Shoring up the Upcountry Vegetable Farmer

Factors Affecting Soil Conservations Practices

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FOREWORD

Resource-poverty in fragile ecologies, both physical and social, one might believe, compromises land-use especially in the case of vegetable cultivation in the Central Province of Sri Lanka. While there has been rapid growth in this sector it has come at a cost, raising questions with regard to sustainability. This is particularly evident in the central hills with intensity making it difficult to mitigate soil erosion. Soil conservation is an easy answer but one which is hard to obtain given social and economic conditions that impinge on environment-friendly thinking, behaviour and agricultural practices.

This study involving the farmers in the districts of Nuwara Eliya and Kandy was successful in obtaining the changes that have taken place over time, drawing from the experiences of practitioners who have long engaged in vegetable cultivation. The topography of the terrain as well as composition of the soils have been considered since they bear upon land management. Enumeration of biological, cultural and structural conservation techniques and degrees of awareness as well as the incorporation of organic manure as amendments yield many important lessons that would be useful in understanding the nature and complexity of the problem and of course in thinking about what kind of strategies are required to ensure sustainable land-use without compromising the incomes of farmers.

Clearly, there is much room for overall improvement in land-use management and these are elaborated in this important and timely inquiry considering both the policy environment and overall economic stress that threatens to compromise food security, not to mention the need for relevant adaptive practices in view of constraints related to climate change. Most importantly, the study has generated useful interventionist recommendations for key institutions in the agrarian sector.

The lessons will not be applicable to all agro-climatic zones, obviously, but this study nevertheless offers important insights in terms of exploratory methodology and behavioral factors that need to be acknowledged and indeed whose weights in relevant social, economic and cultural matrices need to be ascertained.

Dr. G.G. Bandula
Director/Chief Executive Officer

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EXECUTIVE SUMMARY

Vegetable cultivation is a key sector in agriculture in terms of frugality and employment generation. The rapid growth experienced in the agricultural sector has led to resource degradation with an adverse impact on sustainability. A major form of environmental damage associated with agriculture is land degradation; particularly intensive vegetable cultivation practices have caused soil erosion on the steeply sloping lands of Central Hills. This study, conducted in the Central Province of Sri Lanka, mainly focuses on identifying the factors instrumental in soil conservation and investigating farmers' pro-environmental behaviours related to their soil conservation practices.

Using a multi-stage sampling technique, a sample of 384 farmers was surveyed. According to the descriptive analysis, the majority of vegetable growers are small-scale intensive vegetable farmers. With regard to issues, a large majority of vegetable lands in Nuwara Eliya district and 45% in Kandy are in the steep slope category. In this category predominantly the soil texture is clay, which does not support well-draining of irrigation and rainy water. As a result, less crop production and difficult land management were inevitable.
Varied soil conservation techniques (SLM practices); Agronomic, Vegetative, and structural conservation; are practised. In soil conservation, most of farmers follow at least one method of soil conservation. Structural techniques and incorporating organic manure as amendments are popular. Adding organic amendments is a positive impression on soil health. Land restoring with organic amendments is highly recommended to enhance potential crop production. Half of the population does not perform soil moisture conservation practices. Soil testing is rare. The need for awareness programmes on soil and water conservation and land improvements were highlighted.

Farmers follow a combination of mechanical and structural soil conservation methods to varying degrees. Fallowing period is not popular among potato and vegetable farmers as those are lucrative crops; on the contrary, they aim at optimum land productivity. Biological soil conservation is poorly practised and although Zero tillage is proved to be the best soil erosion control technique for undulating landscapes it is rarely practised in the study area.

It was found that land slope directly affects the cost of soil conservation practices and the cost of production. In water applications, traditional methods such as the use of watering cans and watering pipes are still popular. Adoption of advanced irrigation methods is not frequent. The use of high-pressure water pipes accelerates soil erosion. Popular erosion control methods for stream flows are gully control, bank conservation and main cannel conservation. Silt trap is a very effective method to collect the nutrient rich top soil. However, farmers do not practise these methods.

to use technology, which has limited land productivity to a great extent.

To understand the pro-environment behaviours of vegetable farmers the study investigated the effect of two variables "attitude" and "social pressure" on the variable "soil conservation concern". In this regard, the officials of relevant institutions form direct links and interact with farmers, with a focus on issues related to agricultural soils. Extension policies need to be strengthened to incorporate trends that recognize the critical role played by the social environment of farmers and subjective norms in raising awareness of soil conservation.

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ABBREVIATIONS

ANOVA	-	Analysis of Variance
ARPA	-	Agriculture Research and Production Assistant
ASC	-	Agrarian Services Canter
^{0}C	-	Celsius
CI	-	Confidence Interval
DCS	-	Department of Census and Statistics
DOA	-	Department of Agriculture
DS	-	Divisional Secretariat
DSD	-	Divisional Secretariat Division
FYM	-	Farm Yard Manure
GDP	-	Gross Domestic Product
GIS	-	Geographic Information System
GND	-	Grama Niladhari Division
HadCM3	-	Hadley Centre Coupled Model, version 3 General Circulation Model
HARTI	-	Hector Kobbekaduwa Agrarian Research and Training Institute
HH	-	Household
In VEST	-	Integrated Valuation of Ecosystem Services and Trade-offs
K	-	Potassium
N	-	Nitrogen
P	-	Phosphorus
SDR	-	Sediment Delivery Ratio
SLM	-	Sustainable Land Management
USDA	-	United States Department of Agriculture
UN	-	United Nations
VBN	-	Value - Belief - Norm theory
WOCAT	-	World Overview of Conservation Approaches and Technologies

CHAPTER ONE

Introduction

1.1 Background of the Study

Vegetable Cultivation

The agricultural sector, which plays a dominant role in the Sri Lankan economy, contributes 7.4% to the national GDP. The share of fisheries and livestock to the sector is 1.3%, and 0.9 % respectively. Further, over 30% of the population is employed in the agricultural sector (Central Bank, 2020). The sector's contribution to GDP has marked a significant decline over time. For instance, it was 43.6% in 1950, 27.2% in 1980, and 8% in 2010. According to the Department of Census and Statistics (2021), agriculture occupies more than 45% of the total land area of the country; and it is the mainstay of 8.1 million of the agrarian population.

Vegetable cultivation is one of the most important sectors in agriculture. This sub-sector makes a key contribution to the country's economy in terms of saving and earning exchange and providing employment to the rural population.

The non-indigenous varieties of vegetables were introduced to the country by people of European origin who settled in the region, following the institution of the plantation estates. Certain intrinsic qualities of these crops such as their appearance, keeping quality, the flavour and easy preparation might have popularized the varieties among the local population, particularly among urban dwellers. The preparation aligned with local needs, tastes and conditions. Traditionally, in Sri Lanka, including those non-indigenous food varieties, the vegetables are prepared as curries and salads to accompany the meal of rice. Potato is also prepared mostly as a vegetable (Dharmasena, 2017).

According to the agro-ecological adaptability, vegetables grown in Sri Lanka are twofold: up-country types and low-country types. Up-country of Sri Lanka plays an important role in the country's economy, producing a considerable amount of its vegetables and potato. In 2005, 2,424 ha were cultivated by approximately 25,000 farmers to produce 76,900 tons of vegetables. Given its significance this study mainly focuses on up-country vegetable production, which is the most popular among the farmers in Nuwara Eliya, Badulla, Kandy, Matale districts in the central highlands. Tomato, potato, leeks, carrot, beetroot, beans, young jack, cabbage, pumpkin, and green chili are the main vegetable crops cultivated in the area. The upcountry vegetable cultivation is intensive and highly commercialized. These crops are cultivated in mono-cropping or mixed cropping pattern. Farm holdings are small, ranging from about 0.3 to 0.5 hectares on average. Except for Nuwara Eliya, the leading upcountry vegetable cultivation district, the three mid-country districts—Badulla, Kandy and Matale — account for 40% of the *Maha* season's vegetable cultivation and 37.5% of *Yala* season's vegetable cultivation (Department of Census and Statistics, 2015-2019).

Climatic Impact on Vegetable Cultivation in Up-country

The impact of climate change on agriculture production differs from one country to another and several studies confirm that climate changes have a negatively impact on agriculture (Chandrasiri, 2013). Adaptation to particular climate changes seems to be the most appropriate and responsive way for farmers to lower the negative impacts of climate change as it is a means of transmitting the outcome of the farmer's perception on climate change (Fussel and Klein, 2006**).** Agricultural measures such as soil conservation practices are considered as adaptation methods for climate change. Planting dates, cover crops, tillage practices and irrigation are the most widely used adaptation strategies, whereas several socio-economic, environmental and institutional factors and the economic structure are key drivers influencing farmers to choose specific adaptation methods (Bryan *et al*., 2013).

Climate change will have serious impacts on agriculture and its production (IPCC, 2007). Highly productive and environmentally sound agriculture plays a vital role for sustainable development of rural areas. It can be expected that, climate changes have an increased influence on the agricultural productivity and environment (IPCC, 2007).

Resource Degradation and Impact on Conservation Practices

World population has rapidly increased in the previous few decades and as per forecasts, it will reach 9.7 billion by 2050 (UN, 2019). To feed the increasing population, growers are compelled to increase the productivity and carry out agriculture on sloping and marginal lands also with unsuitable cultivation methods (Ali *et al*., 2007). These practices result in adverse effects such as loss of soil particles, plant nutrients, changing of soil structure, reduction of available soil water and soil organic matter contents, that devastate soil productivity (Khan *et al*., 2004).

Three key challenges the agriculture sector faces are feeding a growing population of around 22 million with safe and nutritious food while providing a livelihood for farmers who constitute 27% of the labour force, causing minimal harm to the natural balance of the environment (Central Bank, 2020). Productivity growth in agriculture has long been known as an important tool to enhance the wellbeing of the people while reducing poverty. Land and water are the two key inputs that limit the expansion of cultivation extent as agriculture already occupies nearly half of Sri Lanka's land and irrigation of agricultural crops accounts for 87% of water use in the country (DOA, 2020). This situation exerts pressure on the agriculture sector to increase the efficiency of food production without further expansion of the land extent. In an experiment, Ahmad *et al*., (2014) reported a 5% and 7% increase in total soil porosity and available water content and a 4% decrease in bulk density of the moderately degraded alfisols, following application of Farm Yard Manure (FYM) (20 t ha^{-1}) during four seasons, which is 50% lower than the recommended N and of the same as the recommended P and K doses. The objective was to provide a more realistic and feasible blend of organic and inorganic nutrient sources for restoring the physical qualities and productivity of the soils affected by water erosion.

The soil erosion rate in Nuwara Eliya potato lands is as high as 15 t/ha/year. The impact of these flawed cultivation practices has caused soil erosion and other environmental problems and devastating soil productivity (Samarakoon, 2004).

Physiographical Impact on Farming in Upcountry

Physiographically, the island contains a mountainous area situated in the South - centre and a surrounding intermediate zone of upland ridges and valleys at a lower elevation. The central hill country rises to an elevation of about 2500 meters above sea level. Upcountry is the catchment area of the major rivers of the country. Soil is one of fundamental natural resources that support life on earth. Soil is a finite and non-renewable natural resource which takes between 200 and 1000 years for 2.5 cm of topsoil formation under cropland condition (Pimentel *et al*., 1995).

The fast growth in the agricultural sector in Sri Lanka has led to resource degradation, with adverse impact on sustainability. The major source of environmental damage associated with agriculture is land degradation, particularly soil erosion on the steeply sloping lands of Central Hills. At present, 44% of Sri Lankan agricultural lands face the problem of soil erosion (DOA, 2004).

Soil erosion is one of the most causal processes of land degradation in Sri Lanka affecting the national food production and the natural ecosystems. The undulating landscape in hilly areas directly influences surface soil erosion. Soil erosion has been closely associated with the land use systems. Soil erosion takes away surface soil rich in nutrients initiating harmful responses on productivity of agricultural lands as well as the water storage capacity of reservoirs. Although soil erosion is a naturally occurring process, this has been accelerated by human activities such as intensive agriculture, unsystematic land management, deforestation and cultivation on undulating landscape. Table 1 shows soil erosion status in Nuwara Eliya, Kandy and Badulla Districts (Dharmakeerthi and Wickramasinghe, 2015).

Table 1.1: Eroded Lands in the Central Highlands

Erosion Category	Districts - Extent in ha (%)		
	Nuwara Eliya	Kandy	Badulla
Low	20,443 (12%)	29,968 (16%)	22,000 (07%)
Moderate	35,638 (21%)	19,127 (10%)	24,800 (08%)
High	50,513 (30%)	69,036 (37%)	89,900 (30%)
Very high	45,470 (26%)	58,932 (31%)	79,100 (26%)
Extremely high	18,511 (11%)	12,097 (06%)	88,000 (29%)
High, very high and extremely high	114,494 (67%)	140,065 (74%)	257,000(85%)

Source: Dharmakeerthi and Wickramasinghe, 2015

Heavy usage of fertilizers and agro chemicals is common in these areas. Central highlands are the source of headwater areas for important rivers in the country, excess accumulation of these contaminants in the soil, transport of pollutants with sediments, and subsequent release to the water sources are serious concerns in these areas (Wijewardena, 1998).

Many studies revealed that most of the vegetable growers in the entire upcountry area apply inorganic fertilizers 2-3 times higher than the doses recommended by the Department of Agriculture (Gunawardane et al., 1998). In Sri Lanka, many studies have been conducted to assess soil erosion based on both numerical modelling and actual quantification to find that soil erosion is a severe problem in Sri Lanka (Wickramasinghe, 1988; Wijesekara and Chandrasena, 2001; Wijesekara and Samarakoon, 2001; Jayarathne et al., 2010).

An interrelationship can be found between soil nutrient management and soil erosion due to undulating land scape. Soil erosion is one of the most causal processes of land degradation in Sri Lanka that affects the national food production and the natural ecosystems (Wijesekara and Samarakoon, 2001).

1.2 Rationale for the Research

The rapid growth in the agricultural sector in Sri Lanka has resulted in resource degradation, with adverse impacts on sustainability. The main source of environmental damage associated with agriculture is land degradation. Soil erosion by water is a severe and continuous ecological problem in the upcountry vegetable farming. District-wise, Nuwara Eliya shows the highest amount of soil erosion, about 58% of the potato-cultivated land found to be prone to severe soil erosion (Abeygunasekara, 2004). Soil erosion and land preparation methods on these steeply sloping lands needs to be regulated and restricted.

The hill country of Sri Lanka plays an important role in the economy of the country, producing a considerable amount of its vegetable and potato. In 2005, about 2,424 ha of lands were cultivated by approximately 25,000 farmers to produce 76,900 t of potatoes for consumption.

Due to the economic prospects of potato cultivation, farmers tend to use steeply sloped lands which are not recommended for potato like seasonal crop, while increasing soil erosion (Erabadupitiya, 2006). Both the climate and terrain are prone to soil erosion and serious damage to land and water resources are experienced in the cultivation of potato and vegetables. Damage is mostly due to inappropriate soil conservation measures. Owing to the high cost in soil conservation farmers do not adopt proper soil conservation measures which lead to land degradation in vegetable cultivated areas. The impact of these unsystematic cultivation practices has caused soil erosion and other environmental problems. Spatial variation of potential erosion is not only due to erosivity but also due to slope changes. Undulation of the topography can make large variations in the erosion even within one micro-watershed. It has been found that the soil erosion rate in Nuwara Eliya potato lands can be as high as 15 t/ha/year (Samarakoon, 2004). As a root crop, potato cultivation causes acceleration of soil erosion due to the ground being loosened in several cultivation practices such as land preparation, weeding, fertilizer application, earthing up and even harvesting.

Soil erosion is concentrated in hill country where watersheds of major rivers are located. (Abeygunasekara, 2004).

Scientific evidence has established that a relationship exists between soil erosion and potato cultivation. The average soil replacement cost in Nuwara-Eliya district potato lands was US$ 33/ha or Rs 3,343/ha (Samarakoon, 2004).

Flawed cultivation practices have caused soil erosion as well as the other environmental problems like resource degradation. In Sri Lanka, most of the vegetable farmers practice modern agricultural techniques such as intensive land preparation methods, synthesized fertilizer, hybrid seeds, and agro chemicals which in effect led to high cost of production, environmental pollution, biodiversity reduction, habitat destruction and risks to human health and welfare.

Fresh vegetables are a key source of nutrition in the Sri Lankan diet hence by increasing farmers' knowledge, there is potential to develop ecological farming systems to minimize the ill - effects of modern farming technologies.

Sustainable production has been suggested for enhancing productivity for future generations through the use of locally available resources such as manure and compost. It is well established that the application of organic fertilizer helps to improve the biological, chemical and physical qualities of soils by using sustainable soil conservation techniques in upcountry vegetable farming. According to Erabadupitiya (2006), for appropriate soil conservation, concurrent application of mechanical, biological and cultural practices should be followed adhering to the recommendations of the Department of Agriculture. However, farmers with similar soil erosion issues may adopt different combinations of soil conservation practices, to achieve different levels of soil conservation. It can be categorized as good, average or poor conservation, based on farmers “different socio-economic conditions”.

Farmers may have different attitudes towards soil conservation, which may impact on the selection of soil conservation practices. However, at execution their perception is not fully integrated with their soil conservation practices due to the socio-economic reasons. Abeygunawardene and Gunathilake (1992) have studied the factors that influence soil conservation decisions of tobacco farmers. Samarakoon (2004), reported that socio-economic factors such as education, age, land ownership, liability and subsidies can influence farmers’ decision to adopt soil conservation measures; however, little scientific evidence is available pertaining to the level of soil conservation measures adopted by farmers and the influence of socio-economic factors on farmers’ decision on those levels. In this study VBN (Value-Belief –Norm theory) theory will be applied to identify the farmers’ perception about soil conservation practices in upcountry vegetable farming in Sri Lanka.

1.3 Problem Statement

Rapid growth in the agricultural sector in Sri Lanka has led to resource degradation with an adverse impact on sustainability. A major form of environmental damage associated with agriculture is land degradation; particularly unsystematic cultivation practices have caused soil erosion on the steeply sloping lands of Central Hills. And how farmers' pro-environmental behaviours relate on their soil conservation practices?

1.4 Research Questions

- How do farmers identify the existing soil conservation practices followed and the factors affecting them?
- What are the effects of existing SLM practices followed by upcountry vegetable farmers and erosion category on productivity, unit cost of production, and unit profit?
- What is the relationship between the expenditure for existing SLM practices followed by the upcountry vegetable farmers with productivity, unit cost of production, and unit profit?
- How farmers' attitudes can impact the determination of soil conservation practices for sustainable vegetable production?

1.5 Objectives

Major Objective

A major objective of the study is to identify the factors affecting the soil conservation practices and the relationship of values and beliefs to determine the soil conservation practices used in upcountry vegetable farmers in Sri Lanka.

Specific Objectives

(1) To identify the existing soil conservation practices followed by the upcountry vegetable farmers and factors affecting them.

(2) To find out the effects of existing SLM practices followed by the upcountry vegetable farmers and erosion hazard level on productivity and profit.

(3) To suggest and recommend the strategies and initiatives towards raising awareness, rethink norms and improving knowledge on pro-environment soil conservation behaviours of the farmers.

CHAPTER TWO

Review of Literature

2.1 Different Sustainable Land Management (SLM) Technologies in Oil Conservation

Soil erosion is a grave concern that needs priority attention in developing rain-fed agriculture in the wet zone of Sri Lanka. Various development projects implemented in other wet zones have made great strides in conserving agricultural lands, catchments of reservoirs and stream bank reservations. Most of them were implemented through the community participatory approach. Most of the soils in Sri Lanka are highly erodible. Although the problem of soil erosion has been well recognized in the Central Highlands and effective conservation measures have been clearly identified severe land degradation continues unabated in most of the cultivated lands due to unattended soil erosion. Sustainable Land Management (SLM) Technologies evolved from different countries are now being shared by World Overview of Conservation Approaches and Technologies for other countries to choose their effective adoption. These SLM practices are recommended for sustainable vegetable farming lands.

1. Agronomic practices for vegetable farms

    i. Mulching
    ii. Contour planting
    iii. Minimum tillage
    iv. Application of organic fertilizer
    v. Mixed cropping

2. Vegetative methods for vegetable farms

    i. Biological hedges
    ii. Grass hedges
    iii. Cover crops

3. Structural methods for vegetable farms

    i. Stone bunds
    ii. Terracing
    iii. Gully control structures

Sustainable Land Management (SLM) Technologies have evolved from different countries are now being shared by World Overview of Conservation Approaches and Technologies (WOCAT) for other countries to find possibility of their effective adoption. The WOCAT database on SLM Technologies contains a full range of different case studies documented from all over the world. WOCAT's database currently comprises datasets of around 600 technologies from 50 countries.

SLM is defined as the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions. Various SLM technologies are being practiced around the world — mulching, contour planting, minimum tillage, application of organic fertilizer, mixed cropping vegetative methods for vegetable farms (Biological hedges, Grass hedges, Cover crops), structural methods for vegetable farms (Stone bunds, Terracing, and Gully control structures) (Dharmasena, 2017).

Soil conservation is relevant practices in SLM, which could be adopted in vegetable cultivation. Following SLM practices are recommended for sustainable vegetable farming lands (Dharmasena, 2017).

2.2 Land Degradation

According to Senanayake *et al.* (2013), soil erosion hazard assessment In VEST model resulted in the annual soil loss. In this study, In VEST sediment delivery ratio (SDR) model was used to map and assess soil erosion (Sharp *et al.,* 2015). This map classified five levels of soil erosion hazard (Table 1).

Table 2.1 Erosion Hazard Levels

Erosion hazard level	Average annual soil loss (t/ha/yr.)
Low	0-5
Moderate	5-12
High	12-25
Very high	25-60
Extremely high	>60

Source: Senanayake *et al.*, 2013

Higher soil erosion hazard was observed in up country due to greater contribution of rainfall erosivity and hilly to mountainous topography. Senanayake (2013) stated that areas of both low and moderate levels of soil erosion hazard can be allowed for agriculture. Areas under high, very high and extremely high levels should however be managed for crop cultivation with utmost care to avoid the degradation of lands. Thus, this study revealed that 83.5% of the area of Sri Lanka is under low hazard of soil erosion and 4.8% is under moderate hazard level. Moreover, the percentage of area under high level of hazard is 11.8% which is intolerable for any land use with respect to the sustainable productivity. Implementation of proper soil conservation practices are of utmost importance to arrest the severe erosion presently occurring in these areas.

2.3 Climate Change Impact

Sri Lanka is a tropical nation, highly vulnerable to impacts of climate change. The climate of Sri Lanka experiences three main types of variations, gradual increase in air temperature, changes in pattern of rainfall and increase in frequency and severity of extreme weather events such as floods, droughts and winds (Chandrasiri, 2013). The rural level smallholder farmers are severely affected by climate change due to their low adaptive capacity to climatic change. Adaptation to climate changes is the most appropriate and approachable way for farmers to lower the negative impacts of climate change as it is a means of transmitting the outcome of the farmer's perception on climate change. In Sri Lanka, some scholars point out that adverse impacts of climate change on agricultural production could be minimized by applying suitable adaptation strategies such as introduction of micro irrigation, soil conservation, changing planting dates, reduction of irrigation depth and crop diversification (Esham, 2013). Fewer studies propose that changing planting time to suit rainfall variability and introduction of micro irrigation are the best adaptive methods to minimize the negative impacts of climate change (Aheeyar *et al.,* 2005).

2.4 Policies and Legislations Related to Soil Conservation

Policies and legislations protecting the land resources in the country were introduced following Independence. Poor implementation of these legislations under the present institutional set-up at national, provincial and local levels is a key limitation in land resource management in Sri Lanka (Amarasekara et al., 2008).

Soil Conservation Act introduced in 1951 could not create much impact even after 50 years. The existing institutional set-up lack vigour at the field level; hence capacity building of the institutions with strong political will can be effective in preventing further degradation of land and water resources (Amarasekara *et al*, 2013).

The Table below illustrates the evolution of legal enactments related to land and water conservation in Sri Lanka.

Table 2.2: Evolution of Legal Enactments Related to Land and Water Conservation

Act	Year
Land Ownership Act	1840
Crown Land Encroachment Ordinance	1840
Irrigation Ordinance	1856 1897
Forest Ordinance	1907
Land Development Ordinance	1935
The Fauna and Flora Protection Ordinance	1937
State Land Ordinance	1947
Soil Conservation Act No 25 & 29	1951
Soil Conservation Special Regulations	1953
Agrarian Service Act	1959
Water Resources Board Act	1964
The State Agricultural Corporation Act	1972
National Water Supply and Drainage Board Act	1974
Land Grant Special Provision Act	1979
The Mahaweli Authority of Sri Lanka Act	1979
National Environmental Act	1980
The National Heritage Wilderness Act	1988
Soil Conservation (amended) Act No24	1996
National Watershed Management Policy	1996
National Land Use Policy	to
National Water Resources Policy	2005
(National Agriculture Policy, 2021) Adopt soil and water conservation measures to control soil erosion and land degradation.	2021

Source: Mainly Amarasekara *et.al*, 2013 and Author's survey data, 2021

2.5 Farmers' Pro-Environmental Behaviour

Attitudinal change of farmers about soil conservation also comes under the SLM technologies (Dharmasena, 2017). An objective of this research is to investigate the influence of farmers' subjective beliefs on their decision to actually implement soil conservation, and investigate how these insights can contribute to increase implementation of soil conservation measures at farm level. Many interrelated socio-economic factors such as land fragmentation due to population boom, neglected and poorly-managed tea lands due to low income, and encroachment of sensitive lands have also contributed to soil erosion (Nayakakorale H.B., 1998). Conservation of soil resources is inhibited by two factors: natural and/or climatic conditions and management and conservation of soil resources by human activities (Bayat, Rastegar, & Azizi, 2011). Human activities would cause environmental degradation (Bijani & Hayati, 2015), including soil degradation, by their behaviour towards the environment and making changes in the environment, which is detrimental (Steg & Vlek, 2009). As a result, systematic investigations of the behaviour and the factors affecting its formation (such as environmental concerns and attitudes) are of paramount importance with regard to soil conservation (Abbasian, Chizari, & Bijani, 2017; Adams, 2014).

Studies on factors explaining individuals' behaviours towards issues such as soil, water, air, and environment, in general, have provided a wide range of classifications (Valizadeh et al., 2016). In a general classification, however, studies conducted in this field are of twofold: (1) Studies employing a particular theoretical model; and (2) Studies on pro environmental opinions, concerns, and behaviours that do not utilize a specific theoretical framework. Both have been popular in the fields of environmental sociology (Gross & Hein Richs, 2010), human ecology (Tien, 2009), and environmental psychology (Hsu, 2003).

According to literature review (where pro-environmental attitudes and social pressures act as individuals' behavioural bases and environmental concern is an important factor in shaping pro-environmental behaviour), this study primarily investigates the effect of two variables "attitude" and "social pressure" on the variable "soil conservation concern", and analyzes the effect of the variable "soil conservation concern" on "soil conservation behaviour”. Farmers’ perception on soil degradation, soil conservation, nutrition-based agriculture, bio-fertilizer and bio pesticides, farm waste management, crop management, present status of soil fertility in intensive cultivated vegetables, mitigation of and adaptation to climate change, indigenous knowledge and new technologies have changed. For understanding the farmers’ pro-environmental behaviours, the following conceptual framework was used (Figure 2.1). Based on this theory, pro-environmental behaviour originates from the individual norms such as the feeling of moral obligation to act pro-environmentally. In this study investigating the effect of two variables "attitude" and "social pressure" on the variable "soil conservation concern", and analysing the effect of the variable "soil conservation concern" on "soil conservation behaviour".

Conceptual Framework Adapted from Bijani, *e tal* (2017) to Identify the Pro-environmental Behaviors of the Vegetable Farmers in the Upcountry.

