ANALYSIS OF SOCIO-ECONOMIC AND INSTITUTIONAL FACTORS INFLUENCING SMALLHOLDER FARMER ADOPTION OF SOIL AND WATER CONSERVATION PRACTICES ON MAIZE PRODUCTION, THARAKA NITHI COUNTY, KENYA

HELLENAH MWENDWA GITONGA

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DECLARATION AND RECOMMENDATION

Declaration

This thesis is my original work and has not been presented for an award of diploma or conferment of a degree in any other institution.

Signature ......Hellenah...... Date 06/10/2023......

Gitonga Mwendwa Hellenah
NM25/45619/20

Recommendation

This thesis has been examined, passed and submitted with our approval as University supervisors.

Signature .... Date 06/10/2023......

Prof. Geofrey Kingori Gathungu, Ph.D
Chuka University

Signature .... Date 6/10/2023......

Dr. Peris Wangari Nderitu, Ph.D
Chuka University

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DEDICATION

This thesis is dedicated to my son Nick Alvin Lucky, mother Mary Karea and my siblings Nelly Gatwiri and Dorothy Kinya.

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ABSTRACT

Maize is among the most significant crops in Kenya for food security. Soil and water conservation practices adopted in maize production offer a potential solution to combat climate change by enhancing soil productivity and decreasing soil and water erosion thereby enhancing crop productivity and smallholder farmer's farm income. Despite various interventions to practice improved soil and water conservation technologies (SWCs) in maize production, adoption of these technologies is low resulting to poor output due to various factors. Therefore, this study aimed at analyzing the socio-economic and institutional factors influencing the adoption of SWCs and subsequent effect on maize yield in Tharaka Nithi County, Kenya. A cross-sectional survey research design was used where multi-stage sampling method was applied. Three hundred and eighteen (318) households in Maara and Chuka Sub-Counties were interviewed from a population target of 5250 using a structured questionnaire to obtain data on socio-economic and institutional factors influencing the uptake of SWCs. Descriptive statistics were completed using SPSS version 28 while econometric analysis by Stata version 17. The Propensity Score Matching model (PSM) was employed on the effects of adoption of SWCs on maize yield while Multivariate Probit (MVP) model was employed on both socio-economic and institutional factors affecting the use of SWCs. The MVP model had positive coefficients which indicated that increase in either one of socio-economic and institutional factors increased the adoption of certain SWCs, farm size had a P-value at 1% on intercropping and irrigation, household size P-value at 5%, land topography a P-value at 5% on intercropping, grass strips and stone bunds, extension and training a P-value at 1% on intercropping and grass strips and membership P-value at 1% on intercropping and irrigation. The negative coefficients showed that increase in the factors decreased the adoption of certain SWCs, gender had a P-value at 5% on intercropping and P-value at 10% on mulching, education at 1% on minimum tillage and 5% on stone bunds, perception on soil erosion had a P-value at 1% on intercropping and irrigation and topography of the land had a P-value at 5% on crop rotation. The PSM model applied the logit regression model where positive estimates on socio-economic and institutional factors showed an increase in either of the factors had an increase in adoption of SWCs indicating significance on age at 5% on mulching, household size at 5% on intercropping, land size at 5% on irrigation, extension services at 1% on crop rotation and group membership at 10% on irrigation that influenced adoption of SWCs. The negative coefficients indicated that an increase in either of the factors decreased the adoption of SWCs where land size had a P-value at 5% on grass strips, household size had a P-value at 10% on terraces, age had a P-value at 10% on crop rotation and irrigation, access to extension services had a P-value at 1% on grass strips and group membership had a P-value at 1% on terraces. The PSM used three matching algorithms (Nearest neighbor, radius and stratification) to match the adopters and non-adopters that determined the Average Treatment Effects (ATT). Intercropping and irrigation were positively significant at 5% and 1%, respectively. The positive ATT indicated an average increase in maize yield from intercropping and irrigation as soil and water conservation practices (SWCs) at a range between 290 kgs to 375 kgs and 270 kgs to 725 kgs per hectare, respectively. Stone bunds and minimum tillage were negative and significant at 1%. The negative ATT was significant and showed that there was average decrease in maize production from stone bunds and minimum tillage as SWCs at a range of about 50 kgs to 287 kgs and 248 kgs to 690 kgs per hectare, respectively. The adoption level of SWCs was average given that there was low frequency of implementation by the smallholder maize farmers. Therefore, the study recommends that small-scale maize producers should practice more of intercropping and irrigation as SWCs for increased productivity and increased food security. There is also the need for government and stakeholders' interventions which will enable small-scale maize farmers to increase on adoption of SWCs that results to improvement in crop output and income.

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LIST OF ABBREVIATIONS

ASALs	Arid and Semi-Arid Lands
ATT	Average Treatment Effect
CAs	Crop Advisers
FAO	Food and Agriculture Organization
FBO	Farm-Based Organizations
GDP	Gross Domestic Product
ICT	Information, Communication and Technology
KNBS	Kenya National Bureau of Statistics
LATE	Local Average Treatment Effect
LTR	Land Tenure Regulation
LULC	Land Use and Land Cover
MVP	Multivariate Probit Model
NACOSTI	National Commission for Science, Technology and Innovation
NERICA	New Rice for Africa's Varieties
NGO	Non-Governmental Organization
NRCS	Natural Resources Conservation Service
PSM	Propensity Score Matching
SPSS	Statistical Package for Social Sciences
STATA	Statistics and Data Analysis Tool
SWCs	Soil and Water Conservation Practices

CHAPTER ONE
INTRODUCTION

1.1 Background to the Study

Agriculture is a sector that is very crucial for advancing economic growth, enhancing food security, and reducing poverty. Soil and water resources are non-renewable, making them dynamic and vulnerable to fast degradation due to improper land use hence vital resources for life and survival (Timmis *et al.,* 2021). More than six billion people, growing at a rate of 1.3% per year, are fed by a limited supply of productive lands that make up less than 11% of the world's surface area (Eswaran *et al.,* 2019). Excessive use and improper management of these resources against degradation and soil erosion is necessary for continued productivity and food production for humankind (Arora *et al.,* 2022). However, it was until the 1980s that agricultural policy and soil conservation initiatives considered how agricultural intensification affects water and soil resources (Kopttike *et al.,* 2019).

