

Some issues related to sustainability in the smallholder rubber sector: a case study of three major rubber growing districts

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Abstract

This study was done in the smallholder rubber sector in Sri Lanka to identify socio-economic, technological and environmental issues and their relationships on the sustainability of the smallholder rubber sector. The study was confined to the 3 major rubber growing districts of Sri Lanka, namely; Kegalle, Kalutara and Ratnapura districts. The methodologies involved in this study were Participatory Rural Appraisal (PRA) and questionnaire surveys. Substandard growth in immature lands, low productivity in mature lands, low quality in produced rubber, low societal involvement and improper marketing were identified as major issues at local and regional level while depletion of the rubber extent was of national concern. Appropriate institutional responses to combat adverse impacts of these issues are also discussed to improve the well being of rubber smallholders and the country as a whole.

Key words: Participatory Rural Appraisal, rubber, smallholder

Introduction

Rubber (*Hevea brasiliensis*) is the second most important plantation crop in Sri Lanka, in terms of export earnings and employment generation. In 2006, export earnings from the rubber industry were 56427 million Sri Lankan Rupees (US\$ million 513) from rubber-based products (83%) and as an agricultural commodity (17%) (Central Bank, 2006). The total land area under rubber is 115,992 ha which accounts for about 8% of the total cultivated extent (Ministry of Plantation Industries, 2005). Rubber lands are classified into large

estates, medium estates and smallholder units based on the extent of land. Large estates have more than 20 ha and rubber lands between four and 20 ha are termed as medium estates. The smallholder units have extents less than four ha. Together with medium estates, the smallholder units occupy nearly 63% of the total extent and distributed among nearly 200000 small-scale farmers. The smallholder sector provides a share of about 33% to the national rubber production. However, the productivity of this sector is below the levels of the estate sector and far behind the other

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countries like India and Thailand where the yields are averaging around 1540 and 1362 kg ha⁻¹ year⁻¹, respectively (Viswanathan & Rajasekharan, 2001).

The comparative low yields in smallholdings under Sri Lankan conditions are mainly due to poor adoption of recommended agronomic practices owing to low and unstable income levels and unsatisfactory extension services rendered to smallholder farmers. The low Natural Rubber (NR) prices that prevailed for a lengthy period posed severe constraints on the viability and sustainability of the rubber cultivation as well as on the adoption of cultural operations by smallholders.

The smallholder rubber sector comprises of different stakeholders who are involved in the marketing process of the smallholders' produce to the international market. Smallholders have direct links with the smoke house owners, village dealers and town dealers. They also have direct links with rubber societies, raw latex collectors and scrap millers. However, the links with other stakeholders such as; brokers, latex crepe factories and products manufacturers are non-existing and need to be strengthened through societal arrangements.

Recently, the Government of Sri Lanka has made several attempts to improve the smallholder rubber sector in various ways through government institutions. This is by forming societies mainly to cater to the smallholders in marketing, improving technical know-how, providing necessary materials for processing at concessionary rates and

improving the smoke house conditions. Further, the subsidy for smallholder farmers has been increased by a substantial amount. With all these initiatives and interventions, there is still an uncertainty in the rubber industry among rubber farmers. This leaves a question about the sustainability of the smallholder rubber sector and therefore it is a basic necessity to find out the issues related to the sustainability of this ecosystem and to study the interactions of the environmental, societal and technological factors associated with the identified issues.

The project Interactions between the Environment, Society and Technology (INTEREST) in the smallholder rubber sector of Sri Lanka aimed to achieve the specific objectives; viz. understanding and analyzing local farmer and community ecosystem practices, linking this local knowledge to available scientific knowledge to analyse and describe changes in the pressures between environmental policy, social challenges and technological innovation using a range of dissemination tools, delivering this new and improved knowledge to all levels of society thus strengthening the social and environmental knowledge base. This will provide a greater understanding of environmental challenges at all social levels and lead to improved ecosystem management strategies to maintain production without compromising the resource base. Findings and activities of the INTEREST project would certainly help to understand properly the issues related and the community's dependence

on the ecosystem and perceptions of the farmers on the technology and associated traditional knowledge. This paper presents the information gathered during the study through participatory approaches, rapid sample surveys and case studies focusing on specific objectives of the INTEREST project.

Methodology

Description of the study area

Rubber is found in 14 administrative districts of Sri Lanka.

Each district has several divisions according to the Rubber Development Department, and each division is called a Rubber Development Officer (RDO) range. The highest extent of rubber lands is found in the Kegalle district, followed by the districts Kalutara and Ratnapura. The number of smallholders in the district also follows the same sequence. The study focused on these three districts. For the study, three villages representing 3 RDO regions for each district were selected (Figure 1).

