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Factors associated with choice of tea cultivars in Badulla District of Sri Lanka

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ABSTRACT

This study aims to investigate the impact of demographic, economic status and farming characteristics on the choice of tea plant cultivars among tea smallholders in Badulla district. Since the best selection of tea plant cultivar is the major aspect of raising the tea productivity and yield, tea smallholders face the problem of selecting the best variety to adopt in their farming. 108 tea smallholders were randomly selected from three Divisional Secretariat divisions in the Badulla district. A set of questionnaires was issued to the selected tea smallholders in 2019. The collected data was analyzed using various analytical such as frequency and chi-square test, one way ANOVA and multinomial probit model in the study. The frequency analysis revealed that 43.5% of the smallholders chose VP 20/25 cultivar, while 29.6% and 26.9% chose VP 20/23 and CY9 cultivars, respectively. Results of the chi-square test revealed that gender and types of marketing channels have significantly associated with the choices of tea plants, whereas one way ANOVA implied that the average yield of VP20/25 and VP 20/23 cultivars are the same, but they differ from CY9. The multinomial probit model revealed that gender, secondary education, farm experience, income, land size, output and prices of each tea plant, types of marketing channels and frequency of harvest are major determinants in the choice of tea plants in the study. It is better to extend a study on the choices of tea cultivars with new series and their implications to compare the adoption preferences between different series of cultivars. These findings are useful for tea plant cultivars and tea estate owners to engage in tea farming efficiency.

Keywords: Choice of tea plant cultivars, demographic and economic characteristics, multinomial probit model, marginal effects, tea smallholders

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1. Introduction

Among three major plantation sectors, tea is one of the important agricultural products and industries in Sri Lanka that contributes a substantial amount of foreign exchange income and provides employment opportunities for the people who live in many districts of the country (Perera, 2014). During the British era, tea was introduced in 1867 as a substitute for coffee and out of the total land area, nearly 4% of the land covered by the tea plantations. The introduction of the tea sector in Sri Lanka has a long history which is more interacts with the economy in terms of contribution to the gross domestic product and the major income sources, especially for the estate women who get job opportunities in the country. In the tea sector, the cultivators are smallholders, and they have private-owned lands, while most of the large-scale plantations are managed by the private sector, and the state owns very few. The tea sector and its

performance mainly depend on the production systems of the smallholders. Out of total tea production, 70% of the contribution is given by the smallholders in Sri Lanka (Future of work for Tea Smallholders in Sri Lanka, 2018). Low productivity, low household income, poor adoption of technologies, small land size, senility of tea, poor service receiving from the state agencies, weak infrastructure facilities, labour issues and low prices for green leaf tea are the interconnected critical issues faced by the smallholders at present in Sri Lanka (Mahindapala, 2020).

Smallholders are more important and engage in tea cultivation to provide a higher productive tea yield. Thus, the future of the tea industry in the country will depend on the choices of smallholders regarding tea plant cultivars and their production systems. In the case of the Sri Lankan tea industry, there are fewer opportunities to adopt new farming techniques by the tea estate owners and cultivators. Because of a lack of financial facilities, skills, and knowledge, they could not apply them properly. Even though most tea smallholders have chances to select different cultivars of tea plants in their cultivation, they try to earn more profits with a lower risk by choosing the best one. In the context of the increasing importance of the tea smallholders, it is necessary to understand their role as stakeholders and their adoption decisions which may raise the productivity of the tea yield in the country.

Badulla district has 15 divisional secretariats, and in most areas, tea is the leading sector managed by the estate owners. Out of the major three plantation crops, tea, rubber and coconut, tea is the major crop produced in the district, where most tea estate owners cultivate it. In 2017, 11.9% of the extent of land was used for tea cultivation in the Badulla district (The performance Report and Annual Accounts of District Secretariat, Badulla, 2017). The average tea yield depends on the types of tea plant varieties, planting systems, geographical environment, etc. Based on the ecological differences, growth and yield performance, pest and disease resistance, there are many tea plant cultivars have been suggested by Tea Research Institute for different tea growing districts in Sri Lanka (Warushamana, 2021). In the 1950's tea research institute introduced Vegetative Propagated (VP) improved tea varieties as a high yield and economically viable vegetative propagation method and with other characteristics such as pest and disease resistance among smallholder tea farmers in Sri Lanka. Later on, different varieties of tea plants, seminal series of TRI 2000, 3000 and 4000 cultivars were also introduced by the tea research institute to increase the production of tea plantations qualitatively and quantitatively, which have a higher yield compared to VP tea varieties and they have disease tolerance characters as a source of planting material. The TRI 2000 series is the first VP generation introduced based on different climatic zones. Therefore, TRI 2025 considered suitable for upcountry, TRI 2024 was found as more applicable for up-country and the Uva, while TRI 2023 and 2026 were introduced for low country (Warushamana, 2021).

In later years, new improved tea cultivars, namely, TRI 3000 and 4000 series, were introduced with conventional breeding with more yield potential and improving other characters. This series of cultivars give the potential yield of between 4000-5000 Kg per Ha. Even though there are various tea plant varieties introduced in Sri Lanka, the tea smallholders who engage in the tea sector mostly adapt the VP series in the Badulla district. Mainly, they use three cultivars of tea plants, namely, VP2025, VP2023, and CY9 and they are differing in terms of cost, maturity period, quality, and availability. Mostly they are smallholders, and they aim to earn more income within a short maturity period at minimum risk. There are many factors influencing their choices of tea cultivars, and based on the factors they want to find out the best cultivar to get more yield and income.

The adoption of modern tea plant cultivars is often cited as a key to increasing tea production efficiency. But some growers are maintaining a combination of seedling and VP teas in their plantations as an effective adaptation measure to minimize their risk. Thus, the cultivar of tea plants is also one of the main production factors in small holder tea cultivation.

