IJMS 2022 9(1): 53 - 64

International Journal of Multidisciplinary Studies (IJMS)
Volume 9, Issue I, 2022

An analysis of factors influencing for productivity of rubber smallholdings: A case study in *Moneragala* District of Sri Lanka

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ABSTRACT

Rubber farming, being a new initiative in Moneragala District in Sri Lanka, plays a key role in national rubber production but still lags far behind in potential. This study was carried out to find the factors which determine the Productivity of Rubber Smallholdings (PRSs) and to find out the strategies for enhancement. A questionnaire survey was conducted in 2019, using stratified random sampling. Descriptive statistics and Spearman's correlation analysis were employed in the methodology. The average PRSs is 905 kg/ha/year on dry rubber basis, which is far below in potential to the average of 2500 kg/ha/year. The majority of rubber smallholdings are in the category of low rubber productivity. Key socio-economic factors; gender, age, level of education, experience of rubber farming, membership of the Thurusaviya rubber society, age of the trees and type of clone did not affect to the PRSs, while fulltime rubber smallholders showed a positive relationship. The number of tapped trees in the land, number of tapping days per year and practice of self-tapping system positively correlated with PRSs while extent of rubber holdings was negatively correlated. The participation in training programmes, instructions given by experienced rubber smallholders and by extension personnel and utilization of CDs and leaflets on tapping and manuaring were positively correlated with PRSs. The adoption level of manuaring and tapping practices in rubber smallholdings affected the PRSs. It is also evident that effective strategic extension plans which include formulating appropriate policy measures, especially focusing on utilization of extension communication channels and mass media, development of rubber smallholdings and adoption of manuaring and tapping practices of rubber farming would eventually improve PRSs for the future for the improvement in performance of rubber farming in Moneragala District.

KEYWORDS: *Moneragala, Productivity, Rubber, Smallholdings, Adoption*

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1 INTRODUCTION

Rubber (*Hevea brasiliensis*) is one of the major plantation crops in Sri Lanka in terms of export earnings and employment generation. Rubber sector contributed 0.2 % to the GDP in 2019 (CBSL, 2020). Rubber is a popular crop among smallholders, a subsection that owns lands below 20.2ha in Sri Lanka and there are nearly 200,000 Rubber Smallholders (RSs) operating in 16 rubber growing districts. Smallholder rubber cultivation is considered as the most dynamic segment of the rubber sector as it represents 59% of total rubber extent of Sri Lanka and it contributes >65% to the national rubber production in 2019 (MPI, 2019). At present, the total extent of Rubber Smallholdings (RSHs) in *Moneragala* District is about 5,087ha (9,415 no. of RSHs) and it is the fifth among rubber growing Districts in land extent under the rubber cultivation in Sri Lanka (MPI, 2019).

The Rubber Research Institute of Sri Lanka (RRISL) has developed and recommended a number of Rubber Farming (RF) practices to enhance the Productivity of Rubber Smallholdings (PRSs). Out of them, Manuaring Practices (MPs) and Tapping Practices (TPs) play a key role in increasing the PRSs (Gunarathne, at el., 2019). The knowledge and skill of those practices are disseminated to the Rubber Smallholders (RSs) in *Moneragala* via both public and private extension services. Many approaches that transfer technology are launched by both service sectors to enhance PRSs. However, the entire system is still unable to meet the expectations of PRSs in *Moneragala* (Wijesuriya et al, 2011). As a result, RSs are increasingly experiencing complex socio-economic issues associated with short-term benefits that have adverse effects on the long-term PRSs. This study aims to explore the intervention of factors influencing PRSs in the smallholder RF. There are many studies reported in the literature regarding RF in *Moneragala*. Thennakoon 2002, Wijesuriya et al., (2008, 2010, 2011 and 2012) and Dissanayake et al, (2010 and 2018) studied farmers' expectations, potential and constraints for RF in *Moneragala* District. However, those previous studies do not provide sufficient information on PRSs in *Moneragala*. Hence, the findings of this study would be useful for policy makers, researchers and extension personnel to formulate guidelines and to organize work programmes more effectively to improve PRSs, as *Moneragala* is a non-traditional rubber growing locality with higher areas of newly-planted cultivars. The present study will have an impact on the level on livelihoods of the RSs as well as the sustainability of RF in *Moneragala*, while having a footprint on the country's economic development.

