# Crop Diversification and its Determinants among Vegetable Farmers in Kotagala, Nuwara Eliya District in Sri Lanka

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A sound understanding of the demographic and farming characteristics of smallholder farmers and how they stimulate their crop diversification decisions would help policymakers make appropriate measures for encouraging crop diversification. The objectives of the study are to assess the degree of crop diversification and examine in what ways the demographic and farming characteristics of smallholder vegetable farmers impact their crop diversification at Kotagala area in the 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 the structured questionnaires during the period from October to November 2019. The degree of crop diversification among vegetable farmers was measured using the Herfindahl index, which has a mean value of 0.36. It shows that there is a low degree of crop diversification and the practices in multiple crop cultivation among the farmers is very low. Results of the frequency analysis revealed that 60.5 percent of the farmers are diversifiers, while 39.5 percent of them are non - diversifiers. Further, the tobit regression model was used to examine how demographic and farming characteristics of smallholder farmers influence crop diversification and its results indicated that age squared and education negatively influenced on crop diversification at a 10 percent significance level. On the contrary, crop diversification is positively influenced by the age and size of cultivated land at a 5 percent significance level. The findings of the study will assist the decision makers in developing the best possible policies to support crop diversity, which will motivate farmers to make better choices, boost production, and improve food security in the study area.

**KEYWORDS:** Crop diversification, demographic and farming characteristics, diversifiers and non-diversifiers, Herfindahl index, Tobit regression model.

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**INTRODUCTION**

The Sri Lankan economy grew at a moderate pace, and the agriculture sector has been playing 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 to approximately 4.8 percent of the GDP in 2019 and provided employment opportunities for the population in the country. The agricultural sector in Sri Lanka is dominated mainly by the smallholder farmers who lack inputs and extension services. Agriculture is a risky industry since it involves uncontrollable elements like weather and market conditions, which influence the farmers' varied choices within a given season. Vegetable crop cultivation is a significant part of the agricultural sector and has great potential to raise income levels, produce export earnings, create new job possibilities, boost farm income, and improve public health and nutrition. According to the statistics, the total cultivated area of vegetables is around 93,000 hectares and the annual production is approximately 720,000 metric tons in Sri Lanka (Economic Development Plan Nuwara Eliya Divisional Secretariat (2020-2022). In comparison to other regions of Sri Lanka, the hill country is a great location for temperate crops like carrots, leeks, cabbage, lettuce, beetroot, beans, and potatoes, and the farmers who reside in those places try to plant a variety of vegetable crops. Crop diversification in vegetable cultivation is a useful approach, especially in developing countries like Sri Lanka, where agriculture is the primary source of income. Crop diversity management on the farm is critical for reducing poverty, increasing farm revenue, creating jobs, and ensuring long-term agricultural sustainability by maintaining biodiversity, soil, and water resources.

Crop diversification, which entails cultivating a range of crops while intensifying competition among field crops for arable or cultivated land, is one approach to reducing farm revenue unpredictability. Crop diversification is a tactic for enhancing the utilization of land, water, and other resources, as well as for the general development of agriculture in the nation. It gives farmers a practical choice for growing various crops on their land. Agriculture diversification is also used to reduce risk and unpredictability brought on by climatic and biological whims (Acharya et al., 2011). Crop diversification is significantly influenced by the socioeconomic situation and technological advancement of the area, but the physical environment is more important. It

indicates that crop diversity is the result of action-reaction interactions between the physical environment and other factors (Sohal, 2003). Crop diversification also increases the year-round employment options for agricultural labourers and small farmers.

Sri Lankan farmers grow a wide range of vegetable crops in various districts and regions of the country, nevertheless, practicing crop diversification strategies at the farm level are very rare and they are influenced by many factors such as, demographic, farming characteristics, environmental and social factors.

