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From Latex to Livelihoods: Assessing The Wealth Impact of Rubber Farming Among Smallholders in the Intermediate Zone of Sri Lanka Using a Propensity Score Matching Approach

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Abstract: Rubber (*Hevea brasiliensis* L.) farming was established in Moneragala District (6.7563° N and 81.2519° E) situated in Intermediate Zone by the Government of Sri Lanka, in order to uplift the wealth status of households. This study was carried out to identify and quantify the impact of rubber farming on smallholder community in Moneragala through assessment of major household assets. A questionnaire survey was conducted in 2023, using stratified random sampling with 1026 rubber and non-rubber smallholders' households. This study employed one-to-one nearest neighbor matching algorithms with the propensity score-matching estimation approach to examine the direct impacts of rubber farming adoption on household wealth in Intermediate Zone in Sri Lanka. A household wealth index was developed using principal component analysis incorporating 9 characteristics of living houses, 25 types of household assets and 8 types of agricultural and non-agricultural vehicles. The average treatment effect indicated that the adoption on rubber farming has had a positive and statistically significant effect on household wealth by 16.3%, which is higher than in households of non-rubber smallholders. The government policy should focus on expanding and promoting rubber farming in the Intermediate zone in Sri Lanka to enhance the wealth status of smallholder households.

Keywords: Impact; Rubber farming; Smallholders; Wealth index; Well-being

Introduction

Rubber Farming (RF) is defined as producing rubber (Raw latex/ Ribbed Smoked Sheets (RSS)) by tapping cultivated rubber (*Hevea brasiliensis* L.) trees by Rubber Smallholders (RSs) (MPI, 2021). It was established in Moneragala District (6.7563° N and 81.2519° E) situated in Intermediate Zone by the Government of Sri Lanka, in order to uplift the wealth status of households with the consideration of more ecologically and economically stable farming system (Dissanayake *et al*., 2005a). Moneragala is the first experience in RF which has been implemented in the Intermediate Zone in Sri Lanka (Dissanayake *et al*., 2005a; Dissanayake and Wijesuriya, 2012). In 2023, 4,402 hectors of rubber extent was adopted by smallholders in Moneragala District (MPI, 2021). With this background, there is a great necessity to study the impact on household wealth of adoption of RF in Moneragala District in Sri Lanka. The most of research which were carried out on RF in Moneragala, have only focused on the strategies of technology transfer of RF (Gunarathne *et al.,* 2022; Sankalpa *et al*., 2021; Thennakoon, 2017; Wijesuriya *et al*., 2005b; Wijesuriya *et al*., 2011,) and issues on technical matters during expansion process (Dissanayake *et al.,* 2005a; Dissanayake and Wijesuriya, 2012; Gunarathne *et al.,* 2020; Gunarathne *et al.,* 2021; Samarappuli *et al*., 2005;

Senavirathne, 2005; Wijesuriya *et al*., 2005c Wijesuriya *et al*., 2005a; Wijesuriya *et al*., 2010) and factors influencing for smallholder rubber farming (Thennakoon, 2002; Thennakoon, 2012; Thennakoon, 2018)..

There is a research gap in the studies of household wealth status due to impact of adoption of RF by the Rubber Smallholders Households (RSHs) in Moneragala. The policy makers, practitioners and researchers in relevant organizations in rubber growing countries who are interested in poverty reduction at household level can use the findings of this study to improve the policy decisions that will be useful to get rid of poverty of smallholders. Household wealth is determined by the presence of total value of all tangible and intangible assets owned. There are different assets which could possibly contribute to their wealth status of the given household (Ellis and Bahligwa, 2003; Moser, 2007; Langyintuo and Mungoma, 2008). In middle- and low-income settings, household assets provide a better proxy for a long-run wealth of household compared to information on either income or expenditure (Morris, *et al*., 2000; Filmer and Pritchett 2001; Howe *et al*., 2012). Montgomery *et al*. (2000) and Howe *et al*. (2012) have discussed that the asset-based wealth index is a better measure of socio-economic status of households in middle- and low-income settings over direct measures of income and expenditure of households. As the information required in constructing the asset-based wealth index are reliability, time and cost effectiveness, it is relatively easy and inexpensive than collection of information on income and expenditure. In middle- and low-income settings, one of the widely used measures of wealth status of households is a composite index constructed from a list of household asset items, which is called the Household Wealth Index (HWI) (Howe *et al*., 2012).

Approach of HWI has been used as composite indicator to measure household asset ownership and recommended by many studies to assess the wealth status of households (Filmer and Pritchett, 2001). Filmer and Pritchettt (2001) found that the household asset-based wealth index produces comparable results with other measures and noted that the HWI is significantly correlated with the distribution of household assets. HWI is a more appropriate index to correlate monetary poverty at household level in the assessment of wealth status of households. And also, it has been introduced and developed as an alternative approach to assess the wealth status of households based on non-monetary approaches in assessing household wealth status, so that it was selected to assess the household wealth status in this study.