Problem Statement

In Sri Lanka, the government campaigns to encourage improved tea cultivars and many efforts have been made by Tea Research Institute to develop modern multi-cultivars of tea plants with higher productivity. Even though there is still low usage of these improved cultivars among smallholder tea cultivators in the country, it has been observed that most smallholder farmers have also tended to stick to preferred traditional cultivars due to their personal and existing farming characteristics. Also, among the different cultivars of tea plants, they want to select the best one to get more yields within a three to five years maturity period at a lower risk. High cultivars of plants give a more average yield, which may also have a certain level of risk and uncertainty. To enhance the small-scale farmers to adopt the improved cultivar of tea plants in their farming activities, especially in Badulla district, they should learn about the usage and benefits of the improved tea plant cultivars. The proper awareness program on the adoption of tea plant cultivars should be given to them, and thus, the farmers may be encouraged to select the best cultivar in the tea industry.

In this background, to increase smallholders' access to improved tea plant cultivars and for their effective choices, researchers and development practitioners need to understand how the tea market channels are structured. They should clearly understand the smallholders' preferences for multiple tea plant cultivars by their interactions and collaboration. These interconnections motivate the tea growers to make their choices easily and guide them to apply the appropriate cultivar in tea cultivation in the district.

Objectives of the study

This study focusing on the following objectives.

- To measure the degree of association between socio - demographic, economic and farming characteristics and the adoption decisions towards tea plant cultivars in the study.
- To identify any significant differences in the average productivity of tea across three cultivars of tea plants in the study area.
- To evaluate the impact of tea smallholders' socio - demographic, economic and farming characteristics on adoption decisions towards the choices of tea plant cultivars in the study.

2. Literature Review

Akinwumi et al., (1993), investigated the technical characteristics of yield, taste and tiller, perceptions of the farmers and their adoption decisions among modern mangrove swamp rice cultivars in Sierra Leone. They applied the Tobit model and its results proved that the farmers' perceptions are the driving factors in determining the adoption and use intensities in modern mangrove swamp rice cultivars in the country. Joshi and Bauer (2006) reported that the thresh ability, usage of grains for preparing special products, early maturity of the cultivar, less irrigation requirement, sources of seed, education and the experience of the farmers were the significant variables which effect on farmers' choice of the modern rice cultivars in Nepal.

Phu Nguyen-Vana et al. (2011) examined the decision of farmers toward tea varieties in Vietnam, and they used a multinomial logit model to analyze the data. They found that income, age, family size, contract in farming, usage of organic fertilizers and membership in professional associations are the key determinants in the adoption decision on tea varieties in Vietnam. Another study was done by John Kipkorir Tanui, et al. (2012) analyzed the socio - economic constraints in adopting improved tea farming technologies in Nandi Hills, Kenya. Their results showed that 99% of smallholders grow high yielding TN14/3 and C12 tea cultivars in the country. Results of the logistic model showed that sex of the household members,

awareness of benefits and costs, and extension services significantly impact the adoption of tea farming technologies among tea farmers in Kenya.

Bandara et al. (2015) assess the performance of TRI 3000/4000 cultivars in different agro-ecological regions in mid-country Sri Lanka. Sixty farmers were selected randomly to analyze the data, and their results implied that cultivars of 4053, 4006 and 4046 can be cultivated successfully in every agro-ecological region in mid-country of Sri Lanka.

A study related to the tea sector was done by Sita (2015) evaluated the impact of socio-economic characteristics on tea farming management behavior across tea smallholders in West Java Province. They used proportional random sampling methods to select the 320 respondents which was analyzed by multiple linear regression model. Gender, main job, tea productivity, prices of tea, and tea farming income were found to positively impact the farm management behavior of tea smallholders in the study. Factors determining the adoption decision of farmers who cultivate tea in Vietnam towards agricultural practices were examined by Nguyen-Van et al. (2017). They found that the number of workers in the family, farm size, price of tea, access to irrigation systems, the ratio of tea income, and attendance of training were significant determinants of the decision in Vietnamese agricultural practices.

In the study of determinants of adoption decision of newly improved tea cultivars by tea small holders in Uva region analyzed by Jayasinghe & Alwis (2016) reported that, education of tea small holders, awareness and knowledge level, contact of extension service, experienced with drought, membership of agricultural association, field affected by pest are the factors affecting to increase the adoption decision of newly improved tea cultivars by tea small holders Uva region.

Significance of the study

In Sri Lanka and worldwide, the demand for tea has been rising corresponding to the rises in population, taste of the customers, and quality of the tea and thus to meet the increase in demand and satisfy the consumers high yielding cultivars are important. On the other side, since the tea sector contributes a significant role to the GDP and provides job opportunities for the people in Sri Lankan economy, adopting improved tea plant cultivars is necessary in farming. The outcomes of this research will be beneficial and contribute to the design of the best policies and strategies in tea cultivation and helping tea smallholders in the Badulla district to improve their livelihoods through the adoption of the tea plant cultivars. The knowledge and information on adoption decision towards tea plant cultivars and its impact on tea production help the government and private sector involved in tea business to improve the tea sector in the district.

3. Research Methodology

This section describes the population and sample and sampling framework used in the study. In addition to that, the method of data collection and different methods of analytical tools are also described in this section.

3.1 Population and sample selection

The population of this study covered all tea smallholders who are engaging in tea cultivation in the Badulla district during the period from November to December 2019. The Badulla District has many tea estate owners, and mainly, they are engaging in tea cultivation. Due to this reason, this study was conducted in the Badulla district, which was purposely selected, and from this district, three DS divisions, namely Badulla, Haliela, and Bandarawela were chosen as a sample in the study.

