CROP DIVERSIFICATION AND ITS DETERMINANTS AMONG VEGETABLE FARMERS IN KOTAGALA, NUWARA ELIYA DISTRICT IN SRI LANKA

A.Thayaparan and G.Y.N. Gunathilaka

Abstract

This study examines the how demographic and farming characteristics of smallholder vegetable farmers influence their crop diversification in the Kotagala area in Nuwara – Eliya district of Sri Lanka. Cross-sectional data were obtained from 86 randomly selected farmers who were cultivating nine vegetable crops in the Kotagala division using a structured questionnaire during the period from October to November 2019. The degree of crop diversification among the vegetable farmers was measured using the Herfindahl index which has a mean value of 0.36 showing that a low degree of crop diversification and the practices in multiple crop cultivation among the farmers are very low. Results of frequency analysis revealed that 60.5 percent of the farmers belong to diversifiers while 39.5 percent of them belong to non - diversifiers. Further, the Censored Tobit model was employed to examine how demographic and farming characteristics of smallholder farmers influence crop diversification and its results indicated that age squared, and education negatively influenced crop diversification at a 10 percent significant level. On the contrary, crop diversification is positively influenced by the age and size of cultivated land at a 5 percent significant level. The findings of the study would help policymakers in crafting appropriate policy measures for promoting crop diversification which will encourage the farmers to improve on their right selection and lead to an increase the yield and food security in the study area.

INTRODUCTION

The Sri Lankan economy grew at a moderate pace and the agriculture sector plays a central role in improving food security (Acharya et al., 2011; Pingali & Rosegrant, 1995) and promoting economic transformation and structural changes for the Sri Lankan economy. The contribution of the agriculture sector to the Gross Domestic Product (GDP) is too low to be considered the backbone of the Sri Lankan economy and the sector contributed about 4.8 percent of the GDP in 2019 and provides employment opportunities for the population in the country. The agricultural sector in Sri Lanka is dominated mainly by smallholder farmers who lack inputs and extension services. Agriculture is a risky business because it deals with uncertain factors such as weather and market conditions that affect the farmers' various decisions in a particular season. Among the agricultural sector, vegetable crop cultivation is prominent and has much potential to contribute to the increase in the level of income, and export revenue, generate new employment opportunities, increase farm income, and enhance the nutrition and health of the people. According to the statistics, the total cultivated extent of vegetables is around 93,000 ha, and annual production is approximately 720,000 metric tons in Sri Lanka (Economic Development Plan Nuwara Eliya Divisional Secretariat (2020-2022). Compared to other parts of Sri Lanka, hill country is ideal for temperate crops such as carrot, leeks, cabbage, lettuce, beetroot, beans, potatoes etc. and the farmers who live in those areas try to cultivate these diversified vegetable crops.

Crop diversification is one method of reducing farm income variability which means raising a variety of crops involving intensity of competition amongst field crops for arable or cultivated land. Crop diversification is a strategy to maximize the use of land, water and other resources and for the overall agriculture development in the country. It provides the farmers with a viable option to grow the different crops on their land. Diversification in agriculture is also practised to avoid risk and uncertainty due to climatic and biological vagaries (Acharya et al., 2011). Crop diversification largely depends on the region's socio-economic conditions and technological development but more decisive is the physical environment. It means crop diversification is the product of action, and reaction interaction among the physical and non-physical environment (Sohal, 2003). Crop diversification also gives more employment opportunities for small farmers as well as for agricultural labourers throughout the year.

Over the last few decades, Sri Lanka has made determined efforts for crop diversification to raise farm production and improve the quality of life of the farmers. Significant progress has also been made and a large area has been brought under different crops, especially, chilli and big onion, two very important cash crops. most of these developments have occurred in medium and major schemes resulting in significant increases in the cropping intensity as well as in the participation of fanners. (Proceedings of the Workshop Organized by the Irrigation Research Management Unit, 1996). There has been a slow shift to other vegetable crops by the farmers despite the government support in the shape of more supportive policies and improved infrastructure for promoting diversification programs. Farmers who live in

Kotagala, have a year in and year out remaining cultivating the same crop – mostly carrot and the degree of crop diversification among the vegetable farmers is low. Further, crop diversification strategies have failed in most cases in practical implementation due to the ignorance of factors influencing the respective farming systems. (Proceedings of the Workshop Organized by the Irrigation Research Management Unit, 1996). Therefore, a sound understanding of the demographic and farming characteristics of smallholder vegetable farmers and identifying how these characteristics influence farmers' crop diversification decision-making are the main issues in the study. It would help in formulating appropriate policies regarding crop diversification levels in the study area.

OBJECTIVES OF THE STUDY

The objectives of the study are to assess the degree of crop diversification and examine the impact of demographic and farming characteristics on crop diversification among smallholder vegetable farmers in the Kotagala area.

LITERATURE REVIEW

There are numerous empirical studies done by scholars to identify the determinants of crop diversification and the farmers' decision to diversify their crops in many countries. Ojo et al., (2014) examined the determinants of crop diversification among small-scale food crop farmers in North Central, Nigeria by using the Herfindahl index to measure the extent of crop diversification among the farmers, while ordinary least square regression analysis was used to determine the factors affecting crop diversification in the study. The overall results in the two states combined show that; the mean Herfindahl index of 0.68 implies that the crop farmers in the study area were not too diversified in their cropping pattern. Further, The results of the regression model revealed that farming experience, extension contact, farm size and land ownership positively and significantly affected diversification among the farmers in the study area. A study conducted by Dube & Guveya, (2016) examined the factors influencing smallholder crop diversification in Zimbabwe using the Herfindahl index and Tobit model. The results of the index showed that the mean crop diversity index is 0.54, whereas estimated results from the Tobit model revealed that gender, education, number of livestock units, access to irrigation, membership of farmers group, access to markets, farming experience, farms on flat terrain, farmer to farm extension, routine extension, agro-ecological zone and household income are the positive significant contributors on crop diversification in the country. In contrast, the age of the head of household and the distance of the farm homestead from the nearest town did not significantly influence crop diversification.