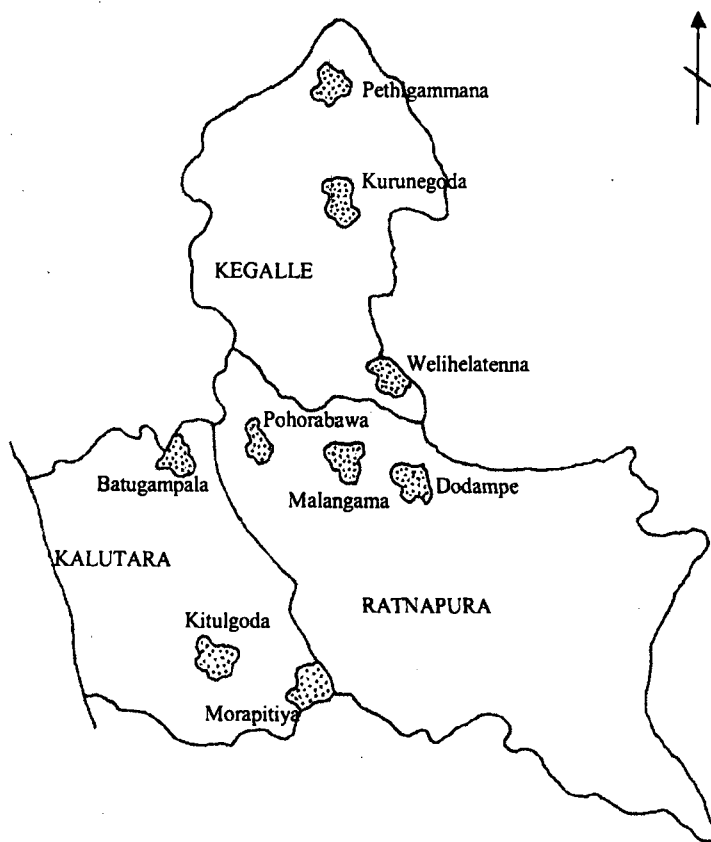


Fig.1. The study area

All nine villages belong to the wet zone of Sri Lanka. The rainfall experience in the study area is bimodal with rainfall peaks coinciding with April-May and October-November period. The average rainfall values in the study areas range from 2000 to 3000 mm (Wijesuriya *et al.*, 2002). The temperature conditions observed in the study areas range from a minimum of 20°C to a maximum of 39°C (Wijesuriya, 2002). Sri Lanka, being a small island and also due to its position in the Indian Ocean, exhibits uniform temperatures throughout the year in the rubber growing areas. The values of sunshine hours range from 4.1 to 7.8 hr day⁻¹ within a year in the selected rubber growing districts (Council for Agricultural Research Policy, 1992).

Soils in the Kegalle district belong to the Great Soil Group of Reddish Brown Latasols while Red Yellow Podzolic soils are predominant in Kalutara and Ratnapura districts. These soils have moderately good physical properties with moderate infiltration rates and water holding capacities. Red Yellow Podzolic soils found in the Kalutara and Ratnapura regions are strongly acid in reaction. A wide variety of tree crops can be grown in these soils (Samarappuli *et al.*, 1998).

Rapid sample survey

A rapid sample survey was done in nine selected villages covering 653 smallholder farmers. The main objective was to identify the sources of variation of the smallholder sector to be utilized effectively in deriving an appropriate

sampling plan for the detailed household survey. This was done during the initial stages of the study, *i.e.* during February and March 2002.

Participatory Rural Appraisal (PRA)

Participatory studies were designed to identify the ecosystem behaviour addressing; socio-economic, environmental and technological aspects. Out of the nine villages involved in the Rapid Sample Survey, three villages were selected for PRA, representing one for each district. The selected villages from Kegalle, Kalutara and Ratnapura districts were Welihelatenna, Batugampola and Pohorabawa, respectively (Fig. 1). Different PRA tools; focus group interviews, voting, ranking methods and mobility mapping were employed to study different aspects of the ecosystem. These studies were done during September 2002 to February 2005.

Detailed household survey

The information gathered during the rapid sample survey was employed in deriving the sampling plan for the household survey. The total sample size was restricted to 300. The detailed sampling plan is given in Table 1. Two separate sets of questionnaires were prepared for immature and mature holdings to collect household details and information on immature and mature rubber holdings. Household surveys were done in the first (2002) and second (2003) years of the project.

Table 1. *The sampling schedule for the detailed sample survey*

District	Village	No. of holdings		Total
		Mature	Immature	
Kegalle	Welihelatenna	42	11	53
	Kurunegoda	25	11	36
	Pethigammana	25	11	36
				125
Kalutara	Batugampola	16	20	36
	Kitulgoda	13	20	33
	Morapitiya	10	21	31
				100
Ratnapura	Pohorabawa	12	23	35
	Dodampe	9	16	25
	Malangama	5	10	15
				75

Analysis of data

The information gathered from the participatory studies was used to develop conceptual frameworks. The methods involved in data analysis are mainly exploratory in nature.