2 MATERIALS AND METHODS

2.1 Study area

Moneragala District (6.7563° N and 81.2519° E) was selected purposely as it is a newly planted area of rubber in the country. It is located in Uva province and is the second largest district in Sri Lanka with an extent of 565,930 ha. It has Wet,

Intermediate and Dry climatic conditions and many agro-ecological regions, out of which IL1c, IL2 and IM 2b are suitable for rubber cultivation, which are distributed among eight Divisional Secretariat (DS) divisions (Dissanayake et al., 2010).

2.2 Sampling techniques

RSHs that have commenced tapping and producing rubber for a minimum duration of five years or more, were selected to the core study using stratified random sampling technique, based on secondary data available, and after discussions with rubber development officers in the Rubber Development Department in *Moneragala*. The minimum total size of the sample was 297, representing 23% of the population at a 90% confidence interval using Raosoft web-based sampling calculator for which stratification was applied on the basis of geographical distribution of RSs in all rubber growing DS divisions (8) in *Moneragala* (http://www.raosoft.com/samplesize.html) . Twenty-three percent of the Grama Niladari (GN) divisions where the highest number of RSHs could be found within each DS division were selected using the statistical sources, followed by random selection of the individual RSHs according to the number in each GN division, so that the survey sample (23% of RSHs of each GN division) was randomly selected based on the number of RS in each GN division.

2.3 Data collection

Pre-tested interview schedule was used to collect data from the RSs/RSHs based on the objectives of the study using a pre-tested questionnaire in 2019. Necessary primary data were collected by the author through personal interviews with the respondents, supplemented with secondary data from relevant sources and field observations.

2.4 Measurement of variables

Studied variables were selected according to the views of the panel of experts of the rubber sector based on objectives. Those were divided into six categories; 1. The key socio-economic characteristics of RSs, 2. The current status of RSHs, 3. The utilization of extension communication channels by RSs, 4. The utilization of mass media by RSs 5. Adoption level of MPs and TPs in RSHs and 6. Productivity of RSHs. The key socio-economic characteristics of RSs were measured as follows. Gender was indicated as male and female. Age (years) was defined as the period from birth to the time of this interview. Educational level (Grade) was defined as the highest level of education completed. Experience (years) in RF was defined as the period since the RS's first involvement in RF to this survey. The main occupation of the respondent was referred to the activity or activities through which, according to RS, earned his living (full time farmer or not). Social participation was highlighted as to the type of individual membership of the *Thurusaviya* Rubber Society (TRS). The current status of RSHs refers to the farm

size (ha) of mature stage rubber cultivation, type of clone cultivated, age of the rubber trees, tapping days per year, and the type of labor for tapping (self-tapping/ hired basis). The monthly rubber production (kg) in dry basis was measured and the mean PRSs was calculated based on kg $ha^{-1}year^{-1}$ in each holding.

The utilization of individual extension communication channels (both public and private) was indicated as the frequency of contacts in the last two years. The utilization of non-formal individual communication channels used by RSs was indicated as the frequency of contacts of experienced RSs in the last two years in order to obtain advice of TPs and MPs, separately. The frequency of participation in TPs and MPs related training programmes and the utilization of mass media (leaflets and CDs) which provides by the extension organizations were measured for last two years.

The level of adoption of field of TPs and MPs were measured by constructing composite indices. Five MPs of R/SA based manuaring system (Type of fertilizer, time of application, amount per tree, frequency and method of application) and five TPs of harvesting system (Tapping on every other day, annual tapping panel marking, opening tapping height, tapping angle and time of commencement of tapping) were selected to measure the adoption level of MPs and TPs respectively, with discussion with experts of the sector.