It is indicated by the previous research conducted up to now, regarding the benefits of rubber cultivation in Eastern Province in Sri Lanka, that there is a significant positive impact on rural livelihood (Rodrigo *et al*., 2009; Rodrigo *et al*., 2014). So that, in order to examine the impact of RF on well-being of rural community in Moneragala in Sri Lanka,

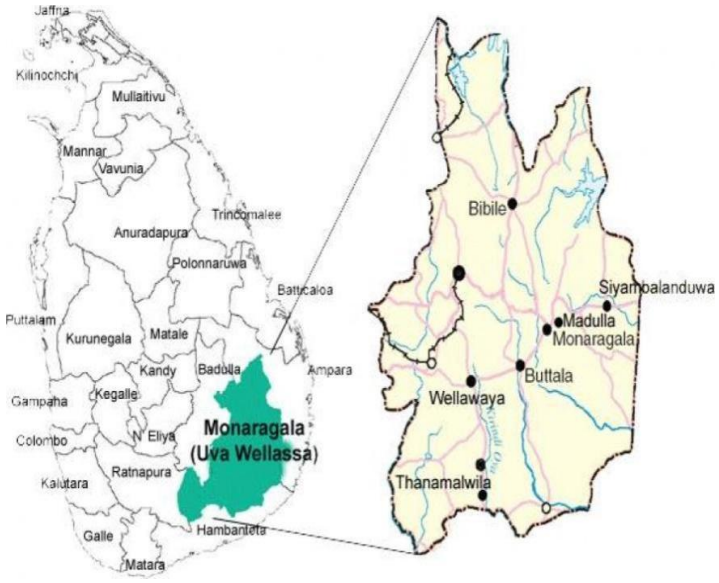

Figure 1: The Location Map of the Study Area in Monaragala District

Source: Ministry of Plantation Industries, 2021

it is necessary to carry out detailed investigations (Gunarathne *et al*., 2019). This study was carried out to identify and quantify the impact of RF on smallholder community in Moneragala through assessment of major household assets.

Methodology

Study Area

Moneragala District (6.7563° N and 81.2519° E) was selected purposely as it is a newly planted area of rubber in Sri Lanka. The study was carried out to represent Moneragala (Figure 1) which is located in South-East and in the Intermediate Zone of Sri Lanka. The total land area of Moneragala is 565,930 hectares (5,659 km^2), which represents approximately 13% of the total land area of the country.

Sampling

For the purpose of this study, smallholders who have been practicing RF were classified as adopters (Rubber Smallholders (RSHs)), while smallholders who do not practice RF as the agricultural livelihood strategy were referred as non-adopters (Rubber Smallholders (NRSHs)). Rubber-producing (tapping stage) RSHs in Moneragala, who have started tapping three years ago in their mature stage rubber smallholdings and also have been practising other different farming systems were selected for this study, as it was estimated that the initial establishment cost of RF has been covered after three years of tapping (RRISL, 2016). The selection of smallholders' households for the core study was based on secondary data available in statistical information on plantation crops (MPI, 2021), and discussion with field officers in the departments of Rubber Development Department and Department of agriculture in Sri Lanka.

According to the distribution of target population (RSHs) stratified random sampling was applied to attempt survey based on the geographical distribution and total upland extent of RSHs and NRSHs, since smallholders normally cultivated more than two crops (Thennakoon, 1998; Wijesuriya *et al*., 2005a). In order to minimize the error, confidence interval 95% and marginal error 3.8% by using sample size formula (Eq. 1), minimum of 513 RSHs were selected as study sample. The sample size was increased by 10% to account for contingencies such as non-response or recording error. Neyman sample allocation method (Eq. 1 and Eq. 2) (Agresti, 1990) was used to calculate the proportion of RSHs according to the categories of land extent in rubber farming areas in Moneragala.

Necessary sample size = $(\text{Z-score})^2$ * Standard Deviation *(1- Standard Deviation)/ $(\text{Margin of error})^2$ .....Eq. 1

$n_h = n * (N_h * S_h) / [\Sigma (N_i * S_i)]$ ……..Eq. 2

Where N_H was the sample size for stratum h, n was total sample size, N_h was the population size for stratum h, and S_h was the standard deviation of stratum h.

According to the distribution of total cultivated up-land extent of smallholder households, there were six land categories (<=1 ac., 1.1 - <=2.0 ac., 2.1 - <=3.0 ac., 3.1 -<=4.0 ac., 4.1- <= 5.0 ac., >5.1 ac.) identified in Moneragala. Using the statistical sources within divisional secretariat divisions, smallholder households were selected randomly in each division. The survey sample was proportionately selected based on number of smallholder households with the land extent in each divisional secretariat division. Table 1 shows the selected sample of RSHs for the study in-depth. A total of 513 RSHs were as total.