Sri Lanka has worked hard over the past few decades to diversify its crops in order to increase farm output and enhance the standard of living for its farmers. Significant development has also been made, and a sizable area has been planted with various commodities, particularly chili and huge onions which are two crucial crops that bring in more revenue. The majority of these advancements took place in medium and large-scale plans, which led to considerable improvements in fanner participation and crop intensity (Proceedings of the Workshop Organized by the Irrigation Research Management Unit, 1996). Despite government support in the form of more accommodating laws and enhanced infrastructure for fostering diversification initiatives, farmers have gradually shifted to other vegetable crops. The majority of the crops grown by the farmers in Kotagala are carrots, and there is little crop variety among these growers of vegetables. In addition, lack of knowledge of factors affecting the respective farming systems has led to the majority of crop diversification methods failing in practice (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.

This study focuses on two main research questions. They are, (1) to what degree do the vegetable farmers engage in crop diversification and (2) to what extent do demographic and farming characteristics influence crop diversification among vegetable farmers in the Kotagala area. According to these research questions, the objectives of the study are stated and they are achieved by analysing the collected data using econometric analysis.

**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 the smallholder vegetable farmers in the Kotagala area.

**LITERATURE REVIEW**

The decision of farmers to diversify their crops throughout different nations has been the subject of numerous empirical studies conducted by academics. The Herfindahl – Hirschman Index was used by Ojo et al. (2014) to gauge how much agricultural diversification was occurring among the farmers, and ordinary least squares regression analysis was utilised to identify the factors affecting crop diversification in the study. The overall results in the two states combined show that the crop growers in the research area did not have a very diverse crop pattern, as indicated by the mean Herfindahl index of 0.68. Further, the results of the regression model revealed that land ownership, farm size, extension contact, and farming experience all had a positive and significant impact on the degree of diversity among the farmers in the research 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 groups, 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 to 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.

In a case study on the determinants and extent of crop diversification among smallholder farmers studied by Sichoongwe et al., (2014) in the Southern Province of Zambia, scholars employed a double-hurdle model to analyse the data and its results indicated 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.

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 findings imply that crop diversification in the study was primarily influenced by asset ownership, quality of soil, agricultural extension, and level of infrastructure development. The determinants and the extent of crop diversification at the household level in Manipur were identified by Aheibam et al., (2017). Results of the study indicated that the decision to diversify crops was positively influenced by the household head's education level, farming experience, and access to a plough in the study area. Another study was conducted by Inoni et al., (2021) in order to find out the drivers of crop diversification: evidence from smallholder farmers in Delta State Nigeria. Age, farm size, credit access, extension contact, and farm income all had significant positive effects on farmers' decisions to diversify their crops, according to the Heckman two-stage model results, while farm size, credit access, extension contact, and attitude to risk had a positive and significant impact on the degree of crop diversification practiced by smallholder farmers in the study.

The crop diversification and livelihoods of smallholder farmers in Zimbabwe were studied by Makate et al., (2016). The findings showed that crop diversification is influenced by factors like the size of the land, farming expertise, asset wealth, location, access to agricultural extension services, information on output pricing, affordable transportation costs and general information availability in the nation. Factors influencing crop diversification strategies among smallholder farmers in the cotton production zone were studied by Dembele et al., (2018). In order to evaluate the variables that influence small-holder farmers' diversification strategies, a multinomial logistic regression model was used. According to the study's findings, families' participation in Mali's four diversification strategies was significantly influenced by the family head's age, level of education, family size, ownership of oxen, farm revenue per capita, and crop pests. Li et al. (2021) investigated crop diversity's socioeconomic factors and their impact on farmer income in Guangxi, Southern China. According to the findings, crop diversity rose with the size of the land, and there is no relationship between crop diversity and profit variability, but farmers who had more land and a wider variety of crops were more profitable.

Esham et al. (2006) used binomial logistic regression analysis to examine the determinants influencing crop diversification in the Sri Lankan environment.