3.2 Method of data collection

The data were collected through a structured questionnaire issued to the sample of smallholder tea estate owners in the central province during the period November to December 2019. Districts, villages and tea estate owners were selected using a multistage random sampling technique, and in the first stage, based on the intensity of tea production Badulla district was taken as the study area. Badulla district has 15 Divisional Secretariat Divisions, and out of them, only three divisions, namely Badulla, Haliela, and Bandarawela were randomly selected in the second stage. Finally, a random sample of 50 tea smallholders was drawn from each division with 150 respondents in the study. However, those data were tested to check whether outliers were present or not and after removing them, 108 respondents were used in the study. To model the adoption decisions of smallholder tea estate owners towards the choice of multiple tea plan cultivars, the primary data related to socio-demographic, economic-related and farming characteristics were gathered using a structured questionnaire.

3.3 Methods of data analytical techniques

To identify the impact of tea smallholders' socio-demographic, economic-related, and farming characteristics on adoption decisions towards the choices of tea plant cultivars, the researcher employed different methods of statistical analysis such as frequency and descriptive statistics, chi-square test, one way ANOVA, multinomial probit model and its marginal effects in the study.

3.3.1 Frequency analysis

The frequency analysis is the way to graphically and table formats to explain the data, which gives more attraction and clear understanding to the readers. Categorical variables related to the demographic and farming characters were used in the frequency analysis.

3.3.2 Descriptive statistics

Descriptive statistics are used to describe the basic features and provide a simple summary of the study. Quantitative data which are applicable in this study were analysed using descriptive statistics such as mean, standard deviation, and custom tables also applied to investigate the relative importance of major variables and attributes of the tea estate owners in the study.

3.3.3 Chi-square test

In the case of categorical variables, the chi-square test is more helpful to express whether there is any significant association that exist or not among them. Chi-square test is employed to identify the association between the three cultivars of tea plants and the selected variables used in the study.

3.3.4 One–way ANOVA

One way ANOVA was applied to examine whether there are any mean differences in the average yield of tea across three tea plant cultivars VP20/25, VP20/23 and CY9 in the study.

3.3.5 Multinomial probit model

When a dependent variable has more than two categorical without any order, the multinomial probit model is more applicable than other regression models. Thus, this model is more useful for comparing the outcome with a reference category. The impact of estimated coefficients on the outcome can be interpreted in terms of likelihood. The model attempts to explain the relative effect of differing explanatory variables on the different outcomes in the process. A multinomial probit model is often in terms of latent variable which can be written as:

$Y_i^{1*} = \beta_1 . X_i + \varepsilon_1$
$Y_i^{2*} = \beta_2 . X_i + \varepsilon_2$
……..
$Y_i^{m*} = \beta_m . X_i + \varepsilon_m$

Where,
$\varepsilon \sim N(0, \Sigma)$

Then,

$$Y_i = \begin{cases} 1 & \text{if } Y_i^{1*} > Y_i^{2*}, \ldots, Y_i^{m*} \\ 2 & \text{if } Y_i^{2*} > Y_i^{1*}, Y_i^{3*}, \ldots, Y_i^{m*} \\ \ldots & \ldots \\ m & \text{otherwise.} \end{cases}$$

That is,

$$Y_i = \arg\max_{h=1}^{m} Y_i^{h*}$$

When the tea smallholders have the possibility of selecting more than one cultivar, they can decide which tea plant cultivar need to adopt in their cultivation. In these circumstances, there are more choices instead of only two choices, the multinomial probit model is more appropriate. To identify the impact of demographic, economic related and farming characteristics on the adoption of tea plant cultivars which has three categories, a multinomial probit model was employed in the study.

Multinomial probit model for socio - demographic characteristics

The impact of demographic factors on the adoption preferences towards different tea plant cultivars was estimated by using the following model.

$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$…… …… (1)

Where,

Yi = Cultivar of tea plants coded as,
1 for VP20/25
2 for VP20/23
3 for CY9
X1 = Age in years
X2 = Education levels coded as
1 for primary, 0 otherwise
1 for secondary, 0 otherwise
1 for higher, 0 otherwise.
X3 = Gender coded as 1 for male and 0 for female.
X4 = Experience in farming in years
ε = Error term
β0 = Constant

β1, β2, β3, β4 are the coefficients of each independent variable.

Multinomial probit model for economic characteristics

The following model was used to identify the impact of economic-related characteristics on the adoption preferences towards different tea plant cultivars in the study.

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon \quad (2)$$

Where,

Y_i = Cultivar of tea plants as mentioned earlier.

X_1 = Income from tea cultivation in Rs

X_2 = Land size in Ha

X_3 = Yield from each tea plant cultivar in Kg

X_4 = Price of each tea plant cultivar in Rs

ε = Error term

β_0 = Constant

$\beta_1, \beta_2, \beta_3, \beta_4$ are the coefficients of each independent variable.

Multinomial probit model for farming characteristics

The impact of farming characteristics on the adoption preferences towards different tea plant cultivars was estimated by using the following model.

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon \quad (3)$$

Where,

Y_i = Cultivar of tea plants as mentioned earlier

X_1 = Availability of training coded as 1 for yes and 0 for no

X_2 = Types of marketing channel coded as 1 for tea factory and 0 for intermediary

X_3 = Frequency of harvest from each tea plant in numbers

ε = Error term

β_0 = Constant

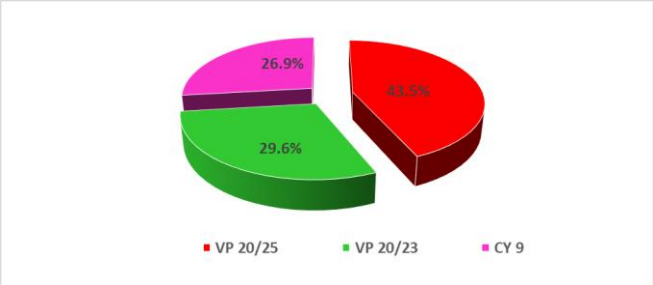
$\beta_1, \beta_2, \beta_3, \beta_4$ are the coefficients of each independent variable.