Table 1: Study Sample of Rubber Smallholder Households

Divisional secretariat divisions	Rubber smallholder households						Total
	Total land extent with rubber cultivation (ac.)						
	<=1	1.1 -<=2.0	2.1-<=3.0	3.1-<=4.0	4.1-<=5.0	>5.1	
Bibila	4	10	15	11	2	1	43
Madulla	12	14	18	11	9	1	65
Madagama	18	28	28	7	9	2	92
Siyabalanduwa	0	2	1	1	0	0	4
Moneragala	15	19	36	15	12	2	99
Badalkumbura	39	42	62	23	10	7	183
Wellawaya	4	4	2	7	3	0	20
Buttala	0	2	2	3	0	0	7
Total	92	121	164	78	45	13	513

Source: Ministry of Plantation Industries, 2021

Table 2 shows the selected sample of NRSHs for the study in-depth. This study employed the Propensity Score Matching (PSM) technique to address the problem of selection bias in RSHs in the study sample which was pairing adopters (RSHs) and non-adopters (NRSHs) of smallholders that are similar in terms of their observable

characteristics. Therefore, before the matching, 525 NRSHs were selected and finally 513 NRSHs were selected from the same DS divisions so that; 1026 smallholder households were selected for the smallholder household survey.

Table 2: Study Sample of Non-Rubber Smallholder Households

Divisional secretariat divisions	Non-rubber smallholder households						Total
	Total land extent with rubber cultivation (ac.)						
	<=1	1.1 -<=2.0	2.1-<=3.0	3.1-<=4.0	4.1-<=5.0	>5.1	
Bibila	4	10	16	11	2	1	44
Madulla	12	14	19	11	9	1	66
Madagama	18	28	29	7	9	2	93
Siyabalanduwa	0	2	1	1	0	0	4
Moneragala	15	19	38	15	12	2	101
Badalkumbura	42	43	65	23	10	7	190
Wellawaya	4	4	2	7	3	0	20
Buttala	0	2	2	3	0	0	7
Total	**95**	**122**	**172**	**78**	**45**	**13**	**525**

Source: Ministry of Plantation Industries, 2021

Measurement of the household wealth

HWI was developed to measure the households' long-run economic wealth. HWI was a composite index that reflects a household's ownership (or lack thereof) of a range of household wealth assets (Filmer and Pritchett, 2001). The group discussion with RSHs and NRSHs was carried out to identify extensive list of key household wealth assets that characterizes the 'wealth of households' continuum. Forty-two assets were selected and incorporated into the questionnaire to develop the HWI, based on the extensive list of key household wealth assets and literature search (Balen *et al*., 2010; Chasekwa *et al*., 2018; Edirisinghe, 2015), basically.

The selected household wealth assets were water purification machine, TV (LCD), TV (Normal), cassette recorder (normal), home theatre, cassette recorder (high), refrigerator (double door), refrigerator (single door), gas cooker, rice cooker, washing machine, sofa, desktop computer, laptop computer, oven, microwave oven, electric kettle, electric iron, smart phones, non-smart (normal) phones, internet, satellite TV, ceiling fans, table fans, stand fans, cement floor, tiled floor, permanent roof, bathroom, gate, pantry cupboards, hot water system, electricity, pumped water, canter, two wheel tractor, four wheel tractor, combine harvester, lorry, car, three wheeler and motor bicycle. Asset variables were measured as the presence or absence of variables during the period of study. All household wealth assets were recoded as dichotomous variables (yes=1, no=0). PCA was applied in order to weigh the HWI (Filmer and Pritchett, 2001, Vyas and Kumaranayake, 2006; Chasekwa *et al*., 2018). The collected household wealth assets were manually checked for completeness and consistency. Household wealth assets with frequencies of < 5% (Hot water system and water purification machine) and > 95% (non-smart (normal) phones, cement floor, permanent roof and electricity) were excluded.

Before applying Principal Component Analysis (PCA), outliers in the rest of 36 household wealth assets examined through the normal Q-Q plot. Results of normal Q-Q plot indicated that there are no outliers. Due to the large sample size (Tabachnick and Fidell, 2007). Skewness, Kurtosis and Linearity were not used to inspect the shape of the distribution. The multi-collinearity issues were tested if any, with Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy test. KMO value was 0.9014, which was indicative of an output PCA, that would be reliable to develop HWI

(Antony and Rao, 2007; Mooi and Sarstedt, 2011). And also, Variance-inflation factor (VIF) was 0.3 (<0.5), which was again suggestive of the absence of multi-collinearity problem.

The null hypothesis that household wealth assets in the population correlation matrix were uncorrelated by the Bartlett's Test of Sphericity tests at a significance level of 0.000 (<0.05) (X^2=17087.349, DF=35). So that, it can be concluded that the strength of relationship among household wealth assets was strong (or the correlation matrix was not an identity matrix) which was required for factor analysis to be valid (Antony and Rao, 2007). These diagnostic procedures indicated that PCA was appropriate for the prevailing data. Using STATA 14.0 software, all the 36 household wealth assets were entered into the PCA with varimax rotation, where 8 components were identified with the use of eigenvalues (>1) and Cattell's Scree plot. So that, 64 % of the total variation in the data set was explained out of which, 28% was accounted by the first component.