A case study on the determinants and extent of crop diversification among smallholder farmers studied by Sichoongwe et al., (2014) in Southern Province, Zambia. Scholars employed a double-hurdle model to analyze the data and its results indicate that the size of landholding, quantity of fertilizer, distance to market and the type of tillage mechanism adopted have a strong influence on whether a farmer practices crop diversification or not in the study.

Aheibam et al., (2017); Inoni et al., (2021) and Mussema et al., (2015) applied Hackman's two-step method to identify crop diversification in different countries. Crop diversification and its evidence from the Oromia region in Ethiopia were investigated by Mussema et al., (2015). The results suggest that asset ownership, soil quality, agricultural extension, and level of infrastructural development as the significant drivers of crop diversification in the study. The determinants and extent of crop diversification at the household level in Manipur were identified by Aheibam et al., (2017). The study results found that the education of the household head, farming experience, and access to plough are found to have a positive influence on the decision to diversify crops in the study area. Another study was done by Inoni et al., (2021) to find out the drivers of crop diversification: evidence from smallholder farmers in delta state Nigeria. The Heckman two-stage model results indicated that age, farm size, credit access, extension contact, and farm income had significant positive effects on farmers' crop diversification decision; while farm size, credit access, extension contact and attitude to risk exerted positive and significant influence on the intensity of crop diversification by smallholder farmers in the study.

Makate et al., (2016) examined crop diversification and livelihoods of smallholder farmers in Zimbabwe. The study results revealed that crop diversification depends on the land size, farming experience, asset wealth, location, access to agricultural extension services, information on output prices, low transportation costs and general information access in the country. Factors influencing crop diversification strategies among smallholder farmers in cotton production zones were studied by Dembele et al., (2018). A multinomial logistic regression model was used to estimate the factors that determine the diversification strategies of smallholder farmers. Its results revealed that the age of the family head, education level, family size, oxen ownership, farm income per capita and crop pest significantly influenced families' participation in the four diversification strategies in Mali. Li et al., (2021) examined crop diversity's socio-economic determinants and its effect on farmer income in Guangxi, Southern China. Results show that crop diversity increased with land size, and there is no relationship between profit variability and crop diversity, but farmers with greater crop diversity and more land were more profitable.

In Sri Lankan context, Esham et al., (2006) investigated the factors influencing crop diversification using binomial logistic regression analysis. The results implied that the availability of family labour, area of land cultivated, credit constraint, lack of water, poor land quality, and lack of extension services and inputs are statistically significant factors influencing crop diversification in Sri Lanka. Factors that influence farmers' decisions to diversify away from rice monoculture in Sri Lanka were studied by Burchfield & de la Poterie (2018). Results indicate that many farmers cannot diversify because of the characteristics of their fields, including elevation, soil quality, irrigation infrastructure, and relative position within an irrigation system in the country.

There are several ways to measure crop diversification, and the most important include the Herfindahl index, Simpson diversity index, Ogive index, Margalef index,

Shannon index, Berger-Parker index, and Entropy index. Another common method for measuring crop diversification is to count the number of crops grown by farmers, which researchers apply in many studies. However, there are lack of research done by Sri Lankan researchers using the index approach. To fill the identified methodological research gap, the study employed the Herfindahl index to identify crop diversification among vegetable farmers in the Kotagala area.

METHOD OF DATA COLLECTION

To identify the determinants of crop diversification among vegetable farmers in the Nuwara-Eliya district, the Kotagala area was selected as the study area. Kotagala is a small town in the Nuwara Eliya District of the Central Province, Sri Lanka which is located 35.8 km (22.2 mi) from Nuwara Eliya. There are 05 Divisional Secretariat divisions in Nuwara-Eliya and out of them, Nuwara-Eliya is one of the Divisional Secretariat divisions which has 72 GN divisions. Out of these GN divisions, the Kotagala GN division was selected using a purposive sampling technique. The "population" was the farmers who engaged in vegetable cultivation in the entire district, while the "sampling unit" was the household heads who were the farmers engaged in vegetable cultivation in the Kotagala GN division.

This division has many villages where the farmers mainly cultivate many vegetable crops and based on their potential to grow many crops, the questionnaire was issued to the 100 farmers and the data was collected during the period October to November 2019. The farmers are requested to choose their crop choice from nine different vegetables such as carrot, nokol, cabbage, beetroot, potato, leeks, beans, parsley and lettuce. Out of 100 farmers, only 86 farmers who filled out the questionnaire correctly were selected for the study. Data related to the total area devoted to each crop and the explanatory variables on demographic characteristics of the vegetable farmers and farm management characteristics were also gathered from the survey. The collected data were analyzed using various analytical tools in line with the objectives of the study.