Results and Discussion***Socio-economic characteristics of rubber smallholders******Demographic characteristics and educational status***

The household size of the sample studied ranged from one to nine with an average household size of five. The age distribution of the smallholders was very similar in the samples of the three districts studied. The majority (49%) of the smallholders were found in the range 40 to 60 years. The

proportion under 40 years was 17% mainly due to the younger generation's preference for other occupations than growing rubber due to socio-economic reasons.

The educational levels of the smallholders were categorized into (1) Primary (Grades 1 to 5), (2) Grades 6-10, (3) Ordinary Level (OL) qualified, (4) Advanced Level (AL) qualified and (5) Diploma/Graduate level. The majority of the farmers belonged to categories (2) and (3); 57%, 52% and 62% respectively, in Kegalle, Kalutara and Ratnapura districts. The percentage with primary education in Kegalle, Kalutara and Ratnapura districts were 23%, 38% and 18%, respectively. There weren't any farmers who did not attend schools in the sample.

Issues related to sustainability in rubber smallholdings

Dependency on rubber

Most of the rubber growers do not solely depend on rubber as their main income source. Those who solely depend on rubber are 5%, 15% and 15% in Kegalle, Kalutara and Ratnapura districts, respectively. Smallholder rubber farmers grow certain other plantation crops, export crops and cereals as other sources of income. They are mainly tea, coconut, cinnamon and paddy as presented in Table 2.

Seventy five percent of the sample is employed while 14% and 11%, respectively are retired and unemployed. Among those who are employed, the majority have stated their occupation as farming (21%). Businessmen (merchants and contractors) and tappers followed next, with percentages of 14, and 12, respectively. Eleven percent of the sample is involved in government jobs. There were several drivers, carpenters, masons and estate workers. Several smallholders in the Ratnapura district are involved in gem mining as well.

Income status

The income distribution of smallholders in these three districts ranged from Rs.2000 to Rs.20000. The average income was Rs.6500, but nearly

50% of the sample had incomes between the range Rs.4000 to Rs.7000. The income sources of rubber smallholders are mainly through; employment, rubber cultivation, cultivation of other crops, and government subsidies.

The villagers used a number of indicators to explain the wealth and well being of different social groups. Some of the common criteria identified in wealth ranking studies by the smallholders to define the wealth status are as follows.

1. Land ownership
2. Ownership of vehicles
3. Type of employment
4. Condition of the house
5. Household appliances held
6. Availability of telecommunication facilities
7. Ownership of private businesses
8. Government subsidies received

Distribution of land

The distribution of unit land sizes of smallholdings is presented in Fig. 2. The three districts followed the same pattern in distribution. The majority of the smallholdings were found in the range of 0.5 to 1 acre, with 45%, 53% and 40%, for Kegalle, Kalutara and Ratnapura districts, respectively.

Table 2. *Percentage of farmers who own other crops in different districts*

Crop	% rubber smallholders growing tea/coconut/cinnamon/paddy in each district		
	Kegalle	Kalutara	Ratnapura
Tea	30	42	41
Coconut	22	13	7
Cinnamon	0	9	2
Paddy	39	24	35

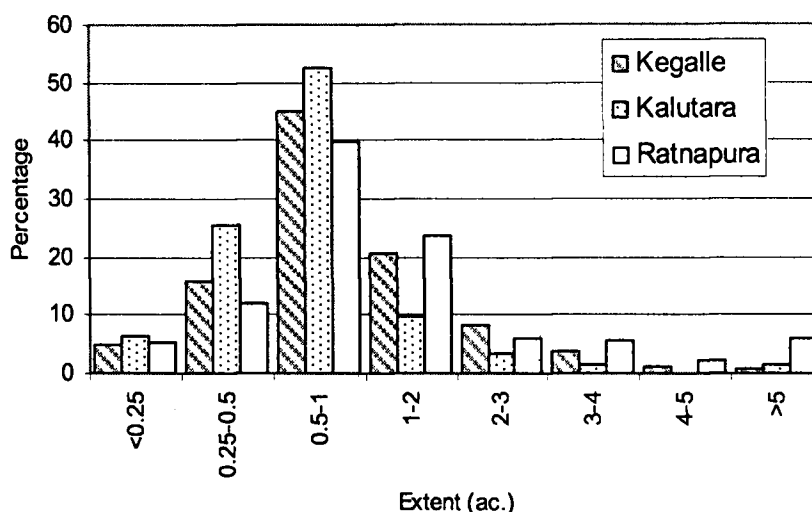


Fig. 2. Distribution of land units among smallholder farmers

Land ownership and operation

Sole ownership was predominant in the three districts with 92%, 66% and 93% and the percentage under joint ownership was 8%, 2% and 7% in Kegalle, Kalutara and Ratnapura districts, respectively. There is a substantial portion (16%) under Land Development Ordinance (LDO) in the Kalutara district. Most of these holdings are registered in the Rubber Development Department (RDD), but nearly 8% of the holdings in Kegalle and Kalutara districts were not registered in RDD.