Rogers and Shoemaker (1971) defined adoption as a decision to make full use of a new idea as the best source of action available. It is the utilization and application of the ten practices which were measured using an adoption scale, which in turn comprised of two different levels of adoption as adopted and not adopted, for which scores of 1 and 0 was given, respectively. The adoption index of a RSH for adoption on each area (manuaring and tapping) was calculated using the eq. 1 developed by Sidhakaran (2010) as follows;

Adoption index = RSH's total score/ Possible maximum score*100... (eq.1)

The total score of RSH for adoption of each practice was constructed by adding the scores in each entry in relation to the given practice of TPs and MPs. The possible maximum score of each practice was calculated by adding the maximum scores in each entry of the given practice. The adoption index of a RSH for each area of adoption, namely, manuaring and tapping, were calculated using the eq.1.

2.5 Data analysis

Collected data was tabulated, coded and scores assigned where required, in order to make them meaningful and quantifiable. Descriptive analysis and Spearman's correlations were used to analyze the data by using STATA version14 software. The respondents were separated into three groups viz. low, medium and high based on their rubber productivity by using the confidence interval method (Fisher, 1935) and the RSHs were categorized as follows; Low Rubber Productivity Group (LRPG) =

Below X – 1.96*SE, Medium Rubber Productivity Group (MRPG) = Between X – 1.96*SE and Between X + 1.96*SE and High Rubber Productivity Group (HRPG) = Above X + 1.96.SE. Cumulative frequency distribution and percentage analysis were used to quantify groups.

3 RESULTS & DISCUSSION

3.1 Rubber productivity

The distribution of RSHs according to PRSs, greater proportion 50% of the RSHs had LRPG while 20% had HRPG. MRPG was evident in 30% of the RSHs. The average PRSs was 905 kg/ha/year, which ranged from 617 to 1512 kg/ ha/year in dry rubber basis. These PRSs is far behind the potential yield, which is nearly 2500 kg /ha/year (RRISL, 2003).

3.2 Relationship between key socio-economic characteristics of rubber smallholders and rubber productivity

According to the household structure of the RSs, 18% of RS families are female-headed households. However, gender of the RSs was not correlated with PRSs (Table 1). The age of RSs varied from 21 to 78 years and the model class of age of RSs was 31 to 40 years, while the involvement of 61 to 80 year age group, was less than 21% in smallholder groups. Also, 42% of farm households were less than 40 years of age while 20% were more than 60 years of age among the RSs. As reported by Thennakoon 2002, Dissanayake et al., 2010, Wijesuriya et al., 2011 and according to the results of this study, there was a gradual intensification of the preference in the younger generation for RFs in these areas. Age of the RSs was not correlated with PRSs (Table 1). However, most of RSs of young group had prominent rubber yield than others. Experience in RF is low since most of RSs are new to RF which varies from 8 to 14 years in RF and mean is 9 years. RF experience of RSs was not related to PRSs (Table 1) in the study area. Nobody was found either in the category of no school or higher education qualified. The most prominent educational level was up to Ordinary Level. The percentage of up to Advanced Level was 21% of the RSs. Education level is an important variable to be considered when studying the adoption of agricultural innovation (Rogers and Shoemaker, 1971; Perera, 2014). Although, the education level of the RSs was not related to PRSs (Table 1), it indirectly affected on improving knowledge of RSs and adoption of TPs and MPs. The majority of the RSs (92%) had been engaged in fulltime farming in the study area, where RSs did not engage in another job except farming. In contrast, RF was popular in part-time farmers who engaged in business activities (3%) and employed jobs (5%) as RF required less attention for mature up keeping. The full time RSs were positively correlated with PRSs ($P<0.05$) (Table 1). It was important that full time RF do cultural practices both in mature and immature up keeping (accurately) as they have sufficient time. It may help to maintain sustainability of RF. TRS is one of the smallholder rubber societies known to operate under the

control of the *Thurusaviya* fund. TRS is the body responsible to provide processing facilities, enhance sales and rubber marketing of RSs (Dissanayake, 2010). Sixty-five percent of RSs were members of TRS. The Membership of TRS of the RSs was not related to PRSs (Table 1). But, membership of the TRS will provide with chances to participate in the training programmes and obtain subsidized materials which are used for RF. Thus, TRS was one of the strongest official communication channel which was developed between public sector extension officials and RSs. However, RSs should be further promoted to get membership in TRS at the village level.