4. Results and discussion

Results of frequency

Frequency analysis is the basic statistical technique to explain the summary picture of the major variables used in the study in terms of percentages and graphs. In the beginning, frequency analysis is applied using a pie chart to illustrate the frequency of the choices of the three different tea plant cultivars among the smallholders.

Figure 1: Frequency of choices on tea plant cultivars



Source: Survey data, 2019/2020

The graph shows that, among the three tea plant cultivars, 43.5% of the smallholders preferred the cultivar of VP 20/25 which is the highest preference, whereas only26.9% of the smallholders preferred the cultivar of CY9 in the study. 29.6% of the respondents chose the VP 20/23 cultivar, which is the second preference they gave in the study.

Table 1: Profile of the tea smallholders

Variables	Category	Frequency	Percentage
Gender	Male	63	58.3
	Female	45	41.7
Availability of training	Yes	39	36.1
	No	69	63.9
Marketing channels	Tea Factory	95	88
	Intermediary	13	12

Source: Survey data, 2019/2020

The sample size of 108 tea smallholders revealed that 58.3% of the tea estate owners are males while the rest, 41.7% of them, are females engaging in the tea sector in the study area. The availability of training facilities for the smallholders on the selection of tea plant cultivars and cultivation techniques reveals that nearly 64% of them do not have any proper training opportunities. In comparison, only 36.1% have those opportunities in the sample. Out of two marketing channels to sell their tea leaves, the majority of them (88%) sell their tea leaves directly to the tea factories, whereas only 12% of them sell the tea leaves through intermediaries in the study.

Results of descriptive statistics

In addition to the frequency statistics, descriptive statistics are also used to describe the basic features of the selected variables related to the average yield derived by the smallholders from three cultivars of tea plants, some selected demographic and related economic characters and farming characteristics of the respondents in terms of mean, median, standard deviation. The descriptive analysis of the choices of tea plants and their yield revealed that the average yield derived from the cultivar of VP 20/25 is the highest one, and the yield from the cultivar of CY 9 is the lowest in their cultivation.

Table 2: Descriptive statistics of tea plants and their yield

Tea Cultivars	Numbers	Average yield	Standard deviation
VP 20/25	47	140.00	88.231
VP 20/23	32	133.50	77.726
CY9	29	87.93	34.396
Total	108	124.09	76.803

Source: Calculated by author, 2019/2020

Based on average value of yield among three cultivars of tea plants, the highest one is VP 20/25 while the cultivar of CY9 gives the lowest yield. The findings of these results coincided with the frequency of choices of tea cultivars. Because of the highest yield of cultivar VP 20/25, it is mostly chosen by the tea smallholders. On the other hand, the cultivar CY9 provides an averagely lower yield, and due to that, only 26.85% of them selected that cultivar in their cultivation.

The below table 3 summarizes the basic statistics of the samples, which showed that the average age of the tea estate holders is nearly 53 years old, with the minimum and maximum ages of 27 and 78years, respectively. On average, they have 73 acres of tea estate land with a standard deviation value of 56 and nearly they have 20 years of farming experience in the tea sector. Furthermore, on average, 124.09 Kg of tea leaves were produced from all three tea plant cultivars with three times harvest per month. Finally, the average price of the tea plant is Rs25/= per Kg with a standard deviation of 4.9 in the sample. Descriptive statistics of selected variables across three cultivars of tea plant adopters were illustrated in Table 4.

According to the above results, age-wise, there was no difference between the three different tea plant cultivars who adopt VP 20/25, VP 20/23 and CY9. Similarly, family size and farming experience also do not have much difference between them, and other variables have significantly differed from each other.

Table 3: Descriptive statistics of the variables

Variables	Maximum	Minimum	Mean	Standard deviation
Age of the farmer	78	27	52.57	10.98
Family size	6	1	3.8f5	1.17
Land size	320	2	73.32	56.47
Experience	50	1	19.85	10.87
Output of tea	350	12	124.09	76.80
Number of harvests	4	1	2.51	0.69
Price of tea plant	36	10	25.48	4.90

Source: Calculated by author, 2019/2020

Table 4: Descriptive statistics across different tea plant cultivar adopters

Types of tea plants	Variables	Mean	Standard deviation
VP 20/25	Age	52.85	10.948
	Family size	4.06	1.111
	Land	83.45	66.329
	Experience	19.81	9.582
	Output	140.00	88.231
	Harvest	2.64	.673
	Price	24.09	5.085
VP 20/23	Age	52.25	11.728
	Family size	3.66	1.066
	Land	58.56	37.322
	Experience	18.25	12.150
	Output	133.50	77.726
	Harvest	2.53	.718
	Price	23.75	4.127
CY 9	Age	52.48	10.582
	Family size	3.72	1.360
	Land	73.21	54.758
	Experience	21.69	11.440
	Output	87.93	34.396
	Harvest	2.28	.649
	Price	29.66	2.439

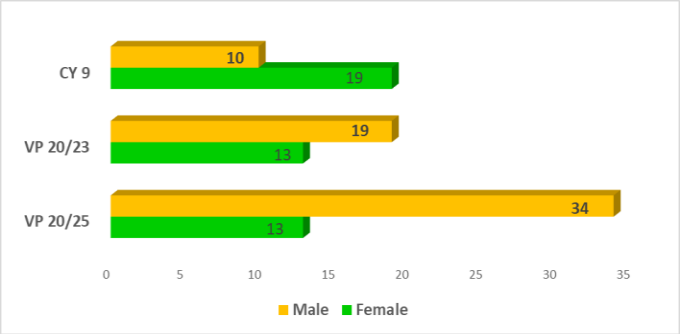
Source: Calculated by author, 2019/2020

The average experience in farming for the cultivars of VP 20/25 and CY9 was nearly 20 and 22 years, respectively, but the experience of the smallholders who chose the cultivar VP 20/23 was 18 years. The average size of land for the cultivars of VP 20/25 and CY9 has 83.45 and 73.21acres, while the cultivated land for the CY9 cultivar is 58.5 acres, which is remarkably lower than the other two. Average output from each cultivar also significantly differs from each other, and according to that, outputs from VP20/25 and VP20/23 were found to around 140Kgs and 133Kgs respectively whereas, from CV9 is nearly 88Kg which is lower than the first two cultivars. Even the frequency of harvest across the three cultivars is the same prices of each tea plant cultivar significantly differ among them. Thus, the above comparative analysis suggests that the only average yield from each tea plant cultivar and average prices significantly differ among the three cultivars. The rest of the other variables were the same in the study.