The percentage under self-farming operation was highest in the Kalutara district (88%), followed by Kegalle (82%) and Ratnapura (72%) districts. Caretakers look after the holdings in 17%, 10% and 4% in Ratnapura, Kegalle and Kalutara

districts, respectively, while joint operation was highest in Ratnapura district (11%) followed by Kegalle (8%) and Kalutara (4%) districts.

Pattern of labour use

The activities that involve labour in rubber cultivation are; field establishment (fencing, lining, holing and planting), maintenance of the holding (weeding and cover crop establishment), fertilizer application and tapping. The type of labour may be either family, hired or both. Some deviations were observed in the pattern of labour use in the three districts (Table 3). Family labour involvement is highest for fertilizer application while it was lowest for tapping in all the districts. Family labour involvement is more for all activities in the Kalutara district when

compared to the other 2 districts. This may be due to several reasons. One may be that 15% of the farmers in the sample solely depend on rubber for their income. Another reason is that the percentage under primary education is highest in Kalutara district, compared to the other 2 districts. Further, it was noted that the percentage fields managed by caretakers was lowest in the Kalutara district.

Societal involvements

Percentage participation in the smallholders' rubber societies in the three districts was 40% in Kegalle and 53% in Ratnapura areas. The participation in the Kalutara district was low, and societies were found only in 2 villages selected for the study. The participation was 20% when only these two villages were considered. In the sample studied, only 14% of female smallholders were members of the rubber society, while it was 43% in the case of male smallholders. Further, the participation was more with the farmers who own large extents of land. The regional level representatives of the smallholders' societies further confirmed this during discussions with them.

Marketing of smallholders' produce

Data generated from the socio-economic survey and PRA were used to develop the smallholder market channel laid out in Fig. 3. The output of the small rubber farmers is of 3 main types; viz. Ribbed Smoked Sheets (RSS), Unsmoked Sheets (USS) and latex. In addition, farmers sell the scrap collected. Though rubber is sold as latex as well, it is predominantly sold as sheet rubber (as RSS or USS).

It is evident that in all three major rubber growing districts, production of sheet rubber is 93% of the total output of small farmers. The majority of the farmers sell their produce as RSS (78%) while 15% of the farmers sell as USS. Only 7% of the sample sells latex. The reason for this low percentage is not that it is not profitable, but the lack of latex collectors in every district, though recently some private companies have started latex collection in some areas. Another reason is that sheet rubber can be stored for sometime with the producers if they wish to do so. Therefore, the major pathway the smallholder production reaches the ultimate buyer is the marketing channel for sheet rubber.

Table 3. *Labour use for different operations in different districts*

Operation	% under different types of labour use in each district								
	Kegalle			Kalutara			Ratnapura		
	Family	Hired	Both	Family	Hired	Both	Family	Hired	Both
Field establishment	38	46	16	81	15	4	59	37	4
Maintenance	45	39	16	83	15	2	60	34	6
Fertilizing	52	40	8	86	13	1	64	34	2
Tapping	38	35	7	60	35	5	52	45	3

