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Extended Cost Benefit Analysis and Ecological Capital Value of Rubber (*Hevea brasiliensis*)

D.N. Naranpanawa, A.K.B. Naranpanawa[1], I.N. Samarappuli[1] and C. Bogahawatte[2]

Postgraduate Institute of Agriculture
University of Peradeniya
Peradeniya

ABSTRACT. *This study examines the economic viability of rubber under the context of environment protection and sustainable development. In the analysis, valuation of non market variables, i.e., non market benefits and non market costs, were carried out in order to estimate the extended costs and benefits and the ecological capital of rubber. Net Present Value (NPV) and Benefit Cost Ratio (B/C Ratio) have been used as the yardstick to measure the environmental economic viability of rubber. The discounted cash flow analysis was carried out for 33 year life span of rubber using 5%, 15% and 30% discount rates. Evaluation was also done for two scenarios i.e., the production of Ribbed Smoked Sheet (RSS) and the production of Crepe.*

The results reveal the economic as well as the environmental feasibility of this crop, which generated NPV of Rs. 278,200/- per hectare and B/C ratio of 2.9 per hectare at 15% discount rate for crepe rubber production. Latex prices and cost of cultivation of rubber were subjected to sensitivity analysis to ascertain the economic and the environmental viability of the crop under different conditions. The conclusion arrived at in this study is that, this plantation crop may be used for industrial purposes as well as for environmental conservation.

INTRODUCTION

The population explosion and economic development pressure create greater demand for natural resources causing a certain level of damage to the

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1 Agricultural Economics Unit, Rubber Research Institute, Dartonfield, Agalawatte.

2 Department of Agricultural Economics, Faculty of Agriculture, University of Peradeniya, Peradeniya.

environment. Therefore, economic development with minimum damage to the environment is of vital importance. A positive link between development and environmental protection is evident (Steer, 1992) and hence to incorporate environmental factors into national income accounting (known as "greening" the national accounts) become relatively important for developing countries.

As an initial step in the process of incorporating environmental values into national income accounting, the estimation of total ecological value and conducting of extended cost benefit analysis for a industrial tree crop such as Rubber (*Hevea brasiliensis*) is of extreme importance in the environmental management programs in Sri Lanka. In recent years, nations all over the world have become increasingly troubled by the buildup in the atmosphere of "green house" trace gases. Out of these gases fifty percent of the contribution to green house effect is from CO_2. In general, cost effective technologies exist to remove most gases excluding CO_2 (Goreau, 1990), as most CO_2 removal methods require too much of energy and are unaffordable. Hence, a viable alternative is to take advantage of photosynthesis in plants which collect and store C in the plant tissue.

Various studies have revealed the contribution of rubber to the natural environment in terms of biomass production, which justifies the hypothesis that the level of carbon dioxide, oxygen and water vapour recycled in rubber plantations are approximately equal to those recycled in rain forest ecosystems (Joseph, 1991; Sivanandyan and Norhayati Moris, 1992; Wan Abdul Rahamar., 1994).

Rubber plays a vital role in the Sri Lankan economy in terms of earning foreign exchange. The export earnings from rubber as a commodity for the year 1994 was Rs. 3582 million (Central Bank of Sri Lanka, 1995) and the export earnings from manufactured rubber goods for the same year was Rs. 4213 million (Rubber Development Department, 1994). Its contribution to the GNP was Rs. 688 million for the year 1994 at constant 1982 factor cost prices (Central Bank of Sri Lanka, 1995). It has been cultivated in the mid and low country areas representing 9% of the total cultivated area in the country. However, there is a vast potential in expanding this crop into intermediate zone, mid and low country marginal tea lands and in mid country high elevated areas where the land area is abundant. Since rubber plays a major role as an industrial crop in the Sri Lankan economy, it is extremely important to evaluate the environmental economic feasibility of this perennial tree crop. However, no such study has been conducted with respect to rubber plantations in Sri Lanka. Hence, studying its contributions to the country's welfare in terms of

economic development as well as environmental protection is of paramount importance.

The main objective of the study is to determine the total ecological capital of rubber (market and non market benefits of rubber) and to estimate Net Present Value and Cost-Benefit ratio by conducting an extended cost benefit analysis.