Chi-Square test

This test was used to identify any significant association between the selected categorical variables and the adoption preferences of tea plant cultivars in the study area. First, the frequency of adoption preferences of three tea plant cultivars across male and female respondents are graphically shown in Figure 2.

Figure 2: Choices of tea plant cultivars across gender



Source: Survey data, 2019/2020

The above graph showed that 34 of the males preferred to adopt VP 20/25 cultivar among total respondents, whereas 19 females preferred to adopt the CY9 cultivar. The CY9 cultivar is less preferred by the males but is the highest preference by the females in the sample.

Results of the chi-square test imply that 28.9% of females choose the cultivar of VP20/25 while the majority of them select the CY9 cultivar as their best choice. Among males, 54% of them adopt the cultivar VP20/25 as their best cultivar, while only 16% choose the CY9 in the sample. The results concluded that male tea smallholders are more likely to adopt the VP20/25 cultivar, whereas females are more likely to adopt the CY9 cultivar. The chi-square value further proves that gender has significantly associated with the choices of tea plants at a 1% level, but the availability of training has not been associated with the choice of tea plants in the analysis.

The choice of marketing channel has associated with adoption preferences towards three cultivars of tea plants, and it is statistically significant at a 10% level. 46% of the tea estate owners sold their output produced from the cultivar VP20/23 sold by the estate owners through intermediaries, but 47.4% of them who chose the cultivarVP20/25 marketed their output to the tea factories directly.

Table 5: Results of the Chi-square test

		Types of tea plants			
		VP 20/25	**VP 20/23**	**CY9**	**χ^2 value**
Gender					10.59***
	Female	28.9	28.9	42.2	
	Male	54	30.2	15.9	
Availability of training					2.46
	No	40.6	27.5	31.9	
	Yes	48.7	33.3	17.9	
Marketing Channel	Intermediary				4.79*
		15.4	46.2	38.5	
	Tea factory	47.4	27.4	25.3	

Source: Calculated by author, 2019/2020

Note: *** and * represents significance at 1%, and 10% levels respectively.

One-way ANOVA

One way ANOVA was used to identify whether there are any significant differences in the average output of tea across three cultivars of tea plants, and its results are shown in Table 6 Because of the differences among three cultivars of tea plants, the Post Hoc test was applied to find out the differences among them. The results of multiple comparisons are given in Table 6.

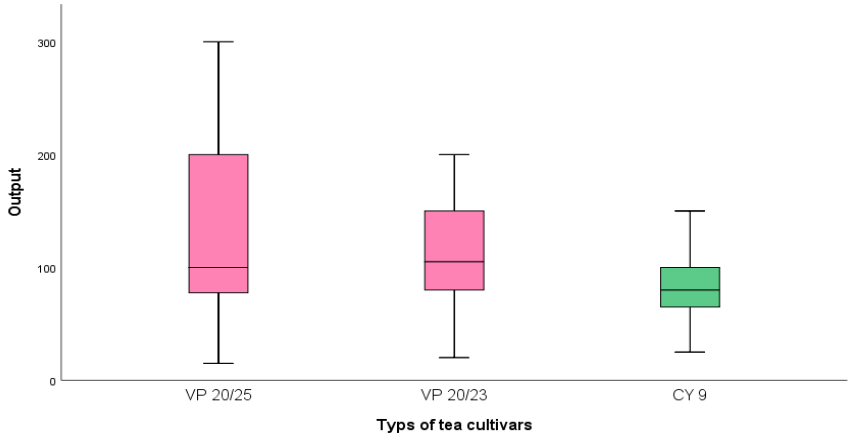
Table 6: Results of multiple comparisons

Tea plants(i)	Tea plants(j)	Mean difference	Standard error	Significance
VP 20/25	VP 20/23	6.50	17.012	0.923
	CY9	52.06***	17.527	0.010
VP 20/23	VP 20/25	-6.50	17.012	0.923
	CY9	45.56**	19.031	0.048
CY9	VP 20/25	-52.06***	17.527	0.010
	VP 20/23	-45.56**	19.031	0.048

Source: Calculated by author, 2019/2020
Note: *** and ** represents 1% and 5% significant levels respectively

The results of the multiple comparisons table explained that the average yield does not differ between the cultivarsVP20/25 and VP20/23 but differs from CY9 with significant at a 1% level. Thus, compared to the cultivar CY9, cultivarVP20/23 provides 45.56 Kg more yield in the study area. Further, the average yield from the cultivar VP 20/23 differs from CY9 by the amount of 45.56 Kg and is statistically significant at a 5% level. In addition to the multiple comparisons, the differences in average output across three cultivars of tea plants can be illustrated using a simple box plot below.