3.3 Relationship between characteristics of rubber smallholdings and rubber productivity

The majority of mature stage RSHs (41.5%) were included in the category of 0.4 ha to 1.9 ha, according to size. Only 1.5% of RSHs were more than the size of 2ha, which is considered low in traditional RF areas (Wijesuriya et al., 2011). Approximately, 40% of land size can be accounted to the size ranging from 0.8 to 1.5 ha and 7.5% of the lands were smaller than the size of 0.4 ha. Land extent was negatively correlated with PRSs ($P< 0.01$). The average land extent of RSHs was 0.4 ha which permits the plantations to be easily managed by the family members without a hired labour force. Dissanayake (2010) highlighted that most RSs can gain substantial economic benefits from their rubber lands due to less land extent of rubber cultivation. Therefore, RF should be expanded among smallholders who have less land extent in *Moneragala*. The majority of the RSHs (47%) were of 14 to 15 years of age, while only 1% was less than 10 years of age. However, most of the RSs have more economic potential for tapping in the future. It was evident that >7 years is required to achieve the tappable girth in 50 % of the holdings. This lapse affected the economic return from RSHs (Wijesuriya et al., 2012). The clone, RRIC 100 was prominent which is planted in 90% of the holdings. The age of trees and type of clone were not related to PRSs in the study area (Table 1). Rubber has traditionally been cultivated as a mono crop, mainly for its latex yield and the current recommended density for a rubber plantation is 512 trees per hectare (Rubber Research Institute of Sri Lanka, 2003). The tapping trees in RSHs was a crucial factor for PRSs and the average was 425 and the median was 377 to 437 tapping trees per hectare in the sample. The reason for low number of tapping trees in the RSHs was Tapping Pannel Dryness (TPD) of trees and the inadequately grown trees (runners). Comparatively, TPD of trees (trees those donot give latex) per acre were lower (12/ha) in non-traditional RF areas (traditional areas, TPD trees/ha= 30) (Wijesuriya et al., 2012). The unproductive trees and the average runners (undergirth rubber plants) per hectare was 3 in the sample. The number of tapping trees in RSHs was positively corelated with PRSs ($P< 0.01$) (Table 1).Therefore, RSs should be advised to maintain a higher number of tapping trees in their RSHs while practising proper cultural practices.

The rubber tree is exploited by periodic excision of a thin shaving of the bark along a sloping groove placed spirally on the bark of the tree trunk to extract latex from latex vessels by a "tapping knife" and the procedure is known as tapping (harvesting) (RRISL, 2003). It is generally expected that rubber requires more time to achieve the tappable girth in the Intermediate Zone where rainfall is comparatively lower than the Wet Zone (Wijesuriya et al., 2012). The sample comprised of mature holdings under virgin tapping panel (A-81% and B-19%). The number of tapping days/year varies with self-tapping (163) and hired-tapping (145). Average tapping days was 154 and it was comparatively high when comparing to the Wet Zone. Number of tapping days/year ($p<0.01$) was positively correlated with PSRF (Table 1). Therefore, RSs always maintain maximum tapping days according to the tapping system per year. The RSs used two types of labour forces for tapping their rubber plantations; 1. Self tapping, and 2. Hired tapping. Females (97%) were prominent in both types of tapping systems, similar to traditional rubber growing areas (Wijesuriya et al., 2012). In *Moneragala*, self tapping system was prominent (62%) than hired tapping (38%). Self-tapping system ($p<0.01$) is positively correlated with PRSs (Table1). Most wives of RSs (79%) adopted to tap their own RSHs. Therefore, RSs should be motivated to practice self-tapping system in their RSHs with appropriate development of tapping skills.

3.4 Relationship between the utilization of extension communication channels and rubber productivity

The training programmes and workshops for manuaring and tapping are mainly conducted by the public sector extension service, while the private sector participated only at a basal level during the year 2017 and 2018 (Dissanayake et al., 2018). The percentages of participation in training programmes on manuaring and tapping were 63% and 71%, respectively. Access to training on TPs ($p<0.05$) and MPs ($p<0.05$) correlated positively and significantly with the PRSs (Table 1). Lesser number of human development programmes was conducted by extension personnel, due to a myriad of reasons. Studies show that RSs can improve their knowledge and skill of MPs and TPs by participating in the training programmes. There are two strategies which can be practiced to improve participation in training programmes; 1. increasing the number of training programmes within the region and 2. Facilitation of RSs to participate.