The built-in regression method in STATA (namely the command, "predict") was applied to estimate the predicted factor score coefficients. Predicted factor score coefficients represent a single score for each smallholders' HWI. A weighed sum of these predicted factors score coefficients was used to generate a Non-standardized HWI for each smallholder $_j$ ($NHWI_j$), as follows (Eq. 3);

Non-standardized Household Wealth Index for each smallholder $_j = \sum_{i=1}^{11} (wi\ X\ PC\ i)$.....Eq. 3

Where;

W_i = Proportion for variance for factor $_i$ / Total variance explained

i = 1.....11

PC_i = Predicted factor score coefficients of i

HWI was standardized with the following formula Eq. 4 (Antony and Rao, 2007);

Household Wealth Index = $(NHWI_j - NHWI_{minimum}) / (NHWI_{maximum} - NHWI_{minimum}) * 100$.....Eq. 4

Measurement of the impact of rubber farming on household wealth status

The adopters (RSHs) and non-adopters (NRSHs) of RF system in Moneragala were statistically compared using null-hypotheses in order to assess the impact of RF in the study area as follows;

H_0 - There is no significant impact of rubber farming on wealth index of smallholders' households in Moneragala.

This study examined the impact of RF on wealth status of smallholders' households by the estimated difference in the impact between the RSHs (Treatment group) and the NRSHs (Control group), who possessed similar characteristics with the application of Propensity Score Matching (PSM) method, which followed four major steps; estimation of propensity scores by logistic regression model, matching the propensity scores by Nearest Nabour Matching 1:1 (NNM) technique, assessment of the impact under the outcome variable (HWI) and sensitivity analysis by Mantel and Haenszel test statistics. In conducting causal inferences in observational studies Rosenbaum and Rubin, 1983; Dehejia and Wahba, 2002; Rosenbaum, 2002; Smith and Todd, 2005; Caliendo and Kopeinig, 2008), PSM methodology has been applied to address the potential selection bias originated by the differences in characteristics between the adopters and non-adopters of innovations in the study population.

First, a probability model for adoption on RF was estimated to calculate the probability (or propensity scores) on adoption for each observation. In the second step, each adopter of RF (RSHs) was matched to a non-adopter (NRHSs) with similar propensity score value, in order to estimate the average treatment effects due to RF. Propensity score was estimated by logistic regression with a dichotomous treatment variable, for instance, 1= adoption on RF and 0 = non-adopters using associated observed background characteristics of the households. A logistic model was used to identify the factors determining decision of smallholders on adoption/engagement in RF in their smallholdings. According to the logistic model, the probability, P_i, of a smallholder adopted on RF system was given by Eq. 5;

$$P_i = \frac{\exp^{Zi}}{1 + \exp^{Zi}},$$

……. Eq. 5

Where, Z_i = a random variable that predicts the probability of the i^{th} smallholder adopted on RF. Therefore, for an individual smallholder (Eq. 6):

$$Z_i = \ln \frac{P_i}{1 - P_i} = \beta_0 + \sum_{n=1}^{n} \beta_n X_{ji},$$

……. Eq. 6

Where, β is an unknown parameter, X is the identified factor contributing to the decision to adopt on RF.

In order to balance the baseline characteristics of the adopters (RSHs) and non-adopters (NRSHs) to reduce potential confounders, PSM was performed using a logistic regression model. Age of household head and the spouse, education level of household head and the spouse, farming experience of household head, memberships in the organizations at village level, total number of children, total number of family members and total farm extent were selected as independent variables which were correlated with selection of RF.

Dependent variable was a binary variable on the decision to practice RF (adoption) or not to practice RF (non-adoption). The propensity score was defined $p(X)$ as the conditional probability of receiving a treatment (RF) given pre-treatment variable (Rosenbaum and Rubin, 1983; Leuven and Sianesi, 2003) and it was given by Eq. 7;

$$p(X)=prob\ [D=1|X]=E[X];p(X)=F(X) \quad \text{……Eq. 7}$$

Where, X was a vector of pre-treatment variables and $F(X)$ represents normal or logistic cumulative distribution frequency. The principal assumption (Conditional independence assumption) in this method was that conditional of propensity scores of the selected observable characteristics of the exposed and control groups had similar distributions (Rosenbaum and Rubin, 1983). NNM 1:1 method was applied to match similar adopter group (RSHs) with smallholders in the non-adopter group (NRSHs) based on the closeness of their propensity scores (Dehejia and Wahba, 2002; Leuven and Sianesi, 2003).