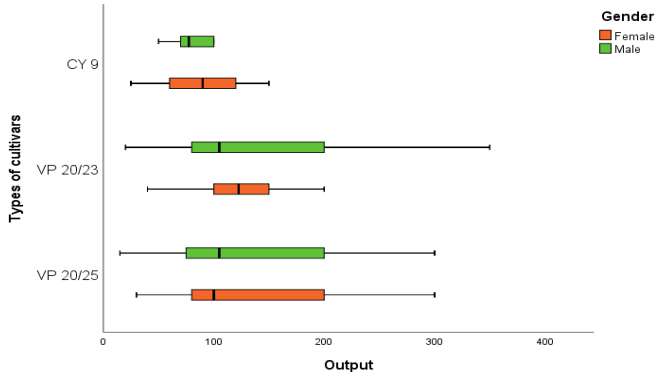
Figure 3: Average output across three cultivars of the tea plant



Source: Based on the survey data, 2019/2020

The above graph suggests that the cultivar of CY9 belongs to one group while the other two cultivars belong to another group. Thus, CY9 cultivar differs from the other two cultivars, VP20/23 and VP20/25, and these two cultivars are nearly identical thus, they belong to the same group.The average yield derived from each tea cultivar was measured across gender and shown graphically below.

Figure 4: Average output of three cultivars across gender



Source: Based on the survey data, 2019/2020

The figure suggests that the average tea yield derived from three different tea cultivars is not the same, which shows that males and females have different experiences and skills across their cultivars in getting their yield in the study.

Multinomial Probit Model

To modelling the tea smallholders' adoption decisions on tea plant cultivars in Badulla district, demographic characters, economic related characters, and farming characters were used to analyze the data. First of all, socio – demographic characteristics and its impact on adoption decisions on tea plant cultivars were analyzed using multinomial probit model. The estimated results were given in Table 7.

Table 7: Results of multinomial probit model for socio - demographic characters

	VP 20/23		CY9	
Variables	**Coefficients**	**Standard error**	**Coefficients**	**Standard error**
Age	0.0032	0.0218	-0.0239	0.2444
Gender	-0.4214	0.4083	-1.4190***	0.4221
Secondary education	-0.8074*	0.4481	-0.2879	0.4588
Higher education	-0.0789	0.5504	-0.1461	0.6015
Experience	-0.0109	0.0234	0.4254*	0 .0249
Constant	0.3900	1.0689	0.9446	1.1413
Number of observations		108		
Log likelihood		-106.152		
Wald > Chi^2 (10)		0.048		

Source: Estimated author using STATA 13, 2019/2020

Note: *** and * represents 1% and 10% significant levels respectively

The impact of each variable on the choice of tea plant cultivar was measured, considering cultivar VP20/25 as the reference group. In the table, the likelihood ratio was -106.152, with the significant value of Wald chi-square, revealing that the estimated model is adequate. Further, it suggests that all five explanatory variables used in the study are collectively significant in influencing the smallholders' choices of tea plant cultivars.

The above table shows that out of five socio - demographic characteristics, only three variables, gender, secondary and farming experience, significantly impact small tea estate owners' adoption decisions towards tea plant cultivars in the study. The coefficient of age has a positive sign for the VP 20/23 cultivar. Still, it has a negative sign for CY9 cultivar indicates that elder farmers are more likely to choose the cultivar VP 20/23. In contrast, younger farmers are more likely to select the CY9 cultivar than the VP20/25 cultivar in the study. However, age and higher education have insignificant in the model suggested that these variables were not influencing choosing any cultivar of the tea plant in the study.

Other demographic variables, namely age, and higher education, are insignificant in the model. In the above table, gender has a negative impact on the probability of adoption preferences on the cultivars. Male tea small holders are less likely to adopt the cultivars VP20/23 and CY9 than females compared to the based group. In other words, males were more likely to choose the cultivar VP20/25, whereas females were more likely to choose VP20/23 and CY9 tea cultivars. Compared to second and third cultivars, cultivar VP 20/25 has more yield and needs to work very hard to get more yields, and this is much more possible for males than females. Because of this reason, males may prefer to adopt the cultivar VP 20/25 compared to females with other cultivars. The coefficient of secondary education has a negative sign with a 10% level of significant proof that the tea estate owners with secondary educational qualifications have less preference to select the cultivars VP20/23 and CY9 than primary and higher educated tea estate owners. Thus, the small tea estate owners with secondary educational qualifications are more likely to adopt the cultivar VP20/25 than the other two cultivars. These results further conclude that tea estate owners who are secondary educated have more farming experience and prefer to get higher output from the cultivar VP20/25 than the other two in the study.

Farming experience in tea cultivation has a significantly negative impact on the adoption preferences of tea plant cultivars with a 10% significant level. This implies that small tea holders who have more farming experience increase their probability of selecting the cultivar CY9 compared to cultivar VP 20/25 and VP 20/23. This indicates that choosing the cultivar of CY9 experience in farming is necessary to get more yield than the other two cultivars. This could be further explained by the fact that compared to the reference cultivar VP20/25, experienced tea estate owners are more likely to choose the CY9 cultivar, whereas they are unlikely on the cultivar of the other two. In addition to the demographic characteristics of tea estate owners, their economic-related characters are also included in the model, and the estimated results obtained from the model are given below.

Table 8: Results of multinomial probit model for economic characteristics

	VP 20/23		CY9	
Variables	**Coefficients**	**Standard error**	**Coefficients**	**Standard error**
Income	-0.9177**	0.4476	-0.7579	0.5581
Land size	-0.0097**	0.0049	0.0043	0.0047
Output from tea plant	0.0031	0.0028	-0.0125***	0.0045
Prices of tea plants	-0.0088	0.0435	0.3305***	0.070
Constant	0.4336	1.0795	-8.0693	1.9626
Number of observations		108		
Log likelihood		-83.5555		
Wald > Chi^2 (10)		0.000		