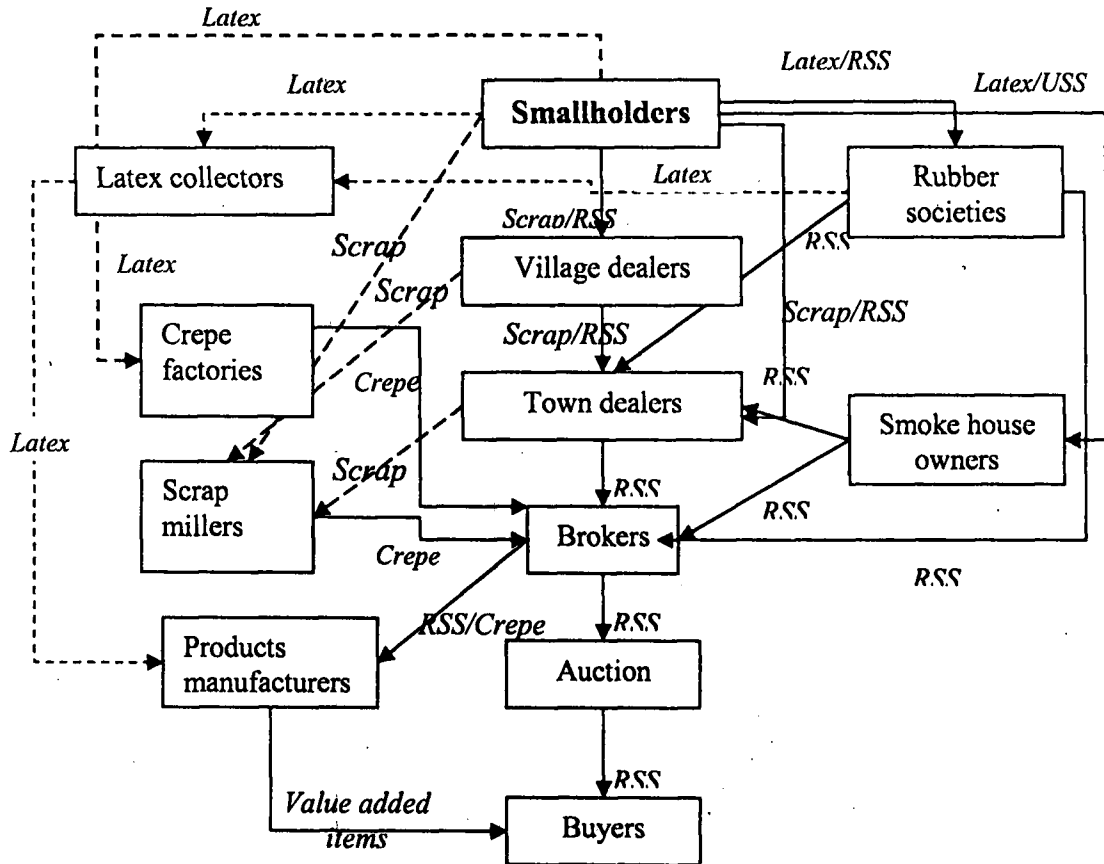


Fig. 3. Market channels for smallholder rubber

Adoption of technologies in the smallholder rubber sector

Type of clone

In immature holdings, new improved clones occupied 82%, 71%, and 91% in the samples of Kegalle, Kalutara and Ratnapura districts (Table 4). The proportion occupied by PB 86 in immature holdings was fairly high in Kalutara district. Among the new improved clones, RRIC 100 was still the most popular clone among the smallholders.

Nearly 60% of the mature holdings were still under PB 86. This clone was very popular in Kegalle district in mature plantations. Kegalle district had 20% of its holdings planted with RRIC 100, which was a low figure compared to other 3 districts. In Kalutara and Ratnapura districts, the farmers have shown some interest on RRIC 100. Further, several farmers had RRIC 121 in their mature holdings (Table 5).

Issues related to sustainability in rubber smallholdings

Table 4. *Clone composition in immature holdings of different districts*

Clone	% immature holdings in different districts		
	Kegalle	Kalutara	Ratnapura
RRIC 100 ^A	80	54	78
RRIC 102 ^A	2	2	5
RRIC 121 ^A	-	15	8
PB 86	16	25	8
Seedlings	-	2	-
Mixed	-	2	1
Not known	2	-	-
% genetically improved clones	82	71	91

^A improved clones

Table 5. *Clone composition in mature holdings of different districts*

Clone	% mature holdings in different districts		
	Kegalle	Kalutara	Ratnapura
RRIC 100 ^A	20	41	42
RRIC 102 ^A	<1	1	1
RRIC 121 ^A	-	3	4
RRIC 101 ^A	<1	-	-
PB 86	77	52	49
Seedlings	<1	1	3
Mixed	<1	2	1
% genetically improved clones	22	45	47

^A New improved clones

These findings indicate that the majority of the farmers who planted their holdings recently (immature holdings) had new improved clones. Yet, several farmers still grow PB 86, which is low yielding and succumbs to most of the rubber diseases.

Type of planting material

There are two types of planting

material available for planting. They are (a) bare root budded stumps and (b) poly bagged plants. Bare root budded stumps are less costly but poly bagged plants are easy to establish in the field. Smallholders have three options; they are to purchase them from the Rubber Development Department (RDD) or from a commercial nursery or prepare them by themselves.

In the three districts surveyed, majority of the farmers used budded stumps (69% in Kegalle, 84% in Kalutara and 88% in Ratnapura). The main source of purchase in Kegalle and Ratnapura districts was from commercial nurseries, while in Kalutara district it was the RDD.

Fertilizer application

The recent policy of the Government is to supply the required fertilizer quantity to all the immature fields registered in the RDD under the subsidy scheme. The recommended fertilizer quantity is distributed to all rubber smallholders under the rubber replanting subsidy scheme implemented by the government up to six years of planting.

