PLANTING RUBBER IN DRIER CLIMATES IN SRI LANKA : ITS IMPLICATION IN CLIMATE CHANGE AND ECONOMICS

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ABSTRACT

To meet the increasing demand for natural rubber, its cultivation in Sri Lanka is in expansion from traditional wet areas to drier climates. It is expected to cultivate 40,000 ha, 10,000 ha and 5,000 ha of rubber in Uva, Eastern and Northern provinces, respectively. Lands targeted have virtually no forest cover; hence despite the potential vulnerability and adaptation, this attempt will undoubtedly contribute to mitigate the climate change through fixing atmospheric CO_2. *Further, this will improve the peasant livelihood providing a steady income; however the Government of Sri Lanka (GoSL) should bear an additional cost to facilitate the expansion process. Therefore, the present study was aimed to assess the impact of this exercise in terms of the amount of* CO_2 *fixed, environmental improvements and the financial implications at the levels of farmer and GoSL. A project period of 30 years was considered with a provisional plan to plant rubber in different regions. Having the capability of fixing 293 MT of* CO_2 *per hectare in rubber trees within 30 year lifespan, this exercise will eventually fix over 15 million MT of atmospheric* CO_2. *Despite the high level of decomposition, the ultimate amount of organic matter added to soil is ca. 1 MT per hectare. Even with own labour, farmers need to bear a cost of ca. Rs. 80,000 per hectare in the first and Rs. 10,000 in subsequent years. However, this is cushioned by the subsidy programme provided by GoSL during the immature phase of rubber, i.e. Rs. 150,000/ha and also, any income received from intercropping. Ultimate on-farm financial viability in terms of Net Present Value (NPV), Internal Rate of Return (IRR) and Benefits Costs Ratio (BCR) is Rs. 1.1 Mn/ha, 24.4% and 1.8 with hired labour and, Rs. 2.4 Mn/ha, 69.9% and 14.8 with own labour, respectively. In terms of direct financial transactions, NPV at GoSL level bears a negative value of Rs. 11.5 billion and so, only the indirect and bequest values (e.g. livelihood improvement/poverty alleviation and benefits to environment) defend the worthiness of this exercise. Justifying the need of carbon trading, incorporation of carbon value reduces the financial burden on GoSL by limiting the loss to Rs. 6 billion.*

INTRODUCTION

Rubber has traditionally been grown for latex providing a unique raw material for the commodities required for the modern day life. It helps the man in every aspect such as deciding the birth, protection, travel and also joy in the life. With steady demand, the area under rubber is increasing in most countries. Being a tree crop, its role in protecting the environment is commendable. At the end of economic life cycle, rubber tree is taken for both timber and fire wood lessening the threat on natural forests. Daily worker requirement per hectare of rubber is ca. 0.6 (Rodrigo, 2012) and so, having grown in 11.8 Mn ha (Anon, 2013), rubber would have been the principal livelihood strategy of over 7 million poor people in the world. Further, it employs a large amount of people in management, processing, product manufacture and in trading. It is considered to be over 500,000 people engaged in rubber industry in Sri Lanka.

With given prominence for climate change, the importance of rubber cultivation beyond the latex production has often been emphasized. On average, a hectare of rubber sequesters 81 MT of atmospheric CO_2 annually (Munasinghe, *et al.*, 2011) and the ultimate the amount of CO_2 fixed at the end of 30 year economic lifespan is ca. 300 MT (Munasinghe, *et al.*, 2008). Allometric relationships have been developed to assess the carbon content in the rubber tree with simple growth indicators such as tree diameter and total height (Munasinghe, *et al.,* 2008). According to the Kyoto protocol adopted in 1997, developed (Annexed 1) countries had an obligation to cut down the emission of their GHGs by 5.2% from the values in 1990 by 2012. With no closer to this target, the second commitment period of Kyoto protocol would extend up to 2020. Among the systems in operation, the Clean Development Mechanism (CDM) of the protocol allows developing countries to participate in new economic ventures on reducing CO_2 emission for carbon trading and planting tree crops like rubber appears to a plausible option. Based on Durban platform, developed countries could develop own mechanisms beyond CDM to meet their commitments (*e.g.* Joint crediting mechanism/ bilateral offset credit mechanism of Japan). Further, voluntary markets (VM) exists for carbon trading where some companies purchase carbon credits voluntarily as a corporate responsibility and use it for advertising their products.