According to the findings, there are several statistically significant factors that affect crop diversification in Sri Lanka, including the availability of family labour, the amount of land that is farmed, credit restrictions, a lack of water, poor land quality, a lack of extension services, and a lack of inputs. Burchfield & de la Poterie (2018) investigated the factors influencing farmers' decisions to diversify away from rice monoculture in Sri Lanka. The findings show that many farmers are restricted in their ability to diversify the attributes of their farms, including elevation, soil quality, irrigation infrastructure, and relative location within a national irrigation system.

The Herfindahl–Hirschman Index, Simpson diversity index, Ogive index, Margalef index, Shannon index, Berger-Parker index, and Entropy index are among the most significant measures of crop diversification. The number of crops that farmers produce is another widely used indicator of crop diversification that researchers use in many studies. However, there is a lack of research done by Sri Lankan researchers using the index approach. To fill the identified methodological research gap, the study employed the Herfindahl – Hirschman Index (HHI) 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 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 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, Kotagala GN division was selected using the 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 Kotagala GN division.

This division has many villages where the farmers mainly cultivate many vegetable crops. Based on their potentiality in growing many crops, the questionnaire was issued to the 100 farmers and the data was collected during the October to November period in 2019. The farmers are requested to choose their crop 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 the questionnaire correctly were selected

in the study. Data related to total area devoted for each crop and the explanatory variables on demographic characteristics of the vegetable farmers and farm management characteristics also gathered from the survey. In accordance with the objectives of the study, the collected data were analysed utilizing a variety of analytical techniques.

## METHODS OF DATA ANALYSIS

To estimate the crop diversification among farmers, HHI index measurement was used in the study and followed by 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 also was 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. HHI index and Tobit regression model were discussed in depth as follows.

### Crop diversification in terms of Herfindahl – Hirschman Index

There are several possible ways to measure the engagement in crop diversification using indices such as, Herfindahl – Hirschman Index (HHI), Simpson diversity index, Ogive index, Margalef index, Shannon index, Berger-Parker index, and Entropy index, all of which indicate the degree of dispersion in crop cultivation with a given time and space by a single indicator. Out of these many indices, the HHI as 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:

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

Where:

$P_i$ = Proportion of ith crop

$A_i$ = Area under i^th crop

$\sum_{i=1}^{n} A_i$ = Total cropped area

i = 1, 2, 3……..n (Number of crops)

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From the above formula, the Herfindahl–Hirschman Index (HHI) can be calculated by:

$$HHI = \sum_{i=1}^{N} P_i^2$$

Where,

N = total number of crops, and

$P_i$ = area proportion of the ith crop in the total cropped area.

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

$$CDI = 1 - \sum_{i-1}^{n} P_i^2 = 1 - HHI$$

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 practiced crop diversification and those who did not (Malik & Singh, 2002).

**Tobit regression model**

After estimating the crop diversification in terms of the HHI, 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 dependent variable CDI lie between 0 and 1, the Tobit regression model is more appropriate compared to other ordinary least squares regression models. Since the sample population is the censored type with an index that varies from 0 to 1, ordinary least squares estimation generates biased and inconsistent parameter estimates. Therefore, the Tobit model was used to examine the factors influencing crop diversification in the study. After estimating the coefficients of the Tobit model, marginal effects were also estimated in the study. One advantage of estimating the marginal effects is that it can be used to examine the impact of each explanatory variable on the dependent variable in terms of probability. Thus, in order to analyse the determinants of crop diversification, the Tobit model was employed with demographic and farming characteristics as explanatory variables, and its implicit form was expressed as,

$$y_i = \begin{cases} y_i^* = \beta X_i + \varepsilon_i & if \ y_i^* > 0 \\ 0 & if \ y_i^* \leq 0 \end{cases}$$

Where:

$$y_i^* = \beta X_i + \mu_i \quad and \quad \mu_i \sim N(0, \delta^2)$$

$y_i^*$ = Crop Diversification Index is the dependent variable.

$X_i$ = the vector of factors influencing farmer's participation in crop diversification

$\beta$ = the vector of unknown parameters.