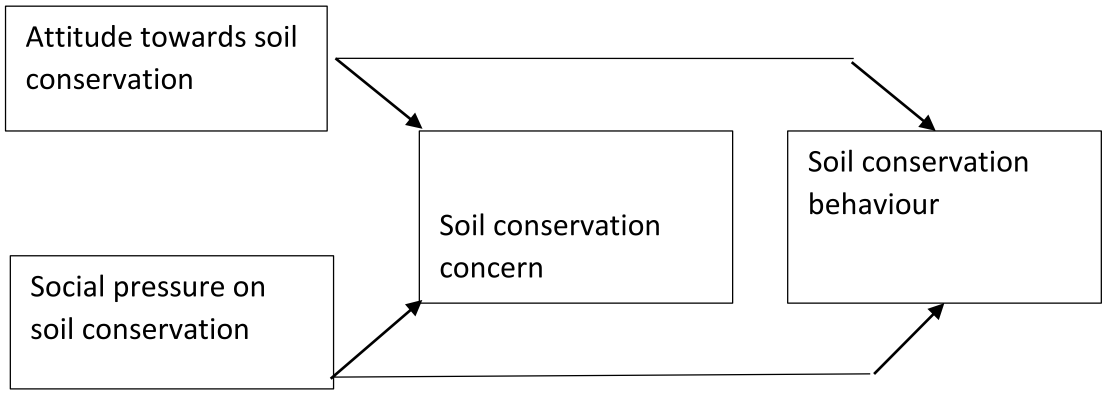


Figure 2.1 Conceptual Framework Adapted from Bijani, *et al*. (2017)

2. 5 Conceptual Framework for the Factors Considered in the Study

The figure below was developed to identify the other factors reflected in the study.

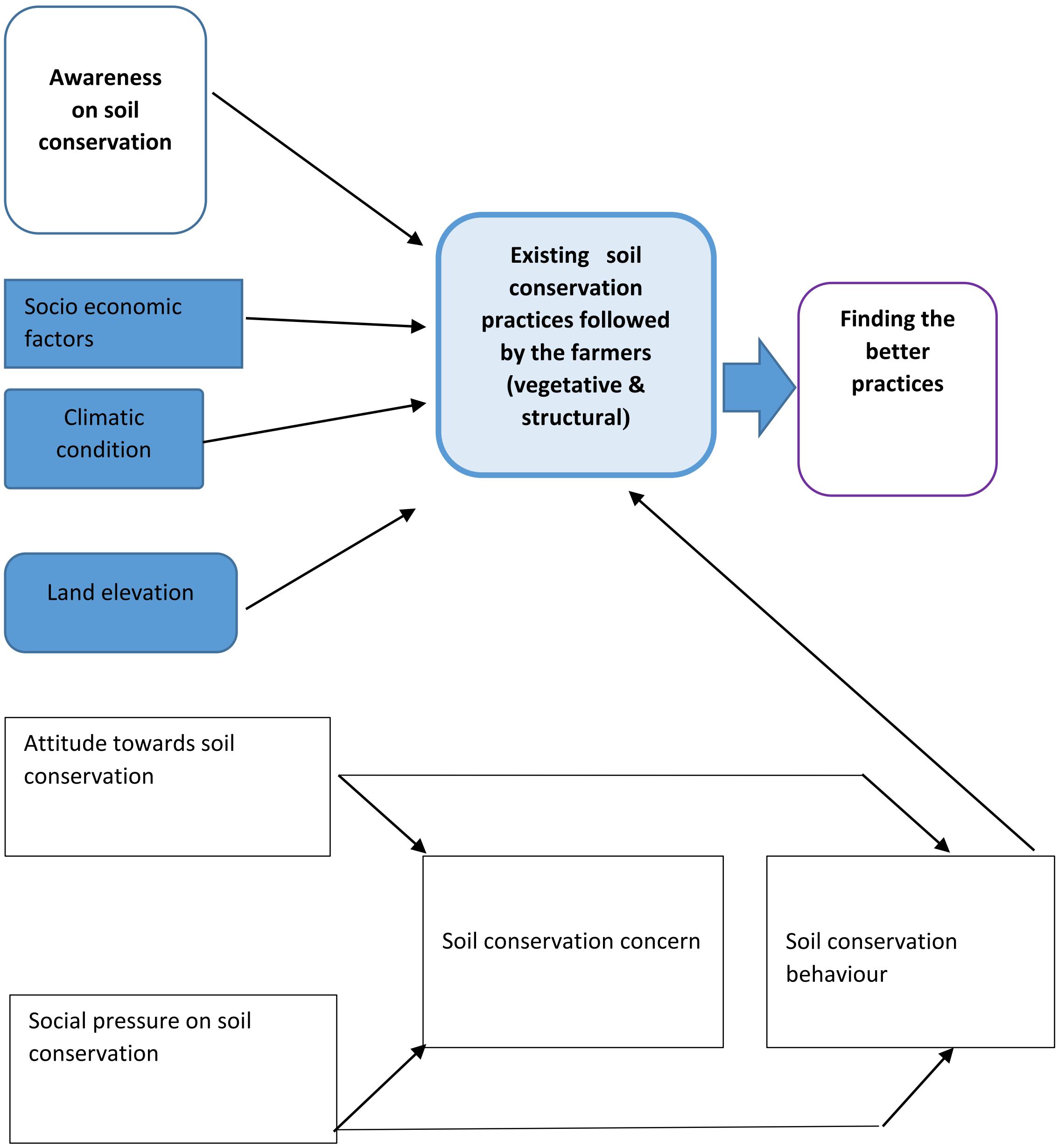


Figure 2.2: Conceptual Framework for Factors' Effect on Soil Conservation Practices

CHAPTER THREE

Methodology

3.1 Sample Selection Investigators

This study was conducted in the Central Province of Sri Lanka. The sample size of a survey is decided considering the margin of error and confidence level of a certain segment of the vegetable farmer's population. Depending on the confidence level and the margin of error, the number of vegetable farmers in the sample varies. In this study, we determined the margin of error and confidence level as 5% and 95% respectively. Then the required number of farmers surveyed was 384. Multi-stage sampling technique was employed to derive the sample.

Having determined the study location (Nuwara Eliya, and Kandy districts), in the first stage, Divisional Secretariats (DSs) belonging to each district are categorised as low, moderate and high based on the erosion category. Then, DSs are selected proportionately to the number of DSs in each erosion category (representing two DSs from the lowest number of DSs possessed erosion category). Next, Grama Niladhari Divisions (GNDs) are selected proportionately as per the number of ASCs in each DS. Finally, sampling is to be applied proportionately in each selected ASC to draw a sample of 384 farmers representing ASC in proportionate to the number of farmers functioning within. Subsequently, it is extrapolated with regard to the entire vegetable farmer population in the upcountry in each erosion hazard level as Low, Moderate, High, Very high and Extremely high (Source: Senanayake et al., 2013).

3.2 Distribution of the Selected Sample

Table 3.1: Sample Distribution

District	DS Division	GN Division	Sample Size (proportionate to the population)	Sample Size (erosion hazard level)
Nuwara Eliya	Nuwara Eliya	Agarapathana, Magoda, Wewaraliya, Kolbook, Dayagama	40	Low, 13 Moderate,25 High,35 Very high 32 Extremely high17
	Walapane	Binganthalawa, Brookside, Udawela, Morabedda, Palalpathana, Ekangapura, Padiyapelalla, Ragala	68	
	Hanguranketha	Goodwood, Udugama	14	
Kandy	Akurana	Dunuvila, Deegala, Dippitiya	15	Low, 41 Moderate, 25 High,92 Very high ,77 Extremely high15
	Ududumbara	Halyala, Hapukanda, Dewahandiya, Pitigoda, Madugalla	16	
	Udunuwara	Ambanwala, Piligalla, HAndessa, Urulewatta, Deliwala, Minuwangamuwa, Angunawala, Elpitikanda, Udugama, Galagedara, Welagedara, Rbbegamuwa, Rangama, Yalegoda, Pihitideniya	20	
	Kundasale	Udagama, Dambarawa, Dodangolla, Maharathenna, Menikhinna, Gurudeniya	17	
	Thumpane	Bananga, Poholiyadda, Kandekumbura, Ethamulla, Udalagama	14	
	Delthota	Delthota, Bopitiya	15	

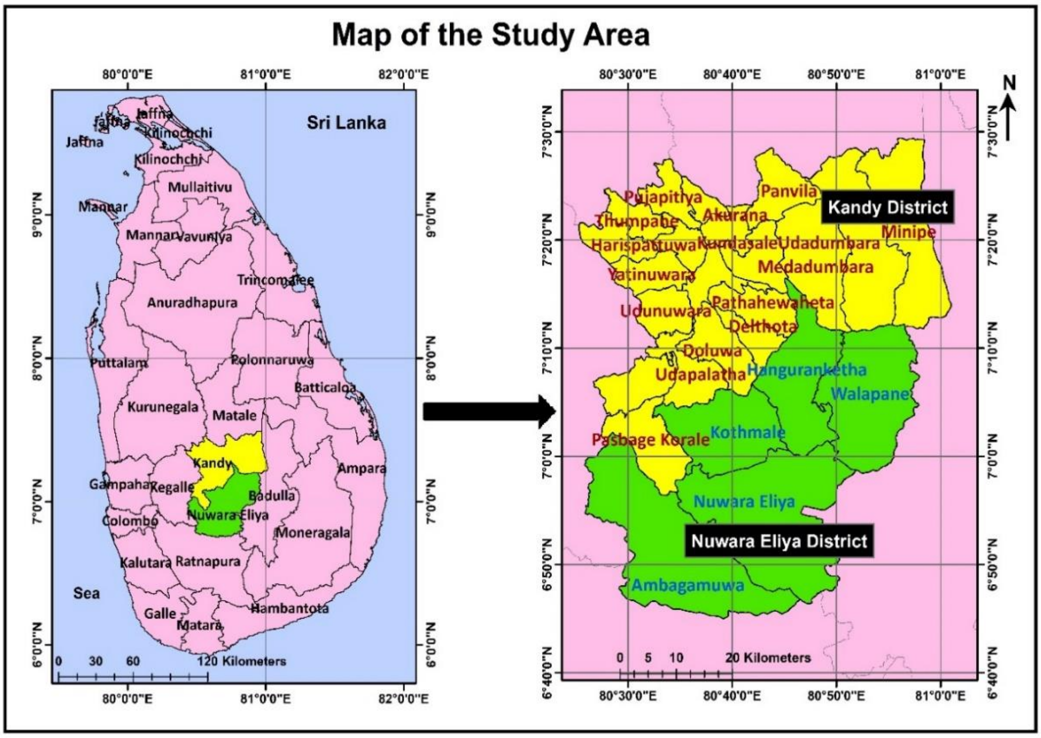
	Doluwa	Doluwa, Wewathenna, Kohawatta, Panvilathenna, Hunukotugama, Nawa Gurukele	10	
	Pathahewaheta	Medagama Udugama, Godamunna, Bolepa, Marassana, Galagoda, Kapuliyadda, Bootawatta, Hewavissa, Welegama, Meeruppa	36	
	Pujapitiya	Batugoda, Ovissa	16	
	Medadumbara	Wathuliyadda, Medamahanuwara, Puwakgahadiwela, Thennalanda, Ambala, Udathenna, Karaliyadda, Doraliyadda, Werathenna, Meegahamaditta	21	
	Minipe	Bebiya, Kolonyaya, Muttettuthenna, Minipe, Gurulupotha	18	
	Yatinuwara	Imbulmalgama, Siyambalagoda	16	
	Hatharaliyadda	Kolugala, Piligalla, Walpalagolla, Welivita Pahalagama	18	
	Harispattuwa	Arambegama, Udadoolwala, Udagokalawela, Ulladupitiya, Thittapathgala	18	

Source: Author's survey data, 2021

3.3 GIS Maps

Pertaining to the study area, GIS maps were developed to indicate the spatial distribution of the sample. GIS software was applied to draw the maps and generate the maps to show the spatial distribution of the sample.

Distribution of the Selected Sample



Source: Author's survey data, 2021

Figure 3.1: Map of the Study Area

3.4 Methods of Data Collection

Both primary and secondary data were collected to achieve the research objectives. Key Informant Interviews, Focus Group Discussions, Structured Questionnaires Surveys and Case Studies were conducted to extract the primary data. The nature of the study demanded a detailed account of primary data and soil conservation practices and farmers. Therefore, a questionnaire focusing on soil conservation practices, household information, land characteristics, cost of production and other socio-economic characteristics of farmers, was used in the interview. The respondents are the current farm operators, the head of the farm households who make decisions on land - use.

Secondary data that consisted of the subsidiary programmes implemented, recommended management practices for vegetable cultivation and the current status of the land use pattern for vegetable cultivation was derived from documents, reports, journal articles, records and maps of the relevant areas.

The Departments of Agriculture and Census and Statistics are the two main sources of secondary data. Additionally, the Natural Resource Management Centre, Department of Agriculture, Peradeniya, Divisional Secretariats and Land Use Division of the district were referred to.

Key Informant Interviews

Key informant interviews were conducted with the responsible officers (Officers of Agriculture Department and Department of Agrarian Development and village level officers (Agricultural Research and Production Assistants and Grama Niladhari of the relevant area) to collect information on the present status of the vegetable cultivation in the study area, existing issues and performance. This was executed with the help of structured and guided schedules.

Focus Group Discussions

Focus group discussions were held with the members of the farmer organizations in the relevant area to obtain cultivation-related details.

Officers of the Agriculture Department and Department of Agrarian Services, Natural Resource Management Centre, Divisional Secretariats and Land Use Division, of the relevant study area participated in those discussions.

Structured Questionnaire Survey

The questionnaire survey comprised two parts: for the vegetable farmers, about the existing practices on the cultivation, to observe the farmer's Pro-environment values about soil conservation practices.

Sample Selection and Questionnaire Surveys

GIS Maps

GIS maps were developed for the study area to indicate the spatial distribution of the sample. GIS software was used to identify the spatial distribution of the sample and the different soil types in the area.

3.5 Data Analysis

Collected data was analysed using descriptive statistics and inferential statistics.

Data Analysis and Analytical Techniques

Objective 1:

To identify the existing soil conservation practices followed by the upcountry vegetable farmers and factors affecting them.

Data Sources: Primary data

According to the objective 1, this study examines the factors affecting the soil conservation practices of Upcountry vegetable farmers. The factors given below were examined by farmer field observations for that end.

SLM Practices Followed by the Upcountry Vegetable Farmers

a) Agronomic practices (Conventional ploughing, Contour planting, Minimum tillage, Application of organic fertilizer)
b) Vegetative methods (Biological hedges, Grass hedges, Cover crops, Mulching)
c) Structural methods (Lock and spill drains, Stone bunds, Soil bunds and drains, Terracing, Gully control structures)
d) Cropping systems (Continuous, Annual rotation, mixed cropping, Intercropping)

- ❑ The existing SLM practices followed by the upcountry vegetable farmers were identified using descriptive statistics.
- ❑ Further, each SLM practice was rated as highly adopted, moderately adopted and not adopted based on the DOA recommendations that consist of different levels and sub levels. For example, conventional ploughing coming under the agronomic practices can be categorised as highly adopted, moderately adopted and not adopted.

Using descriptive statistics, the factors affecting the soil conservation practices used by farmers were discerned. Physical factors affecting soil conservation practices adopted by farmers were observed according to the DOA recommendations (highly adopted, moderately adopted, poorly adopted and not adopted). The logistic regression analysis was applied to find out the effects on the factors effect on soil conservation and adoptability on soil conservation practices

Objective 2:

To find out the effects of existing SLM practices (Agronomic practices, Vegetative methods, Structural methods and Cropping systems) followed by the Upcountry vegetable farmers and erosion hazard level on productivity and profit.

Data Source: Primary data

Analytical Method:

- Two-way factorial ANOVA are to be applied separately to each SLM practice with profit.
- The reason for applying two-way factorial ANOVA is the varied constitution of SLM practices. One-way ANOVA was applied to find out the effects of erosion hazard level on productivity and profit.

Objective 3:

To suggest and recommend the strategies and initiatives directed at raising awareness, rethinking the norms and improving the knowledge, which build pro-environment soil conservation behaviours of the farmers.

Data Source: Primary data

Analytical Method:

The effect of two variables "attitude" and "social pressure" on the variable "soil conservation concern", and analysing the effect of the variable "soil conservation concern" on "soil conservation behaviour" was investigated. The reliability of the questionnaire relevant to objective 3, was calculated using Cronbach's alpha test for the variables measured by the Likert scale. To examine the relationship between variables, Pearson correlation was primarily used. The path analysis was used to determine the explanatory power of the variables.

3.6 Operationalization of Variables in Objectives

Identifying different soil conservation practices/tillage method adopted by vegetable farmers.

Variable	Meaning	Measuring
Cultivated land extent	To identify the vegetable cultivation distribution in Sri Lanka	In acres
Erosion category Erosion hazard levels	Some factors described such as slope, slope length, management factors, soil types are considered here. Average annual soil loss (t/ha/yr.)	(Senanayake et al., 2013)
Physical factors on soil conservation Existing soil conservation practices used by farmers	a) Agronomic practices b) Vegetative methods c) Structural methods d) Cropping systems	Using DOA recommendations
Land tenure	To identify the relationship between land tenure and soil conservation	who can use land, for how long and under what conditions
Subsidy Schemes for soil conservation	To find out the government support	Qualitative data

Operationalization of Variables in Objective 2

Variable	Definition	Unit
Total capital expenditure	Total capital expenditure	Rupees
Annual maintenance cost	Annual maintenance expenditure	Rupees
Construction cost	Total construction cost	Rupees per square feet
Maintenance cost	Total maintenance cost	Rupees per square feet
Labour used in conservation measures	Total man-days	Per day

Operationalization of Variables in Objective 3

To suggest and recommend the strategies and initiatives required to be taken to improve awareness and knowledge which build pro-environment behaviours of the farmers.

Variable	Definition	Unit
Social values/ norms	Farmers' perception of social pressures and expectations to perform pro-environmental behaviours related to healthy crop production	Social values/ norms will be measured with individual and group discussions.
Environmental affections	Negative or positive feeling towards the environment and empathy with nature, as well as creating emotional relationship with nature and the environment	Social values/ norms will be measured with individual and group discussions.
Moral norms	Farmers' self-expectation of performing pro-environmental activities in a special situation (non-use of chemicals) as a feeling of moral obligation	Measured with individual discussions.
Environmental responsibility for soil management	Attributing pro-environmental behaviour to protect and strengthen soil to him/herself	Measured with individual discussions.
Awareness of environmental consequences	People's awareness level of adverse effects of their activities (using chemicals in agriculture) on themselves and the others	Measured with group discussions.
Perceived behavioural control of clean technology	People's perception of their control level on needed resources of pro-environmental behaviours and avoiding non-environmental behaviours to produce healthy crop	Measured with individual discussions.
Attitude toward the environment	A complicated and multi-dimensional concept including negative and positive senses on the environment and a mental state which affects people's selections related to the environment	Measured with individual discussions.
Pro-environmental behaviour (Adoption)	It refers to farmers' decisions in order to accept and utilize modern and clean technologies in their agricultural lands in accordance with environmental protection	Measured with individual and group discussions
Training	The social and the government support on coconut cultivation	Participation for extension services, People who provide extension services, Number of times the extension services is provided, Satisfaction on extension services, Further extension needs

Socio-economic Characteristics of Cultivators Affecting Soil Conservation Practices

Variable	Definition	Unit
Age	Age of the HH decision maker influences the vegetable cultivation.	Age by number of years; Categorical variable
Education Level	Education level of the HH decision maker influences the vegetable cultivation.	A categorical variable consists with primary education to tertiary education
No of Family Members in HH	Number of family members in the family influence on cultivation	By number; A categorical variable
Experience (Years)	Experience about vegetable cultivation	years
Annual Income	Annual income (vegetable cultivation)	Rupees
Family Income	Income level of the family influences the coconut cultivation in HG	As rupees per month; A categorical variable
Hired labour cost	Hired labour cost per day per acre	(Man days/acre)
Family labour	Family labour per day per acre	Man days/acre
Productivity	yield	Kg/acre
Unit cost of production	cost	Rs/acre
Unit profit	Profit (Rs/acre)	Rs/acre

CHAPTER FOUR

Results and Discussion

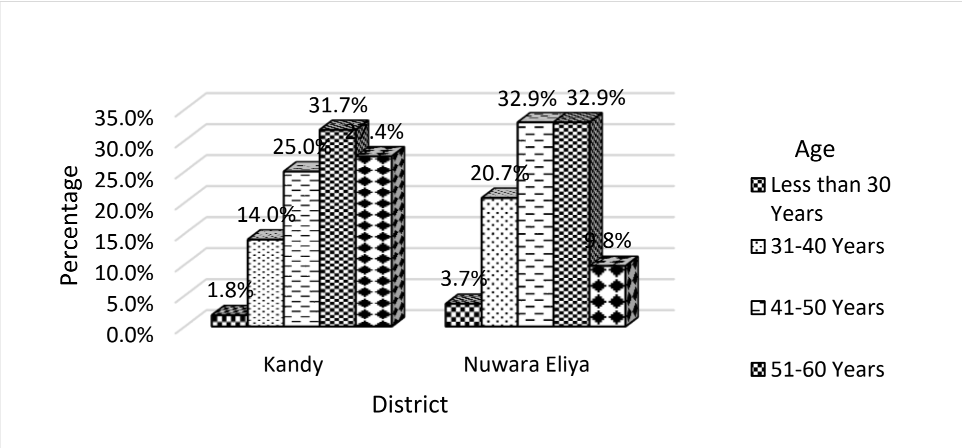
Socio - Demographic Characteristics of the Villagers and the Land Use Pattern of the Study Area

This chapter presents an overview of the main socio-demographic characteristics, socio - economic status of farm families and the nature of farming in detail. The extent of vegetable lands and their distribution across the study locations and the land use pattern of the study area are also discussed. At first, descriptive statistics is used to illustrate the variables.

4.1 Socio - Demographic Factors

4.1.1 Age Distribution of the Vegetable Farmers in the Study Area

The age distribution of the vegetable farmer population is presented in Figure 4.1. Those below 30 years in the population is less than 4% in all districts. The age group of 51-60 years represents a major part of the population in both districts. According to the statistics, the working age population in Sri Lanka, 30-65 years, consists of about 60% of the population in the country (Central Bank Report, 2021). Only 14% and 1.8 % were from 31 years to 40 years of age and below 30 years respectively in the Kandy district. In Nuwara Eliya, 20.7% and 3.7 % were from 31 years to 40 years of age and below 30 years respectively. Compared to the Kandy district, more young farmers were noted in Nuwara Eliya district. It is perceived that younger people's contribution to vegetable cultivation is minimal. According to the statistics, the working age population in Sri Lanka, 30- 65 years, consists of about 60% of the population in the country (Central Bank Report, 2021).



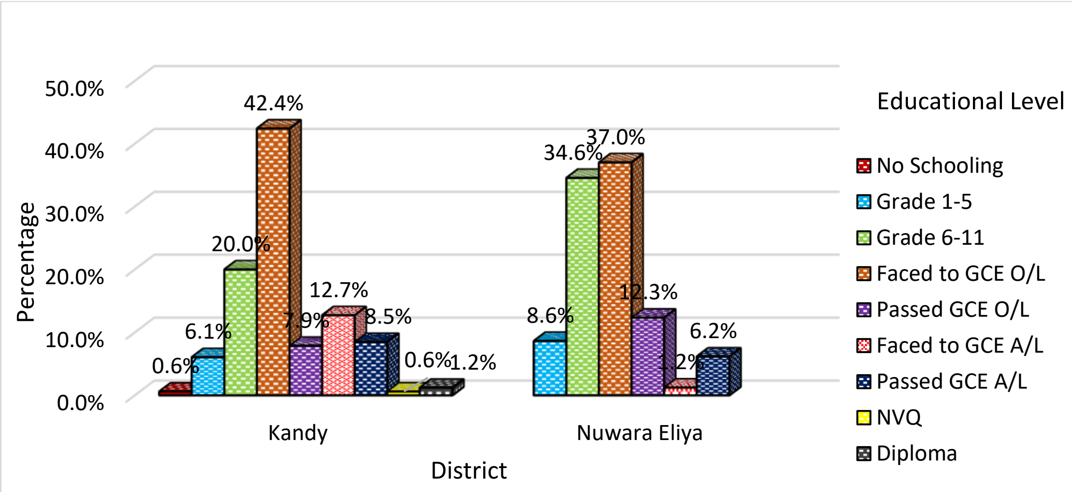
Source: Author's survey data, 2021

Figure 4.1: Age Distribution of the Vegetable Famers

4.1.2 Educational Level of Vegetable Farmers in the Sample Area

The educational level of the vegetable farmer's population is presented in Figure 4.2 as categorical scale data. As per the data, in both districts, the majority has received secondary education, up to the ordinary level.

The graphical representations are similar to that of the year 2021 of the Department of Statistics. It is noted that very few numbers had passed the Advanced Level Examination in Kandy and Nuwara Eliya districts, respectively. Less than 1% had completed a diploma.

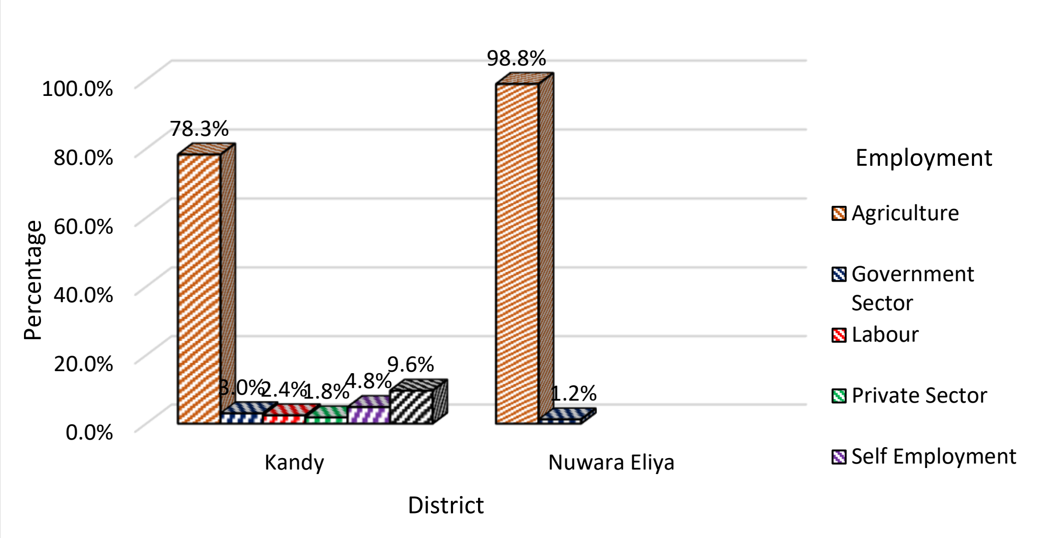


Source: Author's survey data, 2021

Figure 4.2: Educational Status of the Respondents

4.1.3 Employment of the Vegetable Farmers

The interviews revealed various activities which the farmers were engaged in. Further, fewer number of farmers from Kandy and Nuwara-Eliya are engaged in the government or semi government sector employment while a similar percentage is working in the private sector. Only 4.8 % were engaged in self-employment in Kandy, the category for which none was recorded in Nuwara Eliya. The government employment percentage was high in the Kandy district. According to the findings, the majority's mainstay was agriculture.

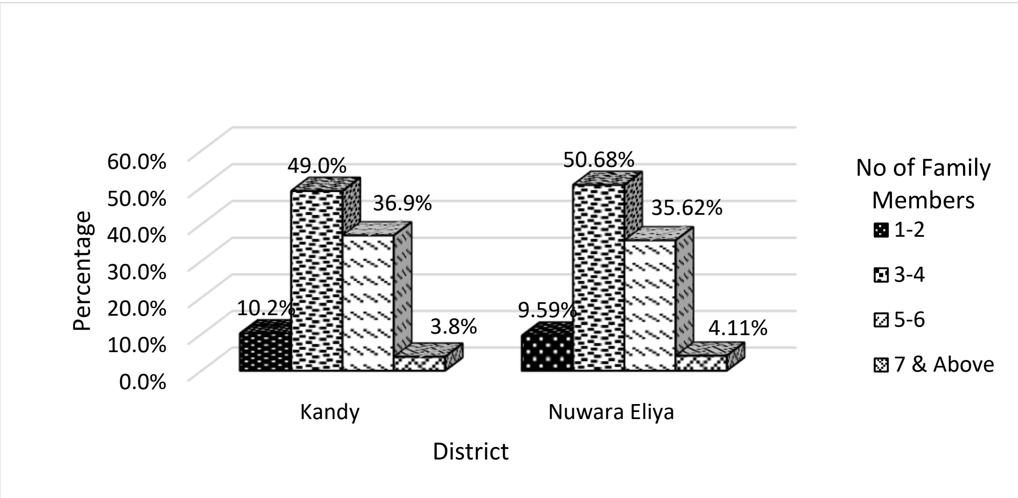


Source: Author's survey data, 2021

Figure 4.3: Distribution of Primary Employment among Vegetable Farmers

4.1.4 Household Size of the Farmer Families in the Study Area

The household's size of the vegetable farmer's population is presented in Figure 4.4 as categorical scale data. Average HH size of the sample is four, which is in accordance with the national statistics in 2020 (Central Bank Report, 2020). According to the survey data, the average number of children per family is two. This corroborates with the national statistics in 2020 (Central Bank Report, 2020).