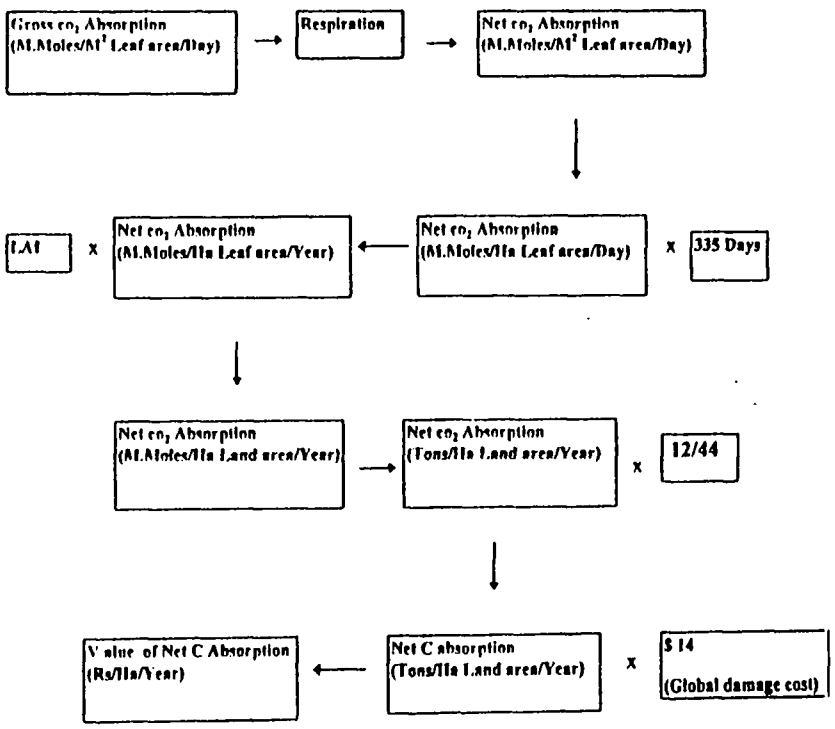
MATERIALS AND METHODS

Estimation of total ecological capital of rubber

Total ecological capital of rubber was estimated for the total extent under rubber in Sri Lanka for the year 1994. The analysis was carried out for the RRIC 100 rubber clone as it is popular among rubber cultivators.

Valuation of non market benefits consisted of estimation of benefit of C sequestration by rubber plantations. In valuing the C sequestration by rubber plantations, only the net CO_2 sequestration by the photosynthetic apparatus of the plant was taken into account. In addition, a rubber plantation would emit CO_2 in the process of decomposition of loss biomass as well as in burning of fuel wood. However, these emissions were not taken into account due to lack of adequate data. Hence, the C sequestration model has been developed giving due attention to the photosynthetic rate and the respiration rate as other forms of CO_2 emissions have been comparatively low in volume. Therefore, the C sequestration can be considered as a non market benefit. The global damage cost of C, *i.e.* $14/ton of C was used in the analysis. The C sequestration was estimated and valued according to the flow chart given in Figure 1.

Valuation of market benefits consisted of i) Latex production using the direct method of valuation of quantity and prices for 1994 (Central Bank of Sri Lanka, 1995). The details are given in Table 1. ii) Timber production: The amount of timber produced by the rubber plantation was calculated according to the data obtained from RRI and it was valued according to the flow chart given in Figure 2 and iii) Fuel wood production: The amount of fuel wood produced by the rubber plantation was estimated according to the data obtained from RRI and it was valued according to the flow chart given in Figure 3.



1. Gross co_2 absorption of mature plant of RRIC 100 clone = 390 mmoles/m^2 leaf area/day.
   Gross co_2 absorption of immature plant of RRIC 100 clone = 342 mmoles/m^2 leaf area/day.
   The percentage of co_2 released during respiration = 20.8
   LAI (Leaf Area Index) of mature plant of RRIC 100 = 3.31
   LAI of immature plant varies from 1st year to 5th year as 0.662, 1.324, 1.986, 2.648, 3.31 respectively.
   (Nugawela, 1989)
2. Wintering period is approximately 30 days.
3. 18% of the total extent under rubber is immature plantations and 3% of the extent is annually replanted (Samarappuli, 1995)
4. Molecular weight of co_2 = 44

Figure 1. Valuation of C sequestration in rubber plantation (1 ha).

Table 1. The market value of latex for the year 1994.

Type	Production million kg	Exports million kg	Export value Rs million*	Consumption million kg	Value of Consumption Rs million**	Total Value Rs million
RSS	44.2	33.7	1697.1	10.5	506.7	2203.8
Crepe	34.6	26.1	1428.8	8.5	436.6	1865.4
Other	26.2	9.4	456.3	16.8	809.7	1266.0
Total	105.0	69.1	3582.2	35.8	1753.1	5335.3

Source: Central Bank (1994)
Rubber Development Dept. (1994)

* F.O.B. prices were used.
** Auction prices were used.