The farmers employed several different application methods, although the recommendation is "forking a few points (three or four) and mixing the fertilizer with soil". The farmers use mamoty or crow-bar as per their convenience. However, 6% of the sample was found to broadcast the fertilizers, which is not advisable in the case of urea as a Nitrogen source. The correct recommendation was practiced by 73% of the farmers while 6% applied

fertilizer around the tree in a circle and 1% in a half circle.

Only 48% of the sample applied magnesium fertilizer separately. The majority was unaware of the importance of applying Dolomite separately with NPK. This malpractice results in loss of nutrients of the applied NPK fertilizer.

In mature fields fertilization helps to increase the yield and encourage the regeneration of the used bark. In general, the adoption of the fertilizer application is low during the mature stage when compared to the immature stage. Nearly 20% of the sample believed fertilizer application is very important, while nearly 25% thinks it is not important. Hence, approximately, half the sample stated fertilizer application is important.

Kegalle district recorded the lowest adoption rate (18%) while Kalutara and Ratnapura districts had 49% and 44%, respectively (Table 6). However, only a very few farmers have applied the recommended dose regularly. These low adoption rates may be due to several reasons. The most important reason for low adoption rates according to the farmers was the low rubber prices.

Table 6. *Adoption of recommended fertilizer applications in mature holdings*

Practices	% reported		
	Kegalle	Kalutara	Ratnapura
Fertilizer to mature rubber at any stage	18	49	44
Irregular/Not the recommended dose	12	34	36
Irregular/Recommended dose	2	2	0
Regular/Not the recommended dose	2	8	4
Regular/Recommended dose	2	5	4

Cover crop management

Cover crops were not established in 11% of the farms due to many reasons. The reasons mentioned by the farmers were lack of awareness of benefits and lack of funds. Although it is generally recommended to establish the cover crops before planting, only 15% practiced it. Among those who establish their cover crop after planting, 35% was able to establish them during the 1st month after planting. Thirty eight percent of the sample took more than three months after planting. Drought conditions, lack of awareness and lack of planting material were the reasons for the late establishment.

The overall adoption rate for cover crop management was only 24% (good-10% and moderate-14%). In 21% of the fields there was no cover underneath rubber, and in 55% of the fields the cover crop was in 'bad' condition.

Weed control

Except for two farmers, all others practiced weed control before fertilizer application in the immature stage. Manual methods were employed by 81%, 4% used chemicals and the remaining 15% used both methods. The method of weeding was mainly circular with 65% of the farmers, while 35% practiced strip weeding.

During the mature stage, the farmers normally practice weeding, yet a few of them do not weed their holdings. The proportion, which does not practice weeding, was less than 5% in all districts. In Ratnapura and Kalutara districts, the

majority of the farmers weed once in several months. In Kegalle, the majority of the farmers weed only once a year.

Disease control methods

In immature holdings, only nine farmers reported *Oidium* disease while 29 farmers reported about white root disease. Only four farmers have taken preventive measures against white root disease.

The proportion of farmers who experienced diseases in their mature holdings was; 30%, 49% and 36% in Kegalle, Kalutara and Ratnapura districts. Among the majority were incidences of root diseases caused by improper land clearing before planting; 78% in Kegalle district, 68% in Kalutara district and 60% in Ratnapura district. Incidence of stem diseases in Ratnapura district was 33%, compared to 20% in both Kegalle and Kalutara districts. Further, there were a few incidences of tapping panel diseases experienced by the farmers in their mature holdings. However, control measures were taken up only in a few holdings, 20% in Kegalle district, 10% in Kalutara district and 7% in Ratnapura district.

Intercropping

Intercropping is a practice recommended by the Rubber Research Institute to increase the productivity of rubber lands. The adoption rate is low due to various reasons. The major reasons were the problem of protecting the crop from thieves and lack of interest. There were some minor reasons such as, the distance from the residence, non-suitability of the land and low investment ability. The adoption rate in immature

holdings was 20 % while it was 9 % in mature holdings. Banana was the most popular crop in immature plantations while cinnamon and tea were popular in mature holdings.

Stand per unit land area

This is an important indicator affecting the productivity of the smallholder sector. The correct stand per unit land recommended by the Rubber Research Institute is 500 trees per ha. However, it was found that the ratio; observed stand to the required stand vary from 0.28 to 1.67 in the selected villages (Table 7).

The situation of stand per ha. was comparatively satisfactory in Kegalle and Ratnapura districts compared to the Kalutara district. However, ratios above 1.2 are also not acceptable, since there may be competition for soil nutrients unless properly managed.