Advisory visits and contacts were done by the public sector advisory personnel (Rubber development and extension officers), experienced RSs and advisory personnel of the private sector (rubber collectors and agriculture input suppliers) as formal sources of communication during 2018 and 2019. Advisory visits and contacts in RF are important, because RF depends on the technical aspects to a greater extent, even more so due to *Moneragala* being a non-traditional RF

area (Wijesuriya et al., 2011). The majority of advisory visits were done at village level by other RSs who were more experienced in tapping (62%) than in manuaring (36%). Comparatively, low level of advisory visits was done by public sector advisory personnel in tapping (16%) and in manuaring (9%). The contacts with advisory personnel (both public and private) for TPs ($p<0.01$) and MPs ($p<0.01$) had a positive correlation with the PRSs (Table 1). However, there is a high density of RSs to be served, in *Moneragala*, for a given number of advisory personnel. The contacts with advisory done by experienced RSs on TPs ($p<0.01$) and MPs ($p<0.01$) have a positive correlation with the PRSs (Table 1). However, experienced RSs who provision advice may not have sufficient knowledge and skill according to the RRISL guide lines, which also has to be taken into account.

3.5 Relationship between the utilization of mass media and rubber productivity

The extension agencies make use of different mass media in transferring improved agricultural technologies to the farmers (Rogers and Shoemaker, 1971). Both the leaflets and CDs published by the RRISL were considered as the utilization of mass media items for knowledge diffusion of MPs and TPs to RSs. The utilization of leaflets on TPs and MPs was 42% and 41%, respectively. The percentage of utilization of CDs on TPs and MPs was 16% and 3%, respectively. Utilization on CDs and leaflets on TPs and MPs was still inadequate and was not satisfactory during 2018 and 2019. The utilization of leaflets on TPs ($P< 0.05$) and MPs ($P< 0.05$) were positively related to PRSs (Table 1). The utilization of CDs on TPs ($P< 0.05$) and MPs ($P< 0.05$) was positively related to PRSs (Table 1). One of the major issues with utilization of leaflets and CDs, highlighted by RSs, was unavailability and inadequacy of the above material in their TRS or in other convenient places. Therefore, distribution of material pertaining to leaflets and CDs, among the RSs should be developed by introducing new strategies and strengthening the current process.

3.6 Relationship between the adoption of manuaring practices and rubber productivity

Manuaring (Fertilizer application) is crucial to maintain the level of productivity in mature rubber plantations (Rubber Research Institute of Sri Lanka, 2003). However, emphasis should be given to maintain the efficiency of manuaring as this implicates a considerably large expenditure and also it is one of the important cultural practices, especially in *Moneragala*. For mature rubber the recommended quantity of fertilizer should be applied annually, in single application within one month after refoliation, before the month of June and with the commencement of rain in March or April (Samarappuli et al., 2005). The overall adoption of MPs of farmers was 32%. MPs were not practised in 55% of the mature holdings. Among the rest of the farmers who applied fertilizer, only 8% had adopted to the correct fertilzer mixture (R/SA 9:9:9:7) in *Moneragala*, while others used to apply immature

fertilizer mixture. However, the correct amount was applied (900g/tree) by 41% of the holdings, while recommended method of fertilizer application was found in 34% of the holdings. The adoption rate of correct time of applying fertilizer was 32%. The overall adoption level on MPs in mature plantations ($p<0.01$) is positively related to PRSs (Table 1). MPs should be promoted as it is a shorterm stratergy to improve PRSs.

3.7 Relationship between the adoption of tapping practices and rubber productivity

TPs of rubber farming play a key role in increasing the adoption of TPs which in turn results in the increase economic lifespan of rubber plantation (Wijesuriya et al., 2010).