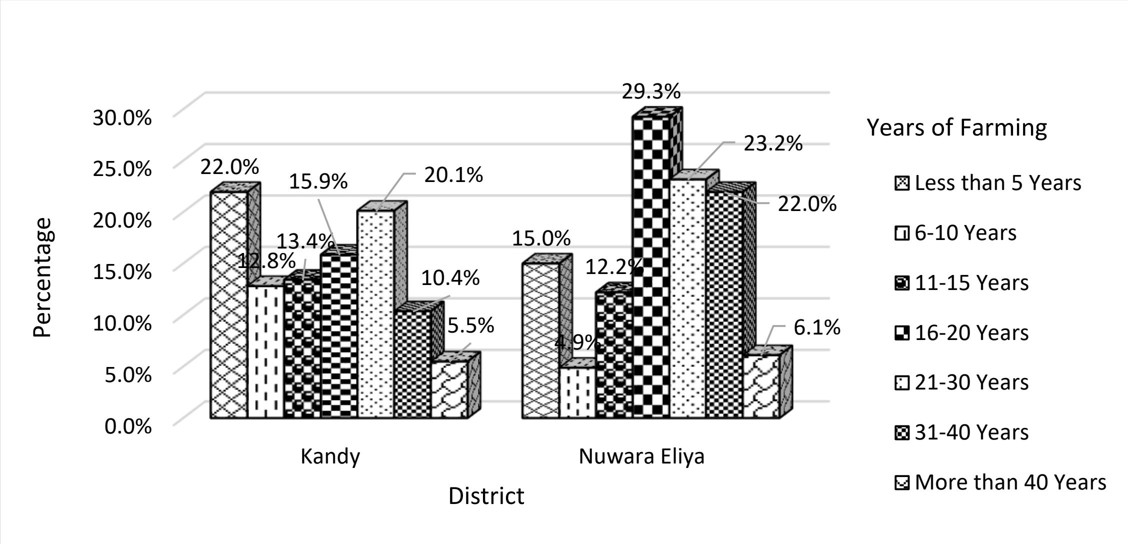


Source: Author's survey data, 2021

Figure 4.4: Number of Family Members in the Study Area

4.1.5 Experience of Vegetable Farmers

The experience of vegetable farmers in cultivating vegetables is presented in Figure 4.5 as categorical scale data. Interestingly, the majority (51.9%) had more than 15 years of experience in Kandy district and in Nuwara Eliya district it was 80.6% (Figure 4.5). The breakdown shows that in Kandy 5.5 % of them had above 40 years of experience and it was 6.1% in Nuwara Eliya. In Kandy 22 % recorded below 5 years of experience at the field while only 2.4% had been practicing farming in Nuwara Eliya. Only 5.7 % had more than 40 years of farming experience. However, it concludes that except a negligible population all farmers had satisfactory experience in vegetable cultivation.



Source: Author's survey data, 2021

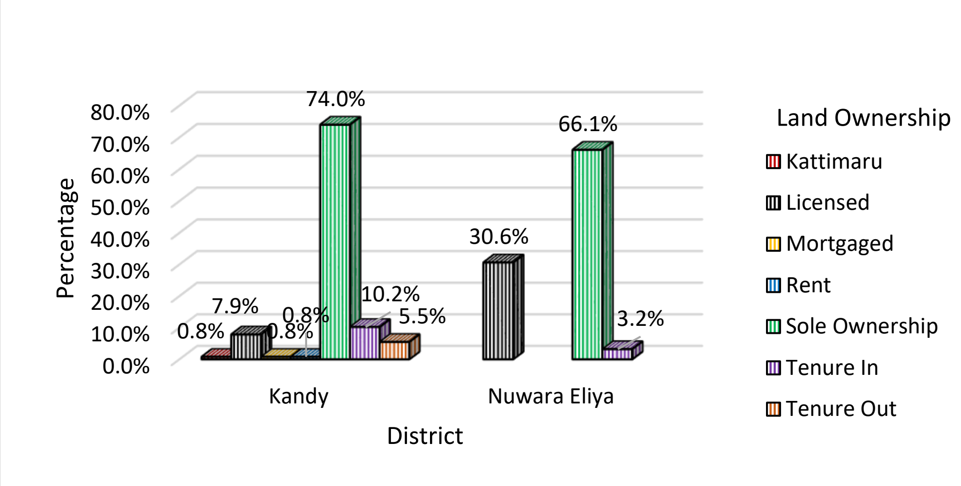
Figure 4. 5: Experience of the Vegetable Cultivation

4.2 Distribution of the Vegetable Lands

4.2.1 Ownership of Lands

The majority of vegetable, farmers (74% in Kandy and 66% in Nuwara-Eliya) had sole proprietorship. Even though most of the sample farmers have more than one plot in their name, the majority of the low land plots in each district were under tenure arrangements in which the ownership rotated at least once (Figure 4.6). Tenurial patterns were only reported for low-lands in up-country. Accordingly, the most prominent land ownership types were owned and leased lands. Other ownership types were relatively insignificant.

The most prominent land ownership type is sole ownership, followed by leased. The other ownership types were not very common.

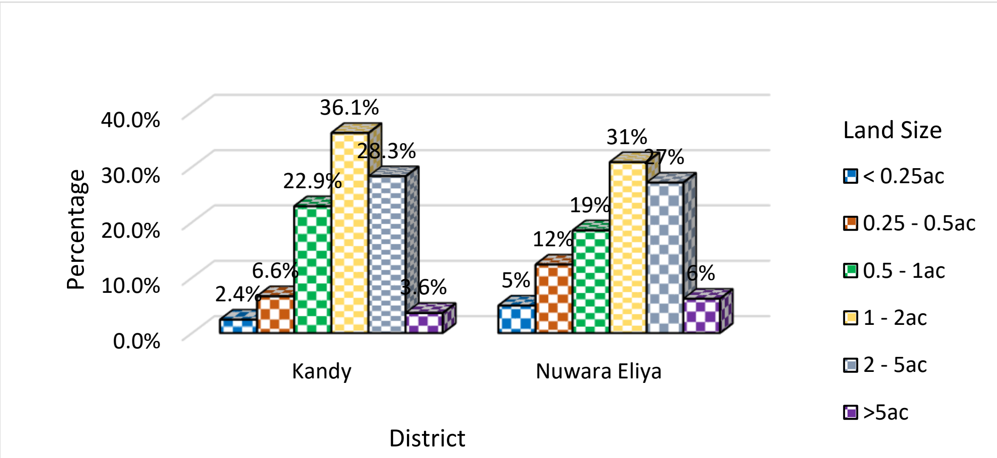


Source: Author's survey data, 2021

Figure 4. 6: Ownership of Lands

4.2.2 Extent of Land Owned

The majority of vegetable farmers (68% in Kandy and 67% in Nuwara Eliya) owned 1-2 acres further, 9% in Kandy and 17% in Nuwara Eliya had half an acre or less (Figure 4.7). In total more than 32% in Kandy and 3% Nuwara Eliya farmers had an acre or less. Only, 5% had more than two acres for vegetable cultivation. Interestingly, this is further divided as 3% in the up-country and 2% in the low-country.



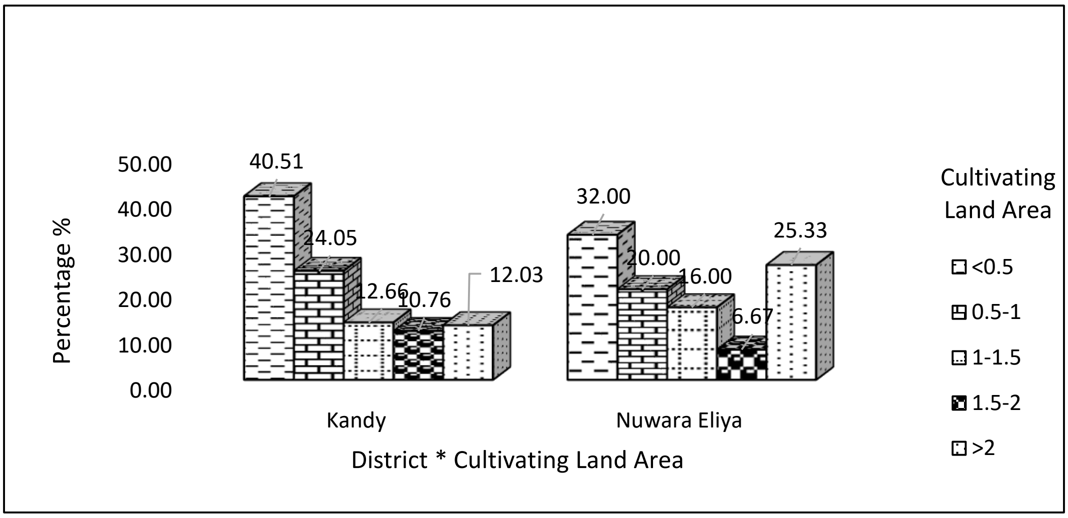
Source: Author's survey data, 2021

Figure 4. 7: Distribution of the Land Owned

4.2.3 Distribution of Vegetable

Cultivated Land Extent

Figure 4.8 demonstrates the land extent owned by vegetable farmers. The majority of vegetable, farmers 40% in Kandy and 32% from Nuwara Eliya owned less than half an acre (Figure 4.8). Further, this implies that the majority of farmers — mostly functioning at small scale — cultivate vegetables in smaller plots compared to other major food crops in Sri Lanka.



Source: Author’s survey data, 2021

Figure 4.8: Cultivated Land Extent (acre)

CHAPTER FIVE

Results and Discussion

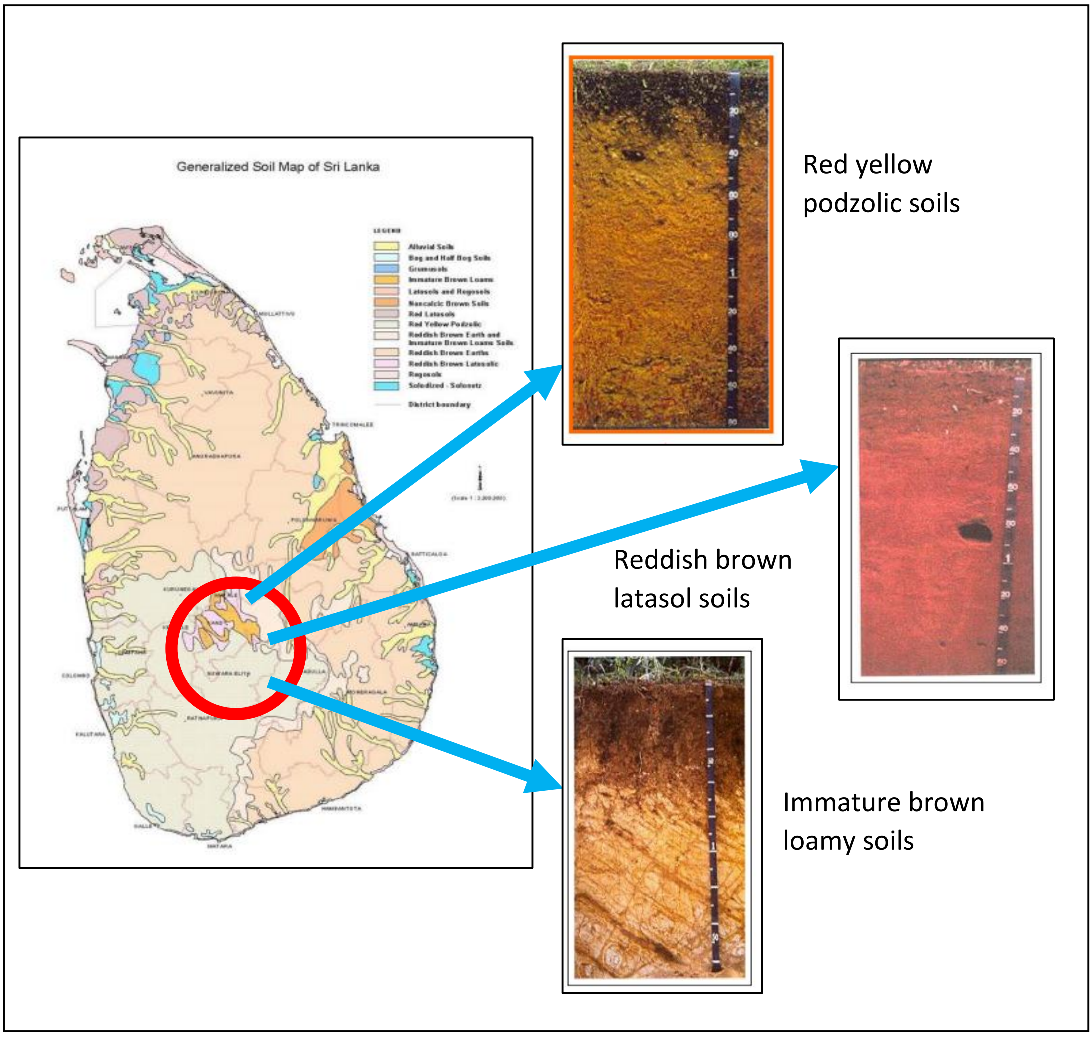
Present Status of the Soil Conservation Practices

This chapter describes the prevailing soil types in the study area and the present situation of the soil and water conservation practices, water usage, water application methods and different sustainable land management practises followed by farmers in the study area.

5.1 Different Soil Types in the Study Area

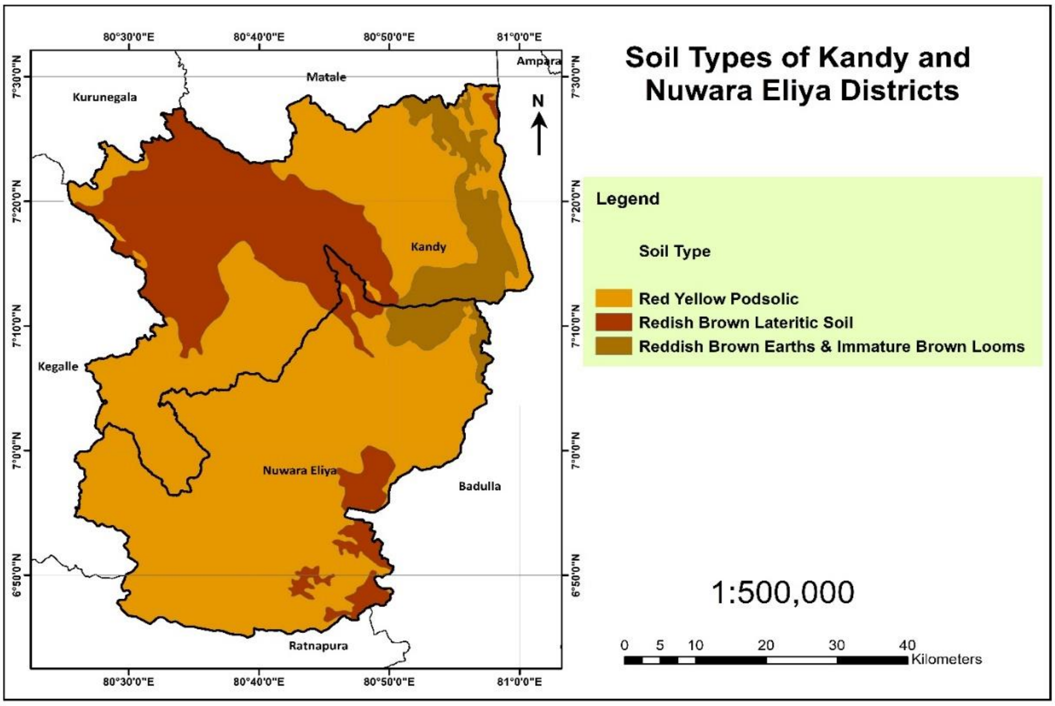
Sri Lanka has a humid tropical climate where year-round high temperatures and precipitation are the main features. Hot and humid climatic conditions result in highly weathered soils. Climatic factors, especially amount of rainfall, play a significant role in the development and weathering of soils of Sri Lanka. Hence, Sri Lanka is divided into wet, intermediate, and dry zones based on the amount and distribution of rainfall. Mineralogical make-up of the soils confirms dry zone and intermediate zone soils are younger or less weathered than soils of wet zone in relation to the stage of soil development. Panabokke compiled a soil map of Ceylon in 1962 on a scale of 8 miles to the inch (l: 506,880). Soil surveys conducted by the Land Use Division of the Department of Agriculture, the soils of Sri Lanka was classified to Great Soil Groups. the great soil groups by Morman and Panabokke in 1961. Detailed reconnaissance surveys are in progress in the areas of a large scale multi-purpose development project.

There are three major soil types in the wet zone: Red Yellow Podzolic Soils (Rhodudults and Tropudults). They occur in diverse landforms and are normally deep. Predominant textural classes of surface soils are sandy loam, sandy clay loam or loam and the structure is usually weak or moderate with crumb or granular structure. Soil reaction is acidic and the cation exchange capacity may vary from 2-10 c mol kg^{-1} in surface soils. Reddish Brown Latosolic Soils (Rhodudults and Tropudults) are the next prominent soil group found in the wet zone of Sri Lanka. Most of these soils occur on terrains that have been incised by ecological erosion. These soils are relatively young. The texture is mostly sandy clay loam and the structure is strong crumb to granular under natural vegetation. These soils are normally deep, soil reaction is slightly acidic and the cation exchange capacity may vary from 4-15 c mol kg^{-1} in surface soils. Immature Brown Loams (Eutropepts and Dystropepts) are young soils occurring in close association with Reddish brown latosolic soils and are mostly found in the wet and semi-wet intermediate zones of the country. Soil texture is predominantly sandy loam or loam. Structure is often weak crumb or subangular blocky. Soil reaction is acidic in the wet zone and the cation exchange capacity can vary from 1-20 c mol kg^{-1} in surface soil. Figure 5.1 and 5.2 specify the different soil types in the study area.



Source: Author's survey data, 2021

Figure 5.1: Different Soil Types in the Study Area



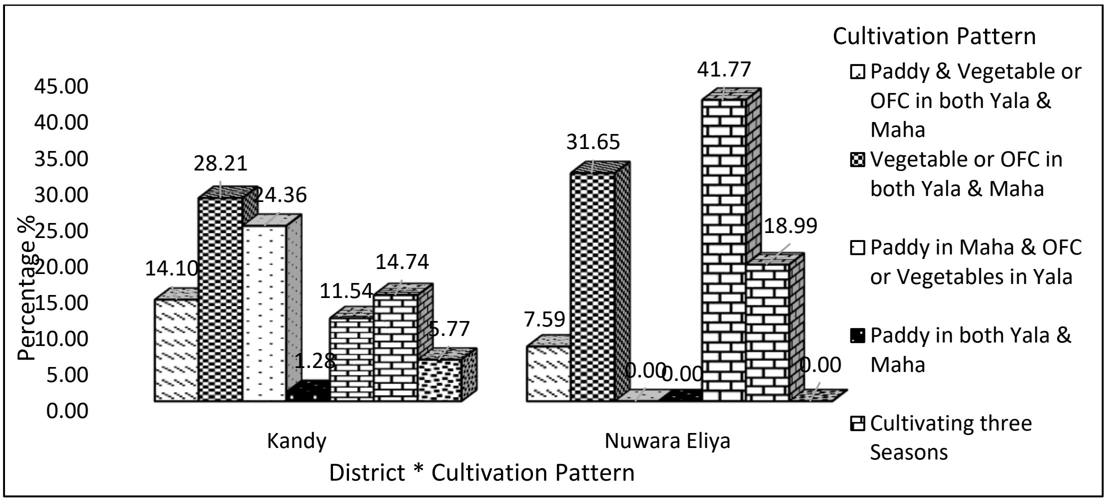
Source: Author’s survey data, 2021

Figure 5.2: Soil Types of the Study Area

5.2 Existing Cultivation Pattern, Soil Conservation Practises in the Study Area

Seasonal Pattern of Upcountry Vegetable Cultivation

Figure 5.3 demonstrates the seasonal pattern of up-country vegetable cultivation. Accordingly, the majority of farmers who cultivated interestingly in three sessions, this pattern of cultivation is significant in Nuwara Eliya. Farmers in Kandy (28%) and Nuwara Eliya (32%) cultivated vegetables in both *Yala* and *Maha* seasons.



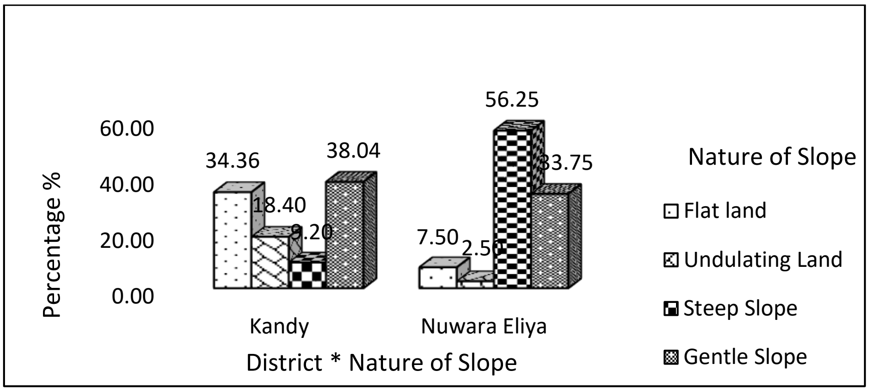
Source: Author’s survey data, 2021

Figure5.3: Seasonal Pattern of Upcountry Vegetable Cultivation

Nature of the Vegetable Cultivated Land

This graph illustrated the land scape of the cultivated farm plot. These four classifications were determined according to the slope gradient of the land as per the land use planning guidelines edited in 2020 of the Department of Land Reclamation and Policy Planning. Nearly 90% of the vegetable lands in Nuwara Eliya district belong to the gentle and steep slope category while in Kandy; nearly 45% of land are in the gentle and steep slope category.

These characteristics can have a significant influence on crop production and management. Sloppy lands will accelerate the top soil erosion. Poorly drained fields or those with low areas can become water logged during periods of excessive rain. Such conditions can enhance the incidence of diseases, reduce plant vigour and yield, and, under excessive conditions, cause plant death.

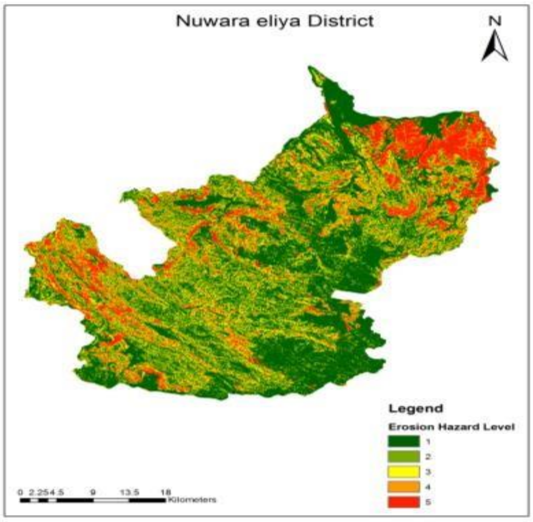


Source: Author's survey data, 2021

Figure 5.4: Nature of the Vegetable Cultivated Land

Nature of the Soil Erosion

Figure 5.5a shows the soil erosion status in the two districts. These five classifications were determined according to the slope gradient of the land (Land use Planning Guidelines Book, 2020) the fast growth in the agricultural sector in Sri Lanka has led to resource degradation, with an adverse impact on sustainability. A major source of environmental damage associated with agriculture is land degradation, particularly soil erosion, on the steeply sloping lands of Central Hills. Soil erosion is concentrated in the hill country where watersheds of major rivers are located. District-wise, Nuwara Eliya records the highest amount of soil erosion, where vegetable cultivated land is found to be prone to severe soil erosion.



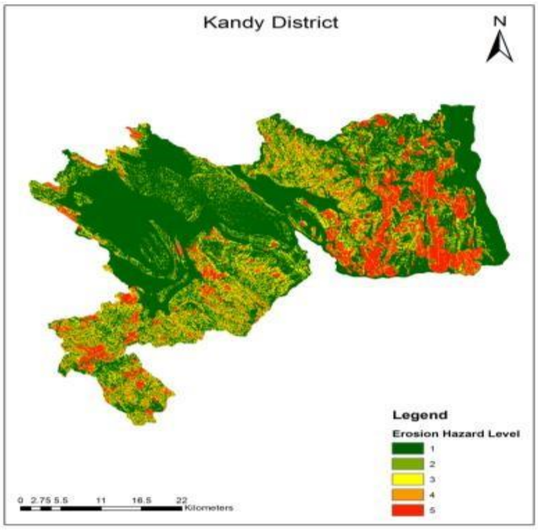


Figure5.5a: Nature of the Soil Erosion of the Nuwara Eliya Districts

Figure 5.5b: Erosion Hazard Maps of Nuwara Eliya District

(1=low, 2=moderate, 3=high, 4=very high and 5=extremely high) This map was classified into five levels of soil erosion hazard (Table 5.1) according to Senanayake *et al. (*2013).

Table 5.1: Erosion Hazard Levels (Senanayake et al., 2013)

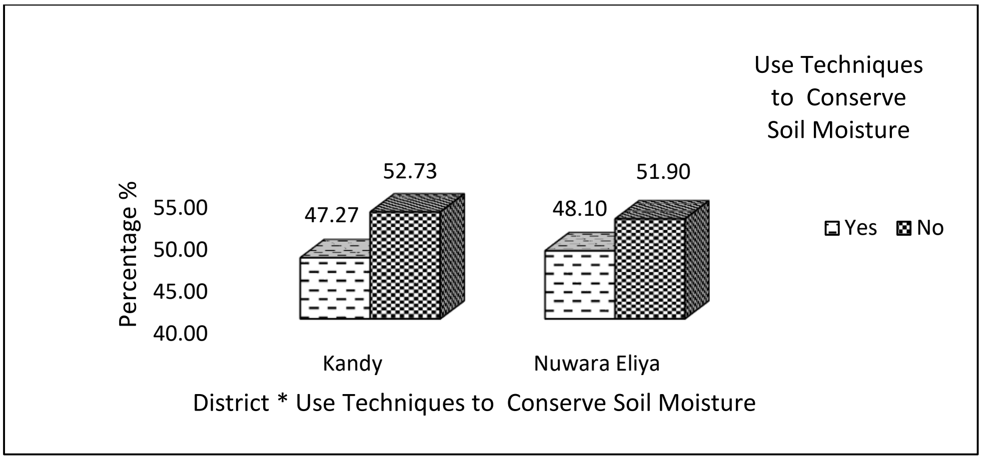
Erosion hazard level	Average annual soil loss (t/ha/yr.)
Low	0-5
Moderate	5-12
High	12-25
Very high	25-60
Extremely high	Extremely high >60

Source: Senanayake et al., 2013

Research findings were derived from Jayasekara *et al* (2018). According to Figure 5.5b of the study (Jayasekara *et al.,* 2018), 32% in Kandy district and 40.7% in Nuwara Eliya district are subject to high to extremely high erosion hazard.

Soil Moisture Conservation Practices

Most of the farmers in the sample do not practise any soil moisture conservation methods. At the same time, 53% and 52% farmers from Kandy and Nuwara-Eliya do not practise any kind of soil moisture conservation method. Among farmers who practised soil conservation practices, organic manure application and terracing are the most popular methods. Fallowing is not popular because these lands being highly valuable in terms of cultivating cash crops such as potato and vegetables. Therefore, high productivity of land is targeted. Biological soil conservation techniques are also poorly practised. Only mulching, which is not accurately maintained, can be seen in the fields as a soil moisture conservation method.

