ECONOMIC ANALYSIS OF SMALLHOLDER RUBBER AGROFORESTY SYSTEM EFFICIENCY IN JAMBI, INDONESIA

A. Rodgers[1)], Bonar M. Sinaga[2)], and Suseno Budidarsono[3)]

ABSTRACT

The objectives of this research were; (1) to analyze production efficiency and profitability of smallholder rubber monoculture and smallholder rubber agroforestry systems, and (2) to find out the effects of policy distortions towards rubber production under smallholder monoculture and smallholder agroforestry. Smallholders are not only judged by yield per hectare; economic efficiency is not only a matter of returns to land and returns to labor but smallholders can adopt low input strategy, continue making profits at prices that would be economically viable. Such flexibility offers the possibility of efficient resource allocation in response to diversification of economic opportunities. The policy analysis matrix (PAM) with the domestic resource cost (DRC) results under the baseline scenario indicated that the use of domestic resources in production of rubber was efficient and socially profitable under the two systems but more desirable under monoculture system given the current prices for physical inputs, outputs, technologies and policy transfer. However, even with sensitivity analysis of 10% increase in the price of rubber holding other factors constant does not make rubber agroforestry system more efficient than its counterpart and a 20% fall in price of rubber made rubber production under agroforestry system less efficient and undesirable. All measures are compared to the alternative policy indicators currently used. Therefore, recommendations made from this study relate to the need for diversification into better practices that can sustain efficient rubber production under the agroforestry system, encouraging private sector participation and reducing disincentives to rubber production.

Key words: smallholder rubber agroforestry, economic efficiency, policy analysis matrix

INTRODUCTION

The uniqueness of agroforestry system has been documented in many reports. Torquebiau (1984), Mary and Michon (1987) and Michon (1993) reveal that agroforestry is like a forest like land use system invented by local people over generations living at the margin of rainforest.

Smallholder natural rubber area in Indonesia covers 3 million ha (hectares) out of which 2 million ha are rubber smallholder agroforests locally called “jungle rubber” (Director General of Estates, 2003). The total area growth of rubber in Indonesia was 1.27 from 1970 to 2003 (Direktorat Jenderal Bina Produksi Perkebunan (2004).

[1)] Country Representative Africa Wind Energy Association, Uganda
[2)] Lecture on Department of Economics and Environmental Resourch, Faculty of Economics and Management, Bogor Agricultural University
[3)] Recearcher in Center for International Forestry Recearch

The rubber-based agroforestry system yields are classified into three product groups namely; (1) latex (2) rubber wood and (3) yields of the intercrops.

From the natural conservation point of view, Muara Kuamang agroforestry affords environmental benefit. The forest like structure of agroforestry allows the conservation of large part of natural forest biodiversity (de Foresta and Michon, 1994). The mature agroforestry is made up of an intimate mixture of various tree crops managed by the smallholders. The trees shade out the crops, occupy different strata and occupy high value products such as fruits and high grade timber. As far as wild animals are concerned, agroforests harbor too many wild species and most of them are protected by the Indonesian law. These animals include; monkeys, gibbons, simang etc.

Rubber agroforestry is particularly interesting for two reasons. Firstly, it is relatively profitable and secondly, it is entirely smallholder-oriented. A jungle rubber plot produces approximately 600 kg (dry equivalent) of rubber per hectare per year (van Noordwijk *et al.* 1995.

From the economic perspective, this land use system provides a wide range source of income to farmers, their neighborhood and actors along the trading chain (Levang, 1989; Dupain 1994; Bouamrane, 1996). Trees with about 65% of the tree community provide regular cash income from the harvesting and total sales. Fruit trees comprise almost a quarter of the tree community although not on a monthly basis, also provide additional cash income.

The interesting part of the story lies in the way farmers initiate and develop this land use. In the first year, after slash and burn, subsistence food crops (primarily dry land paddy) are planted alongside rubber and fruit trees such as durian, duku, rambutan and other trees which have economic value for additional household income. Wherever possible, smallholder farmers plant any kind of vegetable for their own need.