With the liberalized economy, rubber based industries are booming in Sri Lanka targeting both local and export markets. In addition, there is a huge international demand for raw rubber. The production requirement in the country by 2016 has been estimated to be 200,000 MT by the Ministry of Planation Industries (MPI). Lands in the traditional rubber growing areas, *i.e.* in the wet zone, is virtually insufficient to meet this demand. Therefore, rubber cultivation is in the process of expansion to the drier non-traditional areas of the country. Districts likes *Monaragala, Hambantota* and Badulla were the initial targets. It has not been sufficient; hence there is a gradual shift to other regions. With high land per capita, the present focus has been given to Uva, Eastern and Northern provinces in rubber expansion process. Majority of the people in these regions are farmers who are either below or hovering on the poverty line. Hence, livelihood improvement of the peasant community has become the top most objective of MPI in the expansion process of rubber.

Increase in atmospheric CO_2 would have a positive effect on plant growth due to its effect on photosynthesis (Norman, 1981). In direr climates, high levels of atmospheric CO_2 may result in increased water use efficiency through the partial closure of stomata (Xiahong Feng, 1999) and this may be an advantage for the expansion process of rubber. However, it may not be the case with associated temperature increase and its subsequent effects. Less soil organic matter with increased decomposition rates and any negative effect on soil water would affect the growth and yield. On-going analyses have indicated a productivity drop of 10% in rubber lands in India (particularly in traditional growing areas) with the expected climate change (The Director, Rubber Research Institute of India-personal communications). However, technologies developed to plant rubber in drier climates may considerably cushion the vulnerability of rubber to climate change.

Despite the vulnerability and potential adaptation, planting rubber in drier areas will undoubtedly contribute to mitigate the climate change. Lands targeted have virtually no forest cover and are subjected to either being cultivated with seasonal crops or abandoned after shifting cultivation. Any CO_2 fixed in the biomass of seasonal crops is going back to the atmosphere quickly as lands are cleared after the harvests for next planting season. Even the lands which are not utilized for farming may undergo fire set for hunting. Due to the direct socio-economic benefits, rubber plants are looked after by farmers; hence, net fixation of atmospheric CO_2 is guaranteed proving the additionality criterion of carbon trading.

On the above background, this study was aimed to assess the effect of planting rubber in drier areas of Sri Lanka on climate change mitigation through the fixation of atmospheric CO_2. Whist reviewing possible adaptations of rubber cultivation associated with the technologies developed, socio-economic benefits and the cost involved at farmer and the government levels was also evaluated.

METHODOLOGY

In the impact assessment of planting rubber in drier regions of Sri Lanka, the priority provinces, *i.e.* Uva, Eastern and Northern were taken into consideration. The extent proposed to plant rubber in these provinces was 40,000 ha, 10,000 ha and 5,000 ha, respectively. With provisional plan to achieve the targets in 3-5 consecutive years by planting rubber initially in 20,000 ha and then in 4,000 ha per year in Uva, 3,000 ha, 3,000 ha and 4,000 ha in Eastern and 500 ha, 1,000 ha, 1,500 ha and 2,000 ha in Northern provinces respectively a 30 year project period was considered in all analyses.

Predictions on the growth and establishment of rubber in the above regions were based on the functions developed by Munasinghe *et al.,* (2013) for plant girth and total height development in the Intermediate zone and time cause changes in tree density (*i.e.* number of trees per hectare). In order to estimate the carbon content in tree biomass at each time point, the allometric relationship developed by Munasinghe *et al.,* (2013) was employed. With the knowledge on the extent planted in each year, tree density and carbon content of the rubber tree at each stage, time cause change in the overall carbonstock in each region was established.

Potential adaptation of rubber to climate change was reviewed by comparing the expected impacts on plant growth and yield (*i.e.* vulnerabilities) in the regional climate against the technology developed to cultivate rubber in drier areas.