Estimating the treatment effects based on the propensity score requires two assumptions; the conditional independence assumption and the average treatment effects were only defined within the region of common support. This assumption ensures that RSs with the same X values had a positive probability of being either RSHs or NRSHs (Caliendo and Kopeinig, 2008). Once the propensity score was computed, average treatment effects were estimated according to the Eq. 9, Eq. 10 and Eq. 11;

$$ATE=E\{Y_{iRSs}-Y_{iNRSs}|D=1\} \quad \text{……. Eq. 8}$$

$$ATE=E[E\{D_i=1,p(X)\}] \quad \text{……Eq. 9}$$

$$ATE=E[E\{D_i=1,p(X)\}-E\{D_i=0,p(X)|D=1\}] \quad \text{…….Eq. 10}$$

HWI was selected as outcome variable to assess the impact (average treatment effects) of RF. The bootstrapping method was applied to find the standard errors used to calculate the statistical significance of average treatment effects. The NNM 1:1 technique was applied to match adopters (RSHs) and non-adopters (NRSHs) in order to examine the impact of RF on the outcome of wealth status of smallholders in the study area.

PSM analysis was employed using psmatch2 command, implemented on STATA 15.1 platform. The sensitivity analysis was conducted to examine the critical level of gamma (Γ), which indicates the sensitivity of results to unobserved variables (hidden bias) (Rosenbaum, 2002\) by Mantel and Haenszel test statistics of the treatment effects for aggregated outcome of HWI, using the STATA commands *pstest* and *rbounds* by Leuven and Sianesi (2003).

Data collection

Household questionnaire survey was used to gather primary data by structured direct interviews with the adopters and non-adopters. And also, secondary data collection and field observations were used to full fill the specific objectives in 2023, from January to May. Household questionnaire survey was based on the objectives of the study, reviewing the literature and after the preliminary information gathered by the researcher during the visits to smallholders' households. Ten experts from different disciplines in the development of rubber sector in Sri Lanka, were evaluated the questionnaire prior to its use. The household questionnaire was developed covering the identified two key areas; Key socio-economic characteristics of households and Household assets. Household questionnaire was pre-tested in the field with 26 RSHs and 26 NRSHs of every land category (not included in the study sample) selected from every DS division and necessary alternatives were made.

Measurement of variables and data analysis

Both of the panel of experts of the rubber sector and literature review was used to select study variables to achieve objectives of the study. According to the innovation diffusion theory (Rogers, 2003) and based on the literature review,

age of smallholder and the spouse (Perz, 2002; Magaña-lemus *et al*., 2016), education level of the smallholder and the spouse (Allen *et al*., 1991), farming experience of the smallholder, memberships of societies of smallholders at village level, total number of household members (Meijer *et al*., 2015) and total farm land extent were selected as independent variables to develop empirical model. A logistic model was used to identify the factors affect adoption on RF in their smallholdings. Dependent variable was a binary variable on the decision to cultivate rubber (adoption) or not to cultivate (not-adoption).

Age of the smallholders and spouse was defined as the period from birth to the time of this survey. The highest level of education completed by smallholder and spouse was considered the level of education. The period since the first involvement of farming by smallholders to this survey was considered as farming experience. Total farm land extent was defined as the land extent used for cultivation of crops and animal husbandry. The memberships of societies of smallholders at village level was defined as number of memberships in different societies at village level by smallholder. The total number of household members measured as members in household. KMO, Bartlett's Test of Sphericity and Breusch-Pagan tests were carried out. Dependent variable was a binary variable on the decision to cultivate rubber (adoption) or not to cultivate (not-adoption). The mean and median standardized bias for all variables were observed, before matching and after matching. Collected primary data was tabulated and coded. The STATA version 14 software was applied to use PCA and PSM and analyse data on descriptively.

Results

Estimation of propensity scores

The likelihood chi square value of propensity score estimation result shows that it was significant at 1% probability level which confirms the overall fitness of the model. The low pseudo R^2 (0.2545) value shows that the allocation of the programme has been de-facto random. The mean standardized bias for all variables observed, both before matching and after matching were 16.6 and 7.2, respectively and was reduced to 56%. The median standardized bias for all variables observed, both before matching and after matching were 14.9 and 6.8, respectively which was reduced to 54%. The p-values of the likelihood ratio tests indicate that the joint significance of co-variates was always rejected after matching (326.42, p = 0.372), whereas it was never rejected before matching (334.72, p = 0.000). The pseudo-R^2 also dropped significantly from 22% before matching to about 21% after matching. This indicates that there was no systematic difference in the distribution of explanatory variables between RSHs and NRSHs in the study area. The NNM 1:1 technique was applied to match RSHs and NRSHs in order to examine the impact of RF on the outcome variable (HWI). The common support region distribution of propensity score for both groups of RSHs (treated) and NRSHs (controlled) were shown in Figure 2.