METHODS OF DATA ANALYSIS

To estimate the crop diversification among farmers, the Herfindahl index measurement was used in the study and followed by an independent sample t-test, chi-square test and Tobit model.
In order to identify the mean differences in selected demographic and farming characteristics across diversifiers and non-diversifiers in the Kotagala area, an independent sample t-test was also employed in the study. Age, farming experience, land size, and distance to the market were considered to test their mean differences across diversifiers and non-diversifiers in the study. To assess the association between demographic and farming characteristics among diversifiers and non diversifiers the chi-square test was used. Herfindahl index and Tobit model were discussed in depth as follows

Crop diversification in terms of Herfindahl index

There are several possible ways to measure engagement in crop diversification using indices such as the Herfindahl index, Simpson diversity index, Ogive index, Margalef index, Shannon index, Berger-Parker index, and Entropy index which all indicate the degree of dispersion in crop cultivation with a given time and space by a single indicator. Out of these many indices, the Herfindahl index (HI) was selected in the study to measure the degree of crop diversification, because it is widely used in agricultural diversification. It can be calculated as below:

$$p_{i = \frac{A_I}{\sum_{i=1}^{n} A_i}}$$

P_i = Proportion of íth crop
A_i = Area under íth crop
$\sum_{i=1}^{n} A_i$ = Total cropped area
$i = 1, 2, 3\ldots\ldots.n$ (Number of crops)

From the above formula, the Herfindahl index (H_i) can be calculated by:

$$Hi = \sum_{i=1}^{N} p_i^2$$

Where,
N is the total number of crops, and P_i represents the area proportion of the ith crop in the total cropped area.

Now, Crop Diversification Index (CDI) is obtained by subtracting the Herfindahl index (HI) from one which is given by

$$CDI = 1 - \sum_{i-1}^{n} p_i^2 = 1 - HI$$

The CDI is an index of concentration and has a direct relationship with diversification such that its zero value indicates specialization and a movement towards one shows an increase in the extent of crop diversification (Malik & Singh, 2002). Hence, it was easy to identify those farmers who practised crop diversification and those who did not (Malik & Singh, 2002).

Tobit regression model

After estimating the crop diversification in terms of the Herfindahl index, the Tobit model is used to identify the impact of demographic and farming characteristics on the degree of crop diversification among vegetable farmers in the study. Since the values of the Herfindahl index lie between 0 and 1, which represents the extent of crop diversification taken as a dependent variable while other variables on

demographic and farming characters were considered as explanatory variables in the censored Tobit model.

The general formulation of the Tobit model for this study is

$$y_i = \left\{ \begin{array}{c} y_i^* \ if \ = y_i^* > 0 \\ 0 \ if \ y_i^* \leq \ 0 \end{array} \right\}$$

Where,

$$y_i^* = \beta X_i \ + \mu_i \hspace{4cm} \mu_i \ \sim N \ (0, \delta^2)$$

y_i^* = Herfindahl index is the dependent variable.
Xi = the vector of factors influencing farmer's participation in crop diversification
β = the vector of unknown parameters.
μ_i = is the independent normally distributed error term assumed to be normal with zero mean and constant variance.

Based on the previous literature support and data availability, the following independent variables were chosen in the study.

$Y_i = \ \beta_0 \ + \ \beta_1 \ X_1 \ + \ \beta_2 \ X_2 + \beta_3 \ X_3 \ + \ \beta_4 \ X_4 \ + \beta_5 \ X_5 \ + \ \beta_6 \ X_6 \ + \ \beta_7 \ X_7 \ + \beta_8 \ X_8 \ + \beta_9 \ X_9 \ + \ \varepsilon$

Where,
Y_i = Herfindahl index
X_1 = Age of the farmer in years
X_2 = Age of squared of the farmer in years
X_3 = Gender coded as 1 for male and 0 for female
X_4 = Civil status coded as 1 for single and 0 for married
X_5 = Education level coded as 1 for primary, 0 otherwise
X_6 = Distance to market in Km
X_7 = Land ownership coded as 1 for own land and 0 for tenant
X_8 = Types of labour coded as 1for family labour and 0 for hired
X_9 = Land size in acre
β_0 = Constant
β_1, β_2 , β_3 and.............. β_9 are the coefficients of each independent variable
ε = Error term.

RESULTS AND DISCUSSION

Table 1 presents the results of the frequency analysis for selected demographic and farming variables and according to that nearly 56 percent of the sampled smallholder farmers were males and 44 percent of them were females in the study.

Table 1: Demographic profile of the farmers

Variable	Frequency	Percentage
Gender		
Male	48	55.8
Female	38	44.2
Civil status		
Single	17	19.8
Married	69	80.2
Education		
Primary	39	45.3
Secondary	47	54.7
Types of labour		
Family	63	73.3
Hired	23	26.7
Ownership of land		
Own	69	80.2
Tenant	17	19.8

Source: Estimated by authors, 2018/2019

Among the farmers, nearly 80 percent of them were married while nearly 20 percent of them were single and in the case of educational levels, about 45 percent of the farmers were primarily educated and nearly 55 percent of them were secondary educated in the sample. According to the usage of labour resources, 73 percent of the farmers use family labour and the rest of the 27 percent use hired labour. On the other hand, about 80 percent of the farmers cultivate the crops on their land, whereas nearly 20 percent of them are tenant cultivators in the study.

In the beginning, crop diversification was measured by using the Herfindahl index across vegetable farmers and based on the values, they were classified as diversifiers and non-diversifiers. Those two groups of farmers were analysed using frequency, independent samples t-test and chi-square test in the study.

Crop diversification across vegetable farmers was measured using the Herfindahl, with values between 0 and 1. The index takes a value of 1 representing perfect diversification, while approaches 0 represent less diversification or specialisation in only one crop. Table 2 shows the distribution of the Herfindahl index among 86 vegetable farmers in the study.