Recommended practices related to tapping

Proper maintenance of the holding during the immature stage is a

major factor, which determines the attainment of tappable girth (50cm at 120 cm height in 60% of the trees) early. However, very little proportion of holdings has reached the tappable girth at the age of five. In the Ratnapura district majority of the holdings had commenced tapping at the age of six or seven, which is also acceptable in the smallholder sector. In the Kalutara district it was only 50% and in Kegalle it was 44%. Eighteen percent of the holdings in the Kegalle district had reached the tappable girth after 10 years of age. The situation in the Ratnapura district is quite satisfactory (Table 8). Early commencement reduces the immature period of rubber where farmers do not get any income from rubber and ensures early returns from investment. Therefore, farmers should be educated on the importance of proper upkeep to bring the holding into tapping as early as possible. Majority of the farmers stated that they could not commence tapping due to poor girth in the holdings. Several have stated that 'tapping is not profitable' or 'could not find a tapper'.

Table 7. Percentage of holdings under each category of the ratio: observed stand to the required stand

Ratio : (observed stand/ Required stand)	% holdings under each district		
	Kegalle	Kalutara	Ratnapura
≤0.30	1	2	0
0.31 to 0.50	5	5	5
0.51 to 0.80	21	45	20
0.81 to 1.00	61	41	73
>1.00	12	7	2
Minimum	0.28	0.30	0.45
Maximum	1.67	1.10	1.06

Table 8. *Percentages of holdings reached the tappable girth at different ages in different districts*

Age at commencement of tapping	% of holdings under each district		
	Kegalle	Kalutara	Ratnapura
4-5	6	0	0
6-7	44	50	74
8-9	32	48	24
10-11	12	2	2
12-13	6	0	0

Mainly due to the interference of rains, majority of smallholders (73%) of the sample practiced daily tapping instead of the alternate day tapping. The correct angle of tapping cut, which promotes maximum latex removal, is 30° from the horizontal plane. RRI recommends that this angle should be marked with a stencil plate at the correct height, which guides the tapper on the angle as well as the thickness of the shaving. As indicated in Table 9, use of a stencil plate in marking the tapping panel is very rarely practiced in the Kegalle district. As a result, only 37% of the holdings have the correct angle of the tapping cut. In Kalutara and Ratnapura districts a stencil plate is used for marking nearly in two thirds of the holdings. This resulted in a fairly high proportion of the holdings with the correct tapping angle.

The correct height of the tapping panel is 120 cm from the base of the tree. In Kegalle district, the holdings with the correct height were very low compared to the other two districts. According to the results, it

was found that even if a stencil plate is used for marking the tapping panel, it was not held at the correct height while marking. The correct direction is practiced in the majority of the holdings in Kalutara and Ratnapura districts. However, in Kegalle district correct direction is practiced in 53% of the holdings. Correct length of tapping cut ensures a higher yield. A satisfactory adoption rate was observed in 93% of the holdings in Kalutara districts. The adoption rate in Ratnapura district is also acceptable (Table 9). However, in Kegalle district the correct length of tapping cut was observed only in 23% of the holdings. It is evident that proper advice was not given to the sample of farmers in Kegalle district at the commencement of tapping. This may resulted poor adoption rates in Kegalle district when compared to other 2 districts. The time of commencement of tapping varies from 05.30 to 08.00 hours in all three districts, which is the recommended time of commencement for best latex extraction.

Table 9. *Adoption of recommendations related to tapping*

Practices	% adoption of correct practices		
	Kegalle	Kalutara	Ratnapura
Marking of the tapping panel			
using the stencil	17	61	67
Angle of tapping	37	72	64
Height of tapping	3	49	60
Direction of the tapping cut	53	93	80
Length of tapping cut	23	92	76

Recommended practices during processing

The main steps of producing RSS involve latex straining, coagulation, milling and drying. The PRA carried out on adoption of different activities related to rubber processing highlighted that the adoption rate was satisfactory for latex straining; with adoption rates of 100, 96 and 84 percents respectively, in villages, Welihelatenna, Batugampola and Pohorabawa. However, the adoption rate of the correct method of rolling/rinsing with water was very poor in Welihelatenna (21%). The adoption rates observed for Batugampola and Pohorabawa were 52% and 41%, which were also not satisfactory. This is mainly due to poor awareness on making a quality sheet as evident from PRA studies. A satisfactory adoption rate was observed in Welihelatenna for the correct weight of the sheet (85%), while it was moderate in Batugampola (64%) and Pohorabawa (70%).

Major issues of concern in relation to sustainability

The main issues, which have an

impact on the sustainability of the eco-system, are;

- i) substandard growth in immature rubber lands,
- ii) low productivity in mature lands,
- iii) low quality in produced rubber,
- iv) low involvement in societies,
- v) improper marketing system, and
- vi) depletion of the smallholder rubber extent.