Crop mixture has economic importance as it makes the basis of succession of harvestable commercial products before positive cash flow (i.e. 6^{th} year for monoculture system and 9^{th} year for agroforestry system). Food crops (dry land paddy and vegetables) are the first yields that are harvested mainly used for daily consumption before other commercial crops are harvested. Farmers have additional annual income from harvesting these fruit trees.

However, one of the major issues amongst smallholders under rubber agroforestry is how efficient and profitable their system is as compared to smallholder monoculture rubber production considering whether it is financially viable or not. Some of the evidences on this issue were considered, by analyzing the production structure and the arguments made for smallholders production efficiency and profitability. The expected outputs of the efficient production system are; good price, improved product quality and enhancement of a better welfare of farmers and communities.

RESEARCH METHODOLOGY

The Farm Budget Analysis Approach

Farm budget analysis is a commonly used economic tool for assessing performance of agriculture practices. This thesis employed the same technique that

was applied in other profitability assessments (e.g. ASB Indonesia project (Tomich et al, 1998; Budidarsono et al, 1998, 2000), which is Policy Analysis Matrix (PAM).

As long as profitability calculation is concerned, the appropriate measure of profitability for long term investment is net present value *(NPV), i.e.,* the present worth of benefit (revenues) less the present worth of the cost of tradable inputs and domestic factors of productions (Gittinger, 1992). Mathematically it is defined as:

$$NPV = \sum_{t-0}^{t-n} \frac{B_t - C_t}{(1+i)^t}$$

where B_t is benefit at year t, C_t cost at year t, t is time denoting year and i is discount rate. An investment (the practice of smallholder rubber agroforestry and smallholder rubber monoculture for over 30 years since establishment) is appraised as profitable if NPV is greater than 0.

Profitability measured at social prices, so called social profitability, is an indicator of potential profitability. The divergence between private and social profitability shows how policies and market imperfections affect the financial incentives faced by smallholder farmers.

Profitability analysis needs a detailed farm budget calculation and it is necessary to clarify the proper prices for calculating the costs and returns and the macroeconomic assumptions used in this assessment. The study's farm budget calculations were based on macroeconomic conditions that prevailed in Indonesia in the year 2007.

Macroeconomic Parameters Used in 2007 were as follows;

1) Exchange rate (Rp/USD)	9 164
2) Wage rate in Jambi (Rp/person/day)*	20 796
3) Real interest rate	
Private	10.0%
Social	5.0%

Source: Bank Indonesia, 2008

*Calculated wage rate for 2007

The PAM Table Approach of Assessment

Profitability as the first identity of accounting matrix is measured horizontally, across the columns of the matrix as demonstrated in Table 1.

Table 1. Policy analysis matrix

	Revenues	Cost		Profits
		Tradable input	Domestic factor	
Private prices	A	B	C	D[1]
Social prices	E	F	G	H[2]
Effect of divergences	I[3]	J[4]	K[5]	L[6]

Source: Monke and Pearson (1995, p.19)

Important policy parameters from policy analysis matrix

The primary objective of constructing a PAM is to derive few important policy parameters for analysis. The most commonly used parameters are Nominal Protection Coefficient on Tradable Output (NPCO), Nominal Protection Coefficient on Tradable Inputs (NPI), Effective Protection Coefficient (EPC), Private Cost Ratio (PCR) and Domestic Resource Cost (DRC). These parameters are closely related and are implicit in the PAM and hence can be calculated directly from the matrix. Since these are ratios, they can be used as a basis for comparison between different production activities.

Nominal protection coefficient on tradable outputs (NPCO)

NPCO is the ratio between private and social revenue of the output (i.e. the ratio of domestic market price of the product to its parity price at the farm-gate). In Table 1 above, NPCO = A/E. If NPCO >1, this indicates that the private price of output is greater than its parity price and hence producers are positively protected for the product. If NPCO < 1, it indicates that producers are implicitly taxed on the product. If NPCO = 1, it indicates a neutral situation.