Table 2: Distribution of Herfindahl index among vegetable farmers

| Range of Herfindahl Index	Frequency	Percentage
Less than 0.3	34	39.5
Between 0.3 - 0.5	20	23.3
Between 0.6 - 0.8	27	31.4
Above 0.8	05	5.8

Source: Estimation Developed by authors, 2018/2019

Based on the distribution of the Herfindahl index scores, 0.3 was taken as the cut–off score between diversifiers and non – diversifiers in the study. The farmers who have an index less than 0.3 or closer to zero are classified as non – diversifiers and the farmers who have an index of more than 0.3 are classified as diversifiers in crop diversification. According to Table 1, 39.5 percent of the farmers who attained an index less than 0.3 were considered non – diversifiers and the rest of the 60.5 percent of them who attained an index more than 0.3 were considered diversifiers in the study. Among 60.5 percent of diversifiers, the degree of crop diversification differs based on the range of the Herfindahl Index. It shows that 23.3 percent of the farmers belong to the range between 0.3 – 0.5 and 31.4 percent of them belong to the range between 0.6 – 0.8. The highest value of more than 0.8 was attained by only 5.8 farmers in crop diversification.

Based on the results as indicated in Table 1, the farmers were categorized as diversifiers if the index was greater than zero 0.3 and they were categorized as non - diversifiers if the index was less than 0.3 or closer to zero.

Using the above information, frequency, independent samples t-test and chi-square test were applied in the following section.

Results of frequency

The frequency of crop diversifiers and non-diversifiers among the small vegetable holder farmers was described using the graph below.
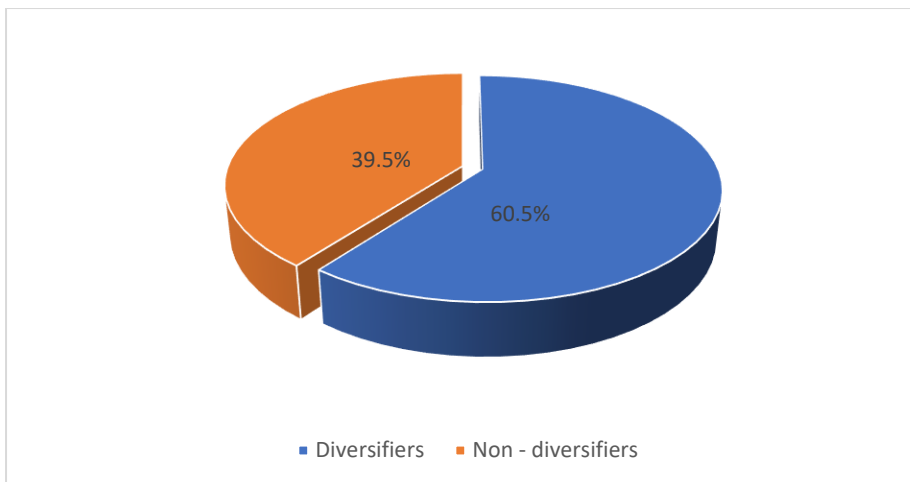
Figure 1: Frequency of diversifiers and non-diversifiers

Source: Developed by author

The frequency of the diversifier and non-diversifier graphically shown in Figure 1 depicts that from the total sample of 86 smallholder farmers, 60.5 percent of them have participated in crop diversification while 39.5 percent of them did not practice it. This means that, the farmers who do not participate in crop diversification as non – diversifiers cultivate only one specific specialized crop, and others who participate in crop diversification as diversifiers cultivate at least two or more two crops in the study.

Out of nine vegetable crop choices, some farmers choose only one crop and some choose a different combination of the crops, but the maximum they cultivate is four crops. The number of crops chosen by farmers is given in Figure 3 and according to that, out of nine vegetables, 39.5 percent of the farmers cultivate only one crop, 27.9 percent and 29.1 percent cultivate any two and three crops respectively. Only 3.5 percent of the engaged in any four crops in the sample.
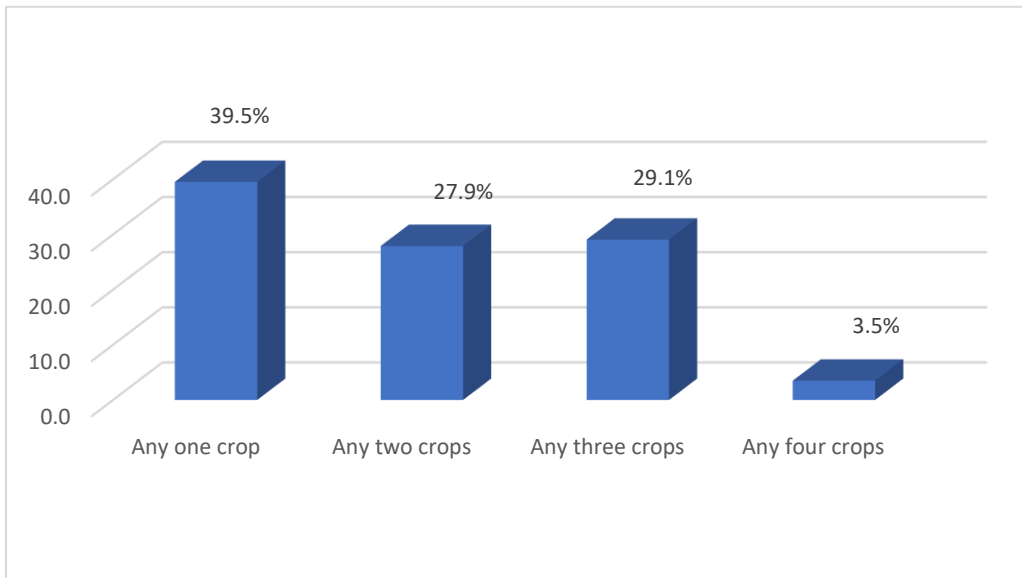
Figure 2: Frequency of multiple crop choices