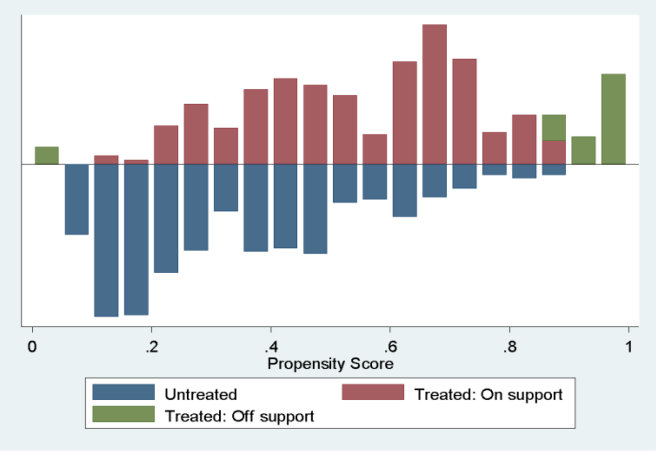

Figure 2: Propensity Score Distribution and Common Support for Propensity Score Estimation

The region of common support is ranged from 0 to 0.999 with a mean of 0.451. The common support assumption is satisfied in the region of (0.0390, 0.9588), with only a loss of 75 (7%) observations from adopters. It was ensured that all combinations of observed household characteristics in the RSHs (treatment) and NRSHs (control group) were matched in the propensity score distributions based on the common support region. Therefore, common support condition was satisfied in this study. Table 3 shows the covariate balancing indicators before and after matching the outcome variable (HWI). The median standardized bias for HWI was reduced to 49.0% after matching (Table 3). The

p-values of the likelihood ratio tests of HWI were rejected after matching, whereas those were never rejected before matching (Table 3).

Table 3: Covariate Balancing Indicators Before and After Matching the Outcome Variable

Out come	Pseudo R^2 (B.M.)	Pseudo R^2 (A.M.)	LR chi^2 (B.M.)	LR chi^2 (A.M.)	*p* value (B.M.)	*p* value (A.M.)	Median bias (B.M.)	Median bias (A.M.)	Total bias reduction (%)
WHI	0.029	0.016	35.58	25.41	0.000	0.235	45.6	23.3	49.0

A.M = After matching, B.M = Before matching

The pseudo-R^2 and LR chi^2 dropped significantly from before matching to after matching of HWI (Table 3). These results suggest that the proposed specification of the propensity score was fairly successful in terms of balancing the distribution of covariates between the two groups of RSHs and NRSHs. There was hypothetically no hidden bias (Γ=1) when the hidden bias increases by increments of 0.05 until Γ=1.60 for HWI with Mantel and Haenszel test statistics.

Household assets of smallholders

Three types of household assets were considered and measured namely, 1. Characteristics of the living house, 2. Durable household goods and 3. Ownership of agricultural and non-agricultural vehicles during the period of study to assess the impact of RF on household wealth. Characteristics of the living house were measured under different categories and the summary of that of RSHs and NRSHs is shown in Figure 3. All the characteristics' percentage pertaining to living houses of RSHs were higher than that of NRSHs.

Characteristics of the living house

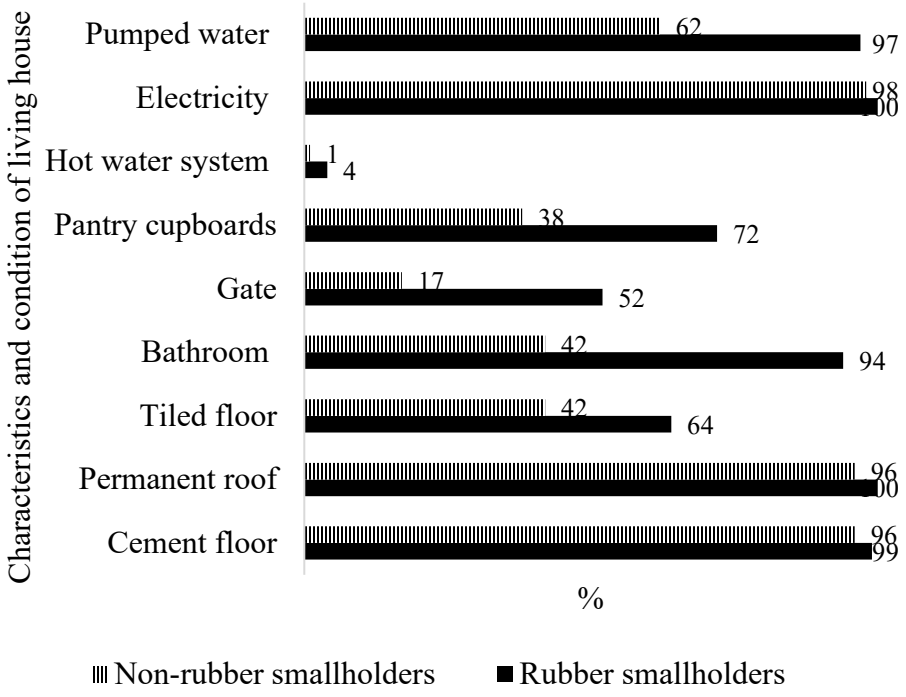

Figure 3: Characteristics and Condition of the Living Houses of Smallholders

[Source: Field Survey, 2022]

Durable household goods

Table 4 indicates the durable household goods of smallholders. Durable household goods were measured with the use of 25 different types of assets. All types of household assets of RSHs were higher than that of NRSHs except for normal phones.