Nominal protection coefficient on tradable inputs (NPCI)

NPI is the ratio of private to social cost of tradable inputs (i.e. the ratio of the private to the social values of all the tradable inputs). In Table 1 above, NPI = B/F. Therefore, if NPI >1, it indicates that producers are taxed when they buy tradable inputs. If NPI < 1, it indicates that they are subsidized and if NPI =1 it represents a neutral situation.

Effective protection coefficient (EPC)

EPC measures the total effects of intervention in both input and output markets. It is defined as the ratio of value-added measured at private prices to that at social prices. From Table 1 above, EPC = (A-B) / (E-F). If EPC > 1, it implies that the overall impact of the existing policy results in a net positive incentive to produce the commodity. EPC < 1 represents a net disincentive. EPC = 1 implies either no intervention or the net impact of various distortions in both the input and product markets results in a neutral effect on value added.

Private cost ratio (PCR)

The PCR is the ratio of domestic resource costs to value added in private prices. PCR = C/ (A-B). The ratio is an indication of how much a system can afford to pay domestic resources, including a normal return to capital, and still remain competitive. Any PCR less than one is an indicator of positive incentives for a given system.

Domestic resource cost (DRC)

This is the ratio of domestic factor cost, valued at social prices to the value-added created by the same resources at social prices. DRC = G/ (E-F). It is, in fact a social cost-benefit ratio, which helps in determining the desirability of certain domestic production system relative to the international market in terms of economic efficiency. The social cost is the opportunity cost of domestic resources involved in the production process. The social benefit is the value - added generated by the resources measured at social prices. If the cost is greater than the benefit (DRC>1), the production of the product is not desirable from the social point of view.

On the other hand, if the cost is less than the benefit (DRC<1,) the production of that product is socially desirable. If the cost is equal to the benefit (DRC = 1), it is just worthwhile to produce the commodity. It also implies that with

regard to the commodity in question, the allocation of productive resources has reached an optimal point in the sense that, with the given economic regime, further reallocation of domestic resources would reduce welfare.

Sensitivity analysis

Since PAM is a static model and cannot capture the potential effects in prices and productivity, therefore a sensitivity analysis was conducted. The primary issue of the sensitivity analysis was estimated at 10% increase and 20% decrease in producer prices. This is based on author's observations who perceived that smallholder agroforestry system's lower yields are realized, particularly in the establishment phase, whereas with continuous production, yields increase as the system balances. This has a negative impact on prices of the final produce, and hence viability of rubber agroforestry. However, it can be argued that even if the price of rubber is likely to fall in the future, rubber agroforestry smallholders will still be in the range of their counterparts. Also, a fluctuating interest rate can have a significant impact on the system's efficiency. Therefore social interest rate of loan to farmers was specified at 10% but currently it is 5.0% while the private interest rate was changed from the actual interest rate of 10% to an estimated rate of 15%. It is a subsidized credit aiming at promoting smallholder rubber farmers to get involved in development without any harmful financial burden for credit repayment. Devaluation in the value of the rupiah will result in better performance of agroforestry social production than social production of her counterpart.

RESULTS AND DISCUSSION

Cost of Rubber Establishment

The result of 30 years farm budget calculation (based on 2007 macroeconomic assumption) figures out that financially, the total expenditure (NPV discounted) spent on rubber establishment under monoculture system was found to be Rp 19 144 million per hectare, whereas under rubber agroforestry system was Rp 8 583 million per hectare.

What about the establishment costs for smallholders to develop rubber plantations? Or in another words, how much money do smallholder farmers need to develop their rubber plantations? Establishment costs here are defined as all inputs used to establish the systems, whereas the terms of "operational costs" are defined to be number of years of positive cash flow. Therefore, using these definitions, the two systems were analyzed during their years of positive cash flow. The discounted operational costs for both systems are financially ranging from Rp 24 797 million under agroforestry to Rp 48 168 million under monoculture, and economically ranging from Rp 37 977 million under smallholder agroforestry system and 75 224 under smallholder monoculture system.