A concept of 'one hectare one family' is adopted in expanding rubber to drier areas. Therefore, an extent of one hectare was taken in assessing the benefits and costs at smallholder farmer level. Benefits will be the steady income received from the sale of raw rubber (latex) and the rubber tree at the end of the economic life cycle whilst the costs comprised the labour involvement and any material costs involved. Monitory values taken for different items are given in Table 1.

Table 1. Monitory values used in financial analyses

Cost item	Monetary value (Rs./unit)
Labour day	687.50
Fencing post	350.00
Barbed wire (25kg)	3500.00
Rubber plant	60.00
Fertilizer/kg - R/SA7:9:9:3	26.00
Benefit item	
Latex/kg	400.00
Tree	2500.00

In general, GoSL provides a subsidy payment of Rs. 150,000/= per hectare to farmers in eight instalments within first six years of plant growth. In addition, a fertilizer subsidy scheme is in operation (*i.e.* about 50% of the market price) and then, GoSL meets the cost involved in research and other development (R&D) activities pertaining to the rubber cultivation in these regions. Direct income to the GoSL would be the Cess collected from the exports of additional rubber produced (Rs. 4/ kg of rubber export). In addition, GoSL could receive carbon credits, should such project be implemented. Benefit cost analysis was performed at the government level based on the information collected on the above. Investment on R&D was difficult to be estimated; however, this task is mainly under the activities of Rubber Research Institute of Sri Lanka (RRISL) and Rubber Development Department (RDD). Therefore, as a reasonable assumption, such costs incurred by these two organizations in 2012 were taken as the annual cost on R&D in the analyses (Rs. 58 Mn).

In order to assess carbon benefits, CO_2 fixation for next 30 years was quantified using the growth models and allometric relationships available (Munasinghe, *et al.,* 2013) and then, its monitory value was estimated at the rate of US$ 10 per 1MT CO_2 (a reasonable rate in carbon market). However in the estimation of the net carbon benefits, over head costs in building up and monitoring a rubber based carbon project were deducted.

As per project period, financial analyses were performed for a 30 year period. Existing market values for commodities were taken for the analyses and to avoid the time cause effect, discounting was adopted (at 10%) to derive the present values of all benefit and cost components. Indices such as Net Present Value (NPV), Benefit Cost Ratio (BCR) and Internal Rate of Return (IRR) were taken to assess the worthiness of the programme at both farmer and GoSL levels. In order to drive a sensible measure to the farming community, average income expected from a hectare of rubber at its maturity (i.e. the extent promoted for a smallholder) was compared with existing income levels.

In addition to CO_2 fixation, organic matter addition to the soil through the leaf fall of rubber plants would mitigate secondary effects of climate change such as temperature associated soil organic matter depletion. Therefore, organic matter addition to soil was estimated from the biomass in annual leaf fall and the fraction remained long-term after decomposition, *i.e.* ca. 2% (Ayanaba and Jenkinson, 1990).

RESULTS AND DISCUSSION

Being in drier climate, crop management practices recommended for rubber cultivation in *Monaragala, Ampara* and *Vavuniya* districts have mainly been focused for improved soil-plant-water relationships. Basically, they work on four directions, *i.e.* quick establishment, facilitate plants to obtain soil water in deep horizons, improved retention of rain water and conserve the soil water with the reduction of evapo-transpiration (Table 2). For instance, use of only well grown plants in deep soils with large size planting holes allows roots to approach deep soil water as quickly as possible. Mulching and the drainage system conserve the soil water. Further, recommendations prevent the potential hazards from high radiation loads, winds and high rainfall (Table 2). General trends in temperature increase (*i.e.* 2°C over the next 100 years) will not be substantial enough to affect the rubber trees in next 30 years; however, climate change may result in extreme weather events such as extended droughts and floods; and the recommendations on planting protocol would at least minimise or ease the damage on the crop. More importantly, increased forest cover by rubber in these regions definitely relieves the harshness of the climate providing comfort for human lives and also for animals.