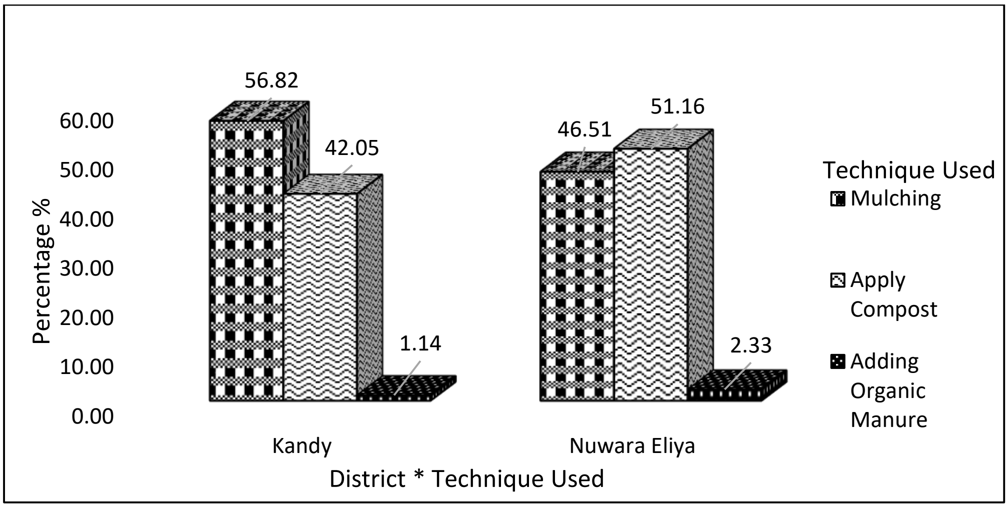


Source: Author's survey data, 2021

Figure 5.6: Application of Soil Moisture Conservation Techniques

Different Soil Moisture Conservation Practices

Figure 5.7 illustrates different soil moisture conservation practices followed by farmers such as compost supplement, adding mulches and incorporating organic manure. Adding organic amendments is improves soil health.



Source: Author's survey data, 2021

Figure 5.7: Different Soil Moisture Conservation Practices

Table 5.2: Soil Test in the Last Two Years Prior to Fertilizer Application

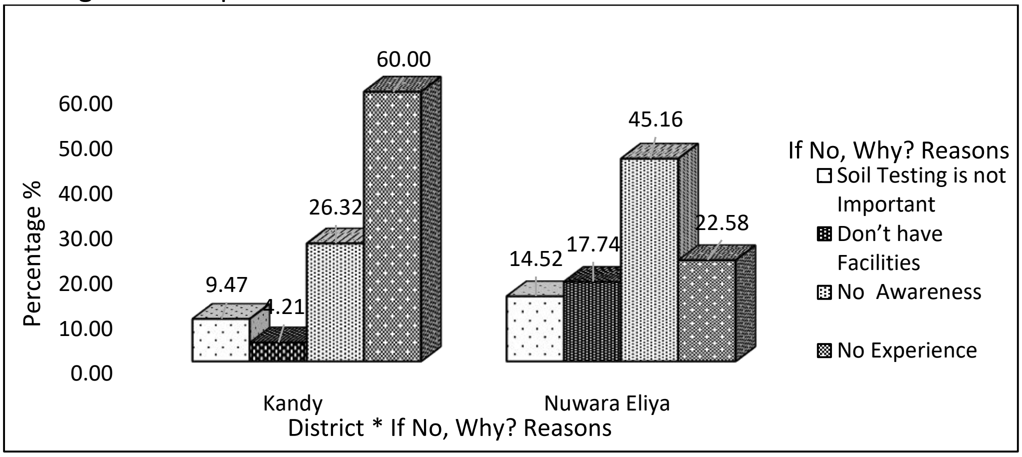
District	Soil tested during last two years - 2020 - 2021		Soil test done before adding fertilizer during this year- 2021	
Kandy	Yes	38.27	Yes	10.56
	No	61.73	No	89.44
Nuwara Eliya	Yes	20.7	Yes	23.46
	No	79.88	No	76.54

Source: Author's survey data, 2021

According to Table 5.1, during the last two years (2020 and 2021), most of the farmers in the study area have not carried out any soil test on their vegetable lands. The soil test-based fertiliser application field trials conducted by the Department of Agriculture (DoA) in the Kandy, Badulla and Nuwara Eliya districts have proved that fertiliser use in vegetable and potatoes can be reduced by 40% (Department of Agriculture, 2021).

Reasons for not Conducting Soil Analysis

Famers cited multiple reasons for not conducting any soil tests. It is significant in the Kandy district that nearly 60% of farmers lack experience in soil testing. The need for raising awareness was highlighted by many in both locations. Fewer perceive soil testing as not important.

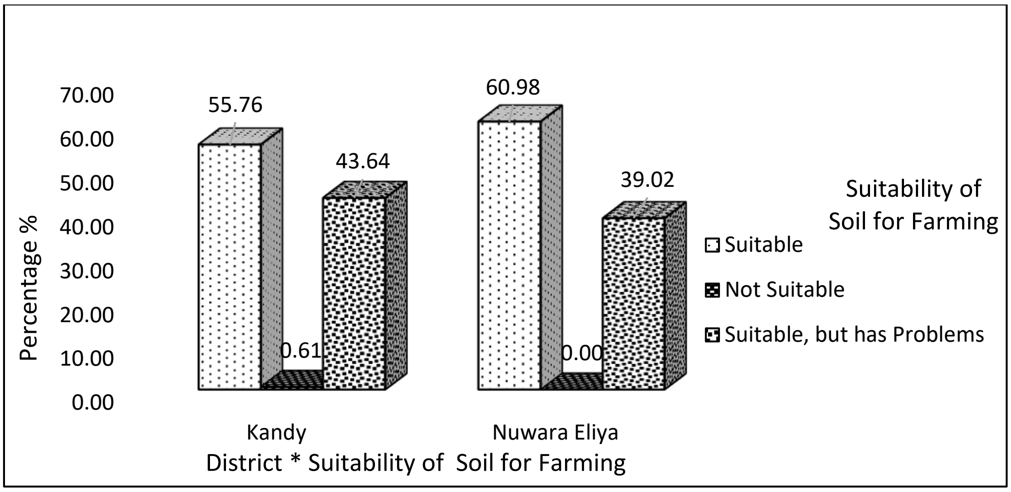


Source: Author's survey data, 2021

Figure 5.8: Reasons for not Conducting Soil Analysis

Land Suitability for Agricultural Activities

More than 50% of the vegetable plots are suitable for agricultural activities (Considering the soil texture, proportion of sand, silt and the clay content). Nearly half of the farmers from Kandy and 39% from Nuwara Eliya highlighted the need for land improvements for farming. Soil texture as a physical property is acceptable in two districts, 56% in Kandy and 61% in Nuwara Eliya, but soil nutrient content should be enhance to receive the potential yield.

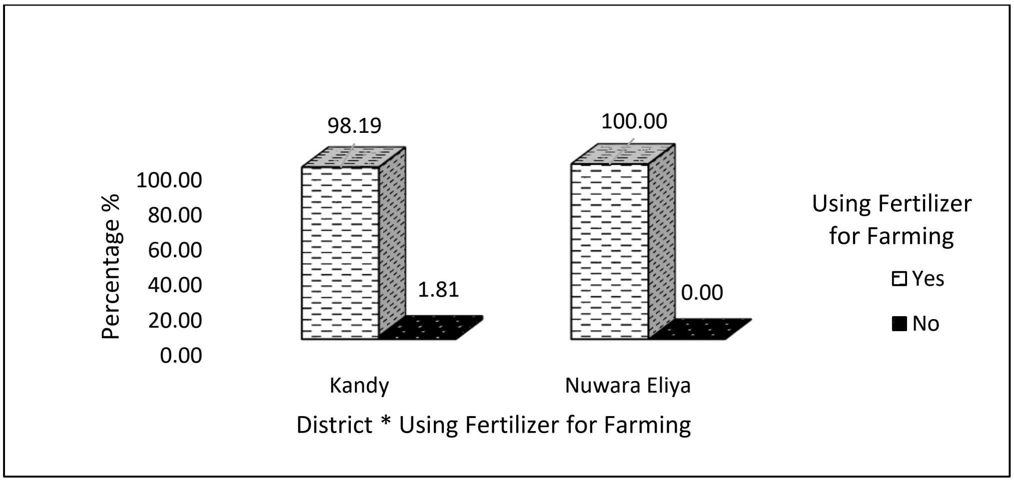


Source: Author's survey data, 2021

Figure 5.9: Suitability of Soil for Agricultural Activities

Fertilizer Application

According to our study area, we found that nearly all farmers applied chemical and organic fertilizers on their cultivations. Further, it was found that the growth of the vegetables varies according to the quantity of fertilizer applied (Ex. carrot, leeks, tomato, cabbage chilly, potato, bean). Popular types of fertilizers are TDM, Urea, ammonium nitrate, ammonium sulfate, triple superphosphate, potassium nitrate. In addition, the upcountry vegetable cultivation is highly susceptible to pet attacks.



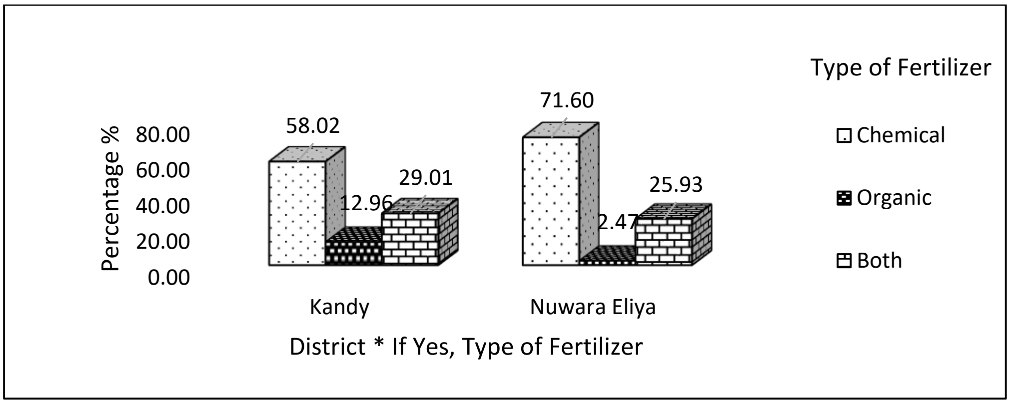
Source: Author's survey data, 2021

Figure 5.10: Fertilizer Application

Fertilize Usage in the Study Area

Since fertilizer usage determines the growth of the vegetable both chemical and organic fertilizer are applied, depending on the crop and location. According to our study area, a quarter of the farmers applied both types of fertilizer.

Figure 5.11 illustrates the application of fertilizers by farmers in the study areas. During the discussion with the farmers, it was noted that the limited supply and the soaring price have restricted the fertilizer usage in the next season. Farmers of Kandy (29%) and Nuwara Eliya (26%) districts opted for organic fertiliser in this season due to limited supply and high cost of chemical fertilizers. According to the statistics, in the Nuwara Eliya district the fertiliser use is three times higher than the recommended amount while it is twice higher in Welimada Low fertiliser use causes low yield and low profitability. Overuse of chemical fertiliser causes accumulation of harmful substances in the soil, which is toxic to plants, eutrophication of water bodies, enhances global warming through production of Nitrogen gas, enhances susceptibility of plants to pests and diseases as well as increases weed population. However, overuse of fertiliser does not contribute to high yield and high income but increases the cost of production.



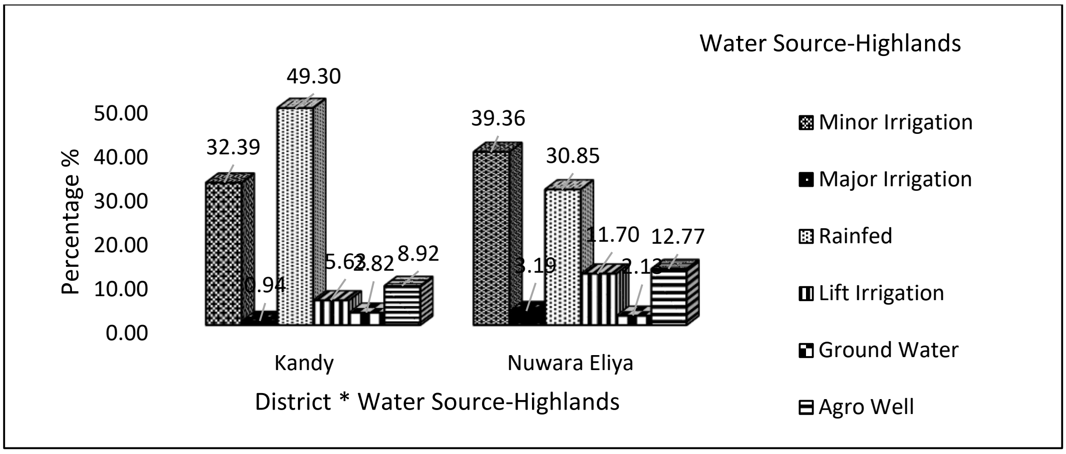
Source: Author's survey data, 2021

Figure 5.11: Fertilizer Usage in the Study Area

5.3 Water Usage in the Area

Irrigation Water Source

The upcountry region is self-sufficient in water supply due to having natural water springs and streams flowing outwardly. Those are considered minor irrigation methods. More than 30% of people in these areas use minor irrigation methods. This area experiences many challenges with regard to water supply. According to the focus group discussion with farmers, May – September period is identified as dry season. Farmers face many challenges in supplying water to vegetable cultivation. To prevent the excessive demand for agricultural purposes, the Agrarian Societies obtain water from natural rivers and other water bodies by agreeing upon a rotation system. However, they complained that some farmers of remote and high elevated areas are subject to inequity in water supply. Fewer farmers use lift irrigation, groundwater and agro wells for water supply. Nearly half of the farmer population in Kandy and 31% in Nuwara Eliya depend on rainfall.



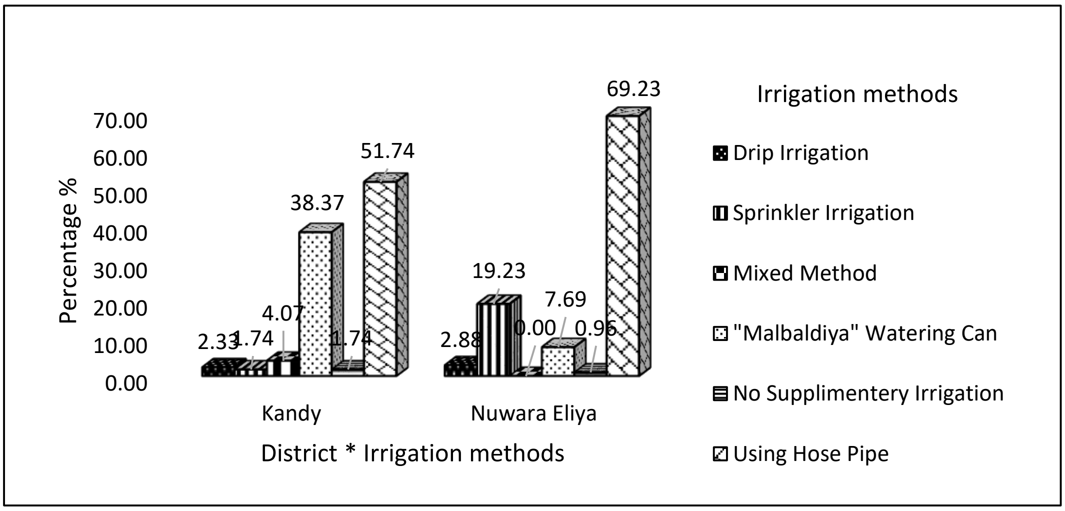
Source: Author's survey data, 2021

Figure 5.12: Irrigation Water Source

Water Application Methods

Famers used various water application systems; however, traditional methods such as watering can and watering pipe are dominant. Adoption of advanced irrigation methods is scarce.

The outdated methods of application systems like the use of hose accelerate the top soil erosion in the study area. It is important to encourage the usage of micro irrigation systems for intensive vegetable cultivation in the Upcountry.



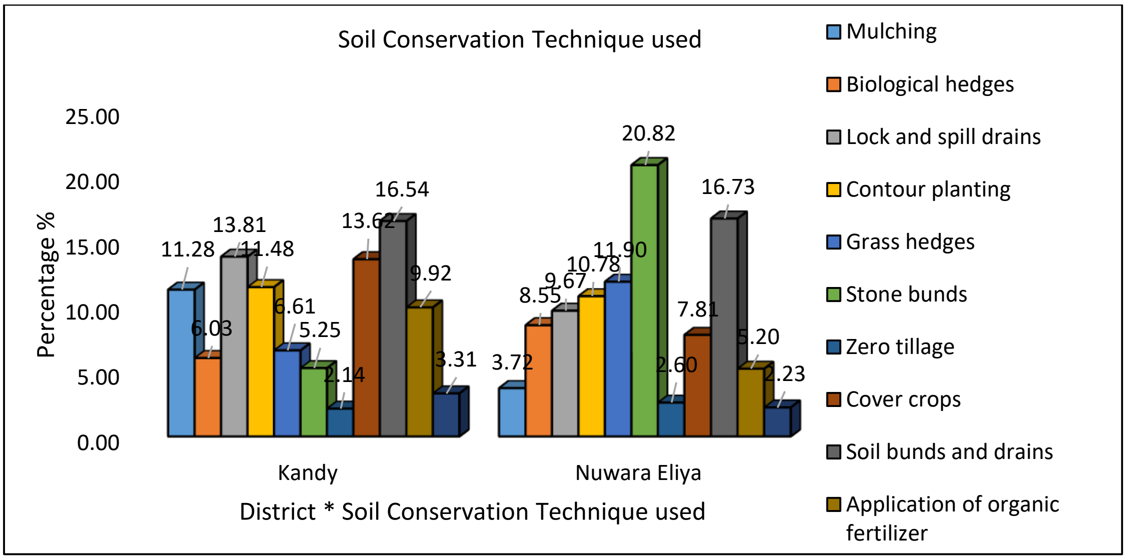
Source: Author's survey data, 2021

Figure5.13: Water Application Methods

5.4 Sustainable Land Management Techniques

Soil Conservation Techniques used in the Study Area

Farmers used different techniques to conserve their soil. Structural techniques and incorporating organic manure as amendments are popular among the farmers in the study area. Adding organic amendments improves soil health. Most of the farmers Nuwara Eliya constructing stone bunds and terracing are the most popular conservation methods.



Source: Author's survey data, 2021

Figure 5.14: Sustainable Land Management Techniques used in the Study Area

Table 5.3: SLM Practices Followed by Upcountry Vegetable Farmers and their Adaptability

Management Practices	Kandy				Nuwara Eliya			
	Highly adopted	Moderately adopted	Poorly adopted	Not adopted	Highly adopted	Moderately adopted	Poorly adopted	Not adopted
Mulching	0.90	8.11	43.24	47.75	10.00	20.00	20.00	50.00
Biological hedges	0.00	13.16	14.04	72.81	27.59	31.03	20.69	20.69
Lock and spill drains	2.48	26.45	29.75	41.32	29.63	40.74	25.93	3.70
Contour planting	14.05	23.14	11.57	51.24	63.33	30.00	3.33	3.33
Grass hedges	2.61	12.17	14.78	70.43	25.71	51.43	14.29	8.57
Stone bunds	1.72	11.21	10.34	76.72	54.24	33.90	6.78	5.08
Zero tillage	0.00	4.59	5.50	89.91	9.52	19.05	4.76	66.67
Cover crops	3.85	28.46	21.54	46.15	30.43	39.13	21.74	8.70
Soil bunds and drains	13.25	30.46	12.58	43.71	48.89	48.89	2.22	0.00
Application of organic fertilizer	1.68	14.29	26.89	57.14	15.00	25.00	30.00	30.00
Fallowing period	0	2.1		86.66	0	1.88		89.1
SALT technique	4.35	6.96	3.48	85.22	5.88	29.41	0.00	64.71

Source: Author's survey data, 2021

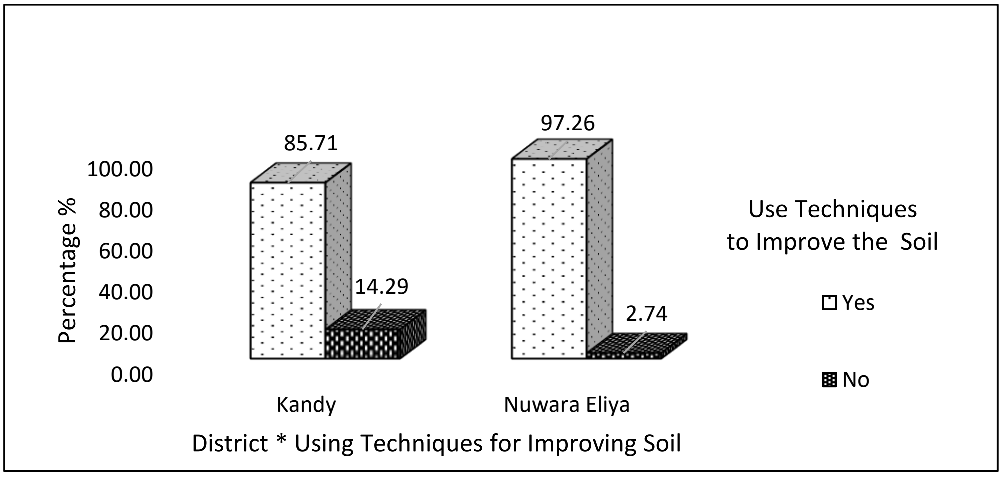
Descriptive statistics are used to identify the factors affecting the soil conservation practices of the farmers. Soil conservation practices adopted by farmers were observed according to the DOA recommendations (highly adopted, moderately adopted, poorly adopted and not adopted).

All practices come under sustainable land management practices (Agronomic practices, Vegetative methods, Structural methods and Cropping systems). Most of the farmers in the sample are following at least one method of soil conservation. Organic manure application and terracing are the most popular conservation methods but fallowing is not popular among potato farmers, because these lands are highly valuable in terms of monetary returns. They practice biological soil conservation techniques poorly. Only live fences, which are poorly maintained, can be seen in the fields as biological methods Zero tillage is identify as a best soil erosion control technique for undulating landscapes, but these management practise does not popular among farmers in the study area. This is highlighted the impotency of training programmes on soil conservation practises.

Farmers are following different combination of mechanical methods such as terrace, drains and bunds, biological such as live fence and cover cropping and cultural methods such as contour farming, and crop rotation levels of soil conservation practices at highly adopted, moderately adopted, poorly adopted and not adopted. Nearly half of the farming population (42%) follows an average level of soil conservation. Number of farmers who practice soil conservation at a poor level is lower than those who practice soil conservation at a good level.

Techniques Used to Improve the Soil Condition

The graph below illustrates the techniques used. Most of the farmers in the study area used soil conservation practises.

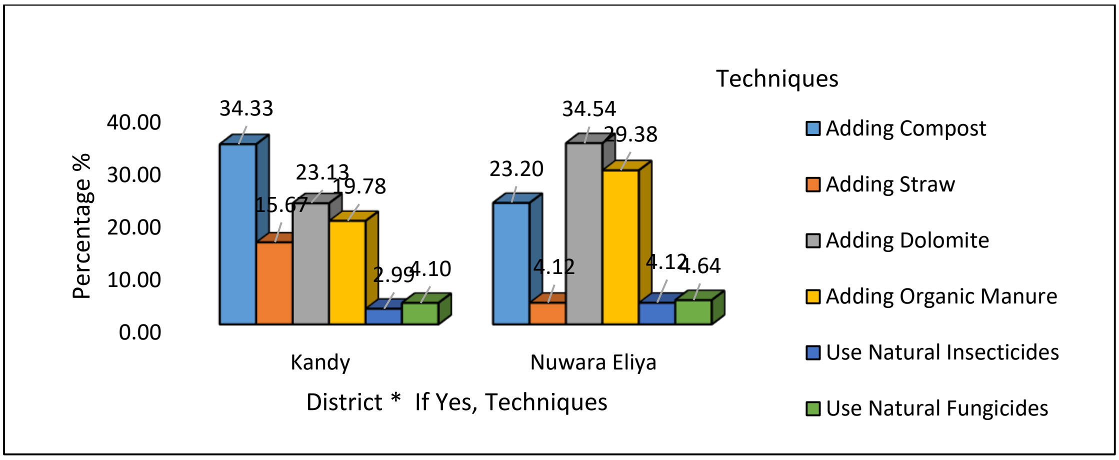


Source: Author's survey data, 2021

Figure 5.15: Soil Conservation Techniques

Soil Conservation Techniques used by Farmers

Farmers use different methods to conserve their soil. Adding compost, adding dolomite and incorporating organic manure as amendments are popular in the study area. Adding organic amendments is a positive impression for soil health.



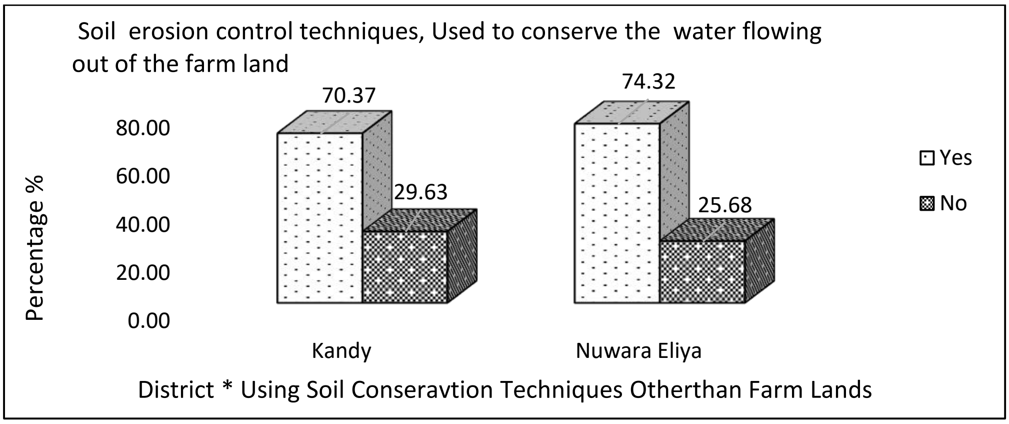
Source: Author’s survey data, 2021

Figure 5.16: Different Techniques used by Farmers

5.5 Soil Conservation Practices Followed by Farmers to Control the Water Flowing Out of the Farm Land

Soil Erosion Control Techniques used to Conserve the Drainage Water of Farm Lands

This is a very important section we have observed during our data collection. Agricultural water drainage can cause significant level of soil erosion. More than 70% of farmers in both districts used these methods. Such acts accelerate the top soil erosion; hence, to control soil erosion training in erosion control techniques aimed at conserving the water flowing out of the farm land.

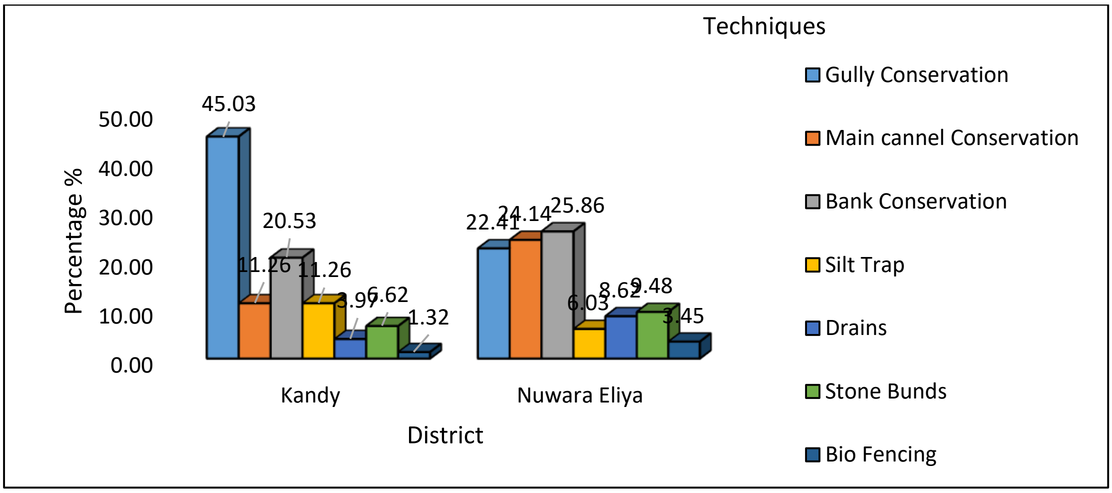


Source: Author’s survey data, 2021

Figure 5.17: Soil Erosion Control Techniques used to Conserve the Water Flowing out of the Farm Land

Different Soil Erosion Control Techniques used to Conserve the Water Flowing out of the Farm Land

Figure 5.18 illustrates different methods practised to control the water flowing out of the farm plot. A popular control method was gully control, bank conservation and main canal conservation. Though silt trap is a key method to collect the nutrient rich top soil, it is less popular. These points highlighted the training requirement of integrated soil conservation methods.