Return to Land and Return to Labor Assessment

Returns to labor and returns to land assessment figures out that rubber establishment for both smallholders under rubber monoculture and smallholders under rubber agroforestry systems are profitable. Based on 2007 macroeconomic

parameters, returns to land per hectare at private prices are 46 737 million for smallholder monoculture system and Rp 18 254 million for rubber agroforestry system respectively. Economically (farm budget calculation valued at social prices), returns to land for these systems are Rp 119 492 million (smallholder rubber monoculture system) and Rp 52 389 million (smallholder rubber agroforestry system) respectively. Similarly, for returns to labor, both systems provide more than double of the wage rate in Sumatra. These estimates indicate that establishing rubber is very attractive for farmers to operate under both systems.

Effect of Divergences or Policy Transfers

It is noted that not all policies distort the allocation of resources; some policies however, endorse to improve efficiency by correcting for failure of product or factor markets to operate properly. A negative transfer in the total revenue indicated that the smallholders were receiving less than the border parity price for the commodity. A negative transfer in the domestic factors represents a positive transfer to the producers (smallholders under monoculture and agroforestry systems) of the commodity as this contributes to an increase in profit while a negative transfer in the tradable column indicated that smallholders are paying less than they would if distortions were not present compared to how it would have been if the result was positive.

The value of output (revenues) transfer was negative for both rubber monoculture and rubber agroforestry and the NPCO of these systems was 0.47 and 0.43 respectively. These suggest the existence of substantial output transfer from farmers to the economy. Apparently, it stemmed from two things, namely, failures in domestic market of output and overvalued official exchange rates. Monoculture farmer and agroforestry farmers actually respectively received only 47% and 43% of the efficient (f.o.b.) price.

The value of tradable input transfer was negative for both rubber monoculture and rubber agroforestry and the NPCI of these systems was 0.59 and 0.69 respectively. This indicates that producers in both systems are not taxed when they buy tradable inputs; hence here producers are protected because of government's subsidy on the tradable inputs like fertilizer (i.e. Urea, TSP and KCl). According to the results, monoculture system looks to be benefiting from subsidies as compared to the agroforestry system. Therefore other crops that are planted along side rubber in the agroforestry system also take advantage of the subsidy provided by the government. These results are consistent with the negative divergences for both tradable input costs of both systems in the policy analysis matrix.

The EPC values of 0.45 and 0.42 for rubber monoculture and rubber agroforestry respectively shows that the transfers of tradable outputs and tradable inputs were significant. Output transfer from farmers to the economy was much higher than the input transfer from the economy to farmers.

The net transfer was negative in both rubber monoculture and rubber agroforestry, but rubber monoculture provided much higher transfer than in rubber agroforestry. This was caused by the higher output quantity in rubber monoculture in comparison with rubber agroforestry.

Impact of Change in Existing Policies

Effects of an increase in producer prices

An attempt was made to determine the effects of an increase in producer price on the efficiency of rubber production from a social point of view while comparing baseline scenario results with a 10% increase effect. Therefore, with 10% increase in producer prices, PCR and DRC for monoculture system decreased from 0.41 to 0.37 and 0.31 to 0.28 respectively as well as decreasing PCR and DRC for rubber agroforestry from 0.48 to 0.45 and 0.37 to 0.35 respectively. This indicates that even with a 10% increase in price of rubber, monoculture still remained more efficient than its counterpart. EPC for rubber monoculture remained the same i.e. 0.45 as well as EPC for rubber agroforestry with 0.42 under both scenarios respectively. Static EPC results under both systems are clear indicators that farmers are receiving net disincentives. NPCO results for both results also remained the same under the two scenarios i.e. 0.47 for monoculture and 0.43 for rubber agroforestry system which is a clear indicator that both systems are implicitly taxed.

Exchange rate and interest rate

The macroeconomic policies which are found to be relevant to smallholder rubber development are interest rate and exchange rate policies. The annual interest rate of loan for farmers was specified at 10%, but currently the actual rate is 5.0%. It is a subsidized credit aimed at promoting smallholder rubber farmers to get involved in development without any harmful financial burden for credit repayment.