Source: Developed by author

The distribution of crop diversification measured by the Herfindahl index across male and female vegetable farmers is shown in Figure 3.
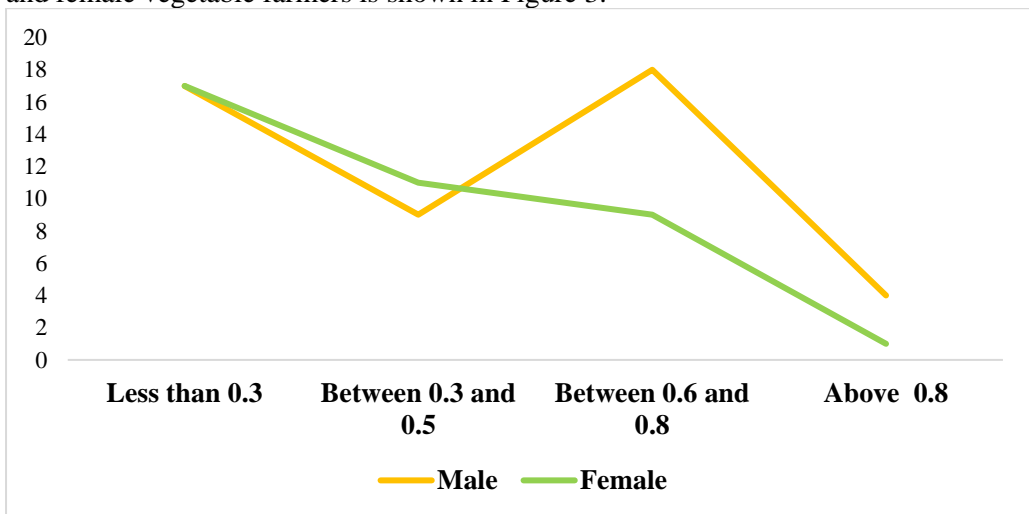
Figure 3: Distribution of crop diversification index across gender

Source: Developed by author

According to the above figure, the index range between 0.6 and 0.8 is mostly attained by male farmers than females. The index range above 0.8 was attained by a smaller

number of female farmers compared to their male counterparts and these results suggest that the intensity to diversify the crops is relatively higher on the men's vegetable farms than their female counterparts in the study.

Results of descriptive statistics

Table 2 shows the results of descriptive statistics of the selected variables and according to that, on average, the age of the farmers was nearly 39 years while the farming experience was about 6 years. Also, they have an average of 3.73 Ha of farmland to grow different crops with a standard deviation of 1.92.
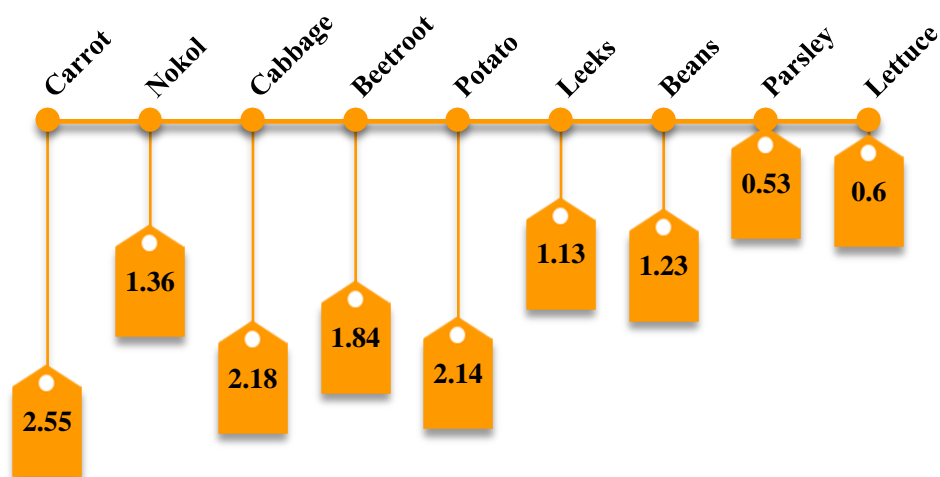
Table 2: Results of descriptive statistics

Variable	Minimum	Maximum	Mean	Standard deviation
Age in years	18	65	38.76	11.83
Farm experience in years	0.5	30	5.60	5.30
Land size in Ha	1	10	3.73	1.92
Market distance in Km	0.5	30	10.27	8.03
Herfindahl index	0	1	0.36	0.32

Source: Estimated by authors, 2018/2019

On average, their participation in crop diversification measured by the Herfindahl index was 0.36, which represents that the farmers are not engaged in multiple crop diversification in the study.

The survey result presented in Figure 5 revealed that farmers allocated their total land for growing various nine vegetable crops which implies the practice of crop diversification adopted by the farmers in the study. According to that, the average size of land allocated for carrots is 2.5 Ha which is the highest than other crops and on average, only 0.6 Ha of land is allocated for the cultivation of lettuce. Among the nine vegetables, in terms of allocated land, most of the farmers allocate their land for carrots, cabbage, potatoes and beetroot while the land allocation for parsley and lettuce has less size than other crops.

Figure 4: Average cultivated area under crops

Source: Developed by author

In addition to the descriptive statistics, custom tables are also used to classify the characteristics of the diversifiers and non-diversifiers based on gender, ownership of land and types of labour usage.