Source: Author's survey data, 2021

Figure 5.18: Different Soil Erosion Control Techniques Applied for Conserving the Water Flowing out of the Farm Land

CHAPTER SIX

Results and Discussion

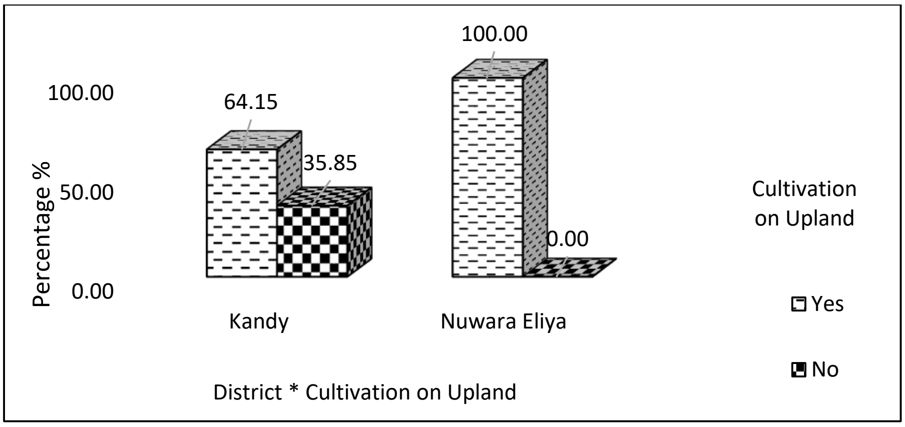
Constraints in Soil Conservation and Awareness of Soil and Water Conservation Practices

This chapter describes constraints in soil conservation and the awareness of soil and water conservation practices in the study area. Descriptive statistics of each variable are presented.

6.1 Constraints in Soil Conservation

Cultivation on Extremely High, Eroded Lands

Figure 6.1 illustrates the cultivation on extremely high eroded lands according to the erosion category. In the Nuwara Eliya district the land area in this category is occupied for intensive vegetable cultivation. This can be attributed to price escalation of upcountry vegetables. Cultivation on highly eroded lands indicates the need for soil conservation practices in these areas.

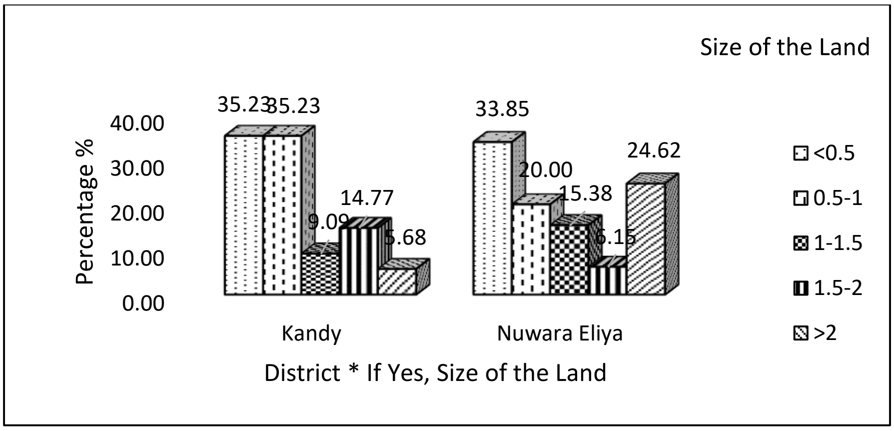


Source: Author's survey data, 2021

Figure 6.1: Cultivation on Extremely High Eroded Lands

Land Extent under Cultivation on Extremely High Eroded Lands

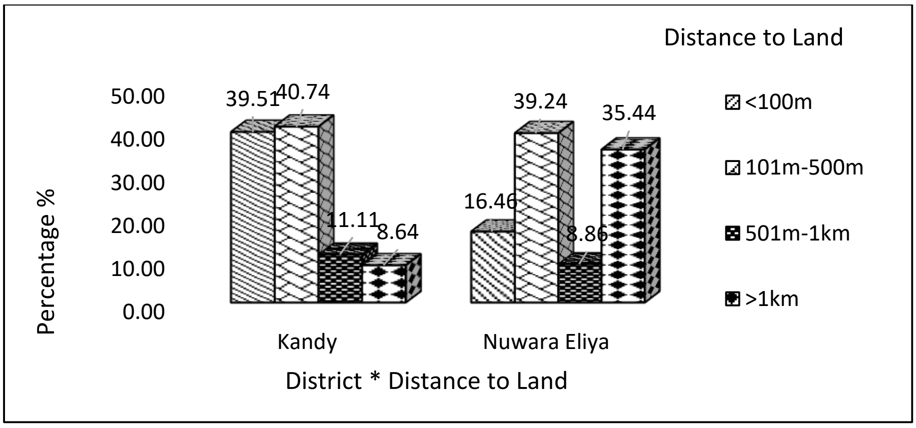
Figure 6.2 demonstrates the land extent owned by vegetable farmers on extremely highly eroded lands. The majority of vegetable farmers 70% in Kandy and 54% from Nuwara-Eliya had less than an acre (Figure 6.2). Further, this implies that the majority of these farmers are small scale farmers.



Source: Author's survey data, 2021

Figure 6.2: Land Extent Under Cultivation on Highly Eroded Lands (acre) Proximity to the Field

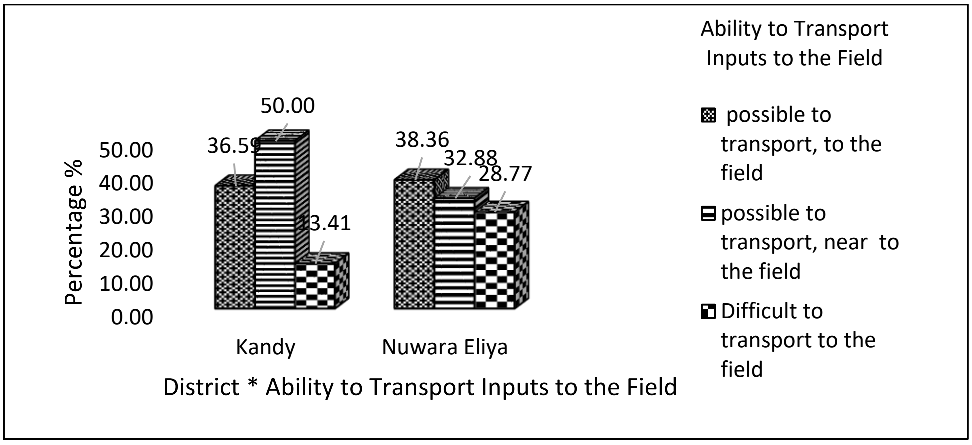
Some farm lands are located in elevated hilly areas. Due to this high elevation, the area has complicated geographical features such as bends, gravel roads and footpaths that make transporting more difficult. Further, these areas experience a lack of transport facilities. According to the below figure, 43 % in Kandy and 20% in Nuwara Eliya farmers have to transport their vegetables up to the main motorable road. Also, the distance to the market determines the mode of transport. Therefore, in this process the farmer goes through numerous obstacles. Pertaining to vegetables transporting is further complicated as different packaging and storing exist during transportation, which are often costly. Figure 6.4 indicates the possibility of transporting inputs to the field.



Source: Author's survey data, 2021

Figure 6.3: Transporting Inputs to the Field based on Distance

Ability to Transport Inputs to the Farm Land

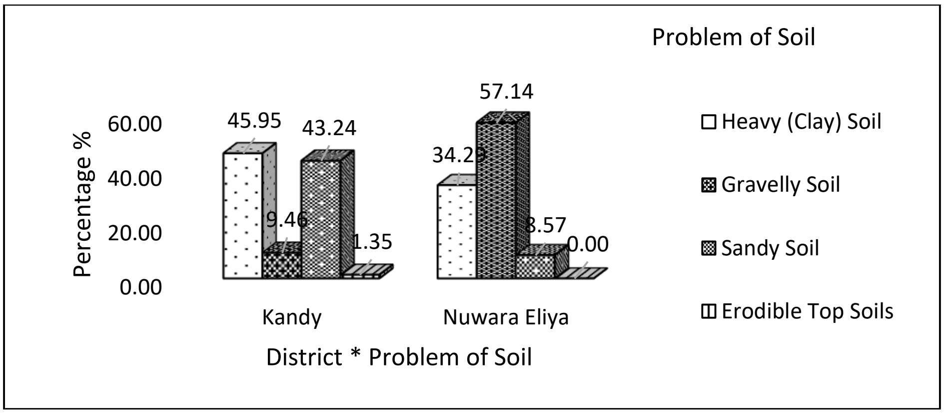


Source: Author's survey data, 2021

Figure 6.4: Ability to Transport Inputs to the Farm land

Complications of the Soil in the Study Area

As per the soil texture, 46% in Kandy and 34 % from Nuwara Eliya, we have observed the clay soil on extremely highly eroded lands. When irrigation water or rainfall slowly penetrates through the soil the area is not well-drained. According to USDA (United States Department of Agriculture) water drainage classification in well-drained soil, water is removed from the soil readily but not rapidly. Poorly drained soils (water is removed so slowly that the soil is wet at shallow depths periodically during the growing season or remains wet for long periods) are often high in clay, in low-lying areas, or compacted. Soils have poor drainage when rainfall or irrigation water cannot easily enter (infiltrate) or move downward through the soil (percolation). Water displaces air in the soil pore spaces depriving roots of oxygen, leading to wilting. In extreme cases, water may pond (sit on top of the ground for days following heavy rainfall) and cause plant death. High clay content and compaction are often cofactors in slow drainage. Another cause is hardpans, compacted soil layers impervious to water, air, and nutrients that can occur at any depth. Soils that are bare or less fertile often suffer from compaction and poor water drainage.



Source: Author's survey data, 2021

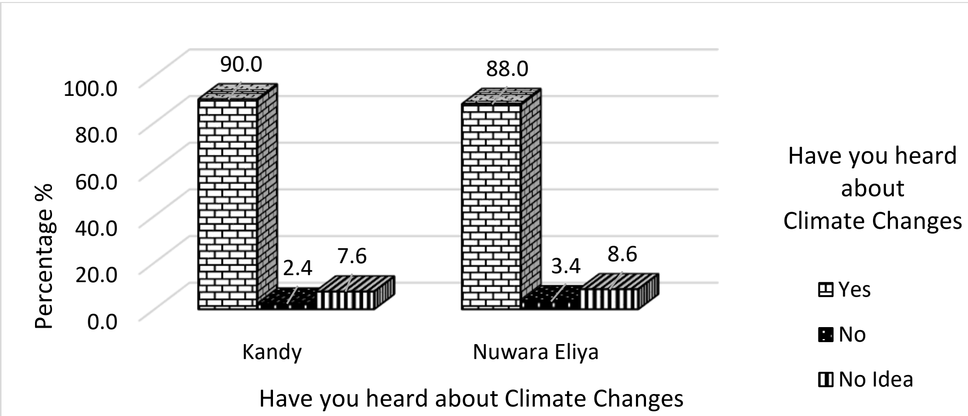
Figure 6.5: Problems of the Soil in the Study Area

6.2 Extreme Climatic Events in the Study Area

Awareness about Extreme Climatic Events in the Study Area

Most of the respondents had observed a change in the climate in the last 10 years and they were of the view that with the increasing temperature and winds and declining precipitation extreme climatic events like floods, drought/prolonged dry seasons, and winds have occurred frequently during that period.

According to literature, climate change will have serious impacts on agriculture and its production (IPCC, 2007). Highly productive and environmentally sound agriculture plays an important role in sustainable development of rural areas. It can be concluded that, climate changes have an increased influence on the agricultural productivity and the environment (IPCC, 2007). The rural level smallholder farmers are severely affected by climate change with low adaptive capacity to climatic change. According to our research findings, majority of smallholder farmers are aware of climate variations in their area.



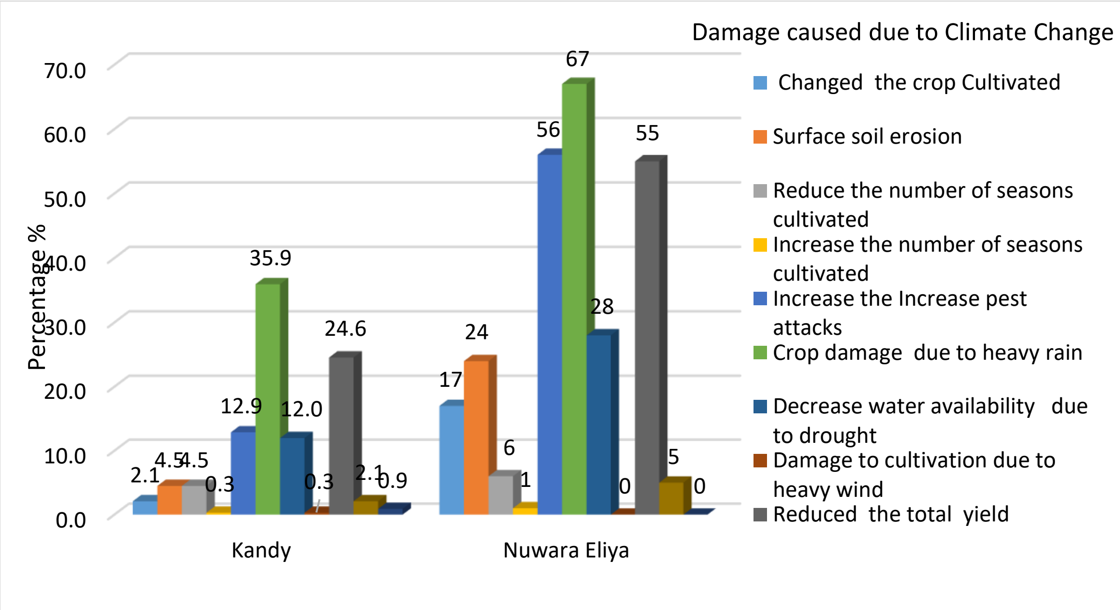
Source: Author's survey data, 2021

Figure 6.6: Awareness about Climate Change

Damage Caused by Climate Change

This section (Figure 6.7) addresses the research question "How do smallholder farmers in upcountry vegetable cultivation adjust their farming practices to cope with the changes in climate?"

The cultivation activities are mostly based on temperature and rainfall. These two factors mostly influence the production of the vegetable. In the Up-country Intermediate zone, there is a huge variation between temperature and rainfall. In this study area, the average temperature is above 15°C-18°C. A range of climatic changes, seasonal changes occur making cultivation highly challenging. Due to these issues, the farmers face so many difficulties in producing the output of this cultivation. Their cultivation will be ruined if a consistent rainfall pattern is not experienced. Heavy rainfall conditions tend to rot the vegetables. Increased temperature, reduced irrigation, water availability, and landslide little affect the cultivation. In the Upcountry region, May- September is identified as the dry season; hence the vegetable productivity is less. Due to heavy rainfall pattern or temperature disease occurrence is high. Vegetables such as leeks, cabbage, are affected by a virus disease. Therefore, farmers need many strategies to overcome these challenges. As a result, the number of cultivation seasons per year has also reduced. Soil erosion is also a problem that occurs due to heavy rains. This may highlight the need for soil conservation practices and climate change adaptation measures



Source: Author's survey data, 2021

Figure 6.7: Damage Caused due to Climate Change

6.3 Usage of New Technology and Awareness of Soil Conservation in the Study Area

Table 6.1: Usage of New Technology

District	Using new equipment for tillage practices		Using new equipment for cultivating practices		Using new equipment for harvesting practices	
Kandy	Yes	No	Yes	No	Yes	No
	89	11	10	90	8	92
Nuwara eliya	Yes	No	Yes	No	Yes	No
	93	7	7	93	5	95

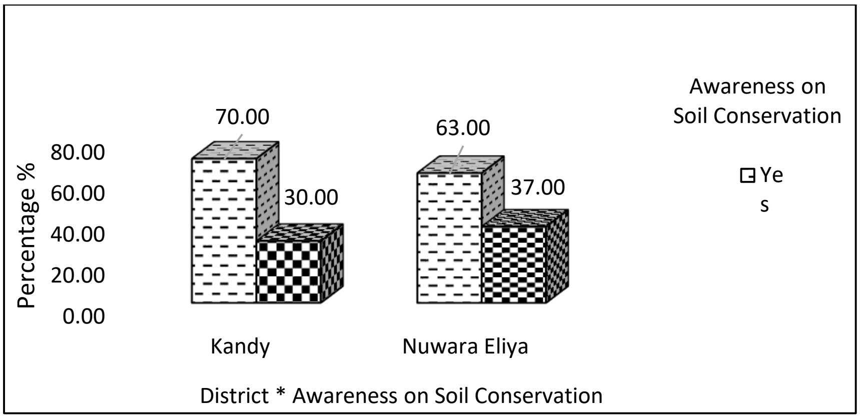
Source: Author's survey data, 2021

In the Up-country region the scarce use of modern technology for tilling, cultivating and harvesting consumed more time. Similarly, a lack of advanced systems and technology in areas such as soil and water conservation in the cultivation affected the production. Further, land restrictions and constraints in using machinery on land due to geographical features limit their profits in a particular vegetation. As well as according to our group discussion, we identified another problem that the farmers are unable to use the high machinery system on their field. Because this region is a high elevated hilly area. Therefore, they faced so many difficulties to carry the machines to the cultivation area.

Awareness on Soil and Water Conservation Practices

The data given below was collected in a structured questionnaire on soil conservation practices. It was revealed they have a sound knowledge on conservation practices. The study reveals that 30% of vegetable famers in the Kandy district and 37% from Nuwara Eliya district have not practised soil and water conservation methods. In this group, they used soil conservation practices, but mostly that are not suitable to the location. They lack awareness on integrated soil conservation practices.

Most farmers had a great understanding about cultivation the contours and other conservation practices in the study area. Awareness on soil conservation seems to be satisfactory. Most of the farmers had not participated in training programmes on integrated soil conservation practises.

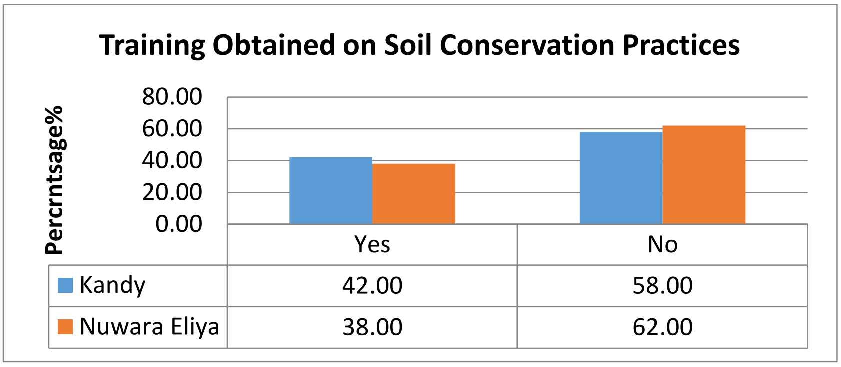


Source: Author’s survey data, 2021

Figure 6.8: Awareness on Soil and Water Conservation Practices

Training Obtained on Soil Conservation Practices

Monitoring and evaluation of the programmes are vital in extension services. Low adoption rates of management practices were among the main issues observed during the survey. These practices can be done away with proper guidance. More than half the people from each district had not received any extension service provided by the government during the last two years.



Source: Author's survey data, 2021

Figure 6.9: Extension Services Received in the Last Two Years

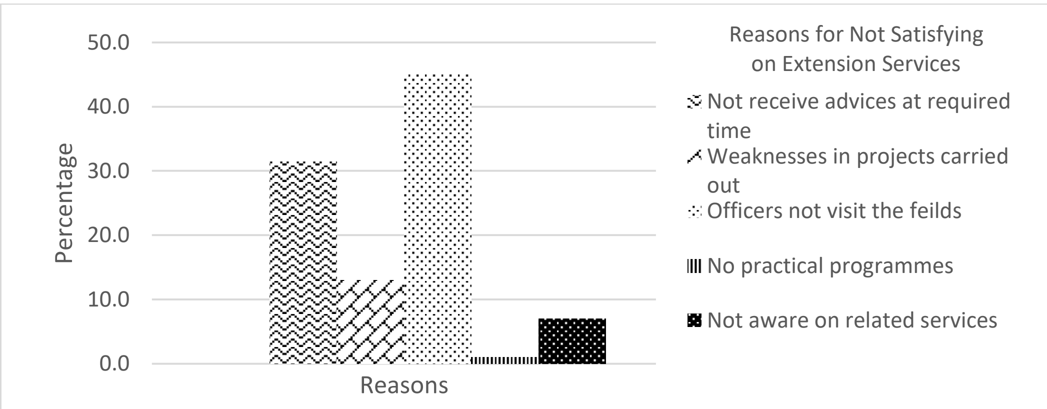
A Review of the Extension Services Received

According to the results, more than half of the study population has not received any extension service provided by the government during the last two years (Figure 6.9). Most farmers are not satisfied with the advisory service in 2020 to 2021 while a great majority has not received any state guidance within the last two years. Upholding the statement: "Government subsidy is essential for soil conservation", they believe that the individual as well as the society benefit from soil conservation.

Table 6.2: Satisfaction about the Extension Services Received

Satisfaction on the Extension Services Received	Satisfied %	Not Satisfied%
Kandy	43	57
Nuwara Eliya	32	68

Source: Author's survey data, 2019



Source: Author's survey data, 2021

Figure 6.10: Reasons for Not being – Satisfied with Current Extension Services

6.2 Factors influencing Soil Conservation and Adoptability on Soil Conservation

Practices in the Study Area

According to the objective 1, factors' effect on soil conservation and adoptability on soil conservation practices were identified with Logistic Regression Analysis. Each SLM practice was rated as highly adopted, moderately adopted and not adopted based on the DOA recommendations that consist of main and sub levels. According to the DOA recommendations (highly adopted, moderately adopted and not adopted). The Logistic Regression Analysis was applied to find out the effects on the factors' effect on soil conservation and adoptability on soil conservation practices.

For this, 205 farmers in the study area have been included in multiple logistic regression analysis and there are no missing cases. According to Model Fitting Information the p-value of the Model row is less than 0.05 and that means model is significant (Annexed 1).

Table 6.3: Model Fitting Information

Model Fitting Information				
Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	449.473			
Final	294.953	154.520	98	.000

Source :Author's survey data, 2021

The significant (sig.) value is the probability value associated with the adjusted odds ratios represented by exp. (B) at 95% CI for each predictor. The significant value of a certain independent variable is on or less than 0.05, that variable can be identified as significant at 95% CI.

Accordingly, (Annexed 2) Gender, Number of family members, Land Ownership and Nature of slope were found to be significant predictors for the adoptability on soil conservation practices at 95% CI. None of the other variables considered for the model were significant predictors according to the sample analyzed.

According to the analysis on adoption to soil conservation practices with land size category, farmers who were moderately adoptable than not adopt to soil conservation methods, less likely with the farmers, land size category 2 (0.5-1 acres) is 12.5(1/0.08) times less adoption on soil conservation practices than category 5(>2acres). And land size category 1 (<0.5acres) is 8.54 (1/0.117) times less adoption on soil conservation practices than category 5(>2acres).

According to the analysis on adoption to soil conservation practices with Nature of Slope category farmers who were adoptable than to not adopt to soil conservation methods, less likely with the farmers, Nature of Slope category 1 (flat land) is

14.92(1/0.067) times less adoption on soil conservation practices than Nature of Slope category 4 (Gentle slope).

Farmers who were not adoptable than to modestly adopted to soil conservation methods, less likely with the farmers. Nature of Slope category 1 (flat land) is 200 (1/0.005) times less adoption on soil conservation practices than Nature of Slope category 4 (Gentle slope). And Nature of Slope category 2 (Undulating Land) is 32.25 (1/0.031) times less adoption on soil conservation practices than Nature of Slope category 4 (Gentle slope).

According to the analysis on adoption to soil conservation practices with gender category farmers who were adoptable than to not adopt to soil conservation methods, less likely with the farmers, male adoption is 5.26(1/0.19) times less adoption.

CHAPTER SEVEN

Results and Discussion

Economic Factors Affecting the Soil Conservation Practices of Upcountry Vegetable Farmers

This chapter finds out the upcountry vegetable farmers land extent, cost of cultivation of vegetables, average yield and farm gate prices of upcountry vegetables. This chapter highlights the effects of existing SLM practices and erosion category, on profit. At first descriptive statistics illustrate the extent, production, average yield and farm gate prices of upcountry vegetables. Second, descriptive statistics of each variable are given and finally two-way factorial ANOVA was applied separately to each SLM practice with profit.