Table 4: Durable Household Assets of Smallholders

Type of household assets	Rubber Smallholder's households (%)	Non-rubber smallholder's households (%)
Water purification machine	4	3
TV (LCD)	66	37
TV (Normal)	36	47
Cassette recorder (Normal)	34	20
Home theatre	14	8
Cassette recorder (High)	63	35
Refrigerator (Double door)	84	35
Refrigerator (Single door)	16	27
Gas cooker	89	51
Rice cooker	91	45
Washing machine	57	34
Sofa	85	43
Desktop computer	69	23
Laptop computer	28	19
Oven	45	23
Microwave oven	45	36
Electric kettle	77	47
Electric iron	95	93
Smart phone	71	58
Normal phone	100	100
Internet	77	35
Satellite TV	68	41
Ceiling fans	73	59
Table fans	65	45
Stand fans	74	58

Source: Field Survey, 2022

Ownership of agricultural and non-agricultural vehicles

Figure 4 shows the ownership of vehicles, both agricultural and non-agricultural, by the smallholders in the study sample. The most of RSHs (93%) and NRSHs (47%) have owned three wheelers which were mainly used for domestic purposes while some were involved in transport of agricultural products and public. Smallholders who owned canters and Lorries used them to transport agricultural goods such as planting material, harvest, fertilizers, etc. So that, an additional income was generated through transport in both categories of RSHs and NRSHs. The percentage of ownership of agricultural vehicles namely combined harvesters (11%), four-wheel tractors (14%) and two-wheel tractors (28%) were higher in RSHs and an additional income was generated through them.

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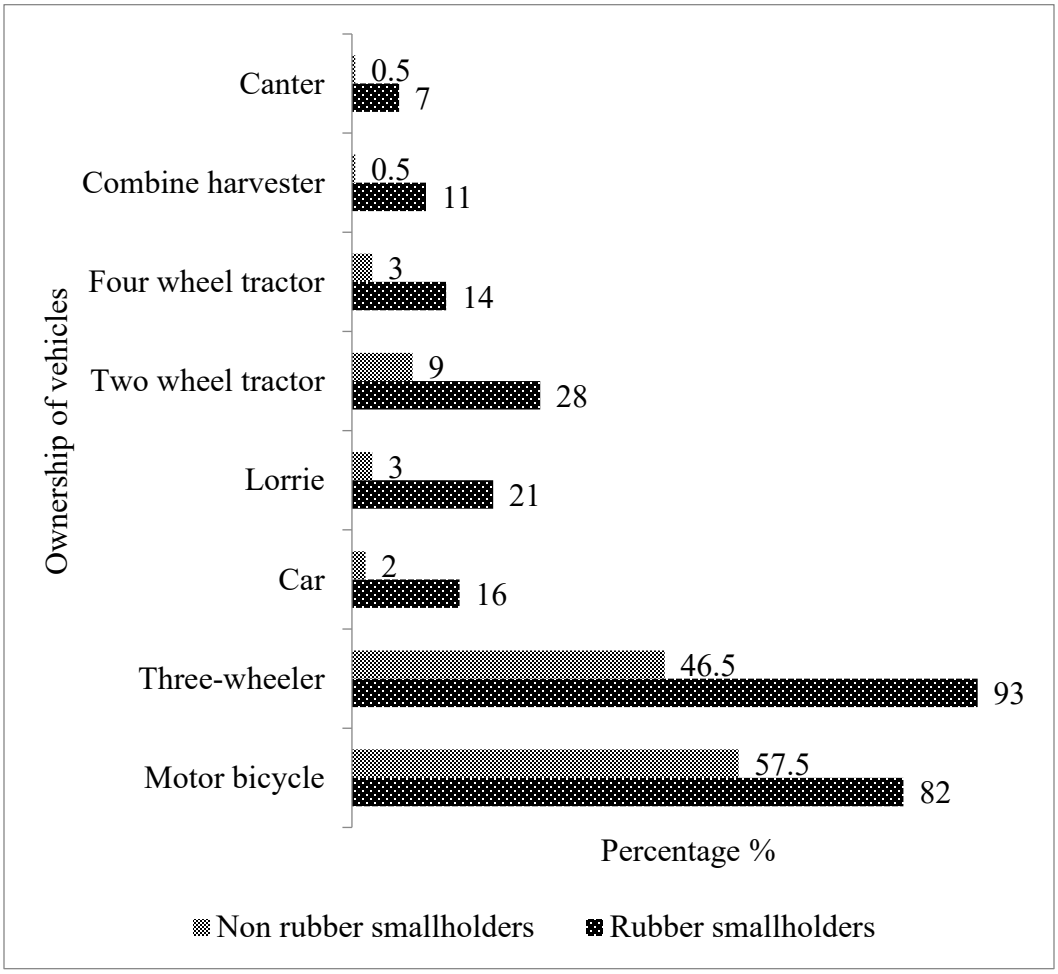