$\mu_i$ = is the independent normally distributed error term assumed to be normal with a zero mean and constant variance.

where $y^*$ is a limited dependent variable that is only observed for values less than 0 and greater than 1 and $X_i$ is a matrix of the explanatory variables that includes factors affecting diversification of crops among the farmers in the study.

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

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

Where:

$Y_i$ = Crop Diversification Index

$X_1$ = Age of the farmer in years

$X_2$ = Age 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 1 for family labour and 0 for hired

$X_9$ = Land size in acre

$\beta_0$ = Constant

$\beta_1, \beta_2, \beta_3$ and............... $\beta_9$ are the coefficients of each independent variable

$\varepsilon_i$ = 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.

Among the farmers in the sample, nearly 80 percent of them were married, while nearly 20 percent of them were single. In the case of educational levels, about 45 percent of the farmers were primary educated, and nearly 55 percent of them were secondary educated. 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 own land, whereas nearly 20 percent of them are tenant cultivators in the study.

**Table 1: Demographic profile of the farmers**

| Variables | 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, 2019*

In the beginning, crop diversification was measured by using the HHI 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 Index across vegetable farmers was measured using the HHI-score, with values between 0 and 1. The index takes a value of 1, representing perfect diversification, while 0 represent no diversification or

specialize in only one crop. Table 1 shows the distribution of the HHI among the 86 vegetable farmers in the study.

**Table 2: Distribution of crop diversification index among vegetable farmers**

| Range of Crop Diversification 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: Estimated by authors, 2019*

Based on the distribution of the CDI scores, 0.3 is taken as the cut off score between diversifiers and non – diversifiers in the study. The farmers who have the index less than 0.3 or closer to zero are classified as non – diversifiers and the farmers who have the index more than 0.3 are classified as diversifiers in crop diversification. According to the Table 1, 39.5 percent of the farmers attained the index less than 0.3 are considered as non – diversifiers and rest of the 60.5 percent of them who have attained the index above 0.3 are considered as diversifiers in the study. Among 60.5 percent of diversifiers, the degree of crop diversification is differed based on the range of CDI. It shows that, 23.3 percent of the farmers belong the range between 0.3 – 0.5 and 31.4 percent of them belong to range between 0.6 – 0.8. The highest value of more than 0.8 is 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 is greater than zero 0.3 and they were categorized as non - diversifiers if the index is less than 0.3 or closer to zero.

Using the above information, the frequency, independent sample 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**



▨ **Diversifiers**    ▢ **Non - diversifiers**
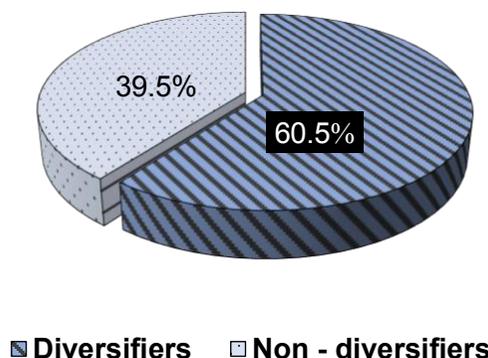
The frequency of the diversifiers and non-diversifiers graphically shown in Figure 1 depicts that, from the total sample of 86 smallholder farmers, 60.5 percent of them participated in crop diversification, while 39.5 percent of them did not practice it. This means that, the farmers who do not participate in crop diversification as a non – diversifier cultivate only one specific specialized crop, while others who participate in crop diversification as diversifiers cultivate at least 2 or more than 2 crops in the study.

Out of 9 vegetable crop choices, some farmers choose only 1 crop, and some have chosen a different combination of the crops, but the maximum they cultivate is considered to be 4 crops. The number of crops chosen by farmers is given in Figure 3 and according to that, out of 9 vegetables, 39.5 percent of the farmers cultivate only 1 crop, while 27.9 percent and 29.1 percent of them cultivate any 2 or 3crops respectively. Only 3.5 percent of those in the sample were involved in any of the four crops.