7.1 Extent, Production and Average Yield and Farm Gate Prices of Upcountry Vegetables

Table 7.1: Extent, Production and Average Yield of Upcountry Vegetables

Table below illustrates the extent, production and average yield of upcountry vegetables in 2018, 2019 and 2020

Crop (Up country)	2018 Annual				2018/19 *Maha*			2019 *Yala*			2019 Annual			2020 Annual	
	Extent	Production (t)	Average yield (t/ha)	Extent	Production (t)	Average yield (t/ha)	Extent	Production (t)	Average yield (t/ha)	Extent	Production (t)	Average yield (t/ha)	Extent	Production (t)	Average yield (t/ha)
Bean	7,344	83,966	11.43	3,549	38,680	10.90	2,912	26,770	9.19	6,461	65,450	10.13	7829	82973	10.59
Beetroot	2,234	51,004	22.83	788	14,757	18.73	1,017	15,291	15.04	1,805	30,048	16.65	2196	36261	16.51
Cabbage	4,202	111,141	26.45	2,384	67,356	28.25	1,769	49,221	27.82	4,153	116,577	28.07	4561	125746	2757
Carrot	3,125	71,051	22.73	2,086	47,130	22.59	1,467	33,637	22.93	3,553	80,767	22.73	3923	90225	23
Knolkhol	1,289	19,502	15.13	703	6,722	9.56	635	8,584	13.52	1,338	15,306	11.44	1489	17045	11.45
Leeks	2,026	51,330	25.34	1,121	14,946	13.33	981	16,933	17.26	2,102	31,879	15.17	2319	35695	15.39
Raddish	3,057	63,137	20.65	1,493	23,144	15.50	1,183	21,100	17.84	2,676	44,244	16.53	2876	55773	19.39
Tomato	6,712	101,404	15.11	3,291	38,771	11.78	2,578	39,145	15.18	5,869	77,916	13.28	7829	82973	10.6

Source: Department of Statistics 2021

Tables 7.2, 7.3.7.4 and 7.5 demonstrate the cost of cultivation of vegetables - 2018/19 *Maha*, 2019 *Yala*, 2019 /20 *Maha* and 2020 *Yala*

Table 7.2: Cost of Cultivation of Vegetables - 2018/19 *Maha*

Crop	Irrigated type	District	Total Cost (Rs/ac)		Net Return (Rs/ac)		Unit Cost (Rs/kg)	
			(1)	(2)	(1)	(2)	(1)	(2)
Cabbage	IR	Nuwara Eliya	198,807	132,273	198,275	264,809	18.28	12.17
Capsicum	IR	Badulla	237,960	133,270	330,192	434,882	65.34	36.59
Carrot	IR	Nuwara Eliya	194,513	123,120	140,137	211,530	40.11	25.39
Pole bean	RF	Badulla	227,595	112,731	161,295	276,159	50.92	25.22
Tomato	IR	Badulla	267,289	118,773	191,077	339,593	26.71	11.87

Source: Socio Economics and Planning Centre, Department of Agriculture
(1) Including Imputed Cost, (2) Excluding Imputed Cost
IR= Irrigated
RF= Rainfed

Table 7.3: Cost of Cultivation of Vegetables - 2019 *Yala*

Crop	Irrigated type	District	Total Cost (Rs/ac)		Net Return (Rs/ac)		Unit Cost (Rs/kg)	
			(1)	(2)	(1)	(2)	(1)	(2)
Cabbage	IR	Nuwara Eliya	195,541	137,115	293,163	351,589	25.61	17.96
Carrot	IR	Nuwara Eliya	212,388	152,238	526,172	586,322	36.81	26.38
Pole bean	IR	Badulla	215,140	121,050	180,167	274,257	65.85	37.05
Tomato	IR	Badulla	273,149	118,183	438,193	593,159	31.10	13.46
Tomato	IR	Kandy	231,788	131,521	180,592	280,859	32.60	18.50

Source: Socio Economics and Planning Centre, Department of Agriculture
(1) Including Imputed Cost, (2) Excluding Imputed Cost
IR= Irrigated
RF= Rainfed

Table 7.4: Cost of Cultivation of Vegetables - 2019 /20 *Maha*

Crop	Irrigated type	District	Total Cost (Rs/ha)		Net Return (Rs/ha)		Unit Cost (Rs/kg)	
			(1)	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
Potato	IR	Nuwara Eliya			882970	n.a	73.04	n.a
Potato	IR	Badulla			655322	n.a	71.37	n.a

Source: Socio Economics and Planning Centre, Department of Agriculture

(1) Including Imputed Cost, (2) Excluding Imputed Cost
IR= Irrigated
RF= Rainfed
n.a. – not available

Table 7.5: Cost of Cultivation of Vegetables – 2020 *Yala*

Crop	Irrigated type	District	Total Cost (Rs/ha)		Net Return (Rs/ha)		Unit Cost (Rs/kg)	
			(1)	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
Maize	IR	Badulla			116,258	n.a	48.23	n.a
Potato	IR	Nuwara Eliya			1,041,774	n.a	63.03	n.a
Potato	IR	Badulla			752,261	n.a	73.02	n.a

Source: Socio Economics and Planning Centre, Department of Agriculture
(1) Including Imputed Cost, (2) Excluding Imputed Cost
IR= Irrigated
RF= Rainfed n.a. – not available

Table 7.6: Annual Vegetable Productions (kg) – Kandy and Nuwara Eliya Districts 2021

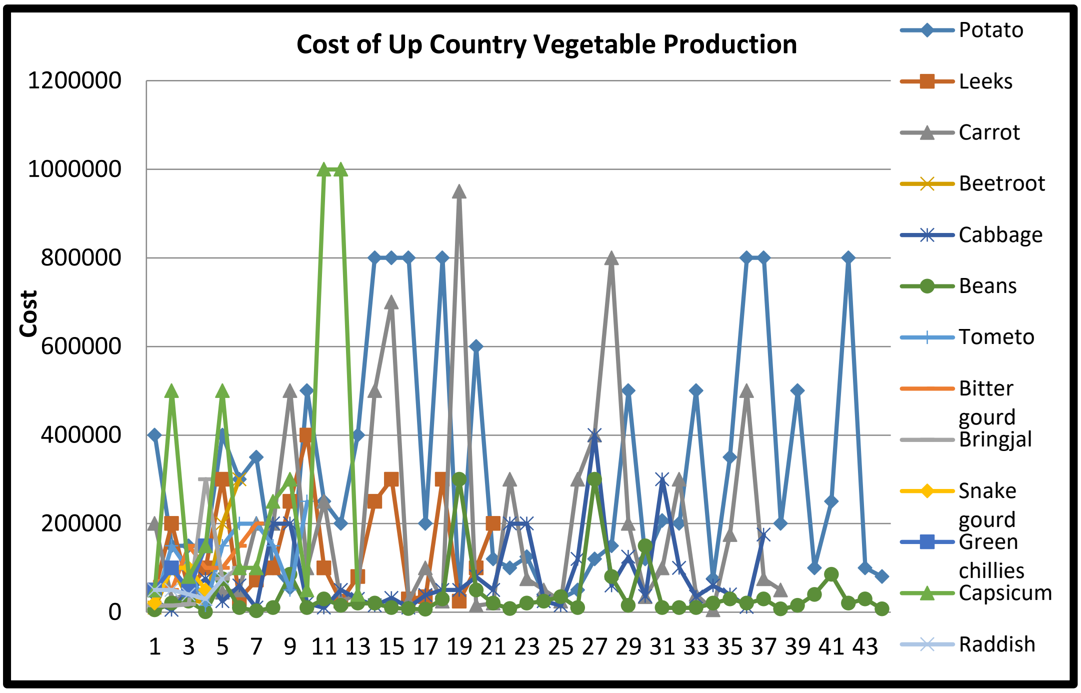
Vegetable type	Kandy District		Nuwara Eliya District	
	Acceptable Quality (in kg)	Rejects (in kg)	Acceptable Quality (in kg)	Rejects (in kg)
Beans	40338	594	96800	1195
Carrot	5210	100	369260	23245
Cabbage	76583	814	68490	4890
Leeks	-	-	132659	9125
Beetroot	235	-	22050	165
Knol-khol	3325	55	300	-
Raddish	3005	50	12000	
Tomatoes	93478	2770.5	7500	208
Ladies Fingers	8804	6	-	-
Brinjal	82518.3	943	600	-
Capsicum	15313	163	60760	635
Pumpkin	4230	-	-	-
Cucumber	13460	800	13460	800
Bitter gourd	64063	1665	-	-
Snake Gourd	31250	300	-	-
Luffa	24325	1024	-	-
Long Beans	34336	465.5	-	-
Chillies	31625	305	200	30
Potatoes	-	-	150103	5765
Sweet Potatoes	695	4	-	-
Manioc	22550	1016	-	-

Source: Author's survey data, 2021

7.2 Cost of Upcountry Vegetable Production

Figure 7.1 indicates the cost of production **(**Rs/ha) in the *Maha* 2021 season, during the data collection period. The production cost for vegetables was calculated using the imputed cost for all vegetables. Family labour and own inputs were included in imputed cost calculation. In terms of upcountry vegetables, the cost is a crucial factor due to the fertilizer policy. Farmers spend more on fertilizers with the ban on chemical fertilizers. The fertilizer shortage shot up the prices of surplus fertilizer, raising the overall cost.

When compared with the upcountry vegetables, potatoes recorded the highest production cost. Currently, the potato farmer is severely affected by the fertilizer crisis and high cost of production. Accordingly, carrots and chilies also cost more. However, beans recorded a lower cost.



Source: Author's survey data, 2021

Figure 7.1: Cost of Production (Rs/ha)

Table 7.7: Farm Gate Prices (in LKR/kg) – Kandy and Nuwara-Eliya Districts- 2021

	Acceptable quality (in LKR/kg)		Rejects (in LKR/kg)	
Vegetable type	**Maximum Price**	**Minimum Price**	**Maximum Price**	**Minimum Price**
Beans	600	40	100	35
Carrot	400	30	150	15
Cabbage	400	35	60	25
Leeks	300	30	12	12
Beetroot	400	30	500	500
Knol-khol	220	25	-	-
Raddish	120	20	-	-
Tomatoes	400	20	100	10
Ladies Fingers	140	50	100	100
Brinjal	200	28	130	10
Capsicum	1000	50	20	20
Pumpkin	100	50	-	-
Cucumber	80	20	-	-
Bitter gourd	30	80	180	30
Snake gourd	200	3	90	30
Luffa	200	35	-	-
Long Beans	300	30	120	50
Chillies	500	65	150	140
Green Chillies	650	70	-	-
Potatoes	350	60	180	10
Manioc	110	30	-	-

Source: Author's survey data, 2021

The Corona epidemic in the country and the ban on chemical fertilizers caused a great loss to many in the agricultural sector. Without chemical fertilizers farmers received lower harvest than in previous seasons. But it is possible to get a good selling price for a low yield. Accordingly, it is clear that the price range for a kilo of standard vegetables is around Rs. 100-800.

The survey conducted mainly in the districts of Kandy and Nuwara Eliya identified lowland vegetable species such as bitter gourd, snake gourd, luffa, ladies fingers and manioc. Accordingly, the above chart shows how the selling price they received for it has been subject to some fluctuations. Overall, farmers seem to be getting a good price. Although some potatoes fetched less than 100 rupees, the farmer was not at a loss. Accordingly, a good price was received for producing vegetables suitable for the climate of the Nuwara Eliya area. However, due to the fertilizer problem, the unit yield of the harvest decreased.

7.3 Effects of Existing SLM Practices (Agronomic practices, Vegetative methods, Structural methods and Cropping systems) Followed by the Upcountry Vegetable Farmers and Erosion Hazard Level on, Productivity and Profit.

According to the objective two, to find out the effects of existing SLM practices (Agronomic practices, Vegetative methods, Structural methods and Cropping systems) followed by the Upcountry vegetable farmers and erosion hazard level on, productivity and profit.

Two-way factorial ANOVA applied separately to each SLM practice with productivity and profit. For this, 205 farmers in the study area have been included. The reason for applying two-way factorial ANOVA is the varied constitution of SLM practices. One-way ANOVA was applied to find out the effects of erosion hazard level on productivity and profit.

7.3.1 Effects of Existing SLM Practices (Agronomic practices, Vegetative methods, Structural methods and Cropping systems) Followed by the Upcountry Vegetable Farmers and Erosion Hazard Level on, Productivity

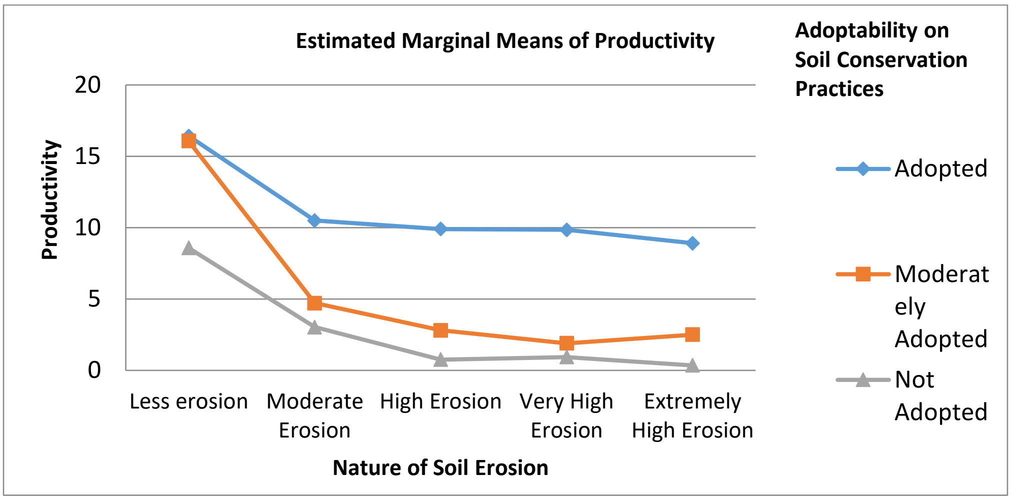
Chapter 2 table 2.1 was used to demarcate the erosion hazard level.

Erosion hazard level	**Average annual soil loss (t/ha/yr)**
Low	0-5
Moderate	5-12
High	12-25
Very high	25-60
Extremely high	>60

Source: (Senanayake *et al.*, 2013)

The two-way factorial ANOVA applied to each SLM practice with productivity (Annex 3). According to the analysis productivity proportionately increasing with the soil conservation adoptability. High eroded areas with soil conservation practises offered a significant crop production.

There is a significant difference in productivity under adoptability on different levels of soil conservation practises. That difference show, the farmers who follow good level of soil conservation can obtain a higher yield Moreover; farmers who adopt a poor level of soil conservation obtain a low amount of yield. Productivity shows a positive co-relation with the level of soil conservation. That means the production is increasing with good level of soil conservation due to soil enrichment influence in increased yield. On the other hand, production is lower with poor soil conservation practices that resulted in reduced yield due to high soil erosion. According to the figure under high eroded areas, farmers can obtain considerable production by observing soil conservation practices.



Source: Author's survey data, 2021

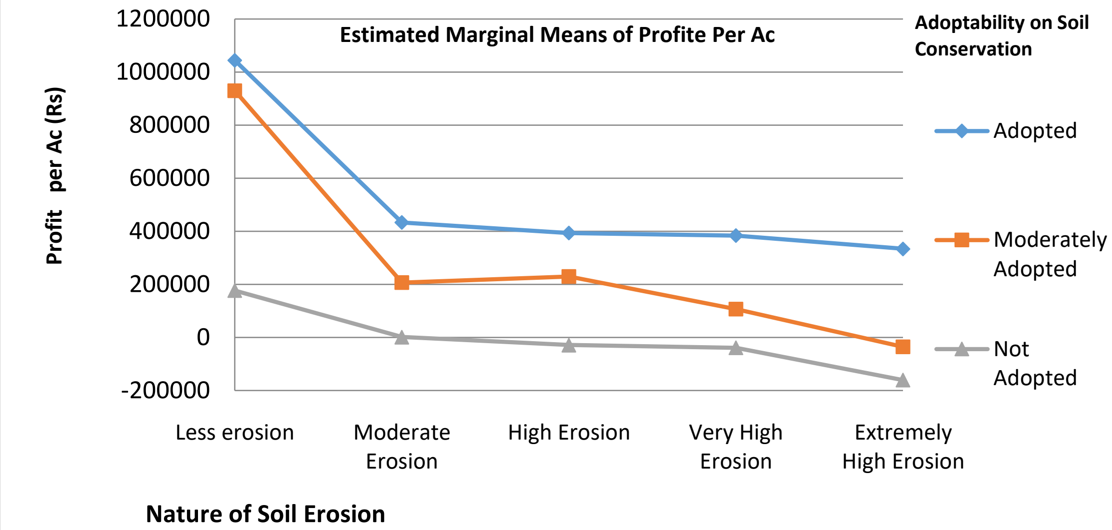
Figure 7.2: Productivity, Nature of Soil Erosion under Different Soil Conservation Adoptability Levels

7.3.2 Effects of Existing SLM Practices (Agronomic practices, Vegetative methods, Structural methods and Cropping systems) Followed by the Upcountry Vegetable Farmers and Erosion Hazard Level on Profit

The two-way factorial ANOVA was applied to each SLM practice with profit (Annex 4). According to the analysis productivity proportionately increasing with the soil conservation adoptability. High eroded areas with soil conservation practises offered a significant crop production.

There is a significant difference in profit under adoptability at different levels of soil conservation practices. That difference shows that the farmers who followed good level of soil conservation can gain higher profit from the yield besides; farmers who adopt a poor level of soil conservation obtain a low yield. Profit shows an increasing relationship with the level of soil conservation. That means the production is increasing with good level of soil conservation due to soil enrichment influence in increased yield. While profit is lower with poor soil conservation practices as a result of reduced yield due to high soil erosion. According to the figure under high eroded areas, farmers can obtain considerable profit by practising soil conservation methods. The two-way factorial ANOVA applied separately to each SLM practice with profit.

According to the analysis profit proportionately increasing with the soil conservation adoptability. High eroded areas with soil conservation practices offered significant profit.



Source: Author's survey data, 2021

Figure 7.3: Profit, Nature of Soil Erosion under Different Soil Conservation Adoptability

CHAPTER EIGHT

Results and Discussion

Of Pro-Environmental Analysis Farmers' Concerns and Behaviours towards Soil Conservation

This chapter presents a pro-environmental analysis of farmers' concerns and behaviours towards soil conservation in upcountry vegetable cultivation. Reliability of the questionnaire relevant to the Objective Four was calculated using Cronbach's Alpha Test for the variables measured by the Likert Scale. To examine the relationship between variables, Pearson Correlation was primarily used. The path analysis was used to determine the explanatory power of the variables.

8.1 Conceptual Framework and the Analytical Method

When vegetable growers decide to cultivate crops, certain factors are considered. Individual behaviour could be explained in the following conceptual framework in vegetable cultivation (Figure 8.1). Collected primary data was analysed using a structured questionnaire. The study population is 384; farmers were selected using stratified random sampling. According to the literature review pro-environmental attitudes and social pressures act as individuals' behavioural bases and environmental concern is an important factor in shaping pro-environmental behaviour, this study is mainly designed to investigating the effect of two variables "attitude" and "social pressure" on the variable "soil conservation concern", and analysing the effect of the variable "soil conservation concern" on "soil conservation behaviour”. Data was collected through a questionnaire (Figure 8.1).

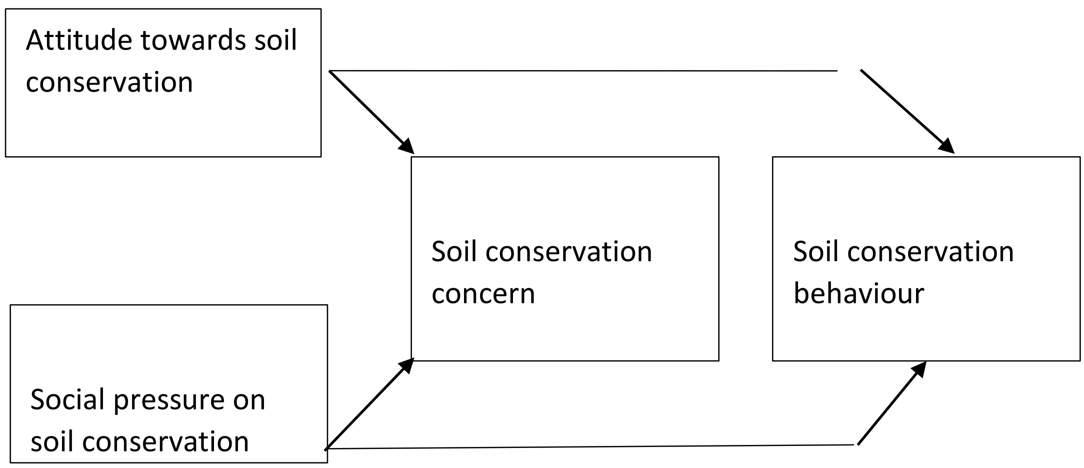


Fig 8.1: Conceptual Framework of the Study Objective 3

The reliability of the questionnaire was calculated using Cronbach's Alpha Test for the variables measured by the Likert Scale. The reliability was confirmed ($0.66 \leq \alpha \leq 0.90$). The data analysis was performed using the SPSS software.

A major dependent variable in this study was "soil preservation behaviour", defined as "behaviours that people consciously do to reduce the negative effects of their actions on soil". With modifications to comply with the study, a number of items were adopted from the studies conducted by Bijani, etal 2017,2012 Salehi and Imam Gholi (2012), Azizi Khalkhili et al. (2012), and Kollmuss and Agyeman (2002). Further, the independent variables affecting dependent variable consisted of: "Social pressures on soil conservation", "attitude towards soil conservation", and "soil conservation concern ". In order to design the items of these variables, the approaches and guidelines mentioned in Bijani etal, 2017, Kollmuss and Agyeman (2002) was used to measure all the variables, a 6-point Likert scale (never (1), very low (2), low (3), medium (4), high (5), and very high (6)) was used. Ajzen (1991) defined attitude as "the extent on which a person evaluates the behaviour favourable or unfavourable". In this regard, the study variable "attitude towards soil conservation", inspired by the definition provided by Ajzen, is defined as "the amount or extent that farmers consider soil conservation favourable or unfavourable". On the other hand, the variable social pressure is also defined as "the extent to which farmer’s practices in the field of soil conservation are influenced by those around them”. This definition is also inspired by the explanation presented by Kollmuss and Agyeman (2002). Moreover, based on a thorough review of all studies in the field of environmental psychology conducted up to 2017, the researchers introduced another variable called "pro-environmental concern" and claimed that this variable acts as a mediating variable between some variables such as "attitude, social pressure" and "behaviour". In this study, pro-environmental concern is defined as "farmers' sensitivity and obsession for soil conservation" Table 8.1 describes the relatability of the questionnaire. The results of ranking the items of other variables (Soil conservation behaviour, soil conservation concern, attitude towards soil conservation, and social pressures on soil conservation) in the conceptual framework are presented in Table 1.

Table 8.1: Reliability of the Questionnaire Calculated using Cronbach's Alpha Test for the Variables Measured by the Likert Scale.

	Mean	SD	Rank
Soil Conservation Behaviour (α=0.617)			
1 In order to fight against diseases and pests, I use pesticides correctly as instructed.	4.12	0.72	B
2 According to vegetable cultivation requirements, I try to plough fields with proper depth and at the right time.	3.89	0.76	D
3 I prefer organic and green fertilizers to chemical fertilizers	2.89	1.08	H
4 I will use conservative plough if the field is steep.	3.74	0.97	E
5 In order to prevent pests I benefit from biological control.	2.88	1.00	I
6 After harvesting, I do not burn the remaining plant residue, use it for compost preparing	3.52	1.13	F
7 I use soil testing to determine fertilizer needs for soil.	2.68	1.03	J
8 I collect empty pesticide bottles and disposes of them properly.	4.15	0.74	A
9 I grow dicotyledonous legumes (seeds, beans, etc.). (On the edge of the land)	3.29	1.03	G
10 I avoid disposing of household waste in or around the plantation.	3.96	0.86	C
Concern for Soil Conservation (α=0.659)			
1 I am too concerned about the fertility of the soil, when cultivating vegetables	3.99	0.75	B
2 In most cases, does not contaminate the environment, I ask about the dosage of pesticides prior to using them.	4.02	0.68	A
3 After applying chemical fertilizers to my field, I take care of the soil conservation	3.69	0.85	C
Attitude towards Soil Conservation (α=0.902)			
1 Nature must be protected because it is a sign of God's existence.	3.60	0.80	E
2 The environment must be protected as it belongs to the next generation as well	3.80	0.76	C
3 Because man is part of the environment, its security leads to his existence	3.71	0.83	D
4 Natural resources such as water and soil are used for cultivation on farms and conservation of those resources should be considered.	3.88	0.76	A
5 All living things, such as animals and plants, have the right to life.	3.82	0.77	B
Social Implications of Soil Conservation (α=0.604)			
1 Many villagers are sensitive to the fact that farmers maintain soil conservation in their fields.	3.47	0.68	A
2 Residents criticize release of empty pesticide bottles into the environment	2.56	1.31	D
3 Agricultural experts often recommend me to use organic and green manures	3.37	1.01	C
4 On the recommendation of my wife and children, I do not burn farm residues after harvest	3.38	0.99	B

Source: Author's survey data, 2021

Behaviour A (collect empty pesticide bottles and disposes of them properly as instructed, M=4..15, SD=0.74) and behaviour *B* (To fight diseases and pests, I use pesticides correctly as instructed, M=4.12, SD=0.72) was rated the highest among the items of soil conservation behaviour and behaviour *I* (To prevent pests I resort to biological control, M=2.88, SD=1) and behaviour *J* (I use soil testing to determine fertilizer needs for soil M=2.68, SD=1.03) also had the lowest rank among all soil conservation measures.

These results showed that concern *A* (In most cases, does not contaminate the environment, I ask about the dosage of pesticides prior to using them, M=4.02, SD=0.68) had the highest rating among the items of soil conservation concern and concern *C* (After applying chemical fertilizers to my field, I take care of the soil conservation, M=3.68, SD=0.85) had the lowest rank among the soil conservation concern items. On the other hand, attitude *A* (Natural resources such as water and soil are used for cultivation on farms and conservation of those resources should be considered, M=3.88, SD=0.76) and social pressure *A* (Many villagers are sensitive to the fact that farmers maintain soil conservation in their fields, M=3.47, SD=0.68) had the highest rank among the measures of attitude towards soil conservation and social pressure on soil conservation, respectively.

8.2: Relationship between Variables, Pearson Correlation

Table 8.2: Correlation Matrix of the Conceptual Framework Variables

	Soil Conservation Behaviour	**Soil Conservation Concern**	**Social Pressures**	**Attitude Towards Soil Conservation**
Soil conservation behavior	1			
Soil conservation concern	0.278**	1		
Social pressures	0.309*	0.382**	1	
Attitude towards soil conservation	0.2*	0.588**	0.178*	1

** Sig. at 0.05 errors

Table 8.3: Calculation of Direct Effects on the Soil Conservation Behaviour and Concern

	Independent Variables	B	Beta	t	Sig. t
First sub-model (direct effects on behavior)	Constant	17.130	-	2.15	0.033
	Attitude towards soil conservation	0.236	0.060	0.691	0.491
	Soil conservation concerns	0.1600	0.082	0.770	0.439
	Social pressures on soil conservation	0.682	0.283	4.450	0.001
R=0.461 R^2=0.213 R^2_{Adj}=0.192 F=10.45 Sig. F=0.001					
Second sub-model (direct effects on concern)	Constant	0.692	-	0.197	0.050
	Attitude towards soil conservation	0.947	0.68	7.53	0.001
	Soil conservation concerns	0.259	0.32	4.01	0.001
R=0.652 R^2=0.425 R^2_{Adj}=0.415 F=43.19 Sig. F=0.001					

Table 8.4: Analysis of Direct, Indirect, Causal and Non-causal Effects of Variables Affecting Soil Conservation Behavior

No. Variables	Direct Effects	Indirect Effects	Total Effects	Non-causal Effects
Attitude towards soil conservation	0.06	0.051	0.105	0.095
Social pressures on soil conservation	0.283	0.026	0.309	0.137
Soil conservation concern	0.082	-	0.082	0.194

According to the correlation results (Table 2), the variables "attitude towards soil conservation" and "social pressures on soil conservation" have a significant positive correlation ($p=0.01$) with the variable "soil conservation concern". There is a significant relationship between "attitude towards soil conservation" and "soil conservation concerns".

The findings showed a significant positive correlation between the variable "soil conservation concern" and "soil conservation attitude".

The path analysis was used to determine the explanatory power of the variables "soil conservation behaviour" and "soil conservation concern". Path diagrams are typical graphical devices to show the direct and indirect variables. Therefore, all independent variables were simultaneously and in two stages (Since the study conceptual framework (Figure 8.1) was divided into two sub-models for the path analysis) included in the analysis (Table 3) and direct, indirect, causal and non-causal effects of the independent variables on the dependent variable " soil conservation behaviour" were investigated (Tables 3, 4). Regarding the direct effects of independent variables on the dependent variable "soil conservation behaviour", the variable "social pressures on soil conservation" had the highest direct and standard effect ($\beta=0.283$), representing the relative importance of this variable compared to other variables in explaining the variable "soil conservation behaviour".

According to Figure. 8.1, the direct effect of the variables "attitude towards soil conservation" and " soil conservation concerns " on the variable "soil conservation behaviour" was also significant (beta values greater than 0.05 are considered significant). It is considered that the direct effects of these two variables on the soil conservation behaviour are lower than the direct effect of the variable "social pressures on soil conservation". On the other hand, the results of the analysis in terms of the direct effects of the variables "attitude towards soil conservation" and "social pressures on soil conservation" on the variable "soil conservation concerns" indicated that both variables were of significant importance (predictive power) in explaining the dependent variable. Comparing the direct effects of these two variables indicate that the explanatory power of the variable "attitude towards soil conservation" is greater than that of the variable "social pressures on soil conservation ".

Considering the indirect effects (Table 4), the findings suggested that the indirect effect of the variable "attitudes towards soil conservation" ($0.63\times.084=0.082=0.051$) is greater than the indirect effect of the variable "social pressures on soil conservation" ($0.32\times0.082=0.026$). One of the main reasons for this result is that the direct effect of the variable "attitude towards soil conservation" on the variable "soil conservation concerns" ($\beta=0.63$) is greater than the direct effect of its corresponding variable ($\beta=0.32$) on "soil conservation concern ". Despite that fact, the total effect of the variable "social pressures on soil conservation" ($0.283+0.026=0.309$) compared to the total effects of the variables "attitude towards soil conservation" ($0.060+0.051=0.105$) and "soil conservation concern" (0.082) was slightly greater. This is also because the direct effects of the variables "attitude towards soil conservation" and "soil conservation concern" in the analysis were lower. With respect to the non-causal effects of the variables in the given path analysis, observed, the variables affecting "soil conservation behaviour", the variable "soil conservation concern" represents the greatest non-causal effect (0.20–0.105=0.095) and this shows that other variables or factors may have affected the relationship between these two variables. In general, considering direct, indirect, causal and non-causal effects of the independent variables on the variables "soil conservation protection" and "soil conservation concerns", the explanatory power of the independent variables for the soil conservation behaviour is not at a high level (R^2 =0.2); however, the explanatory power of the independent variables for the variable "soil conservation concern" is at an acceptable and/or favourable level (R^2 =0.307).

