 260	Clone PB 260	Clone PB 260	Clone PB 260
Tapping days (frequency) per year		200	200	120	120	120	120	120
ASSOCIATED TREES								
FGT (fast growing trees) for pulp		natural REGROWTH	natural REGROWTH	no	natural REGROWTH	fruit/timber	cinnamon	fruit/timber pulpwood species
RICE		year 1	year 1	year 1 to 3	year 1	year 1 to 3	no	year 1
Local		yes	yes					
improved with fertilisation				yes	yes	yes		yes
Covercrops		no	no	yes LCC for rubbe	no	no	yes	yes flemingia

NOTE : discount rate = 15 % (real interest rate)

Main characteristics of selected clones for RAS/OFT. Provinces with severe leaf disease risks (West-Kalimantan and West-Sumatra).

CLONE	*ADVANTAGES*	DISADVANTAGES
PB 260	*very good growth, very high yielding, very good shadowing, resistant to Colletotrichum. No stimulation required. Permit D3 or D4 exploitation system (save labor)*	susceptible to *Corynespora*, pink disease and TPD, exploitation system should be D3 or D4, not very adapted to D2. High risk with over stimulation or over-exploitation.
RRIC 100	*very good growth, very high yielding, very good shadowing, resistant to Colletotrichum and Corynespora. Adapted to D2, No stimulation required*	Average susceptibility to leaf *Phytophtora* and pink disease. Heavy canopy.
RRIM 600	*average growth, high yielding. The most planted clone in Thailand. Resistant to Colletotrichum.*	Susceptible to wind damage. Should be avoided in Riau and North-Sumatra. Susceptible to Oidium (no incidence in West-Kalimantan).
BPM 1	*good growth, very high yielding with a regular increase of production, very good shadowing, rlatively resistant to Colletotrichum and Corynespora. Adapted to D2 expoitation system.*	Average susceptibility to *Phytophtora*. Average susceptibility to Oidium (no incidence in W-Kalimantan). Not widely grown, so not well known Grafting is considered by farmers as difficult.


RUBBER PRODUCTION PATTERNS
FOR VARIOUS SYSTEMS
IN KG/ha/year
1800
1600
1400
1200
1000
800
600
400
200
0 3 6 9 12 15 18 21 24 27 30 33
YEAR
JR
JR/CS
TCSDP
RAS 1
RAS 2.2
RAS 2.5
RAS 3


TOTAL PRODUCTION AND AVERAGE YIELD
FOR RUBBER SYSTEMS
IN KG
50000
40000
20000
10000
0
IN KG/HA
1600
1400
1200
1000
800
600
400
200
0
CSDP
RAS 2.2
RAS 3
SYSTEMS
TOTAL
Average

raskal3