Carbon stock variation from the 9th year of plant growth in a hectare of land is shown in Fig. 1. The rate of CO_2 fixation declines due to the decrease in tree density and also to some extent by the declining growth rate of mature tree. On average, 12.2 MT of CO_2 per hectare is fixed annually. This includes 3.5 MT of CO_2 fixed in leaf biomass. Ultimate amount of CO_2 fixed in one hectare of land within 30 year lifespan is 293 MT.

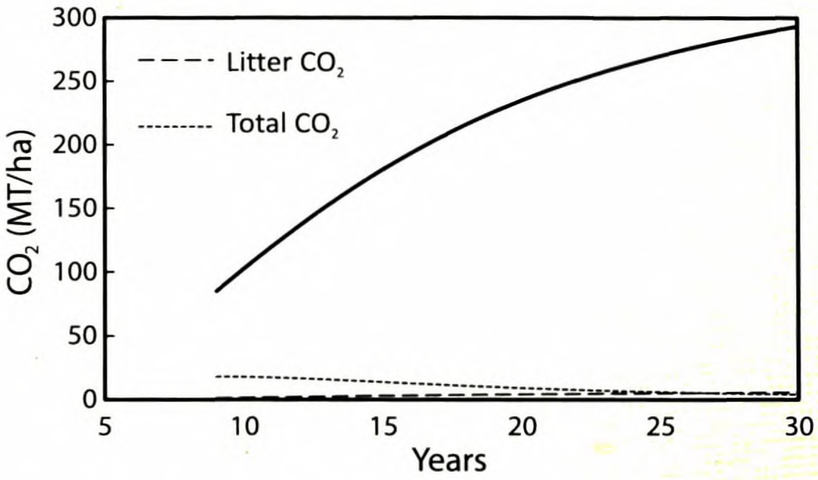

Fig. 1. CO_2 stock variation in rubber lands

Having 40,000 ha rubber to be planted in *Monaragala* district would fix the greatest amount of CO_2 (11.5 million MT) followed by the Eastern and Northern provinces (2.9 and 1.4 million MT, respectively) (Fig. 2). In total, it is expected to fix over 15 million MT CO_2 in rubber trees in all three provinces. CO_2 fixed in leaf biomass is eventually added to the soil with annual leaf fall enriching soil organic matter content. Although 39 MT of organic matter are added in this way to a hectare of land within the 30 year lifespan, decomposition limits the ultimate amount remaining in the soil. According to Ayanaba and Jenkinson (1990), only about 2% remains in tropical climate and so, soil organic matter enrichment by rubber leaf fall would be ca. 0.8 MT per hectare. Soil organic matter in the top soil (0 -15 cm) is generally assessed for soil fertility. Assuming that added organic matter remains within this limit, rubber leaf fall would ultimately increase the soil organic matter content by ca. 0.05%.

Table 2. Crop management practices to be adopted in planting rubber in drier regions in Sri Lanka and their subsequent effects

Crop management practice	Subsequent effect/s on plant growth and adaptability to withstand climate change
Site selection	
Only deep soils (over 1.5 metres)	Assure proper anchorage and access to water; Avoid water logging in the events of high rainfall
Availability of ground water during dry spells	Maintain plant water status even in events of droughts; Avoid less soil moisture conditions
Ability to apply water during the dry spells during first 3-4 years	Facilitate faster early growth and proper establishment; Ability to withstand extreme weather conditions
Land preparation	
Avenue planting to facilitate intercropping (2.5m x 7.75m)	Sustain the livelihood with crop diversity hence reduced vulnerability to social impacts of climate change Less soil erosion
Larger size of the planting hole for hard soils (1m x 1m x 1m)	Facilitate faster early growth and proper establishment; Ability to withstand extreme weather conditions
Addition of organic manure, if possible - ca. 5kg/planting hole	Assure plant growth; Reduced vulnerability for soil organic matter degradation
Drainage system *cum* rainy season rainwater harvesting (lock and spill lateral drains)	Reduced less soil moisture conditions
General crop management	
Planting at the beginning of *Maha* season	Facilitate faster early growth and proper establishment; Ability to withstand extreme weather conditions
Use only two whorl polybagged plants	Facilitate faster early growth and proper establishment; Ability to withstand extreme weather conditions
Fully removal of the bag at planting	Assure proper anchorage and facilitate faster early growth; Ability to withstand extreme weather conditions
Deep enough planting to keep the bud grafted union below the ground but soil should not touch greenish area of the stem	Reduce heat stress and better anchorage; Ability to withstand extreme weather conditions
No stagnating water at plant base during rainy season	Adopt to high rainfall events
Intercropping with traditional crops	Sustain the livelihood with crop diversity Less soil erosion
Planting *Gliricidia* for shade - 1.5 m high four sticks 1 m away from the plant	Reduce heat stress Minimise the possibility of reduced soil nitrogen
Thick mulch leaving about 10 cm from the plant (not to touch the plant)	Conserve soil moisture and nutrients Maintain soil organic matter Reduce heat stress
Application of lime on brownish area of the stem in immature rubber trees during droughts	Reduce heat stress Maintain plant water status
Fertilizer - three doses per year with Sulphate of Ammonia based mixture 7:9:9:3 (N:P:K:Mg).	Maintain soil nutrient level