Extended cost benefit analysis

In this analysis several measurements of project worthiness such as net present value (NPV), and cost benefit ratio (C/B) have been used for the determination of return on investment when environmental values were incorporated. The analysis was done using market values as this has been a financial analysis. The study was conducted using three different discount rates. As environmental valuations are usually carried out at lower discount rates, 5% discount rate has been considered. Since this is a financial analysis 30% discount rate was also taken to represent the opportunity cost of capital under inflationary situations. However, a 15% discount rate was also used to strike a balance between the two varying discount rates. The analysis was carried out for a 33 year life span per hectare of rubber with 1994 prices for the market commodities. In order to determine the flexibility of results of the analysis a sensitivity analysis was done by increasing total cost by 20% while decreasing total benefits by 20%.

The market benefits consisted of the following:

a) Latex value: An assumption was made of an annual average yield of 1153 kg/ha and 1 ha of rubber was considered in the analysis. In rubber, tapping starts only in the 7th year after planting. Therefore, the latex value was obtained from the 7th year to the 33rd year by multiplying the quantity by market price and,

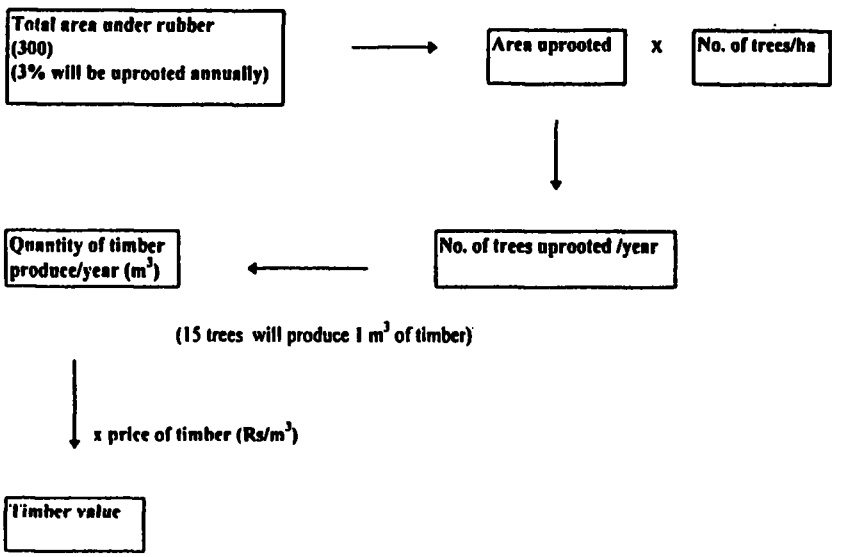


Figure 2. Valuation of timber.

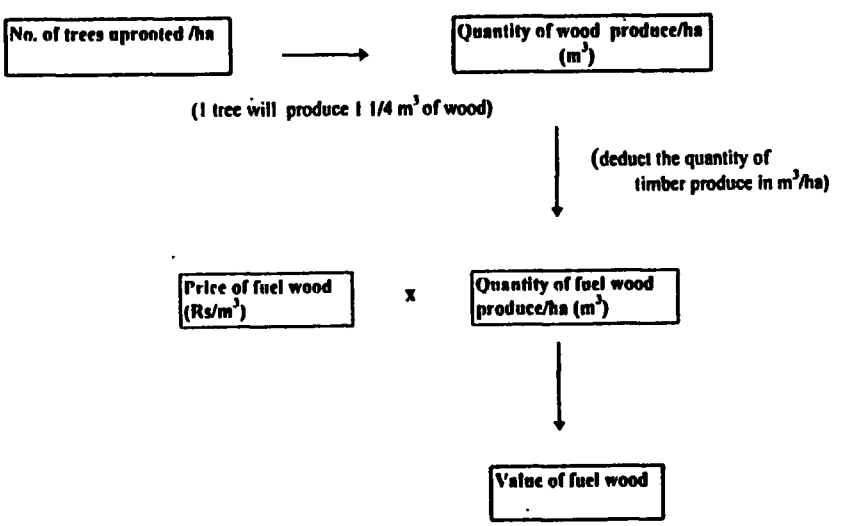


Figure 3. Valuation of fuel wood.

b) Timber value and fuel wood value: Calculated as the previous valuation for 1 ha of area under rubber. In this study, an assumption was made as, at the beginning of the project, uprooting was carried out. Hence, the benefits and costs of timber and fuel wood were obtained at the first year.