Table 4: Results of custom tables

						Diversifier	Non - diversifier
Labour	*Family*	Ownership of land	Own	Gender	Male	18	12
					Female	17	11
			Tenant	Gender	Male	0	2
					Female	1	2
	Hired	Ownership of land	Own	Gender	Male	5	3
					Female	1	2
			Tenant	Gender	Male	8	0
					Female	2	2

Source: Estimated by authors, 2018/2019

According to the above table, 18 male farmers belong to diversifiers using family labourers cultivating their land whereas 17 female farmers belong to diversifiers with

the same characteristics as males. No male tenant farmers belong to either diversifier or not using hired or family workers in the study.

Figure 5 graphically displays the frequency of farmers from crop diversifiers and non - diversifiers under different farming characteristics and it shows that 85.7 percent of farmers
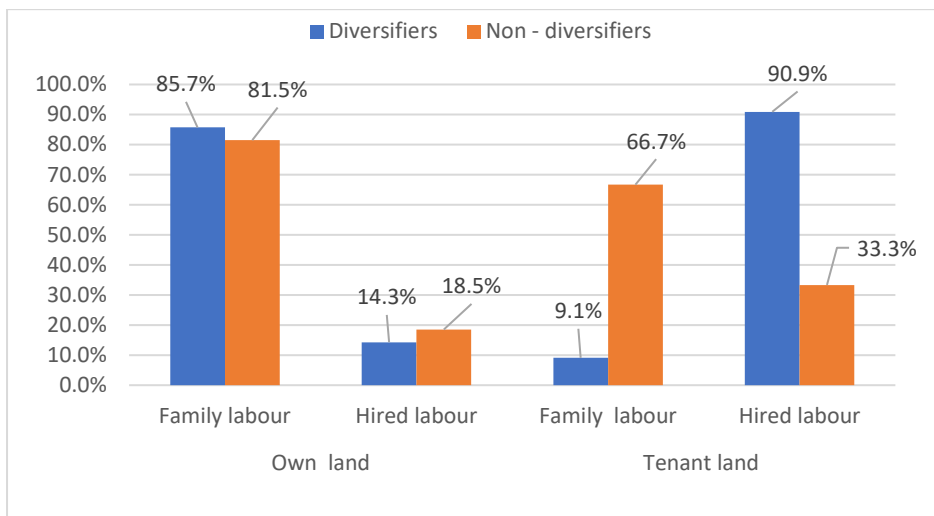
Figure 5: Frequency of diversifiers and non-diversifiers across different farming characters
Source: Developed by author

This belongs to diversifiers who have their land using family labour whereas only 9.1 percent of the farmers belong to diversifiers who have tenant land using family labour. There is no significant difference between diversifiers and non-diversifiers who have their land use hired labourers in the cultivation, which is represented by 14.3 percent and 18.5 percent respectively.

Results of independent samples t-test

The independent samples t-test was carried out to test the mean differences for selected variables across diversifiers and non- diversifiers and its results are shown in Table 5.

Table 5: Independent samples t-test

Characteristics	Diversifier n = 52		Non – diversifier n = 34	
	Mean	Sd	Mean	Sd t -value
Age of the household head	41.92	10.75	33.91	11.91[*]
				-3.23
Farming experience	5.98	4.82	5.01	5.99
				-0.82
Land size	4.17	2.05	3.05	1.50[*]
				-2.73
Distance to the market	11.25	6.60	8.77	9.74
				- 1.40

Note: * represents the statistical significance level at 1%. t – values are taken under the assumption of equal variances.

Source: Estimation developed by authors, 2018/2019.

As shown in the above table, there is no significant difference between the two groups of farmers concerning their farming experience and distance to the market, while age and cultivated land area are significantly different between the two groups. The results show that on average, the age of the crop diversifiers is greater than non-diversifiers and usually, older farmers have more experience in cultivation and thus have more interest in cultivating diversified crops than young farmers. It is interesting to note that participant farmers have cultivated significantly larger areas of farmland than the non - participant farmers. Because the farmers who have sufficient land could grow multiple crops and they may be able to allot their land for more than one crop compared to smallholders. However, there are no significant differences in farming experience and distance to the market between the above two groups of cultivators in the study area.

Results of the chi-square test

The significant association between the selected categorical variables and the status of crop diversification was measured using the chi-square test and the results were given in Table 6.

Table 6: Results of the chi-square test

Characteristics	Diversifier n =52		Non – diversifier n = 34		χ^2
	Frequency	Percent	Frequency	Percent	
Gender					0.77
Male	31	64.6	17	35.4	

Female	21	55.3	17	44.7	
Education					13.91***
Primary	32	82.1	7	17.9	
Secondary	20	42.6	27	57.4	
Civil status					5.61**
Single	6	35.3	11	64.7	
Married	46	66.7	23	33.3	
Types of labour					1.08
Family	36	57.1	27	42.9	
Hired	16	69.6	7	30.4	
Ownership of land					0.15
Own	41	59.4	28	40.6	
Tenant	11	64.7	06	35.3	

Note: *** and ** represent the statistically significant at 1% and 5% levels respectively

Source: Estimation developed by authors, 2018/2019

Among the five variables, only the respondents' educational qualification and civil status have been significantly associated with the status of crop diversification. Education level is significant at 1 percent level indicating that 82.1 percent of the primarily educated respondents belong to diversifiers where whereas 57.4 percent of the secondary educated belong to non-diversifiers which illustrates that the majority of the diversifiers have primary educational knowledge less percentage of them have secondary education in the sample. Similarly, civil status, whether the respondent is single or married, is significantly associated with crop diversification status. 66.7 percent of the married farmers cultivated more than one crop while 64.7 percent of the single farmers were considered non - diversifiers. Other variables such as gender, types of labour, and ownership of land have not been significantly associated with the status of crop diversification.