**Figure 2: Frequency of multiple crop choices**
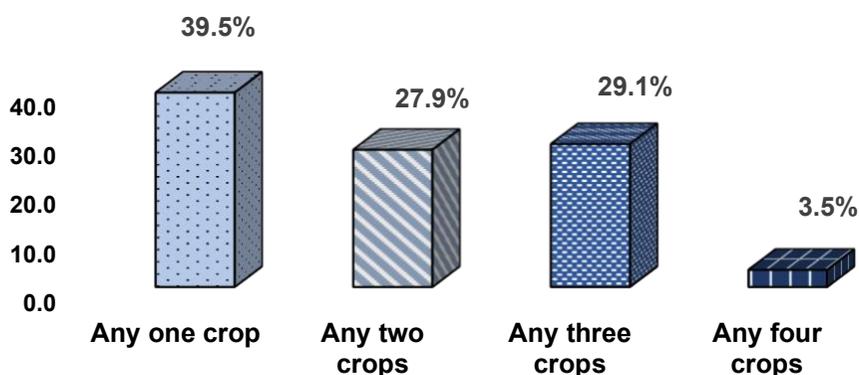


The distribution of crop diversification index across male and female vegetable farmers is shown in Figure 3.

**Figure 3: Distribution of crop diversification index across gender**
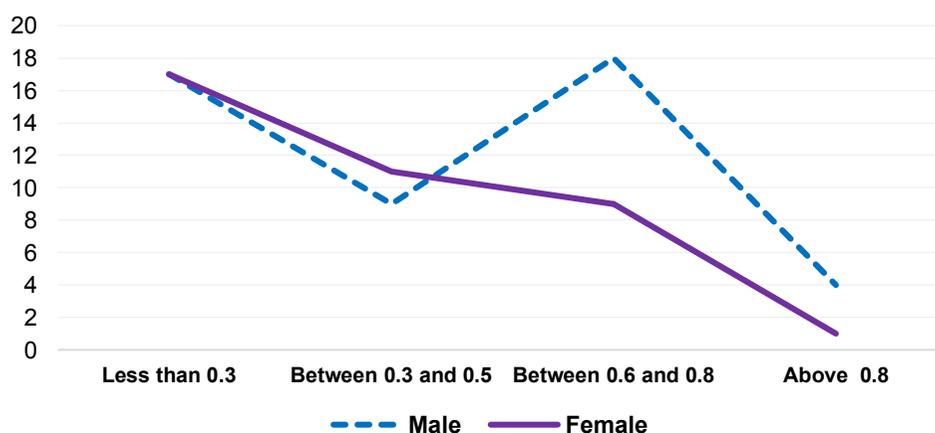


According to the above figure, the index range between 0.6 and 0.8 is mostly attained by male farmers rather than females. The index range above 0.8 is attained by a smaller number of female farmers compared to their male counterparts, and these results suggest that the intensity to diversify the crops

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is relatively higher on the vegetable farms of males than their female counterparts in the study.

**Results of descriptive statistics**

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

**Table 3: Results of descriptive statistics**

| Variables | 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 |
| Crop diversification index | 0 | 1 | 0.36 | 0.32 |

*Source: Estimated by authors, 2019*

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

The survey result presented in Figure 5 revealed that farmers allocated their total land for growing 9 different 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 more than other crops and on average, only 0.6 Ha of land is allocated for the cultivation of lettuce. Among the 9 vegetables, in terms of allocated land, most of the farmers allocate their land for carrot, cabbage, potato and beetroot, while the land allocation for parsley and lettuce is smaller than that for other crops.