Exchange rates are managed by Bank Indonesia using floating exchange rate system. It is obvious that the official (market) exchange rates of Rupiah per US dollar gradually increase from year to year. The official exchange rate 2007 was Rp 9 164 per US dollar. In Indonesia, exchange rates tend to be overvalued. According to ICRAF expert, the overvaluation rate was approximately 10 percent. This is an indicator that monetary crisis has been taking place, whereby the exchange rates go up and down.

With the new interest rate i.e. scenario C (i.e. 5% increase in private and social interest rate) in comparison with the baseline scenario (status quo), EPC increased from 0.45 to 0.52 for rubber monoculture and from 0.42 to 0.53 for rubber agroforestry. The increasing EPC implies if the interest rates keep on increasing, then the two systems could easily lose their competitiveness but at this time, they are still competitive and this could be an emergence of efficient production technology and the impacts of economic reforms. Since EPC values remained less than one it also implies that the net impact of government policies influencing product markets would lower private profits than if there were no commodity policies. This is however not a complete indicator of incentives.

From the PAM point of view, the appreciation of the real value of IDR implied that the f.o.b. price of product (in IDR) decreases in real terms (and so will the farm-gate price). A decrease in price of rubber makes the crop undesirable from the social point of view (i.e. with a 20% decrease in price of rubber DRC increases from 0.35 (agroforestry) and 0.28 (monoculture) under scenario A (i.e. 10% increase in the price of rubber) where it is efficient with better results, to 0.39 (monoculture) and 0.42 (agroforestry) under scenario B (20% decrease in the price

of rubber). According to the results it was becoming undesirable for farmers but more under agroforestry than monoculture system. The opposite is also true (i.e. with a depreciating RER, profits realized in excess of normal returns to domestic resources will decrease). It is important to note that on the other hand, an appreciating real value of the IDR implies that the c.i.f. prices of inputs (in IDR) will also decrease. However, the DRC is insensitive to changes in parity prices of tradable inputs under monoculture than its counterpart. Costs of non-tradable elements such as labour, warehousing, port charges, and transportation outweigh costs of tradable elements. Thus, the overall effect (combining effect on produce price and effect on input price) is a disincentive to exporting the crop. However, it is worth noting that Indonesia's inflation rate is on a steady decline.

Effects of policy distortions

The net policy effect was negative for both systems in all scenarios, which is a clear indication that the overall, policies are reducing net private profitability below net social profitability. This suggests that in general government policies are taxing agricultural output. The gap between the two, nevertheless, varies widely signaling different policy pressures between two systems.

The output price transfers shows a significant gap between social and private (market) producer prices, with market (private) prices being lower in both systems. The gap between private and social output prices is narrower for both rubber monoculture system and rubber agroforestry system. This is an indication that private prices in both monoculture and agroforestry are comparable and competitive to the world market prices with effective protection coefficients ranging from 0.42 to 0.54 under rubber agroforestry and 0.45 to 0.52 for rubber monoculture with change in policies calculated for rubber monoculture and rubber agroforestry respectively.

The existing gap between private and social output prices widened significantly and the reason for this could be due to estates growing and exporting rubber offers low prices to smallholder farmers. The world price fluctuation for rubber is a big threat to Jambi's smallholder rubber industry. The export tax previously imposed on all export crops reduced small profit previously received by farmers in this industry. These factors are part of the explanation for the rising and falling of market prices for rubber. When the prices of rubber fall, smallholders under rubber agroforestry reallocate factors of production (i.e. capital and labor) to other crops and return them back when the prices of rubber increase again in order to meet the daily expenses. Therefore price fluctuations affect the production of rubber under agroforestry system whereas; smallholders under monoculture system maintain their tapping and maintenance schedule for future benefits.

The study found, overall increase in private input prices. This stemmed from poor infrastructure and lack of competition in the transport sector resulted into very high transport costs and inflating private input prices. Input traders charge high market prices as they struggle to recover their marketing costs (inflated by high transport cost). It therefore means that producers are unnecessarily paying more for inputs than they normally would if the transport industry was competitive. Also, the sales tax imposed on inputs such as chemicals, fertilizers (e.g. KCl) inflate the input market price, pushing it above the social price.