Results of Censored Tobit regression model

Crop diversification among vegetable farmers and its determinants were identified using the Tobit model and its marginal effects. The results in Table, Pseudo R^2 have a value of 0.2686 and the probability of chi-square is also significant at a 1 percent level indicating that overall, the model is statistically significant and the nine explanatory variables used in the model are collectively able to explain the variations in crop diversification among the smallholder vegetable farmers in the study area. Nine variables related to demographic and farming characteristics were taken as explanatory variables. Out of them, the size of cultivated land and age positively impact crop diversification at 1percent and 5 percent significant levels respectively while ageing squared and education level negatively impact it at 10 percent level.

Results revealed that the gender of the household head was insignificant in the determination of crop diversification, while Dube & Guveya (2016) found contradictory results which implied that the gender of the farmer significantly and positively influences crop diversification. Further, the market distance was found to be insignificant in the determination of crop diversification in the model, which is consistent with the findings of Dube & Guveya (2016) while, Sichoongwe et al., (2014) found a significant impact on crop diversification. Ownership of land has an insignificant impact on crop diversification in the studied area but Ojo et al., (2014) found a positive and significant effect on diversification among the farmers. Furthermore, civil status and type of labour were insignificant in the current study. However, Esham et al., (2006) found family as a factor which is impeding crop diversification in Sri Lanka.

The age of the farmer has positive coefficient sign with a 5 percent significant level implying that elderly farmers were more likely to engage in multiple crops in cultivation than young farmers and the likelihood of diversification into several crop enterprises increases with the age of the farmer. Thus, the age of the household head plays a vital role in diversification into several crops since it can be used to indicate the farmer's experience in different farming systems, which is consistent with the findings of Dembele et al., (2018) and Inoni et al., (2021) while Dube & Guveya (2016) found age as an insignificant factor which contradicts the findings of the current study. Further, the marginal effect of age has a value of 0.062 which is significant at a 5 percent level revealing that a one-year increase in age reduces the probability of crop diversification by 6.2 percent. This would happen due to older farmers put more prominence on crop diversification than young farmers. Because older farmers may try to attain their family food security and raise their income by producing multiple crops than young farmers.

Table 7: Results of Tobit model and marginal effects

Variables	Coefficients		t - value	Standard error	Marginal effects	
Age	0.086	(0.023)	2.32	0.037	0.062	(0.020)
Age squared	-0.0008	(0.050)	-1.99	0.0004	-0.0006	(0.045)
Gender	0.077	(0.502)	0.68	0.114	0.056	(0.500)
Civil status	0.120	(0.496)	0.68	0.175	0.090	(0.509)
Education level	-0.192	(0.070)	-1.83	0.105	-0.140	(0.066)
Market distance	0.006	(0.336)	0.97	0.006	0.004	(0.333)
Land ownership	-0.170	(0.234)	-1.20	0.142	-0.115	(0.195)
Types of labour	-0.048	(0.703)	-0.38	1.127	-0.034	(0.698)
Size of land	0.106	(0.000)	3.87	0.027	0.077	(0.000)

Constant	-2.079	(0.012)	-2.56	0.811	……..

Number of observations = 86	LR Chi^2(9) = 37.16
Probability > Chi^2 = 0.000	Pseudo R^2 = 0.2686
Log likelihood = -50.60	Observation summary:
	34 left censored observations at crop diversification index < =0
	51 uncensored observations
	01 right censored observations at crop diversification index > =1

Note: P – values are in the parentheses.
Source: Estimation developed by authors, 2018/2019

The coefficient of age squared negative sign with the negative value for marginal effect shows that even if the farmer's age increases, after a certain age, the probability of engaging in crop diversification will reduce by 0.06 percent. The farmers who have primary education their likelihood to participate in crop cultivation is lower by 14 percent compared to the secondary educated farmers. Since the farmers have more knowledge may help them to adopt new farming systems on multiple crop cultivation than primarily educated farmers. Align with the current study Dube & Guveya (2016) also found that household members with secondary education significantly and positively influence crop diversification by farmers. The above Tobit model results further show that the coefficient of land size as an independent variable was found to be significant with a positive impact at a 1 percent level on the probability of farmers diversifying the crops in the study and the study findings aligned with the findings of Inoni et al., (2021); Li et al., (2021); Makate et al., (2016); Esham et al., (2006); Ojo et al., (2014) and Sichoongwe et al., (2014). According to that, a farmer who has more acre of land is more likely to grow more crops than a farmer who has less acre of land. The marginal effect of land size is 0.077 revealing that a one-hectare increase in total area under cultivation will increase the probability of crop diversification by 7.7 percent and the farmers with large sizes of land would have more intention to diversify their vegetable crops in the study area. This implies that, as land is one of the factors of production, it is confirmed that the farmers with sufficient land area are more likely to grow multiple crops than small landholders. Because, large-scale farmers may enable to allot their land for more than one crop compared to smallholders. Thus, the findings of this study concluded that land size, age squared, and education level significantly influenced crop diversification among the vegetable farmers in the Kotagala area.

Limitations of the study

In this study, determinant factors on crop diversification mainly focused on demographic and farming characteristics. But crop diversification could be influenced by many other factors such as financial return received by the farmers

from each crop, market stability, irrigation systems, and requirements. Hence, the study results are limited to the demographic and farming characteristics in the current study. Further, the yield of each crop depends on the type of soil where they cultivated them, even though it was not included in the model. Because there is not much soil variation across the land where the farmers cultivate the various crops in the study area. Since this is a case study done in considered Kotagala division, the outcomes and findings are primarily applicable only to the specific study area, and those findings cannot be generalized to the entire country of Sri Lanka.