Source: Estimated author using STATA 13, 2019/2020

Note: *** and ** represents 1% and 5 % significant levels respectively

The maximum likelihood estimates of the multinomial profit regression model for factors influencing the adoption decisions and the choices towards the tea plant cultivars indicated that the fit of the model was satisfactory. The variation of the independent variables on adoption decisions towards tea plant cultivars in the multinomial probit regression model depends upon the variables whose p-value became significant. In the above table, the log-likelihood value is -83.55 with the Wald chi-square test at a 1% significant level, reflecting that all four economic characteristics such as income from tea cultivars, size of land, output from three tea plant cultivars, and prices of each type of tea plant were important in deciding the smallholders' choices of tea plant cultivars in the study. Among these variables, tea output from chosen tea plant cultivars and prices of plants were most highly significant than the other two variables in the model. Regarding income variable, it has significant at 5% level, indicates that smallholders' adoption decision in choosing tea plant cultivars influencing by the income. As income increases, they have less likely to choose the cultivars VP 20/23 and CY9 than the cultivar VP 20/25. Since cultivar VP 20/25 gives more yields, it will encourage the tea estate owners to adopt it more than other cultivars. The coefficient of land size has a positive sign for CY9, whereas VP 20/23 has a negative sign, which implies that the probability of chosen CY9 cultivar tends to increase, but the VP 20/23 cultivar tends to reduce with the size of land in the study area. Estate owners who have more land size, the probability of choosing VP 20/25 cultivar will be higher than who have less size of land and prefer to select the other two cultivars by allocating more land to cultivate them. A larger tea estate owner can produce more output, which motivates them to select the cultivar VP 20/25 compared to the other two cultivars than small tea holders. The coefficient of output from each tea plant cultivar has significance at a 1% level, implying that an increase in expected output from each tea plant cultivar was expected to be less likely to select CY9 cultivar and more likely to choose the other two cultivars in the sample. The results further reveal that based on the output from each cultivar, they will decide their choices among the three cultivars.

Another economic-related variable is the prices of each tea plant which is statistically significant at a 1% level in the model. This result implies that as the prices of each tea plant increase, the probability of choosing CY9 also increase while choices of the other two cultivars will be less in the study. Because of the price concerns, many small tea holders are more likely to select the cultivar CY9 while less likely to select the cultivar VP 20/23 than the cultivar VP 20/25. Also, tea smallholders' response to the price level of each tea plant has mostly influenced their choices among the different tea cultivars in the study.

In addition to the above two characteristics, other three variables related to the farming characteristics, such as availability of training, choices of marketing channel and frequency of harvest from each tea plant also taken in the model and their results are depicted in Table 9. It reveals that the log-likelihood value was -109.80 with significance at a 10% level, ensuring that all the slope coefficients are significantly different from zero. In other words, the dependent variables are collectively significant in describing the choices of plant cultivars made by the tea smallholders in the study area.

Table 9: Results of multinomial probit model for farming characteristics

	VP 20/23		CY9	
Variables	**Coefficients**	**Standard error**	**Coefficients**	**Standard error**
Availability of training	-0.0328	0.3877	-0.5407	0.4212
Marketing channel	-1.3002**	0.6325	-1.3111**	0.6480
Frequency of harvest	-0.2082	0.2720	-0.6096**	0.2965
Constant	1.404	0.932	2.474	0.980
Number of observations		108		
Log likelihood		-109.8066		
Wald > Chi^2 (10)		0.0803		

Source: Estimated author using STATA 13, 2019/2020.
Note: ** represents 5 % significant level.

Out of these three variables, choice of marketing channel and frequency of harvest were significant at a 5% levels and availability of training is insignificant in the model. Coefficient of marketing channels shows that the owners who are selling their tea output directly to the tea factory, have less probability of selecting VP 20/23 and CY9 cultivars compared to VP 20/25. In other words, the marketing channel has significantly negative effects on the cultivars of VP 20/23 and CY9 while it has a positive impact on VP 20/25. This implies that the tea estate owners who are selling their tea output directly to the factories have more probability of adopting the VP20/25 cultivar. In contrast, the owners who sell their yield by intermediaries prefer to adopt the other two cultivars in the sample. The cultivar VP20/25 provides more yield than the other two cultivars. Thus, owners are more likely to sell directly to the tea factories with proper motor transport. Its entire output can also be sold quickly to the tea factories. In the case of frequency of harvest, as the number of harvests per month increases, the probability of choosing the cultivars VP 20/23 and CY9 will be lower than cultivar VP 20/25. This means that they prefer to adopt the cultivar VP20/25 because they can get more output from that cultivar with more frequently than other two cultivars, which motivates them to select the VP 20/25 cultivar in their cultivation.

Results of marginal effects

Estimated parameters of the multinomial probit model are better interpreted in terms of marginal probability, which measures the change in the likelihood of each outcome with respect to a change in each independent variable. The marginal effects for each independent variable related to socio – demographic characteristics were calculated in the multinomial probit model, and its results are depicted in Table 10.

Table 10: Marginal effects for socio - demographic characters

Variables	Types of tea plants		
	VP 20/25	**VP 20/23**	**CY9**
Age	0.0028	0.0033	-0.0062
	(0.0059)	(0.0053)	(0.0054)
Secondary education	0.1718	-0.1855*	0.0137
	(0.1151)	(0.1042)	(0.0993)
Higher education	0.0335	-0.0063	-0.0272
	(0.1505)	(0.1311)	(0.1268)
Gender	0.2656***	0.0452	-0.3109***
	(0.0979)	(0.0942)	(0.0932)
Experience	-0.0041	-0.0074	0.0116**
	(0.0062)	(0.0057)	(0.0054)

Source: Calculated by author, 2019/2020

Note: ***, ** and * represent 1%, 5% and 10% significant levels respectively and standard errors are in the parentheses.

Primary education taken as the base category

Marginal effects of secondary education for the VP 20/23 cultivar have the value of -0.1855 implies that for tea estate owners who have secondary education, the probability of selecting this cultivar decreased by 18.5% at 10% significant level, while the probabilities of selecting the other two cultivars, namely, VP 20/25 and CY9 will increase by 17.18% and 1.37% respectively, but they are insignificant. The marginal effect of gender, which has a positive value of 0.2656 and a negative value of 0.3109, indicates that male owners have 26.5% more likely to adopt the cultivar VP 20/25, whereas 31.09% or less probability of selecting cultivar of CY9 and they are statistically significant at 1% level respectively. In other words, male tea estate owners are more likely to choose the VP 20/25 while female owners are more likely to select the CY9 cultivar in the study.