CONCLUSIONS AND POLICY IMPLICATION

Conclusions

(1) This study being an application of a policy analysis matrix under two competing systems (i.e. smallholder rubber agroforestry and smallholder rubber monoculture) in Jambi, DRC and PCR indicators were found to be less than 1 under the baseline scenario which shows that rubber is efficiently produced in both systems but more efficiently produced under monoculture than its counterpart. Interestingly enough, these results are consistent with the government policies of achieving smallholder's production and subsidization of inputs (e.g. fertiliser).

(2) Since PAM is a static model, which cannot capture the potential changes in prices, costs and productivity, the rankings were subject to changes in the market condition. In order to overcome the limitation, a set of sensitivity analyses were carried out by changing farm gate prices and real interest rate (i.e. price of rubber and real interest rate both at private and social prices). The general conclusion from this analysis is that, even with 10% increase in the price of rubber and 5% increase in social and private interest rates, smallholder rubber agroforestry system did not out-compete its counterpart efficiently and profitably thus making monoculture the best option if farmers are looking for the best profitable system.

(3) Based on farm budget calculation, the study revealed that smallholder rubber monoculture system in managing the plantation during rubber establishment had higher returns, employed more labor and also more profitable than smallholder rubber agroforestry traditional systems. An effort to prolong the plantation stage brings in significant changes in the farmers economy and the neighborhood as it created more employment opportunities in the villages.

(4) Price distortions reduce the production of rubber under smallholder rubber agroforestry system. With a 20% decrease in prices of rubber reduces the systems efficiency (i.e. from 0.37 DRC under baseline scenario to 0.42 under scenario B for smallholder rubber agroforestry system) and (0.31 DRC under baseline scenario to 0.39 DRC under scenario B for smallholder rubber monoculture system) thus making rubber more less desirable under scenario B for smallholder rubber agroforestry system. When the price of rubber falls, smallholders under rubber agroforestry system reallocate factors of production (i.e. capital and labor) to other crops thus leaving rubber unattended to in order to meet their daily expenses. Therefore smallholders resume tapping when there is an increase in rubber prices again. Therefore price fluctuations affect the production of rubber under agroforestry system whereas; Smallholders under monoculture system maintain their tapping and rubber maintenance schedule for future benefits.

(5) While more intensive monoculture rubber offers better rubber productivity (yield and profitability), it also requires much higher capital and input that is beyond reach for smallholders under rubber agroforestry especially during the establishment stage.

(6) Finally, although rubber agroforestry system has the capacity to provide smallholder farmers with diversified income and a range of non timber forest

products than monoculture for economic benefits; monoculture stands out to be a better option.

Policy Implications

(1) Given the relatively low yields of rubber from smallholder farmers under agroforestry system and the disincentive effect of the overvalued exchange rate, a special credit scheme is necessary for farmers if rubber production is to be more efficient and attractive under smallholder agroforestry system.
(2) The increasing profitability and efficiency of rubber with higher price relative to other crops may have a negative effect on food production and vice versa under smallholder rubber agroforestry system. If the profit gap is deemed unacceptable by the government, it should be off-set by increasing the official price of both food crops relative to that of rubber in order to maintain the production of other crops under agroforestry system.
(3) If smallholder rubber agroforestry system is to be efficient compared to its counterpart, better policies and high yielding varieties have to be put in place.
(4) Although Price fluctuations are normal for any commodity, rubber is a volatile commodity. Major rubber producing provinces in Indonesia like Jambi need sophisticated financial instruments e.g. providing price fluctuation insurance to farmers. This requires complicated rural banking arrangements and well-organized markets which Indonesia government must put in place.

Areas for Future Research

This study has led some useful findings and conclusions about improving economic efficiency and distortions affecting smallholder rubber farmers. However, there are critical areas that need further research and these are;

(1) Switch from one crop to another exists (i.e. from rubber to other crops like Palm oil);
(2) Credit intended for agricultural production activities, is diverted to non rubber farming activities for other activities like weddings other than rubber production resulting into a decline in crop yields and loss of income, causing households to default loan repayment

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