Substandard growth in immature rubber lands

Substandard growth in rubber holdings is due to several pressures. The quality of planting material plays an important role in subsequent growth. The present situation is that the farmers receive their planting material from the RDD and due to recent increased demand generally no selection is being done before releasing the planting material. Further, according to the present policy, only the new improved clones are released to the smallholders. The performances of these high yielding clones are associated with other improved management practices recommended by the Rubber Research Institute (RRI). Therefore, negligence

becomes a pressure for poor growth conditions. Poor growth is also a result when rubber is grown in unsuitable lands, and this condition is further provoked in the absence of proper cultural practices.

Substandard growth increases the immature period of rubber where the farmers do not get any income from their fields. Therefore, approaches to increase adoption such as; subsidies and awareness programs on soil moisture conservation would be ideal. Quality control in nurseries would be the answer to poor quality planting material.

Low productivity in mature lands

There is a great scope of increasing the productivity in the smallholder sector, since some of the farmers are already receiving a reasonable income through rubber farming. This study reported an average yield of 1050 kg ha⁻¹year⁻¹, but the values ranged from 214 to 1927 kg ha⁻¹ year⁻¹ (Wijesuriya *et al.*, 2005).

The pressures upon low productivity are mainly related to tapping. Labour migration and social problems are responsible for the non-availability of skilled tappers, as rubber tapping is not considered as a reputable occupation in Sri Lanka. Among the natural causes, rain interference is the main factor that affects the productivity of rubber. Land suitability also affects productivity when the farmers do not properly manage unsuitable lands. Low productivity creates low-income levels at local level and affects the health and

well being of the society as well. Hence, the institutional responses should be to improve awareness on correct agronomic and tapping related activities to improve adoption, which in turn improves the productivity of the smallholder sector. Introducing rain-guards is the only available solution to avoid rain interferences on tapping. Although rain-guards are being used extensively in the estate sector, the awareness is very poor among smallholders. Effective awareness programs and demonstration plots are of immense importance in improving the adoption of fixing rain guards.

Low quality in produced rubber

The smallholders are not very keen on producing RSS1, which is the best grade of RSS. In general the smallholders' produce goes to the market as RSS3 or RSS4. The dealers buy sheets from them as a bulk and no proper grading system is adopted during the deal. This has been identified as a significant reason for the low quality in smallholders' produce. Non-awareness of correct practices of processing that result in low adoption rates and lack of facilities are also among the pressures of the system when processing is concerned.

Low income at local level is the impact of this issue. Although the smallholders produce RSS1, in most cases they do not get any benefit since the dealers buy rubber as bulk. Improving the status of smoke houses and machinery through extension

programs and encouraging the farmers to sell their produce through the societies would be the appropriate institutional responses. This can increase the bargaining power of smallholders in selling their produce. This issue is related to improper market systems, which are also a major issue in the smallholder rubber sector.

Low involvement in societies

This study has highlighted that the involvement in societies related to rubber is not satisfactory. No proper institutional structure to centralize the activities of local level societies and non-awareness of farmers on the benefits that could be achieved through societies are the main pressures on this issue. These have created political conflicts and difficulties in organizing markets and other facilities through societies. Organizing programs to develop leadership skills, provision of technical, social and economic know-how through the societies should be the responsibilities of the institutions involved in the smallholder rubber sector.

Depletion of the smallholder rubber extent

Moving into other crops or uses is an indication of the sustainability of the system. The pressure is exerted by the human interventions of changing the land use of rubber plantations into other crops or uses. Therefore, the long-term impact is the depletion of the rubber extent and subsequent reduction in

production. In addition, there are repercussions like increased soil erosion and decreased soil moisture retention and increased atmospheric CO₂, which affects the equilibrium of the ecosystem. As this issue is of a higher scale, national programs to plant more rubber and to address the value of rubber plantations as a forest cover are of immense importance. Government interventions such as subsidies, market facilities and societal arrangements should also be given highest priority.

Conclusions

This study has identified several issues; viz. substandard growth in immature rubber lands, low productivity in mature lands, low quality in produced rubber, low involvement in societies, improper marketing systems, and depletion of the smallholder rubber extent, which have an impact on the sustainability of the ecosystem.

Low adoption rates of recommended technologies were observed for immature and mature phases of rubber cultivation and also during the manufacturing process and were responsible for marketing inefficiencies. The proposed societal arrangements in this regard were not functioning properly. These have led to low income levels of the rubber growing community and as a result there is a tendency to convert rubber lands into other uses or crops for better income.

Awareness programs to improve adoption of technologies at all stages

from planting to processing and Government interventions such as increased subsidies, market facilities and societal arrangements should be given priority to make the smallholder sector more productive.

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