CONCLUSION

This study was conducted to identify the impact of demographic and farming characteristics on crop diversification among vegetable farmers who cultivate different vegetable crops in the Kotagala area in Nuwara – Eliya district of Sri Lanka. The Herfindahl index measures crop diversification, and its computed mean value is 0.36, indicating that crop diversification among vegetable farmers is low. Among the diversifiers, 8.1 percent of them attained an index value of .7071 and the lowest index value of .3211 was attained by 1.2 percent of the vegetable farmers in the study. The independent samples t-test was carried out to identify the mean differences in selected demographic and farming characteristics across diversifiers and non-diversifiers in the study area. Its results revealed significant mean differences in the age of the household head and size of the cultivated land between diversifiers and non - non-diversifiers.

Furthermore, the results showed that on average, the age of the crop diversifiers and the size of cultivated land is greater than non- diversifiers. However, there are no significant differences in farming experience and distance to the market between the above two groups in the study. The findings of the Tobit results concluded that the size of cultivated land, age, age squared and education level significantly impact crop diversification while other variables related to gender, civil status, distance to the market, ownership of land and types of labour were not influencing the crop diversification in the study.

Recommendations and implications

The study recommends increased capacity building of young farmers in their selection and decision-making of multiple vegetable crops and providing necessary facilities to engage vegetable cultivation in more size of land areas as the measures of promoting crop diversification in the study.

Implications for future research

Based on the findings derived from the study the authors can give some suggestions for further improvement in future.
- The degree of crop diversification could be measured using various indices as mentioned in methods of data analysis. Even though this study focused on

the Herfindahl index only. By measuring other indices, the findings may be compared across different indices in the participation of crop diversification.

- The impact of demographic and farming characteristics on crop diversification was examined by using the Tobit model. Compared to this model, ideally, the double-hurdle model or Heckman model would have been used in further studies.

REFERENCES

Acharya, S. P., Basavaraja, H., Kunnal, L., Mahajanashetti, S., & Bhat, A. R. (2011). Crop Diversification in Karnataka: An Economic Analysis §. *Agricultural Economics Research Review*, *24*(2), 351–357.

Aheibam, M., Singh, R., Feroze, S., Singh, N. U., Singh, R., & Singh, A. (2017). Identifying the determinants and extent of crop diversification at household level: An evidence from Ukhrul district, Manipur. *Economic Affairs*, *62*(1), 89–95.

Burchfield, E. K., & de la Poterie, A. T. (2018). Determinants of crop diversification in rice-dominated Sri Lankan agricultural systems. *Journal of Rural Studies*, *61*, 206–215.

Dembele, B., Bett, H. K., Kariuki, I. M., Le Bars, M., & Ouko, K. O. (2018). Factors influencing crop diversification strategies among smallholder farmers in cotton production zone in Mali. *Advances in Agricultural Science*, *6*(3), 1–16.

Dube, L., & Guveya, E. (2016). Factors influencing smallholder crop diversification: A case study of Manicaland and Masvingo Provinces in Zimbabwe. *International Journal of Regional Development*, *3*(2), 1–25.

Esham, M., Kobayashi, H., Usami, K., & Matsumura, I. (2006). Factors influencing crop diversification in Sri Lanka. *Japanese Journal of Farm Management*, *44*(1), 148–152.

Inoni, O. E., Gani, B. S., & Sabo, E. (2021). Drivers of Crop Diversification: Evidence from Smallholder Farmers in Delta State Nigeria. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, *69*, 6.

Li, C., Chen, X., Jiang, A., Lee, M.-B., Mammides, C., & Goodale, E. (2021). Socioeconomic Determinants of Crop Diversity and Its Effect on Farmer Income in Guangxi, Southern China. *Agriculture*, *11*(4), 336.

Makate, C., Wang, R., Makate, M., & Mango, N. (2016). Crop diversification and livelihoods of smallholder farmers in Zimbabwe: Adaptive management for environmental change. *SpringerPlus*, *5*(1), 1–18.

Malik, D., & Singh, I. (2002). Crop diversification economic analysis. *Indian Journal of Agricultural Research*, *36*(1), 61–64.

Mussema, R., Kassa, B., Alemu, D., & Shahidur, R. (2015). Determinants of crop diversification in Ethiopia: Evidence from Oromia region. *Ethiopian Journal of Agricultural Sciences*, *25*(2), 65–76.

Ojo, M. A., Ojo, A. O., Odine, A. I., & Ogaji, A. (2014). *Determinants of crop diversification among small–scale food crop farmers in north central, Nigeria*.

Pingali, P. L., & Rosegrant, M. W. (1995). Agricultural commercialization and diversification: Processes and policies. *Food Policy*, *20*(3), 171–185.

Sichoongwe, K., Mapemba, L., Ng'ong'ola, D., & Tembo, G. (2014). *The determinants and extent of crop diversification among smallholder farmers: A case study of Southern Province, Zambia* (Vol. 5). Intl Food Policy Res Inst.

Sohal, K. (2003). Changes in crop diversification in Punjab: 1951-2001. *The National Geographical Journal of India*, *49*.

Crop Diversification Strategies for Minor Irrigation Schemes (1996).

Proceedings of the Workshop Organized by the Irrigation Research Management Unit, Irrigation Department and the Sri Lanka National Program, International Irrigation Management Institute Held at the Irrigation Department, Colombo, Sri Lanka.

Economic Development Plan Nuwara Eliya Divisional Secretariat (2020-2022). preparedby: Integrated Economic Development Project Nuwara Eliya.