**Figure 4: Average cultivated area under crops**
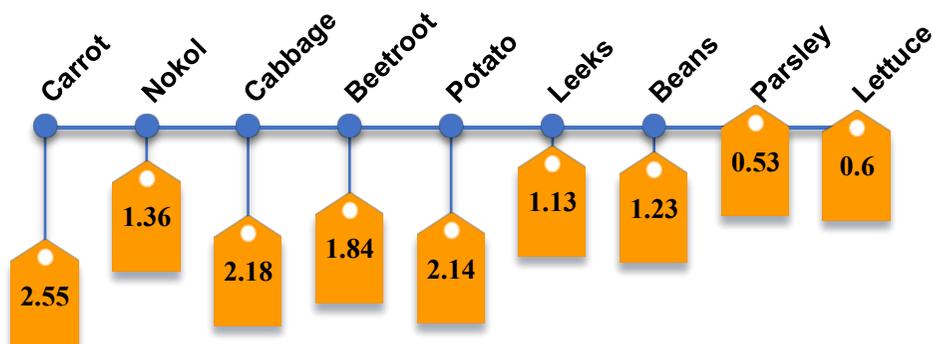


In addition to the descriptive statistics, custom tables are also used to classify the characteristics of diversifiers and non- diversifiers based on gender, ownership of land, and types of labour usage.

**Table 4: Results of custom tables**

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

*Source: Estimated by authors, 2019*

According to the above table, 18 male farmers belong to diversifiers using family labour to cultivate their own land, whereas 17 female farmers belong to diversifiers with the same characteristics as males. No male tenant farmers belong to either diversifiers or are 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 its show that 85.7 percent of farmers.

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**Figure 5: Frequency of diversifiers and non- diversifiers across different farming characteristics**



  □ **Diversifiers**  ■ **Non - diversifiers**
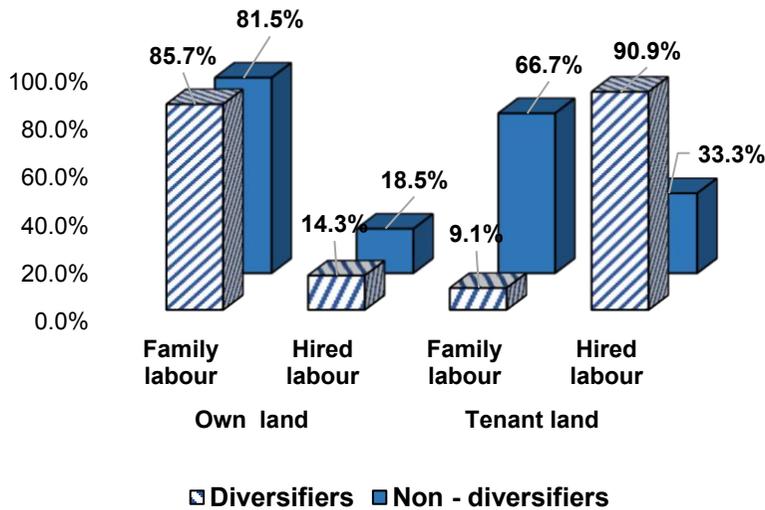
belong to diversifiers who have their own land using family labours whereas only 9.1 percent of the farmers belong to diversifiers who have tenant land using family labour. There is no significant difference between diversifiers and non-diversifiers who have their own land and use hired labour in cultivation, 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.

As shown in Table 5, there is no significant difference between the two groups of farmers with respect to 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 crop diversifiers is

greater than non- diversifiers and usually, older farmers have more experience in cultivation and thus have more interest in cultivating diversified

**Table 5: Independent samples t-test**

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

*Note: ** represents the statistical significance level at 5%.*
*t – values are taken under the assumption of equal variances.*
*Sd = Standard Deviation*
*Source: Estimated by authors, 2019.*

crops than younger farmers. It is interesting to note that participant farmers have cultivated significantly larger areas of farm land than the non - participant farmers. 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 or distance to the market between the above two groups of cultivators in the study area.