The non market benefits included in the analysis consisted of, C sequestration: calculated as the previous valuation (valuation of ecological capital).

The non market costs included a) the cost of nutrient loss through soil erosion and, b) the cost of effluent produced during rubber manufacturing. Under rubber cultivation, nutrient loss occurs, only in the first three years after planting, during the period at which the ground cover or the mulch is partially established. A well-managed rubber land with good ground cover is capable of reducing the rate of runoff to well below the acceptable value of 5 tons/ha/year even at very high slopes (Yogaratnam, 1985). Hence, in this study, nutrient loss was estimated for the 1st three years of life cycle, using the replacement cost method. This is an indirect method, to value the potential expenditure on conventional markets. Here, the cost that would have incurred in order to replace a damaged asset was estimated. This involves estimating the value of fertilizer needed to replace the nutrient loss through soil erosion. This method is only relevant if the fertilizer would actually be applied (Munasinghe, 1993). In this estimation, labour cost and transport cost of fertilizer were not taken into account, as they were highly variable.

Effluents, which are environmentally hazardous are produced during primary rubber production *i.e.*, production of ribbed smoked sheet (RSS), crepe and technically specified rubber (TSR). However, in Sri Lanka, production of RSS is done mainly on a small scale. Hence, effluent discharged during RSS production is negligible (Warnakula, 1996). Therefore, effluent resulting from crepe rubber and TSR production is the major environmental problem associated with the natural rubber manufacturing in Sri Lanka. This study concentrates only on effluents produced during crepe rubber production. Therefore for the purpose of simplification the whole analysis has been categorized in to two scenarios *viz.* i). scenario 1 - production of RSS - effluent production is negligible and ii). scenario 2 - production of crepe rubber - effluent problem is taken into account.

Since environmental damages from discharging effluents to water ways are difficult to assess, an indirect valuation technique, actual digressive or preventive expenditure method (Munasinghe, 1993) was used to value the damage cost of effluent. In this method, ex-post costs of mitigating damage caused by environmental impacts provide a minimum estimate of original costs.

In this study, the total cost of effluent treatment was used as the indirect value of environmental damage. Data for the above analysis were obtained from a crepe rubber manufacturing factory and from the RRI.

In estimating market costs, the cost of production including cost of manufacture was considered. Capital as well as recurrent costs were used for a hectare of rubber for a period of 33 years. The relevant data were gathered from a previous study (Yogaratnam *et al.*, 1995).

RESULTS AND DISCUSSION

Estimation of total ecological capital of rubber

The total ecological capital of rubber for the year 1994 would be the sum of total market value of latex, total market value of timber, total market value of fuel wood and the total non market value of C sequestration for the total extent under rubber, *i.e.*, Rs million 10684.2. However, out of this total value, 44.4% is coming from the non market value (environmental benefit) which is due to C sequestration. This may seem to be a little over estimation as CO_2 emission due to decomposition of biomass and burning of fuel wood was not included in the estimation. Among the market benefits, the major contribution comes from the latex, that is 49.9% of the total ecological capital, and the balance is composed of timber and fuel wood that contribute 0.81% and 4.82% respectively. However, the timber and fuel wood factors have an indirect environmental value in terms of preventing deforestation, which was not estimated due to non-availability of data. Therefore, the over estimation of non market benefits would be cancelled off. Hence, the above value can be considered as a realistic estimate of non market benefit of rubber. Although in national income accounting environmental benefits of rubber is not incorporated, this value of total ecological capital emphasize the importance of incorporation of environmental benefits in GNP calculations. The details are given in Table 2.

Extended cost benefit analysis

Under scenario 2, at the end of the 33 year project cycle, NPV of Rs. 2,78,200 and a benefit cost ratio of 2.9 were estimated under extended cost benefit analysis conducted at 15% discount rate. However, at 5% and 30% discount rates NPV of Rs. 9,10,485 and NPV of Rs. 1,00,507 were generated

Table 2. **Components of ecological capital of rubber in the year 1994.**

Component	Value (Rs million)
Total rubber production	5335.3
Total timber production	87.1
Total fuel wood production	515.8
C sequestration	4746.0
Total ecological value	10684.2

Table 3. **The results of extended cost benefit analysis for sheet rubber production. (scenario 1).**