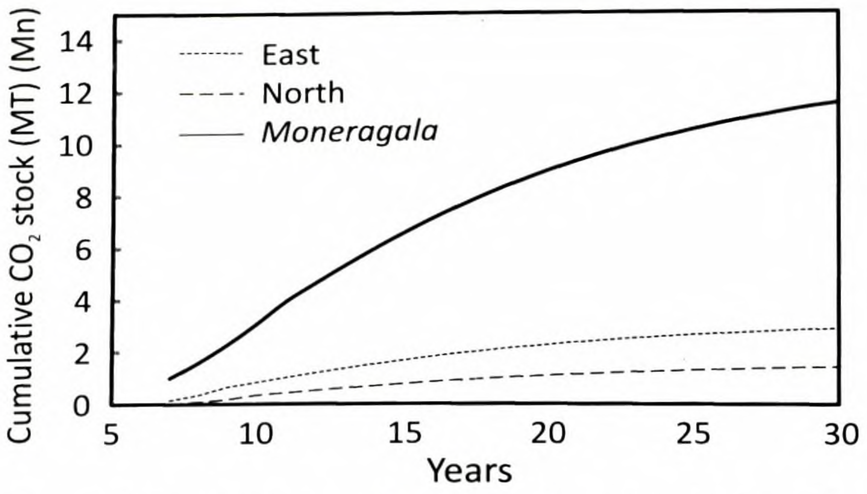

Fig. 2. Time cause variation in the cumulative CO_2 stock in different regions

Rubber is always promoted to be grown with other crops (Table 2) to sustain the rural livelihood and also to promote the growth of rubber plants by ameliorating the crop microclimate (Rodrigo *et al.*, 2001). It is also advised to add crop debris as a mulching material around rubber plants. If not interested in economically important other crops, cover crops are allowed to grow as soil conservation (Yogaratnam *et al.*, 1984). All the biomass produced by other crops in the system goes to the soil and therefore, ultimate soil organic matter enrichment will be higher than the value given before. According to Samarappuli and Yogaratnam (1997), 6 MT of organic matter is added to a hectare of land by leguminous cover crops. Temperature increase associated with climate change would increase the decomposition rate (Kirschbaum, 1995) resulting in reduced level of organic matter in the soil. Although the same principle will apply to the decomposition of biomass given by rubber cultivation, the ultimate level of soil organic matter in the soil of rubber lands should increase from the present level since the addition rate would be higher than the decomposition.

Annual cash flow at the farmer level is negative up to seventh year if workers are hired for farming (Fig. 3). In the case of using family labour, cash flow is negative only in the first year as the farmer has to bear the material cost particularly for fencing. Though no latex harvested from rubber trees during the initial six years, the annual cash flow is positive in subsequent years because of the subsidy payments received. The highest latex yield was recorded in 14th year and so the highest positive (Rs.381,500) value until the trees are sold in the last year providing Rs. 712,500 per hectare. On average, Rs. 11 Mn could be received from selling latex during the mature phase and the cost involved is virtually nothing if family labour is used for latex harvesting. In the case of hired labour, ca. Rs. 4.8 Mn have to be spent reducing the level of profitability. The majority of people in Uva, Eastern and Northern provinces are generally farmers (as per the information in relevant district secretariats); hence own labour is used for farming activities of rubber. Therefore, the former scenario is more likely to happen and it indicates the level of livelihood improvement providing high value for farmers' own time/labour (Fig. 3).