Overall adoption level on TPs was satisfactory (57%). The RSs of 83% of the holdings commenced tapping between 5 am to 6 am. The recommended alternate day tapping was practised in about 48% of the holdings. This seems to be a very good circumstance when compared to traditional RF areas, where RSs tap every day to compensate the number of days lost due to rain (Wijesuriya et al., 2011). The correct angle (30^0) of tapping cut facilitates and promotes a maximum removal of latex from the horizontal plane. The RRISL recommends that, this angle should be marked with a stencil plate at the correct height of tapping, more preferably on an annual basis, which guides the tappers on the angle of tapping. The correct angle was adopted in 46% of the holdings in the sample. In the rest of the plantations, the angle was more than or less than 30 degrees, which is one of the possible reasons for yield loss and inability to gain potential yield. In 56% of the holdings, the correct depth of tapping is practised which always ensures a better yield. The deep and shallow depth, which may cause damage to the tapping panel which is one of the possible reasons for low yield and productivity. The correct height at opening of tapping cut from the ground level (120 cm) was found only in 51% of the holdings, while there was no holdings, where the tapping height was more than 120 cm. Majority of the RSs practised a tapping height less than 120 cm which in turn leads to reduced economic lifespan of the tree. The overall adoption level on TPs ($p<0.01$) was positively related to PRSs (Table1). The low adoption in TPs formulated by the RRISL was one of the key issues which adversely affects the sustainability of RF. Certain repercussions due to this issue were identified namely, damaged trees, early uprooting, less potential yield due to poor tapping quality, abandoning of tappable holdings which finally lead to low national rubber production (Wijesuriya et al., 2010). Therefore, enhancement of the level of knowledge and adoption in TPs is important in meeting up with the national rubber production targets and sustainability of RF.

Table 01: Correlation between rubber productivity, socio-economic factors of rubber smallholders, characteristics of rubber smallholdings, utilization of mass

media and extension communication channels and adoption of rubber farming practices.

Variables	**Correlation**	**Significance**
Socio-economic factors of rubber smallholders		
Gender	0.3351	0.3422
Age	0.4235	0.4567
Experience	0.3222	0.4526
Education	0.3425	0.5678
Fulltime farmers	0.3652	0.0200*
Membership of *Thurusaviya* society	0.4432	0.4331
Characteristics of rubber smallholdings		
Clone	0.5532	0.4563
Extent	-0.4262	0.0021**
Trees in tapping	0.8722	0.0037**
Age of the trees	0.3432	0.1321
Tapping days per year	0.4782	0.0000**
Self-tapping system	0.5677	0.0003**
Utilization of extension communication channels		
Participation of training programmes on TPs	0.6222	0.0020**
Participation of training programmes on MPs	0.6222	0.0030**
Advisory visits done by experienced RSs on TPs	0.6832	0.0020**
Advisory visits done by experienced RSs on MPs	0.6832	0.0000**
Advisory visits done by extension personnel on TPs	0.7827	0.0000**
Advisory visits done by extension personnel on MPs	0.7827	0.0001**
Utilization of mass media		
Utilization of CDs on TPs	0.5567	0.0111**
Utilization of CDs on MPs	0.6567	0.0102**
Utilization of leaflets on TPs	0.7567	0.0234**
Utilization of leaflets on MPs	0.8567	0.0107**
Adoption		
Adoption on MPs	0.9871	0.0000**
Adoption on TPs	0.8856	0.0001**

*Significance at 0.05 level and
** Significance at 0.01 level

4 CONCLUSION & RECOMMENDATIONS

There is a productivity gap between the potential and present levels of RSHs. The majority of RSHs belongs to the low productivity group. Maintaining more number of tapping trees in the RSHs, enhancing the number of tapping days, promotion of self-tapping system, the improvement of the level of adoption of TPs and MPs developed by the RRISL, improving the accessibility of participation in training programmes focused on TPs and MPs, advisory visits

done by experienced RSs and by extension personnel and utilization of leaflets and CDs on TPs and MPs should be highlighted when formulating strategic extension and development plans of smallholder rubber sector in *Moneragala* to achieve the maximum yield from RSHs.

ACKNOWLEDGMENTS

The authors are grateful to the rubber smallholders in *Moneragala* District for their valuable support.

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