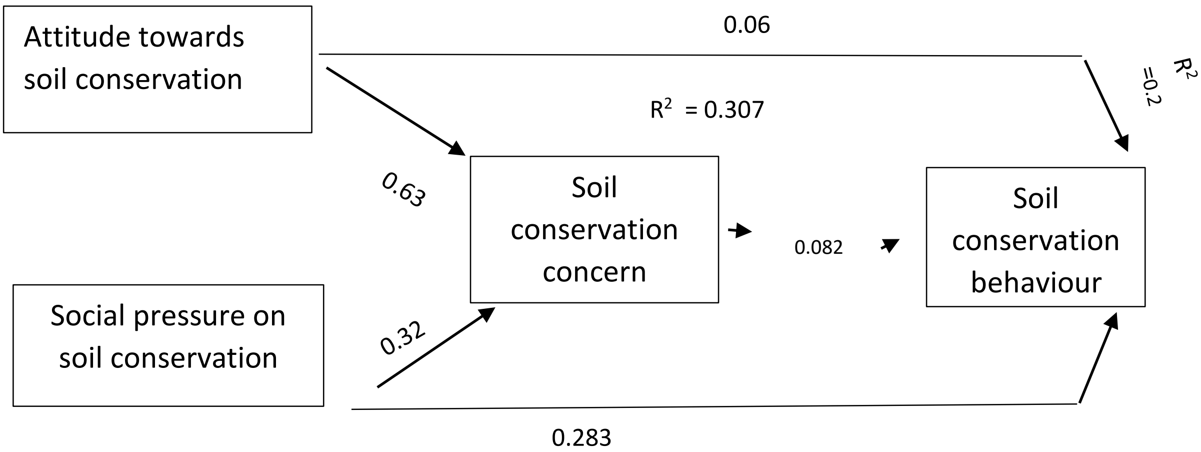


Figure 8.2: Casual (path) Model and Path Coefficients of the Variables

According to the analysis in this chapter, the effects of variables "attitude towards soil conservation", "social pressures on soil conservation" and "soil conservation concern" on “soil conservation behaviour" exhibited that significant effects persist on the soil conservation behaviour. Accordingly, it can be claimed that the presented framework (causal chain) and its variables are of an acceptable reliability. Hence, it is highly recommended that the role and status of such empirical frameworks are promoted in soil conservation programmes.

The variables that have a direct effect on the soil conservation behaviour, “social pressures on soil conservation" had the most significant beta coefficient. In this regard, the officials of institutions and organizations such as Agriculture Extension Organization which directly interact with farmers, with a focus on issues related to agricultural soils, can result in farmers' higher sensitivity and higher social pressures on soil conservation. Similarly, the current extension policies need to be strengthened to incorporate trends that recognize the critical role played by social environment of farmers and knowledge raise with regard to soil conservation.

CHAPTER NINE

Conclusion and Recommendations

9.1 Conclusions

Vegetable cultivation is a key sector in agriculture in terms of frugality and employment generation. Mismanagement experienced in the agricultural sector has led to resource degradation with an adverse impact on sustainability. A major form of environmental damage associated with agriculture is land degradation; particularly intensive vegetable cultivation practices have caused soil erosion on the steeply sloping lands of Central Hills. This study mainly focuses on identifying the factors instrumental in soil conservation, and investigating farmers' pro-environmental behaviours related to their soil conservation practices. This study was conducted in the Central Province of Sri Lanka, specifically in Kandy and Nuwara Eliya districts. A sample of 384 farmers was surveyed. Multi stage sampling technique was applied to derive the sample.

Demographic details of the sample were derived; majority of farmers have received primary education, most have studied up to the ordinary level, majority were small scale, practising intensive vegetable cultivation. Of the vegetable farmers, 68% in Kandy and 67% in Nuwara Eliya used 1-2 acres of land for vegetable cultivation. This implies that the majority of farmers cultivate vegetables in smaller plots compared to other major food crops in Sri Lanka. In other words, the majority of the vegetable growers are small scale intensive vegetable farmers.

According to the findings most of the vegetable farmers' mainstay was agriculture, most have over 15 years of experience in farming, related to vegetable cultivation in Kandy and Nuwara Eliya districts. Over 70% in Kandy and 66% in Nuwara Eliya vegetable farmers had sole proprietorship, youth engagement in agriculture remains very low and farmers of 51-60 years constitute a major part of the farming population in both districts. Majority of farmers who cultivated three sessions, this pattern of cultivation is significant in Nuwara Eliya. Farmers in Kandy (28%) and Nuwara Eliya (32%) cultivated vegetables in both *Yala* and *Maha* seasons.

When considering problems faced by farmers, nearly 90% of the vegetable lands in Nuwara Eliya district are under the steep slope category. In Kandy district nearly 45% of land fall in the steep slope category. In this category 46% in Kandy and 34 % from Nuwara Eliya, we have observed the clay type soil when considering the soil drainage. When irrigation water or rainfall slowly penetrates through soil it is evident that the area is not well-drained. These characteristics can have a strong influence on cultivating lands resulting in less crop production and difficult land management. Land restoring with organic amendments is highly recommended to enhance the crop production potential.

Further, sloping lands accelerate the top soil erosion. Poorly drained fields or those within lowlying areas can become water logged during periods of excessive rains. Such conditions cause diseases, reduce plant health and yield. Under extreme situations it can cause plant death.

With regard to soil moisture conservation practices, half of the population does not adopt soil moisture conservation practices. In 2020 and 2021, it could be observed that most of the farmers have not conducted soil physical or chemical test on their cultivation land. Farmers mentioned different reasons for not doing any soil tests. It is significant in Kandy district, that nearly 60% of farmers do not have experience in soil testing; 26% in Kandy and 45% from Nuwara Eliya highlighted the need for awareness programmes on soil and water conservation.

In both districts the need for land improvement for farming activities was highlighted. Limited supply and high price of the chemical fertilizers are also constraints. The farmers (around 30%) have used organic fertiliser during this season (2021 *Maha*) due to the limited supply and high price of chemical fertilizers.

In water application systems traditional methods such as the use of watering can and watering pipe are still popular. Adoption of advanced irrigation methods is not frequent. The use of high-pressure water pipes accelerates soil erosion with soil particles detaching from soil surface.

Varied soil conservation techniques are practised in the study area: biological, cultural and structural conservation methods. Structural techniques and incorporating organic manure as amendments are popular among the farmers in the study area. Adding organic amendments is a positive impression for soil health.

Using descriptive statistics, the factors affecting the soil conservation practices used by farmers were identified. Soil conservation practices adopted by farmers were assessed according to the DOA recommendations (highly adopted, moderately adopted, poorly adopted and not adopted). Considered all the practises under Sustainable land management practises (Agronomic practices, Vegetative methods, Structural methods, and Cropping systems). In soil conservation, most of the farmers follow at least one method of soil conservation. Organic manure application and terracing are the most popular conservation methods. Fallowing period is not popular among potato and vegetable farmers as those are lucrative crops; on the contrary, they aim at optimum land productivity. Biological soil conservation is poorly practised and although Zero tillage is proved to be the best soil erosion control technique for undulating landscapes it is rarely practised in the study area.

Farmers are following different combination of structural methods such as terrace, drains and bunds, biological such as live fence and cover cropping and cultural methods such as contour farming, and crop rotation. The levels of soil conservation practices were assessed as highly adopted, moderately adopted, poorly adopted and not adopted. Nearly half of the farming population (42%) follows an average level of soil conservation. Number of farmers who practised soil conservation at a poor level is lower than those who practised soil conservation at a good level (highly and moderate).

Soil erosion control techniques used to minimize the water flowing out of the farm land (off-farm) is a very important measure in top soil conservation, an important aspect that was observed during our data collection. Because significant amount of soil eroded from the farm land due to mismanagement of a well-developed drain water system out of the farm field to the main water way. More than 70% of farmers in both districts used those methods. However, still more than 25 % of farmers in both districts are not adopting these methods. This accelerates the top soil erosion, when water flowing out from the farm land to the main water way. This highlights the training needs in control techniques to reduce top soil erosion by water drain out from the farm lands.

Popular erosion control methods for stream flows are gully control, bank conservation and main cannel conservation. Silt trap is a very effective method to collect the nutrient rich top soil. However, farmers do not practise these methods. These points heighted the training on equipment of integrated soil conservation methods.

In the Nuwara Eliya district the entire land area, where intensive vegetable cultivation is practised experiences severe erosion. With great demand for Upcountry vegetables, the cultivation on highly eroded lands calls for urgent soil conservation measures.

Climate change is a dominant constraint in the study area. Cultivation activities are mostly based on the temperature and rainfall— the factors that mostly influence crop production. The Up-country Intermediate zone experiences a large variation of temperature and rainfall. Consequently, the number of cultivation seasons per year is reduced. Soil erosion occurs due to adverse impact of heavy rainfall, which stresses the need for soil conservation practices and climate change adaptation measures. The study shows that smallholder farmers in rural community in Sri Lanka need to take adaptation strategies to cope with climate change. Farmers shifted to short-season crops, drought-resistant crops, change of irrigation methods, changing planting dates and planting trees to cope with climate change. The smallholder farmers have high responsiveness to rainfall, temperature and wind and have taken appropriate measures to mitigate impacts of climate change.

In the Up-country region farmers do not apply modern technology for tillage, watering, cultivating and harvesting, that makes processes time consuming. A wide range of practices is available for soil and water conservation in the crop management phase.

Poor use of new technology in land preparation is another issue that has to be addressed. Farmers are unable to use high machinery system on their fields due to geographical formation of the elevated land. Therefore, limitation of technology application has limited their land productivity to a great extent.

According to the results, more than half of the population has not received any extension service granted by the government during the last two years (Figure 6.12). Further, 57% of farmers are not satisfied with the advisory service they had during 2020 - 2021. However, 68% of had not received any officer encouragement or guidance within these two years. Strongly agreed with the statement “Government subsidy is essential for soil conservation”. They believe that soil conservation is beneficial to individual farmer as well as the society.

Findings revealed that the farmers have depended on long term experience to determine crops suitable for the soil. Interestingly, one-third of the farmers have considered recommendations of the soil testing reports. Minor irrigation systems were the major water source (46%) of vegetable farmers and nearly one third (31%) of farmers have used agro-wells and tube-wells. However, a great majority of more than 80% were satisfied with the available water source while the rest was struggling without access to water sources. Nearly half of the interviewed farmers have used water-pumps to supply water to their vegetable plots and one-fifth of the farmers use the most efficient water use technologies such as drip irrigation and sprinkler systems. According to literature, climate change will have serious impacts on agriculture and its production (IPCC, 2007). Highly productive and environmentally sound agriculture plays an important role in sustainable development of rural areas. The rural level smallholder farmers are severely affected by climate change with low adaptive capacity to climatic change. According to our research findings, majority of smallholder farmers are aware of climate variations in their area. Considering the economic factors affecting soil conservation practices of upcountry vegetable farmers. According to the objective two, to find out the effects of existing SLM practices (Agronomic practices, Vegetative methods, Structural methods and Cropping systems) followed by Upcountry vegetable farmers and erosion hazard level on, productivity and profit. There is a significant difference in productivity and profit under adoptability on different levels of soil conservation practises. That difference shows the farmers who follow good level of soil conservation can obtain a higher yield. Moreover; farmers who adopt a poor level of soil conservation obtain low yield. Productivity shows an increasing relationship with the level of soil conservation. That means production is increasing with good level of soil conservation. While production is lower with poor soil conservation practices as a result of reduced yield due to high soil erosion. Under high eroded areas farmers can obtain a considerable production by practising soil conservation methods.

According to the results, farmers tend to invest more on soil conservation measures with the increase of their farm income, level of awareness of soil conservation practices and the security of the land ownership. However, farm income is determined by various other technical and socio-economic factors that can be manipulated to increase income. To understand the pro-environment behaviours of the vegetable farmers the study investigated the effect of two variables "attitude" and "social pressure" on the variable "soil conservation concern", while analysing the effect of the variable "soil conservation concern" on "soil conservation behaviour". Since the effects of variables "attitude towards soil conservation", "social pressures on soil conservation" and "soil conservation concern" on "soil conservation behaviour" revealed that these variables have significant effect on the soil conservation behaviour. Consequently, it can be applied to the presented framework (causal chain) and its variables are of acceptable reliability. Hence, it is identified that the role and status of such empirical frameworks are taken into consideration in social and encouraging soil conservation programmes. Of the variables, having a direct effect on the soil conservation behaviour, the variable "social pressures on soil conservation" had the most significant beta coefficient, compared to other variables. In this regard, the officials of institutions such as the Department of Agrarian Development that form direct links and interaction with farmers, with a focus on issues related to agricultural soils. The present extension policies need to be strengthened to incorporate trends that recognize the critical role played by social environment of farmers and subjective norms in raising awareness on soil conservation.

9.2 Recommendations

1) By secondary data and focus group discussions, the importance of restoring soil health was stressed. Soil health can be restored by applying organic manure; they apply farmyard manure regularly and directly after harvesting. Consequently, the practice of using organic manure after harvesting takes place concurrently with restoration of soil health and improvement of physical, chemical, and biological properties of soil. Restoring soil health with organic amendments is highly recommended to protect the top soil erosion, because fallowing period is not much popular among farmers for soil fertility regeneration.

2) More than 50% of the vegetable plots are suitable for agricultural activities considering the soil texture. Nearly half of the farmers from Kandy and 39% from Nuwara Eliya highlighted the need for land improvements for farming. Soil texture as a physical property is acceptable in two districts, 56% in Kandy and 61% in Nuwara Eliya, but soil nutrient content should be enhanced to receive the potential yield by sustainable soil conservation practices.

3) Soil conservation practices adopted by farmers were observed according to the DOA recommendations (highly adopted, moderately adopted, poorly adopted and not adopted). All practices come under sustainable land management practices (Agronomic practices, Vegetative methods, Structural methods and Cropping systems). Most of the farmers in the sample are following at least one method of soil conservation. Organic manure application and terracing are the most popular conservation methods but other methods are not popular among farmers, because these lands are highly valuable in terms of monetary returns. They practice biological soil conservation techniques poorly and this stresses the Importance of training programmes on soil conservation practises for undulating landscapes.

4) In both districts the need for land improvements for farming was observed. Soil nutrient management is the key in sustainable crop production as fertile soil provides all essential nutrients for optimum crop growth. Generally, soils contain essential nutrients to a certain extent, which support the plant growth and the amount of nutrients varies with soil types. In agricultural lands continuous cultivation of crops leads to deplete soil fertility as soil nutrients are removed from the lands with harvested crops. Soil nutrient management in intensive vegetable cultivation is effective in soil conservation. Introducing and adopting modern eco-friendly input management techniques (including soil-test based fertilizer application, organic matter application, use of bio pesticides/botanicals/predator mites for pests and disease control) is recommended.

5) When considering the problems faced by vegetable farmers, nearly 90% of the vegetable lands in Nuwara Eliya district are under the steep slope category. In Kandy district nearly 45% of land under the steep slope category. In this category 46% in Kandy and 34 % from Nuwara Eliya, observed the clay soil. When irrigation water or rainfall slowly penetrates through soil it is evident the area is not well-drained. These characteristics can have a weighty influence on cultivating lands result in less crop production and difficult land management. Land restoring with organic amendments is highly recommended to enhance the potential vegetable production in land under the steep slope category. This will help increase the national vegetable production.

6) In Sri Lanka, limited land extent is a constraint to expand Upcountry crop production. However, it was observed that the whole land is not cultivated. Hence utilization of the total land for cultivation should be encouraged.

7) Senanayake (2013) stated that agriculture can be practised in areas susceptible to both low and moderate levels of soil erosion but areas under high, very high and extremely high levels of erosion hazard should however be brought under crop cultivation with utmost care to avoid degradation of lands. Implementation of effective soil conservation practices are of utmost importance to arrest the severe erosion presently occurring in these areas.

8) Due to inefficient methods of water application systems like the use of hose pipe accelerate the top soil erosion. Encouraging the use of micro irrigation systems for intensive vegetable cultivation in Upcountry is a timely move. Training programmes and seminars can help farmers to obtain new technological improvement in their cultivation field for water application and high level of education could be used for train farmers who are willing to use new technology for water application.

9) Farmers of remote and high elevated areas are subject to inequity in water supply. Fewer farmers use lift irrigation, groundwater and agro wells for water supply. It is important to use these water sources efficiently and uniformly. It is necessary to provide financial support or introduce low interest loan schemes to

encourage installation of micro irrigation systems for remote and high elevated areas.

10) Zero tillage is proven to be the best soil erosion control technique for undulating landscapes but rarely practised, among farmers in the study area. This again stresses the importance of training to be provided on effective land preparation practices.

11) The eroded sites have been identified as the sources of higher soil loss rates, low soil quality soils, marginal land, overgrazed lands, and mono-cropping cultivated land system with poor soil management and conservation measures. Therefore, introducing appropriate site-specific interventions such as agroforestry, agronomic practices, enclosure of degraded lands, and conservation measures based on the model erosion maps are practical viable solution towards sustainable environmental management. Bioengineering techniques are important in reducing stream bank erosion and landslides.

12) Most of the farmers in the sample do not practice any soil moisture conservation methods. Biological soil conservation techniques are also poorly practices. Only mulching, which is not accurately maintained, can be seen in the fields as a soil moisture conservation method. As a basic freely available, low-cost practice, mulching should be encouraged among farmers at Agrarian Services Centres, which is timely.

13) Conserving off-farm water management is an essential process. Soil erosion control techniques used for conserving the water that drains out of the farmland is very important in topsoil conservation. This is a very important section we have observed during our data collection. Because significant amount of soil eroded from the farmland due to the mismanagement of a proper drain system out of the farm field to the main water way, it is important to develop an off farm -soil erosion control system monitor by the agrarian research and production assistants.

14) Popular off-farm water control methods were gully control, bank conservation and main canal conservation. Silt trap is also an important method to collect the nutrient rich top soil. Training on integrated soil conservation methods is needed to educate farmers on appropriate methods.

15) Damage caused due to climate change can be minimized by resorting to the right soil conservation practices and climate change adaptation measures. The study shows that smallholder farmers in rural community in Sri Lanka need to take adaptation strategies to cope with climate change. Farmers shifted to short-season crops, drought-resistant crops, change of irrigation methods, changing planting dates and planting trees to cope with climate change. The smallholder farmers have high responsiveness to rainfall, temperature and wind and have taken appropriate measures to mitigate impacts of climate change. It is important

to transform weather forecast data for farmer leaders at district committee meetings.

16) In the Up-country region, limited numbers of younger people are involved in vegetable cultivation. Therefore; the development of the vegetable production sector requires a greater involvement of youth farmers. Majority of farmers did not use modern technology for tillage, cultivating and harvesting and these situations lead to time consumption. There are so many new technologies used for soil and water conservation in cultivation activities. Training and awareness programmes are needed to introduce modern technology, a stimulation towards this end.

17) Natural forests with high biological and hydrological value should be conserved as strict conservation forests. Other forests can be assigned for regulated multiple use.

18) Farmers (26%) in Kandy and (45%) Nuwara Eliya highlighted the need for awareness programmes on soil and water conservation. Training, awareness and educational programmers relevant to protection, conservation and improvement of the quality of the natural resources associated with land should be implemented. The extension service should be updated to create awareness among the farming community.

19) Certain areas of the farm lands are elevated hilly areas. Due to this high elevation, farmers have to transport their vegetables up to the road. Also, transport facilities are determined by the distance to the market. Therefore, the farmer face numerous challenges with regard to transport. Pertaining to vegetables, transporting is further complicated as different packaging and storing exist during transportation, which costs more. Thus, using a cooperative system to collect vegetables is timely.

20) According to the pro-environmental analysis, the study investigated the variables, that have a direct effect on the soil conservation behaviour, the variable "social pressures on soil conservation" had the most significant beta coefficient, compared to other variables. In this regard, the officials of institutions such as the Department of Agrarian Development that form direct links by directly interacting with farmers, with a focus on issues related to agricultural soils, can result in farmers' higher sensitivity and higher social pressures soil conservation programmes. The present extension policies need to be strengthened to incorporate trends that recognize the critical role played by social environment of farmers and subjective norms in raising awareness in soil conservation. It is recommended that one possible approach to attain soil conservation is through strategies by considering local groups that include those facilitate in capacity building and social capital strengthening. Training of trainers in the community to upgrade local knowledge, leadership and innovation in the field of soil conservation is suggested. In addition, community

participatory policies can play a major role in fostering cooperation in participatory action on management of soil resources.

21) Considering the economic factors affecting soil conservation practices of upcountry vegetable farmers there is a significant difference in productivity and profit under adoptability on different levels of soil conservation practises. That difference show, the farmers who follow good level of soil conservation can obtain a higher yield. Productivity shows a positive correlation with the level of soil conservation. That means the production is increasing with good level of soil conservation. While production is lower with poor soil conservation practices as a result of reduced yield due to high soil erosion. Under high eroded areas, farmers can obtain a considerable production by practising soil conservation methods.

22) The current extension policies need to be strengthened to incorporate trends that recognize the critical role played by the social environment of farmers and subjective norms in educating the farmers in soil conservation. The degradation of land and water resources in the upcountry area has been a multi-dimensional issue, stemming from policy lapses occurred in the last few decades.

23) Though the Soil Conservation Act was introduced in 1951, even after 50 years, its impacts are not satisfactory. The existing institutional set-up is not adequate to implement the Act in the field level; therefore, capacity building of the institutions is a favourable measure for preventing the land and water resources from further degradation.

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ANNEXES

Annex 1: Factors Effect on Soil Conservation and Adoptability on Soil Conservation Practices in the Study Area

According to the objective 1, Factors effect on soil conservation and adoptability on soil conservation practices were identified with logistic regression analysis. Each SLM practice was rated as highly adopted, moderately adopted and not adopted based on the DOA recommendations that consist of different levels and sub levels. According to the DOA recommendations (highly adopted, moderately adopted and not adopted). The logistic regression analysis was applied to find out the effects on the factors effect on soil conservation and adoptability on soil conservation practices

For this, 205 farmers in the study area have been included in multiple logistic regression analysis and there are no missing cases. According to Model Fitting Information the p-value of the Model row is less than 0.05 and that means model is significant.

Model Fitting Information				
Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	449.473			
Final	294.953	154.520	98	.000

Source :Author's survey data, 2021

Goodness-of-Fit			
	Chi-Square	**df**	**Sig.**
Pearson	343.629	310	.092
Deviance	294.953	310	.722

Source :Author's survey data, 2021

Pseudo R-Square	
Cox and Snell	.529
Nagelkerke	.596
McFadden	.344

Source :Author's survey data, 2021

Parameter Estimates									
Adoptability on Soil Conservation Practices[a]		**B**	**Std. Error**	**Wald**	**df**	**Sig.**	**Exp(B)**	**95% Confidence Interval for Exp(B)**	
								Lower Bound	**Upper Bound**
Adopted	Intercept	21.330	1965.097	.000	1	.991			
	[Gender=1]	.774	.671	1.331	1	.249	2.168	.582	8.067
	[Gender=2]	0[b]			0				
	[Age=1]	-1.124	1.571	.512	1	.474	.325	.015	7.067
	[Age=2]	-.529	.840	.398	1	.528	.589	.114	3.053
	[Age=3]	-.813	.744	1.195	1	.274	.443	.103	1.906
	[Age=4]	-.686	.703	.952	1	.329	.504	.127	1.998
	[Age=5]	0[b]			0				
	[Family Members=1]	-2.594	1.655	2.457	1	.117	.075	.003	1.914
	[Family Members=2]	-3.049	1.500	4.135	1	.042	.047	.003	.896
	[Family Members=3]	-3.369	1.511	4.970	1	.026	.034	.002	.665
	[Family Members=4]	0[b]			0				
	[Employment=1]	.337	1.702	.039	1	.843	1.401	.050	39.394
	[Employment=2]	2.055	2.128	.933	1	.334	7.810	.121	506.185
	[Employment=3]	.090	2.311	.002	1	.969	1.094	.012	101.427
	[Employment=4]	-3.315	1.972	2.825	1	.093	.036	.001	1.734
	[Employment=5]	1.853	2.624	.499	1	.480	6.381	.037	1092.904
	[Employment=6]	0[b]			0				
	[Education=1]	-.883	1.681	.276	1	.599	.413	.015	11.144
	[Education=2]	-1.460	1.626	.807	1	.369	.232	.010	5.621
	[Education=3]	-.709	1.588	.199	1	.655	.492	.022	11.058
	[Education=4]	-1.179	1.497	.620	1	.431	.308	.016	5.787
	[Education=5]	1.873	1.703	1.210	1	.271	6.511	.231	183.432
	[Education=6]	-1.179	1.599	.544	1	.461	.308	.013	7.064
	[Education=7]	.430	1.229	.122	1	.726	1.538	.138	17.103
	[Education=9]	-.401	1.763	.052	1	.820	.670	.021	21.219
	[Education=10]	0[b]			0				
	[Experience Farming=1]	-16.513	1965.094	.000	1	.993	6.739E-08	0.000	.[c]
	[Experience Farming=2]	-17.219	1965.094	.000	1	.993	3.324E-08	0.000	.[c]
	[Experience Farming=3]	-17.436	1965.094	.000	1	.993	2.677E-08	0.000	.[c]
	[Experience Farming=4]	-16.433	1965.094	.000	1	.993	7.299E-08	0.000	.[c]
	[Experience Farming=5]	-16.823	1965.094	.000	1	.993	4.944E-08	0.000	.[c]
	[Experience Farming=6]	-18.502	1965.094	.000	1	.992	9.220E-09	0.000	.[c]
	[Experience Farming=7]	0[b]			0				
	[Land Ownership=1]	.836	1.178	.504	1	.478	2.308	.229	23.240
	[Land Ownership=2]	3.019	2.554	1.397	1	.237	20.469	.137	3057.719
	[Land Ownership=3]	.885	1.073	.680	1	.410	2.422	.296	19.832
	[Land Ownership=4]	-.820	1.604	.261	1	.609	.440	.019	10.221
	[Land Ownership=5]	1.342	1.124	1.424	1	.233	3.825	.422	34.657
	[Land Ownership=6]	.020	0.000		1		1.021	1.021	1.021
	[Land Ownership=7]	0[b]			0				
	[Land Size Ac Levels=1]	1.117	1.012	1.218	1	.270	3.054	.420	22.195
	[Land Size Ac Levels=2]	.891	1.000	.793	1	.373	2.438	.343	17.318
	[Land Size Ac Levels=3]	-1.221	1.089	1.257	1	.262	.295	.035	2.494
	[Land Size Ac Levels=4]	.961	1.132	.721	1	.396	2.615	.285	24.033
	[Land Size Ac Levels=5]	0[b]			0				
	[Cultivating Land Area Levels=1]	-.748	1.223	.374	1	.541	.473	.043	5.207
	[Cultivating Land Area Levels=2]	-.572	1.143	.250	1	.617	.564	.060	5.304
	[Cultivating Land Area Levels=3]	.554	.997	.309	1	.579	1.740	.246	12.293
	[Cultivating Land Area Levels=4]	-.823	.881	.872	1	.350	.439	.078	2.469
	[Cultivating Land Area Levels=5]	0[b]			0				
	[Cultivation on Upland=1]	-.414	.600	.477	1	.490	.661	.204	2.141
	[Cultivation on Upland=2]	0[b]			0				
	[Nature of Slope=1]	-2.696	1.157	5.426	1	.020	.067	.007	.652