Figure 4: Ownership of Vehicles of Smallholders

Source: Field Survey, 2022

Impact of rubber farming on household wealth

HWI was normally distributed. HWI which reflects household's ownership (or lack thereof) of a range of household wealth assets (Characteristics of the living house, durable household goods and ownership of agricultural and non-agricultural vehicles) was developed to measure the households' long-run economic wealth during the period of study to assess the impact of adoption of RF on household wealth in Intermediate Zone in Sri Lanka. The means of HWI of RSHs and NRSHs were 63.5% (Range = 14% - 98%, SD = 23.2) and 45.8% (Range = 9% – 93%, SD = 18.2), respectively. The impact of RF on HWI of the households is estimated with the NNM 1: 1 model. The average treatment effect has indicated that adoption on RF exerts a positive and statistically significant effect on HWI by 16.3%, which is higher than NRSHs. As a result of that null hypothesis (H_0) was rejected, as there is a significant impact of RF system on the smallholders' HWI in Moneragala District.

Discussion

Some studies (Ashley and Hussein, 2000; Nath and Inoue, 2009; Rist *et al*., 2010; Scoones, 2009) has shown the impact of newly introduced cropping systems (without rubber farming) on livelihood of rural farming communities by developed varies methodologies. Several studies have explored the impact of rubber farming on rural livelihood assets (Nath *et al*., 2013; Viswanathan and Shivakoti, 2006; 2008) and financial aspects (Fu *et al*., 2009; Fox and Castella, 2013; Viswanathan and Shivakoti, 2006). Furthermore, Nath *et al*., 2013, Munasinghe *et al*., 2019; Gunarathne *et al*., 2023; Gunarathne *et al*., 2019; Stirling, 2000 and Thennakoon, 2002 have explored how existing rubber cultivation and farming enhance rural livelihood in the Sri Lankan context. Dietary needs of smallholders in Intermediate and Dry Zones in developing countries basically depend on the subsistence agriculture. Additional agriculture production was sold to fulfill the other household needs.

The high risk and uncertainty of subsistence agriculture, climate vulnerability and poor application of technology are key issues in hidden poverty in developing countries. The most of smallholders receive the regular social benefits given to the poor by the government. In 2021, 8 % of smallholders in Moneragala district were also benifited by monthly monitory benefit called *Samurdhi payment.* The expansion of rubber farming in Moneragala aims at providing a permanent income source to the poor for the livelihood improvement in Sri Lanka which was the focal point of the present study.

Improvement in condition of the living houses (*e.g. pantry cupboards, bathrooms, gates, pumped* water supply, tiled floor), durable household assets (*e.g.* electric appliances and furniture), ownership of vehicles (*e.g. Non-farm vehicles and farm vehicles/machineries*) of smallholders reflect the changes in living standards of them associated with rubber farming in Moneragala. Many of RSHs have upgraded the basic infrastructure facilities of their houses (e.g. Tiled floor, bathroom, gate and pantry cupboards), some luxury appliances of convenience (e.g. electric appliances and furniture) due to the RF. Similar finding has been reported by Nath and Inoue (2009) and Nath *et al*. (2013).

Q_mh+ for overestimation of the treatment effect and *Q_mh-* for underestimation of the treatment effect have resulted in a similar value implies the unobserved selection bias or absence of hidden. So that, according to (Smith and Todd, 2005), it was implied that the matching process significantly reduced the selection bias, causing the balancing property to be satisfied. Accordingly, unobserved hidden bias was absent in this average treatment effect analysis with regard to HWI. Therefore, the selection process indeed has ensured that the two parties (RSHs and NRSHs) have the same observed covariates, while possessing the same chances of getting the treatment, which in turn results in an odds ratio of one. There was no difference in the distribution of the observed covariates between treated and control groups. These results suggest that the proposed specification of the propensity score was successful in terms of balancing the distribution of covariates between the two groups of RSHs and NRSHs.

Accordingly, there is a significant impact on enhancement in household assets of smallholders is due to the income from farming. Before introducing rubber farming into Moneragala district, the majority of smallholders live on under rain-fed agriculture and no guarantee is available to provide stable family income under the climate vulnerability and crop nu-certenity. The most of time, by the community development projects pumped cash towards the smallholders as aids for enhancement of their socio-economic status in Moneragala district. By the introducing of rubber farming in Moneragala district will create a win-win situation where the Sri Lankan Government can develop the rubber industry by supporting the rural smallholders. Finally, the findings of this study show the positive impact of rubber farming on the economy at household. Therefore, it is justified the efforts and investments made to expand the rubber farming in the areas of Intermediate Zones for the enhancement of smallholders' socio-economic status.

conclusion and Recommendations

The characteristics pertaining to living houses and household assets (excluding normal phone) and both agricultural and non-agricultural vehicles of the households were all higher among rubber smallholders compared to non-rubber smallholders. The average treatment effect indicated that the adoption on rubber farming has had a positive effect on household wealth by 16.3%, which is higher than households of non-rubber smallholders in study area. The policy intervention should focus on expansion of rubber farming into Intermediate Zone in Sri Lanka with the aim to enhance the wealth status of smallholder households.

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