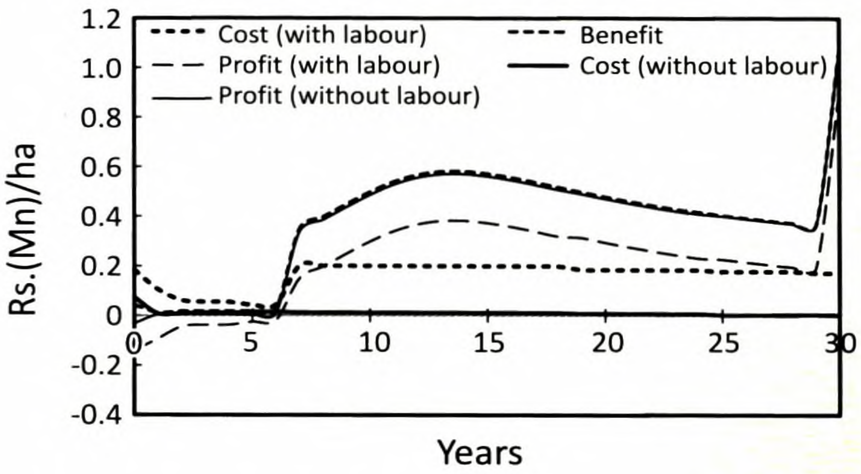

Fig. 3. Annual cash flow of rubber cultivation at farmer level

High level of overall profitability and the return for investment with own labour is well proven with Rs. 2.4 Mn NPV per hectare and 14.8 BCR, respectively (Table 3). Even with hired labour, NPV is above one million rupees with 1.8 BCR confirming high profitability and extraordinary value given to farmers' labour inputs. Because of very high IRR in either scenario, any expenditure on material inputs and or labour could be met even with borrowings at high interest rates.

At GoSL level, a huge cost has to be met for direct subsidy payments to farmers totalling Rs. 6 Bn, 1.5 Bn and 0.75 Bn for *Moneragala, Ampara* and *Vavuniya* districts, respectively. Also, overhead costs on field inspection and subsidy management in the Rubber Development Department are to be incurred. At present, Rs. 52 Mn are spent annually for such costs which include the maintenance of the regional office at *Monaragala* in *Uva* province. This component will increase further (though not counted in the present study) with more rubber in the Eastern and Northern regions

Table 3. Summary of benefit cost analyses at farmer level.

Parameter	With hired labour	With family labour
Net Present Value (at 10% discount rate)	Rs.1.1 Mn/ha	Rs.2.4 Mn/ha
Benefit Cost Ratio (at 10% discount rate)	1.8	14.8
Internal Rate of Return	24.4%	69.9%

as new structures for administrative works and nurseries are to appear. In addition, GoSL spends ca. Rs. 6 Mn per annum through the RRISL for research and other development work for these regions. Because of these costs, annual cash flow at GoSL has been negative even up to the last stage of the project period (*i.e.* up to 27th year) (Fig. 4). If benefits from carbon credits are included the annual cash flow becomes positive at 9th year. This doesn't mean that GoSL will gain a profit from rubber cultivation (Fig. 4).

According to the discounted (10%) financial analyses, NPV at GOSL level carries a negative value of Rs. 11.5 billion at business as usual scenario (*i.e.* with no carbon credits). Return for the investment as shown by BCR is only 0.1. Even with the benefits from carbon credits, NPV is negative; however, the ultimate loss is limited to Rs. 6 billion. The return for the investment is just half as shown by BCR of 0.5. Therefore, livelihood improvement of the peasant community and overall development of these under privileged regions, increased forest cover and other environmental benefits are main pay backs to the GoSL. To cover the cost to some extent, the need of carbon credits can be justified. Obviously, rubber cultivation in these regions fulfils the criterion of additionality in carbon fixation as lands used for rubber cultivation in these regions have been cleared well before 1990 and at present, either covered with shrubs or cultivated with seasonal crops.