	Cost			Benefit				(Rs/ha/yr)	
Year	Cost of nutrient loss	Cost of production	Total cost	Benefit of C sequestration	Benefit from rubber	Benefit from fuel wood	Benefit from latex	Total benefits	Net cash flow
1	237	88378	88615	5825	18000	106500	-	130325	41710
2	237	5694	5931	11647	-	-	-	11647	5716
3	237	4638	4875	17464	-	-	-	17464	12589
4	-	5818	5818	23299	-	-	-	23299	17481
5	-	6289	6289	29134	-	-	-	29134	22845
6	-	5626	5626	29134	-	-	-	29134	23508
7	-	34233	34233	30475	-	-	58053	88528	54295
8	-	34233	34233	30475	-	-	58053	88528	54295
33	-	34233	34233	30475	-	-	58053	88528	54295

NPV at 15% discount rate = 278221.31
B/C ratio = 2.941

Under sensitivity analysis (20% increase in cost and 20% decrease in benefit)

NPV at 15% discount rate = 117511.4
B/C ratio = 1.961

Table 4. The results of extended cost benefit analysis for crepe rubber production. (scenario 2)

	Cost				Benefit					(Rs/ha/yr)
Year	Cost of nutrient loss	Cost of production	Effluent cost	Totasl cost	Benefit from timber	Benefit from fuel wood	Benefit from latex	Benefit of C. Sequestration	Total benefits	Net cash flow
1	237	91837	-	92074	18000	106500	-	5825	130325	38251
2	237	9153	-	9390	-	-	-	11647	11647	2257
3	237	8097	-	8334	-	-	-	17464	17464	9130
4	-	9277	-	9277	-	-	-	23299	23299	14022
5	-	9748	-	9748	-	-	-	29134	29134	19386
6	-	9085	-	9085	-	-	-	29134	29134	20049
7	-	37692	7559	45251	-	-	84157	30475	114632	69381
8	-	37692	1022	38714	-	-	84157	30475	114632	75918
19	-	37692	1022	38714	-	-	84157	30475	114632	75918
20	-	37692	7559	45251	-	-	84157	30475	114632	69381
21	-	37692	1022	38714	-	-	84157	30475	114632	75918
33	-	37692	1022	38714	-	-	84157	30475	114632	75918

NPV at 15% discount rate = 233278.799
B/C ratio = 2.5846

Under sensitivity analysis (20% increase in cost and 20% decrease in benefit)

NPV at 15% discount rate = 110610.4
B/C ratio = 1.723

respectively. This implies that even under higher discount rate the investment on this plantation would be worthwhile.

Under the scenario 1, at the end of the 33 year project cycle, net present value (NPV) of Rs. 2,33,278 and benefit cost ratio of 2.5 were estimated under extended cost benefit analysis conducted at 15% discount rate. However, at 5% and 30% discount rates NPV of Rs. 6,98,880 and NPV of Rs. 95,804 were generated respectively. This also indicates that even under higher discount rate the investment on this plantation would be beneficial.

However, without incorporating environmental factors into the analysis (Conventional project analysis), the study generated a NPV of Rs.

132,923 and a benefit cost ratio of 2.2 at 15% discount rate under crepe rubber production. At 30% discount rate it generated a NPV of Rs. 40,329. Therefore, these results suggest that the rubber plantations generate a significant amount of non market benefits in addition to its market benefits. Hence this would further justify the environmental economic feasibility of rubber plantations. However, in this analysis we do not compare the economic feasibility of crepe rubber production over RSS production as it would need more information on market shares and other factors to come to a conclusion.

A sensitivity analysis was performed by projecting 20% increase in cost of production while decreasing total benefits by 20%. This analysis generated a positive NPV and a benefit - cost ratio under both scenarios.

The above analysis suggests the viability of this perennial crop as an environment friendly industrial tree crop. The details are given in Tables 3 and 4.

POLICY IMPLICATIONS

This study can be considered as an initial step in order to carry out an extensive study on the valuation of ecological capital of rubber in the future which would assist in incorporating environmental values of rubber plantations into the GNP calculations. The results obtained in this study, *i.e.*, NPV of Rs. 278,200 and B/C ratio of 2.9 under extended C/B analysis and NPV of Rs. 132,923 and B/C ratio of 2.2 under conventional C/B analysis at 15% discount rate in crepe rubber production, suggest the feasibility of this crop in environmental management. Thus, it is worthwhile to test this industrial crop with other forestry crops in reforestation programs in the mid country region where it is now being grown as a plantation crop. Furthermore, this study can be used as a basis in the determination of economic life span of rubber giving due attention to non market benefits and costs.

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