**Results of 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 are given in Table 6.

**Table 6: Results of chi-square test**

| Variables | Diversifier (52) | | Non - diversifier (34) | | Chi Squared ($\chi^2$) |
|---|---|---|---|---|---|
| | 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 | |
| **Type 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 ** represents the statistically significant at 1% and 5% levels respectively*
*Source: Estimated by authors, 2019*

Among the five variables, only the respondents' educational qualifications and civil status are significantly associated with the status of crop diversification. Education level is significant at the 1 percent level, indicating that 82.1 percent of the primary educated respondents belong to diversifiers, whereas 57.4 percent of the secondary educated respondents belong to non-diversifiers which illustrates that the majority of the diversifiers have primary educational knowledge. A smaller 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 Tobit regression model**

Crop diversification among vegetable farmers and its determinants were identified using the Tobit model and its marginal effects. The results in the table, Pseudo $R^2$ has a value of 0.2686 and a probability of chi-square also significant at the 1 percent level indicates that overall, the model is statistically significant and the 9 explanatory variables used in the model are collectively able to explain the variations in crop diversification among the small-holder 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 1 percent and 5 percent significant levels respectively while age squared and education level negatively impact on it at 10 percent level.

Results revealed that the gender of the household head was insignificant on 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 on 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 to be a factor that impedes crop diversification in Sri Lanka.

The age of the farmer has a positive coefficient sign with a 5 percent significant level, which implies that elderly farmers are 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 to be 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 the 5 percent level. This revealed that a one-year increase in age reduces the probability of crop diversification by 6.2 percent. This would happen due to older farmers putting more prominence on crop diversification than young

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farmers. Because older farmers may try to attain their family's 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 |

*Source:  Estimated by authors, 2019*
*Note:  P - values are in parentheses.*

The coefficient of age squared with the negative sign and the negative value for the marginal effect show that even though the farmer's age increases, after a certain age, the probability of engaging in crop diversification will reduce by 0.06 percent. The likelihood of participating in crop cultivation by the farmers who have primary education is lower by 14 percent when compared to the secondary educated farmers. Since the farmers have more knowledge, it may help them adopt new farming systems on multiple crop cultivation than

primary educated farmers. Aligned 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 the 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). Accordingly, a farmer who has more acre of land is more likely to grow more crops than a farmer who has fewer acres of land. The marginal effect of land size is 0.077 which reveals that as the farmer increases his area of land under cultivation by one more acre it will increase the probability of crop diversification by 7.7 percent and farmers with a large size 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 be able 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 into the model. Because there is not much soil variation across the land where the farmers cultivated various crops in the study area. Since this is as a case study done in 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 assess the degree of crop diversification and also identify the impact of demographic and farming characteristics on crop diversification among vegetable farmers who cultivate different vegetable crops in the Kotagala area in the Nuwara-Eliya district of Sri Lanka. The Herfindahl index was used to measure crop diversification as an index, 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 attain an index value of .70 and the lowest index value of .32 is attained by 1.2 percent of the vegetable farmers in the study. The independent sample 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-diversifiers.

Furthermore, the results showed that, on average, the age of the crop diversifiers and the size of cultivated land are greater than non- diversifiers. However, there are no significant differences in farming experience and distance to the market among 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 crop diversification in the study. The age of the farmer has  positively impacted crop diversification, and it can be concluded that ageing farmers were more likely to engage in more than one crop cultivation than young farmers.The coefficient of age squared negative sign reveals that  as age increases, the probability of engaging in multiple crops increases. Even when farmer's age increases, after a certain age, the probability of engaging in crop diversification will reduce. The coefficient and marginal effects for land size is highly significant. This concludes that the farmers with a large area of land would have more intention to diversify their vegetable crops than the farmers with a small area of land in the study area. Thus, the farmers who have sufficient land area are able to cultivate multiple crops compared to smallholder vegetable farmers in the Kotagala area.

## 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 the vegetable cultivation in bigger areas of land as the measures of promoting crop diversification.

## Implications for future research

Based on the findings derived from the study, the authors can make 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 can be used in further studies.

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