	[Nature of Slope=2]	-2.015	1.114	3.273	1	.070	.133	.015	1.183
	[Nature of Slope=3]	-1.432	.961	2.222	1	.136	.239	.036	1.570
	[Nature of Slope=4]	0[b]			0				
	[Nature of Soil Erosion=1]	.181	1.282	.020	1	.888	1.198	.097	14.790
	[Nature of Soil Erosion=2]	.066	1.250	.003	1	.958	1.068	.092	12.384
	[Nature of Soil Erosion=3]	-.224	1.280	.031	1	.861	.800	.065	9.836
	[Nature of Soil Erosion=4]	1.104	1.082	1.041	1	.308	3.015	.362	25.118
	[Nature of Soil Erosion=5]	0[b]			0				
Moderately Adopted	Intercept	28.462	7801.582	.000	1	.997			
	[Gender=1]	-1.616	.704	5.273	1	.022	.199	.050	.789
	[Gender=2]	0[b]			0				
	[Age=1]	-1.091	1.685	.419	1	.517	.336	.012	9.134
	[Age=2]	-3.237	1.097	8.700	1	.003	.039	.005	.338
	[Age=3]	-2.223	.901	6.086	1	.014	.108	.019	.633
	[Age=4]	-1.568	.815	3.703	1	.054	.208	.042	1.029
	[Age=5]	0[b]			0				
	[Family Members=1]	-2.223	1.875	1.406	1	.236	.108	.003	4.272
	[Family Members=2]	-2.068	1.619	1.630	1	.202	.126	.005	3.023
	[Family Members=3]	-3.188	1.680	3.600	1	.058	.041	.002	1.111
	[Family Members=4]	0[b]			0				
	[Employment=1]	12.398	3604.577	.000	1	.997	242275.363	0.000	.[c]
	[Employment=2]	14.894	3604.577	.000	1	.997	2940852.900	0.000	.[c]
	[Employment=3]	12.569	3604.578	.000	1	.997	287460.765	0.000	.[c]
	[Employment=4]	11.831	3604.577	.000	1	.997	137390.774	0.000	.[c]
	[Employment=5]	18.516	3604.578	.000	1	.996	109949327.290	0.000	.[c]
	[Employment=6]	0[b]			0				
	[Education=1]	1.333	2.112	.398	1	.528	3.792	.060	238.242
	[Education=2]	-1.663	2.027	.673	1	.412	.190	.004	10.071
	[Education=3]	-.169	1.973	.007	1	.932	.845	.018	40.417
	[Education=4]	1.272	1.856	.469	1	.493	3.566	.094	135.527
	[Education=5]	2.684	2.052	1.711	1	.191	14.645	.263	816.970
	[Education=6]	.101	1.900	.003	1	.958	1.106	.027	45.811
	[Education=7]	1.548	1.665	.864	1	.353	4.700	.180	122.823
	[Education=9]	1.185	2.172	.298	1	.585	3.272	.046	231.064
	[Education=10]	0[b]			0				
	[Experience Farming=1]	-16.938	1965.094	.000	1	.993	4.403E-08	0.000	.[c]
	[Experience Farming=2]	-17.684	1965.094	.000	1	.993	2.089E-08	0.000	.[c]
	[Experience Farming=3]	-17.840	1965.094	.000	1	.993	1.788E-08	0.000	.[c]
	[Experience Farming=4]	-16.654	1965.094	.000	1	.993	5.853E-08	0.000	.[c]
	[Experience Farming=5]	-17.940	1965.094	.000	1	.993	1.617E-08	0.000	.[c]
	[Experience Farming=6]	-19.399	1965.094	.000	1	.992	3.760E-09	0.000	.[c]
	[Experience Farming=7]	0[b]			0				
	[Land Ownership=1]	-18.740	6634.010	.000	1	.998	7.268E-09	0.000	.[c]
	[Land Ownership=2]	-32.629	8088.478	.000	1	.997	6.752E-15	0.000	.[c]
	[Land Ownership=3]	-17.290	6634.010	.000	1	.998	3.099E-08	0.000	.[c]
	[Land Ownership=4]	-16.839	6634.010	.000	1	.998	4.863E-08	0.000	.[c]
	[Land Ownership=5]	-16.432	6634.010	.000	1	.998	7.303E-08	0.000	.[c]
	[Land Ownership=6]	-16.010	6634.010	.000	1	.998	1.114E-07	0.000	.[c]
	[Land Ownership=7]	0[b]			0				
	[Land Size Ac Levels=1]	-2.147	1.087	3.900	1	.048	.117	.014	.984
	[Land Size Ac Levels=2]	-2.493	1.130	4.867	1	.027	.083	.009	.757
	[Land Size Ac Levels=3]	-1.107	1.072	1.066	1	.302	.331	.040	2.704
	[Land Size Ac Levels=4]	-.925	1.179	.616	1	.433	.396	.039	3.997
	[Land Size Ac Levels=5]	0[b]			0				
	[Cultivating Land Area Levels=1]	.804	1.327	.367	1	.545	2.234	.166	30.117
	[Cultivating Land Area Levels=2]	1.120	1.232	.826	1	.363	3.065	.274	34.288
	[Cultivating Land Area Levels=3]	-.216	1.089	.039	1	.843	.806	.095	6.808
	[Cultivating Land Area Levels=4]	-.468	.997	.220	1	.639	.626	.089	4.421
	[Cultivating Land Area Levels=5]	0[b]			0				
	[Cultivation on Upland=1]	-.067	.658	.010	1	.919	.935	.258	3.395
	[Cultivation on Upland=2]	0[b]			0				
	[Nature of Slope=1]	-5.225	1.333	15.366	1	.000	.005	.000	.073

	[Nature of Slope=2]	-3.468	1.223	8.045	1	.005	.031	.003	.342
	[Nature of Slope=3]	-1.468	1.031	2.025	1	.155	.230	.031	1.740
	[Nature of Slope=4]	0[b]			0				
	[Nature of Soil Erosion=1]	2.893	1.598	3.279	1	.070	18.052	.788	413.560
	[Nature of Soil Erosion=2]	2.218	1.553	2.038	1	.153	9.185	.437	192.872
	[Nature of Soil Erosion=3]	2.290	1.543	2.203	1	.138	9.878	.480	203.235
	[Nature of Soil Erosion=4]	2.724	1.482	3.379	1	.066	15.237	.835	278.037
	[Nature of Soil Erosion=5]	0[b]			0				

a. The reference category is: Not Adopted.

b. This parameter is set to zero because it is redundant.

c. Floating point overflow occurred while computing this statistic. Its value is therefore set to system missing.

Source :Author's survey data, 2021

Annex 2: Factors Effect on Soil Conservation and Adoptability

Likelihood Ratio Tests				
Effect	**Model Fitting Criteria**	**Likelihood Ratio Tests**		
	-2 Log Likelihood of Reduced Model	**Chi-Square**	**df**	**Sig.**
Intercept	294.953[a]	0.000	0	
Gender	308.238	13.285	2	.001
Age	308.362	13.410	8	.099
Family Members	303.816	8.863	6	.181
Employment	312.610	17.658	10	.061
Education	317.499	22.547	16	.126
Experience Farming	309.047	14.094	12	.295
Land Ownership	315.996	21.043	12	.050
Land Size Ac Levels	312.739	17.786	8	.023
Cultivating Land Area Levels	302.699	7.746	8	.459
Cultivation on Upland	295.547	.595	2	.743
Nature of Slope	318.447	23.495	6	.001
Nature of Soil Erosion	303.184	8.231	8	.411

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

Source :Author's survey data, 2021

Classification				
Observed	**Predicted**			
	Adopted	**Moderately Adopted**	**Not Adopted**	
Adopted	43	16	14	58.9%
Moderately Adopted	14	43	5	69.4%
Not Adopted	16	5	49	70.0%
Overall Percentage	35.6%	31.2%	33.2%	65.9%

Source :Author's survey data, 2021

Univariate Analysis of Variance

Between-Subjects Factors

		Value Label	N
Nature of Soil Erosion	1	Less Erosion	39
	2	Moderately Erosion	48
	3	High Erosion	62
	4	Very High Erosion	29
	5	Extremely High Erosion	18
Adoptability on Soil Conservation Practices	1	Adopted	34
	2	Moderately Adopted	103
	3	Not Adopted	59

Descriptive Statistics

Dependent Variable: Productivity

Nature of Soil Erosion	Adoptability on Soil Conservation Practices	Mean	Std. Deviation	N
Less Erosion	Adopted	16.4227	19.66069	11
	Moderately Adopted	16.0710	18.11217	20
	Not Adopted	8.5763	4.83589	8
	Total	14.6328	16.72703	39
Moderately Erosion	Adopted	9.4063	7.25259	8
	Moderately Adopted	4.7070	3.16447	27
	Not Adopted	3.0208	2.56141	13
	Total	5.0335	4.41420	48
High Erosion	Adopted	5.5662	4.69575	13
	Moderately Adopted	2.7970	2.63982	40
	Not Adopted	.7522	.61949	9
	Total	3.0808	3.31853	62
Very High Erosion	Adopted	2.2200	1.73948	2
	Moderately Adopted	1.3917	1.04488	12
	Not Adopted	.9313	1.05756	15
	Total	1.2107	1.10671	29
Extremely High Erosion	Moderately Adopted	1.0500	.77283	4
	Not Adopted	.3471	.22832	14
	Total	.5033	.48546	18
Total	Adopted	9.7853	12.71231	34
	Moderately Adopted	5.6436	9.70278	103
	Not Adopted	2.2624	3.44085	59
	Total	5.3442	9.29914	196

Levene's Test of Equality of Error Variances[a,b]					
		Levene Statistic	df1	df2	Sig.
Productivity	Based on Mean	6.683	13	182	.000
	Based on Median	2.994	13	182	.001
	Based on Median and with Adjusted df	2.994	13	34.979	.005
	Based on Trimmed Mean	4.685	13	182	.000

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Dependent variable: Productivity

b. Design: Intercept + Nature of Soil Erosion + Adoptability + Nature of Soil Erosion * Adoptability

Tests of Between-Subjects Effects

Dependent Variable: Productivity

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5320.454[a]	13	409.266	6.454	.000	.316
Intercept	2740.747	1	2740.747	43.217	.000	.192
Nature of Soil Erosion	2776.950	4	694.238	10.947	.000	.194
Adoptability	359.651	2	179.825	2.836	.061	.030
Nature of Soil Erosion * Adoptability	231.023	7	33.003	.520	.818	.020
Error	11541.993	182	63.418			
Total	22460.372	196				
Corrected Total	16862.447	195				

a. R Squared = .316 (Adjusted R Squared = .267)

Annex 3

Productivity
Univariate Analysis of Variance

Between-Subjects Factors			
		Value Label	N
Nature of Soil Erosion	1	Less Erosion	39
	2	Moderately Erosion	48
	3	High Erosion	62
	4	Very High Erosion	29
	5	Extremely High Erosion	18
Adoptability on Soil Conservation Practices	1	Adopted	34
	2	Moderately Adopted	103
	3	Not Adopted	59

Descriptive Statistics

Dependent Variable: Productivity

Nature of Soil Erosion	Adoptability on Soil Conservation Practices	Mean	Std. Deviation	N
Less Erosion	Adopted	15.4227	19.66069	11
	Moderately Adopted	15.0710	18.11217	20
	Not Adopted	8.5763	4.83589	8
	Total	14.6328	16.72703	39
Moderately Erosion	Adopted	12.4063	7.25259	8
	Moderately Adopted	5.7070	3.16447	27
	Not Adopted	4.0208	2.56141	13
	Total	5.0335	4.41420	48
High Erosion	Adopted	10.5662	4.69575	13
	Moderately Adopted	3.7970	2.63982	40
	Not Adopted	1.7522	.61949	9
	Total	3.0808	3.31853	62
Very High Erosion	Adopted	7.2200	1.73948	2
	Moderately Adopted	3.3917	1.04488	12
	Not Adopted	.9313	1.05756	15
	Total	1.2107	1.10671	29
Extremely High Erosion	Moderately Adopted	2.0500	.77283	4
	Not Adopted	1.3471	.22832	14
	Total	.5033	.48546	18
Total	Adopted	9.7853	12.71231	34
	Moderately Adopted	5.6436	9.70278	103
	Not Adopted	2.2624	3.44085	59
	Total	5.3442	9.29914	196

Levene's Test of Equality of Error Variances[a,b]

		Levene Statistic	df1	df2	Sig.
Productivity	Based on Mean	6.683	13	182	.000
	Based on Median	2.994	13	182	.001
	Based on Median and with Adjusted df	2.994	13	34.979	.005
	Based on Trimmed Mean	4.685	13	182	.000
Tests the null hypothesis that the error variance of the dependent variable is equal across groups.					
a. Dependent variable: Productivity					
b. Design: Intercept + Nature of Soil Erosion + Adoptability + Nature of Soil Erosion * Adoptability					

Tests of Between-Subjects Effects

Dependent Variable: Productivity

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5320.454[a]	13	409.266	6.454	.000	.316
Intercept	2740.747	1	2740.747	43.217	.000	.192
Nature of Soil Erosion	2776.950	4	694.238	10.947	.000	.194
Adoptability	359.651	2	179.825	2.836	.061	.030
Nature of Soil Erosion * Adoptability	231.023	7	33.003	.520	.818	.020
Error	11541.993	182	63.418			
Total	22460.372	196				
Corrected Total	16862.447	195				

a. R Squared = .316 (Adjusted R Squared = .267)

Estimated Marginal Means

1. Nature of Soil Erosion

Estimates

Dependent Variable: Productivity

Nature of Soil Erosion	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Less Erosion	13.690	1.369	10.989	16.391
Moderately Erosion	5.711	1.298	3.151	8.272
High Erosion	3.038	1.225	.621	5.456
Very High Erosion	1.514	2.140	-2.708	5.737
Extremely High Erosion	.699[a]	2.257	-3.756	5.153

a. Based on modified population marginal mean.

Pairwise Comparisons						
Dependent Variable: Productivity						
(I) Nature of Soil Erosion	(J) Nature of Soil Erosion	Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
Less Erosion	Moderately Erosion	7.979*	1.886	.000	4.257	11.700
	High Erosion	10.652*	1.837	.000	7.027	14.276
	Very High Erosion	12.176*	2.540	.000	7.163	17.188
	Extremely High Erosion	12.991*,b	2.640	.000	7.782	18.200
Moderately Erosion	Less Erosion	-7.979*	1.886	.000	-11.700	-4.257
	High Erosion	2.673	1.785	.136	-.848	6.194
	Very High Erosion	4.197	2.503	.095	-.741	9.135
	Extremely High Erosion	5.013[b]	2.604	.056	-.125	10.150
High Erosion	Less Erosion	-10.652*	1.837	.000	-14.276	-7.027
	Moderately Erosion	-2.673	1.785	.136	-6.194	.848
	Very High Erosion	1.524	2.466	.537	-3.342	6.390
	Extremely High Erosion	2.340[b]	2.568	.364	-2.728	7.408
Very High Erosion	Less Erosion	-12.176*	2.540	.000	-17.188	-7.163
	Moderately Erosion	-4.197	2.503	.095	-9.135	.741
	High Erosion	-1.524	2.466	.537	-6.390	3.342
	Extremely High Erosion	.816[b]	3.111	.793	-5.322	6.953
Extremely High Erosion	Less Erosion	-12.991*,c	2.640	.000	-18.200	-7.782
	Moderately Erosion	-5.013[c]	2.604	.056	-10.150	.125
	High Erosion	-2.340[c]	2.568	.364	-7.408	2.728
	Very High Erosion	-.816[c]	3.111	.793	-6.953	5.322

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (J).

c. An estimate of the modified population marginal mean (I).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Univariate Tests					
Dependent Variable: Productivity					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Contrast	3003.450	4	750.862	11.840	.000	.206
Error	11541.993	182	63.418			
The F tests the effect of Nature of Soil Erosion. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.						

2. Adoptability on Soil Conservation Practices

Estimates				
Dependent Variable: Productivity				
Adoptability on Soil Conservation Practices	**Mean**	**Std. Error**	**95% Confidence Interval**	
			Lower Bound	**Upper Bound**
Adopted	8.404[a]	1.773	4.906	11.901
Moderately Adopted	5.203	1.063	3.106	7.301
Not Adopted	2.726	1.070	.615	4.836
a. Based on modified population marginal mean.				

Pairwise Comparisons						
Dependent Variable: Productivity						
(I) Adoptability on Soil Conservation Practices	**(J) Adoptability on Soil Conservation Practices**	**Mean Difference (I-J)**	**Std. Error**	**Sig.[d]**	**95% Confidence Interval for Difference[d]**	
					Lower Bound	**Upper Bound**
Adopted	Moderately Adopted	3.200[a]	2.067	.123	-.878	7.279
	Not Adopted	5.678[a,*]	2.070	.007	1.593	9.763
Moderately Adopted	Adopted	-3.200[c]	2.067	.123	-7.279	.878
	Not Adopted	2.478	1.508	.102	-.498	5.453
Not Adopted	Adopted	-5.678[*,c]	2.070	.007	-9.763	-1.593
	Moderately Adopted	-2.478	1.508	.102	-5.453	.498
Based on estimated marginal means						
*. The mean difference is significant at the .05 level.						
a. An estimate of the modified population marginal mean (I).						
c. An estimate of the modified population marginal mean (J).						
d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).						

Univariate Tests					
Dependent Variable: Productivity					
	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Contrast	506.789	2	253.395	3.996	.020	.042
Error	11541.993	182	63.418			

The F tests the effect of Adoptability on Soil Conservation Practices. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

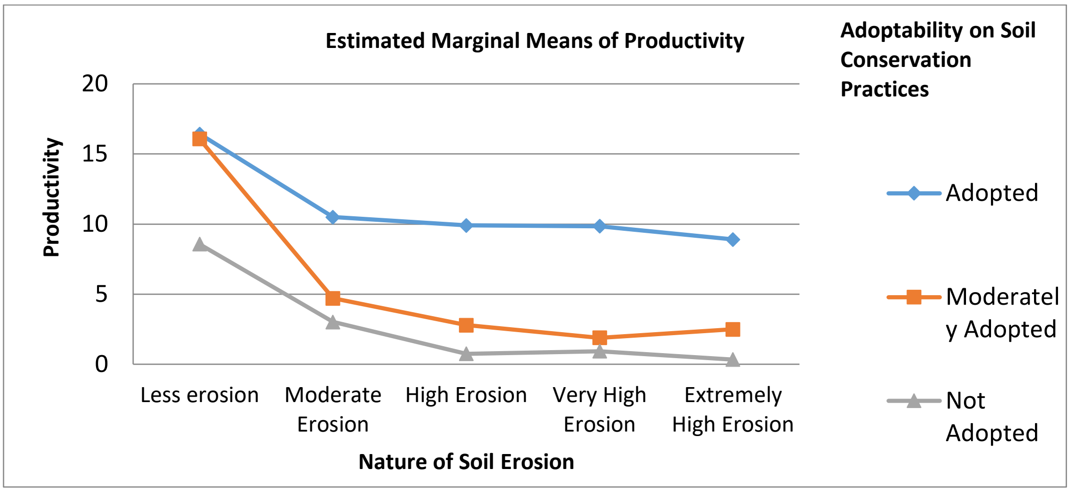
3. Nature of Soil Erosion * Adoptability on Soil Conservation Practices

Dependent Variable: Productivity

Nature of Soil Erosion	Adoptability on Soil Conservation Practices	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Less Erosion	Adopted	16.423	2.401	11.685	21.160
	Moderately Adopted	16.071	1.781	12.558	19.584
	Not Adopted	8.576	2.816	3.021	14.132
Moderately Erosion	Adopted	9.406	2.816	3.851	14.962
	Moderately Adopted	4.707	1.533	1.683	7.731
	Not Adopted	3.021	2.209	-1.337	7.379
High Erosion	Adopted	5.566	2.209	1.208	9.924
	Moderately Adopted	2.797	1.259	.313	5.281
	Not Adopted	.752	2.655	-4.485	5.990
Very High Erosion	Adopted	2.220	5.631	-8.891	13.331
	Moderately Adopted	1.392	2.299	-3.144	5.928
	Not Adopted	.931	2.056	-3.126	4.988
Extremely High Erosion	Adopted	.[a]	.	.	.
	Moderately Adopted	1.050	3.982	-6.806	8.906
	Not Adopted	.347	2.128	-3.852	4.547

a. This level combination of factors is not observed, thus the corresponding population marginal mean is not estimable.

Profile Plots- Productivity



Annex 4

Profit
Univariate Analysis of Variance

Between-Subjects Factors

		Value Label	N
Nature of Soil Erosion	1	Less Erosion	50
	2	Moderately Erosion	50
	3	High Erosion	65
	4	Very High Erosion	30
	5	Extremely High Erosion	20
Adoptability on Soil Conservation Practices	1	Adopted	35
	2	Moderately Adopted	104
	3	Not Adopted	76

Descriptive Statistics

Dependent Variable: Profit Per Ac

Nature of Soil Erosion	Adoptability on Soil Conservation Practices	Mean	Std. Deviation	N
Less Erosion	Adopted	1044097.25	1584324.836	12
	Moderately Adopted	929729.40	2704246.218	20
	Not Adopted	176783.33	217490.939	18
	Total	686117.10	1888501.151	50
Moderately Erosion	Adopted	433604.13	254137.934	8
	Moderately Adopted	106960.89	325345.667	27
	Not Adopted	1985.20	1107.005	15
	Total	127731.10	292822.627	50
High Erosion	Adopted	473531.00	834253.543	13
	Moderately Adopted	329989.80	1211672.366	41
	Not Adopted	-28550.09	83065.068	11
	Total	298022.06	1036537.424	65
Very High Erosion	Adopted	233904.50	16476.295	2
	Moderately Adopted	106772.33	752076.144	12
	Not Adopted	-38815.12	376762.536	16
	Total	37601.17	543908.029	30
Extremely High Erosion	Moderately Adopted	-135000.00	261470.202	4
	Not Adopted	-260207.69	340865.145	16
	Total	-235166.15	324288.857	20
Total	Adopted	646334.63	1076542.200	35
	Moderately Adopted	343782.52	1450914.585	104
	Not Adopted	-24822.87	291602.767	76
	Total	262737.47	1133042.393	215

Levene's Test of Equality of Error Variances[a,b]					
		Levene Statistic	df1	df2	Sig.
Profit Per Ac	Based on Mean	2.127	13	201	.014
	Based on Median	.807	13	201	.653
	Based on Median and with adjusted df	.807	13	50.224	.650
	Based on trimmed mean	.970	13	201	.482

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Dependent variable: Profit Per Ac

b. Design: Intercept + Nature of Soil Erosion + Adoptability + Nature of Soil Erosion * Adoptability

Tests of Between-Subjects Effects

Dependent Variable: Profit Per Ac

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	26718704684630.875[a]	13	2055284975740.836	1.666	.071	.097
Intercept	6095388746532.268	1	6095388746532.268	4.940	.027	.024
Nature of Soil Erosion	10642292552716.914	4	2660573138179.229	2.156	.075	.041
Adoptability	4747674836553.465	2	2373837418276.732	1.924	.149	.019
Nature of Soil Erosion * Adoptability	2766443083023.340	7	395206154717.620	.320	.944	.011
Error	248011299262474.620	201	1233887061007.336			
Total	289571664221362.000	215				
Corrected Total	274730003947105.500	214				

a. R Squared = .097 (Adjusted R Squared = .039)

Estimated Marginal Means

1. Nature of Soil Erosion

Estimates

Dependent Variable: Profit Per Ac

Nature of Soil Erosion	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Less Erosion	716869.994	160923.569	399555.026	1034184.963
Moderately Erosion	180850.071	177073.287	-168309.500	530009.643
High Erosion	258323.571	162337.353	-61779.148	578426.291
Very High Erosion	100620.569	297561.458	-486121.977	687363.116
Extremely High Erosion	-197603.844[a]	310479.350	-809818.360	414610.673

a. Based on modified population marginal mean.

Pairwise Comparisons

Dependent Variable: Profit Per Ac

(I) Nature of Soil Erosion	(J) Nature of Soil Erosion	Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
Less Erosion	Moderately Erosion	536019.923*	239272.531	.026	64213.611	1007826.235
	High Erosion	458546.423*	228582.176	.046	7819.743	909273.104
	Very High Erosion	616249.425	338288.659	.070	-50800.502	1283299.352
	Extremely High Erosion	914473.838*,b	349705.336	.010	224912.091	1604035.586
Moderately Erosion	Less Erosion	-536019.923*	239272.531	.026	-1007826.235	-64213.611
	High Erosion	-77473.500	240225.655	.747	-551159.216	396212.216
	Very High Erosion	80229.502	346262.574	.817	-602543.683	763002.687
	Extremely High Erosion	378453.915[b]	357424.643	.291	-326329.045	1083236.875
High Erosion	Less Erosion	-458546.423*	228582.176	.046	-909273.104	-7819.743
	Moderately Erosion	77473.500	240225.655	.747	-396212.216	551159.216
	Very High Erosion	157703.002	338963.476	.642	-510677.554	826083.558
	Extremely High Erosion	455927.415[b]	350358.164	.195	-234921.603	1146776.433
Very High Erosion	Less Erosion	-616249.425	338288.659	.070	-1283299.352	50800.502
	Moderately Erosion	-80229.502	346262.574	.817	-763002.687	602543.683
	High Erosion	-157703.002	338963.476	.642	-826083.558	510677.554
	Extremely High Erosion	298224.413[b]	430046.798	.489	-549757.562	1146206.388
Extremely High Erosion	Less Erosion	-914473.838*,c	349705.336	.010	-1604035.586	-224912.091
	Moderately Erosion	-378453.915[c]	357424.643	.291	-1083236.875	326329.045
	High Erosion	-455927.415[c]	350358.164	.195	-1146776.433	234921.603
	Very High Erosion	-298224.413[c]	430046.798	.489	-1146206.388	549757.562

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. An estimate of the modified population marginal mean (J).

c. An estimate of the modified population marginal mean (I).

d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Univariate Tests						
Dependent Variable: Profit Per Ac						
	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Contrast	12540086924671.807	4	3135021731167.952	2.541	.041	.048
Error	248011299262474.620	201	1233887061007.336			
The F tests the effect of Nature of Soil Erosion. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.						

2. Adoptability on Soil Conservation Practices

Estimates				
Dependent Variable: Profit Per Ac				
Adoptability on Soil Conservation Practices	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Adopted	546284.219[a]	246084.046	61046.713	1031521.725
Moderately Adopted	267690.485	148159.963	-24456.739	559837.710
Not Adopted	-29760.874	129184.496	-284491.580	224969.832
a. Based on modified population marginal mean.				

Pairwise Comparisons						
Dependent Variable: Profit Per Ac						
(I) Adoptability on Soil Conservation Practices	(J) Adoptability on Soil Conservation Practices	Mean Difference (I-J)	Std. Error	Sig.[d]	95% Confidence Interval for Difference[d]	
					Lower Bound	Upper Bound
Adopted	Moderately Adopted	278593.733[a]	287243.333	.333	-287803.157	844990.624
	Not Adopted	576045.093[a,*]	277931.632	.039	28009.355	1124080.830
Moderately Adopted	Adopted	-278593.733[c]	287243.333	.333	-844990.624	287803.157
	Not Adopted	297451.359	196570.620	.132	-90153.766	685056.485
Not Adopted	Adopted	-576045.093[*,c]	277931.632	.039	-1124080.830	-28009.355
	Moderately Adopted	-297451.359	196570.620	.132	-685056.485	90153.766
Based on estimated marginal means						
*. The mean difference is significant at the .05 level.						
a. An estimate of the modified population marginal mean (I).						
c. An estimate of the modified population marginal mean (J).						
d. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).						

Univariate Tests						
Dependent Variable: Profit Per Ac						
	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Contrast	6354515408918.586	2	3177257704459.293	2.575	.079	.025
Error	248011299262474.620	201	1233887061007.336			
The F tests the effect of Adoptability on Soil Conservation Practices. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.						

3. Nature of Soil Erosion * Adoptability on Soil Conservation Practices					
Dependent Variable: Profit Per Ac					
Nature of Soil Erosion	Adoptability on Soil Conservation Practices	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Less Erosion	Adopted	1044097.250	320661.694	411804.816	1676389.684
	Moderately Adopted	929729.400	248383.480	439957.787	1419501.013
	Not Adopted	176783.333	261819.176	-339481.277	693047.944
Moderately Erosion	Adopted	433604.125	392728.765	-340792.791	1208001.041
	Moderately Adopted	106960.889	213774.462	-314567.400	528489.178
	Not Adopted	1985.200	286808.538	-563554.345	567524.745
High Erosion	Adopted	473531.000	308081.790	-133955.921	1081017.921
	Moderately Adopted	329989.805	173478.547	-12081.528	672061.138
	Not Adopted	-28550.091	334920.216	-688957.999	631857.818
Very High Erosion	Adopted	233904.500	785457.529	-1314889.331	1782698.331
	Moderately Adopted	106772.333	320661.694	-525520.100	739064.767
	Not Adopted	-38815.125	277701.173	-586396.435	508766.185
Extremely High Erosion	Adopted	.[a]	.	.	.
	Moderately Adopted	-135000.000	555402.345	-1230162.621	960162.621
	Not Adopted	-260207.688	277701.173	-807788.998	287373.623
a. This level combination of factors is not observed, thus the corresponding population marginal mean is not estimable.					

Profile Plots-profit