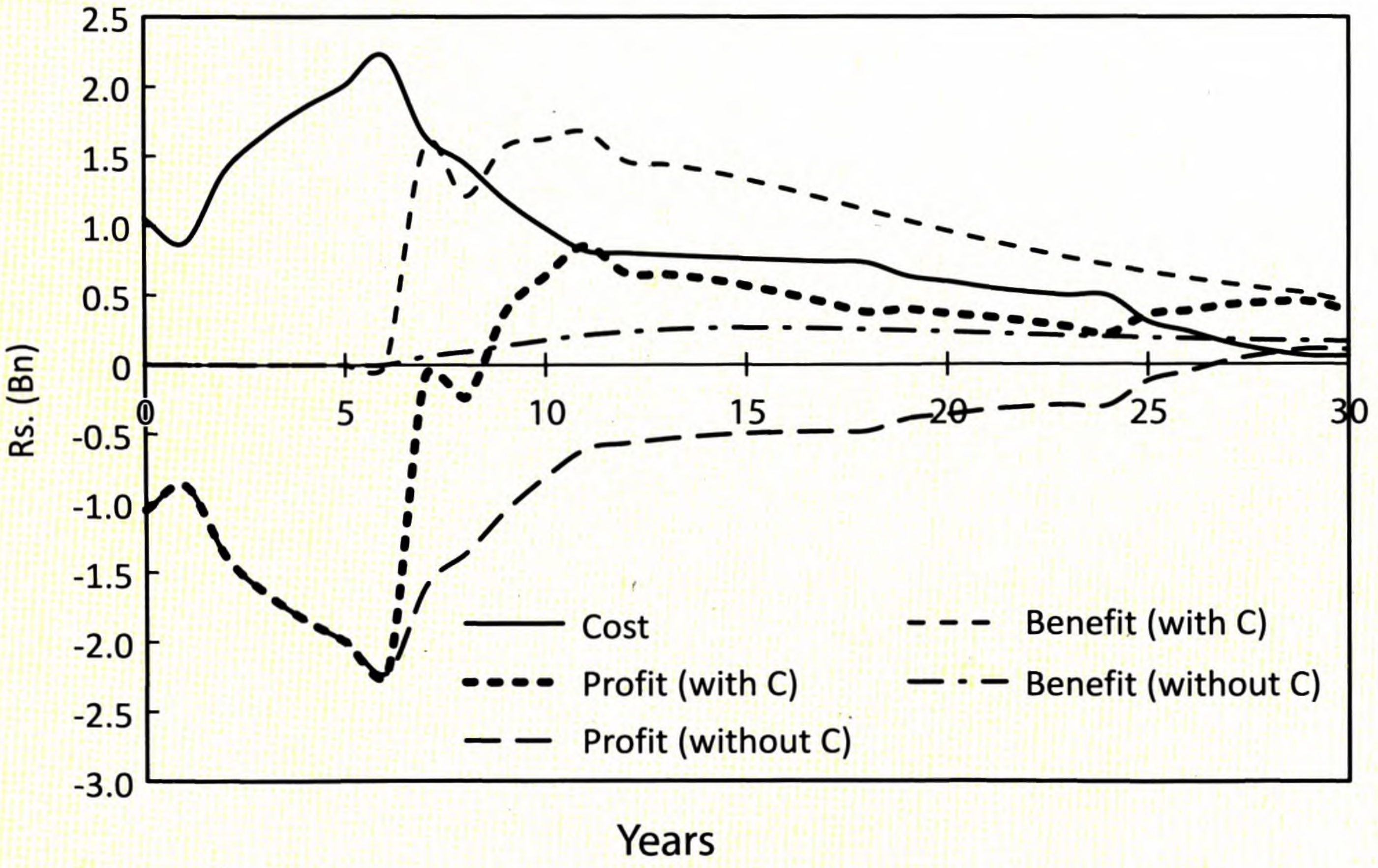

Fig. 4. Annual cash flow at government level for rubber cultivation in drier areas in Sri Lanka

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