Table 11: Marginal effects of economic-related characters

Variables	Types of tea plants		
	VP 20/25	**VP 20/23**	**CY9**
Income	0.2521**	-0.1932*	-0.0588
	(0.1079)	(0.1017)	(0.0728)
Land size	0.0016	-0.0029**	0.0013*
	(0.0012)	(0.0013)	(0.0007)
Output from each tea plant	0.0005	0.0016**	-0.0021***
	(0.0008)	(0.0007)	(0.0007)
Prices of each tea plant	-0.0287**	-0.2416**	0.0529***
	(0.0125)	(0.0115)	(0.0117)

Source: Calculated by author, 2019/2020

Note*:* ***, ** and * represent 1%, 5% and 10% significant levels, respectively, and standard errors are in the parentheses.

Marginal effects of income indicates that, tea estate owners who are earning more and more income, the probability of selecting the first cultivar increased by 25.2% while the probability of selecting VP 20/23 decreased by 19.3% at significant levels of 5% and 10% respectively. However, marginal effect on income in the selection of CY9 cultivar is not significant in the study.

Marginal effects of land size imply that tea smallholders who have more land size, the probability of adopting the 2nd cultivar reduced by 0.2%. However, there is a 0.16% and 0.13% higher probability of adopting 1st and 3rd cultivars with more land to cultivate tea. The value of marginal effect for tea output shows that for the tea estate owners who are getting more output, the probability of selecting 3rd cultivar will be reduced by 0.2% however, owners who are getting more output from tea estate will be chosen 2nd and 3rd cultivar with a percentage of 0.16% and 0.05% respectively and it is statistically significant at 1% level. The marginal effect of price of tea plants indicates that when the price increases, the tea smallholders will adopt the third cultivar with a percentage of 0.52% while reducing the selection of first and third cultivars at a 1% level of significance.

Table 12: Marginal effects of farming characteristics

Variables	Type of tea plants		
	VP 20/25	**VP 20/23**	**CY9**
Availability of training	0.0791	0.0479	-0.1271
	(0.1032)	(0.0961)	(0.8724)
Marketing channel	0.3365***	-0.0176	-0.1604
	(0.1107)	(0.1468)	(0.1450)
Frequency of harvest	0.1202*	0.0103	-0.1305*
	(0.7286)	(0.0663)	(0.0666)

Source: Calculated by author, 2019/2020

Note: *** and * represent 1% and 10% significant levels respectively and standard errors are in the parentheses.

Among the farming characters, marginal effects for marketing channel and harvesting frequency were significant at 1% and 10% levels respectively whereas, availability of training is insignificant. The marginal impact of the marketing channel indicates that for small tea holders who are selling their output directly to the tea factory, the probability of selecting the cultivar VP20/25 will be increased by 33.65%. The choice of the other two types of tea plant cultivars will be reduced by 1.76% and 16.04%, respectively. In contrast, the tea smallholders selling their tea yield by intermediaries have a 16.04% more probability of choosing CY9 cultivar but 33.65% less probability of selecting VP20/25 cultivar in their tea cultivation.

Finally, as the frequency of harvest, which means the number of time getting output from each tea plant cultivar, increases, the probabilities of adopting preferences on CY9 cultivar will be reduced by 13.05%, while cultivars of VP20/25 and VP20/23 will increase by 12.02% and 1.03% respectively and they are statistically significant at 10% level. The overall results of the marginal effects concluded that the farmers interested in increasing the frequency for getting the tea output would select the VP20/25 or VP20/23 than the CY9 cultivar in the study area.

These results have policy implications for tea technology improvement research in Sri Lanka. First, it shows that the yield performance of tea technology needs to be evaluated by tea smallholders under their socio-demographic, economic-related and farming characteristics. Secondly, the analysis proved that tea technology development efforts should not only concentrate on farming characteristics. The strong significance of the economic-related characteristics indicates that choices on tea plant cultivars are more concerned with economic and socio-demographic factors.

5. Conclusion

This study examined the factors influencing small tea holders' adoption decisions towards the three different tea plant cultivars in Badulla. Apart from this econometric analysis, other basic statistical tools such as frequency and descriptive statistics, chi-square test and one-way ANOVA were also employed in the study. The identification of different tea plant cultivars adopted in the study area was done by applying the multinomial probit model and marginal effects. Choices of three different tea plant cultivars grown by the smallholder tea estate owners were analyzed using frequency. Its results revealed that 43.5% chose the VP 20/25 cultivar, followed by 29.6% who preferred to adopt the VP 20/23 cultivar. Only 26.9% of them preferred to adopt the cultivar CY9 in tea cultivation in the study area. On the other hand, to determine the factors that influence the adoption of different tea plant cultivars, the multinomial probit model was estimated and its results showed that males were more likely to choose the VP20/25 cultivar, whereas females more likely to choose VP20/23 and CY9 tea cultivars in the sample. In addition to the most significant factor of gender, other socio-demographic variables such as secondary education and farming experience also significantly influence the study's adoption decision. All economic-related characteristics such as income range between Rs10001/= to Rs 20000/=, size of land, output from three tea plant cultivars and prices of each type of tea plant were the significant factors in the model. Among them, the average yield derived from tea plant cultivars and prices of tea plant cultivars were the key drivers in determining the adoption decision of tea smallholders in the selection of tea plants. Finally, the overall results derived from the multinomial model suggested that, among demographic characters gender has strong influence on the choices of tea plant cultivars while among economic-related factors, output obtained from each tea plant cultivar and the prices of each tea plant were the most significant factors in their choices.

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