Erosion on farmland worldwide, approximately averages to 30 tonnes/ha/year (Betela *et al.,* 2021) and due to soil erosion, around 10 million ha of agricultural land are said to be unusable and left each year (Nyawade *et al.,* 2019). Rates of soil erosion and loss is extreme to continents like Asia, Africa and South America, showing tiny farms in marginal areas to have low soil value and frequently steep topography suffer from considerable soil losses (Sartori *et al.,* 2019). Arid regions cover about 41% of the earth terrestrial area where desertification currently affects more than 2.6 billion people globally (Jat *et al.,* 2020). Land deterioration is a major concern for sustainable development in Asia (Anantha *et al.,* 2021) where soil erosion is significantly increasing (Li *et al.,* 2023). Land needs to be investigated to meet demands through agriculture and development to realize the goal that is sustainable in having no hunger, good health and wellbeing by applying appropriate management measures (Bouma *et al.,* 2022)

In China, 80% of the grasslands are drylands (Liu *et al.,* 2018) where traditional tillage farmlands experience higher soil loss rates than those of the majority of other nations (Guo *et al.,* 2019) therefore, strategies to conserve soil and water are being considered to ease effects on runoff and severe water erosion (Chen *et al.,* 2020). In India, farmers' ability to secure their food supply and means of subsistence is directly impacted by the land degradation brought on by erosion (Meena *et al.*, 2020). India faces a burning risk of erosion in soil due to its location in the humid subtropical zone (Rajbanshi *et al.*, 2020). The shifting Land Use and Land Cover (LULC) structure, mainly is due to a lot of practices done in agriculture and extreme deforestation, which has made soils more vulnerable to water erosion (Duan *et al.,* 2020) and as a consequence, about 74 million tonnes of key nutrients is lost in relation to crop output, extent of land use and shifting crop pattern (Bhattacharya *et al.,* 2020). Thus, cover management factor and conservation factors are put into practice to manage accelerated soil degradation (Fayas *et al.,* 2019).

Up to 65% of productive farms are degraded, and 55% of Africa's agricultural land is at very high risk of future desertification due to 45% of the Africa’s land already being affected by it (Darkoh and Michael, 2018). The restoration of Africa's dry lands is essential for adaptation and the development of resilient and sustainable agricultural systems since they are extremely susceptible to climate change (Mansourian *et al.,* 2021). Agro-based economies dominate Africa’s countries like Ethiopia, Kenya, Malawi, Mozambique and Nigeria where drought affect these countries that generate the majority of the region's food (Katengeza *et al.*, 2019). Success in the agricultural sector directly affects social welfare, expansion of the economy and food security (Gniza *et al.,* 2023) therefore, its significance is evident in rural areas, whose households mainly rely on farming to make ends meet and mitigating the extreme effects of climate change affecting Africa’s production (Thinda *et al.,* 2020). These nations' agricultural sectors struggle because of biological, physical, and economic factors that restrict agricultural development, despite the struggles, a range of practices are used (Iseman *et al.,* 2021).

Most smallholder farmers believe that the main obstacle preventing them from boosting food production is the loss of soil fertility, where soil erosion reduces agricultural productivity (Faridi *et al.,* 2020). Adoption rates of SWCs in southern Africa have remained low (Bell *et al.,* 2018) compared to Brazil and Argentina where acceptance rates are more than 70% (Kassam *et al.,* 2019). Sub-Saharan Africa's smallholder farmers in countries such as Ethiopia, Zambia and Nigeria still use outdated traditional cultivation techniques (Iyilade *et al.,* 2020). The agriculture sustainability, environmental stability, economic and social growth are all threatened by land degradation, which results in deteriorating soil quality and decreased land and soil production (Eswaran *et al.,* 2019). If suitable soil, water and land management practices are not implemented, yields will continue to decline increasing the likelihood that more people in Africa will experience food insecurity (Lindenmayer *et al.,* 2023). Rates at which the sustainable agricultural methods are being adopted in African countries is also below its peak in the rural areas of these growing nations, despite several national and international campaigns to induce and make investments in farm lands (Meemken *et al.,* 2021).

Kenya benefits from having high-altitude regions with significant agricultural potential, where the majority of the population resides. Nevertheless, Kenya occasionally has food scarcity due to the fact that more than three quarters of the nation is arid or semi-arid (ASALS) (Laibuni *et al.*, 2020). The strategy for mitigating crop production risks on maize yields would be to improve conservation through surface techniques promoted by conservation-effective study in Mbeere South and Meru South in humid parts of Kenya (Kiboi *et al.,* 2021). In Kisii Kenya, populations that depend on agriculture are expected to suffer from climate change making food insecurity worse since they are less capable of adjusting to hostile shocks (Nyang'au *et al.*, 2021) and to adequately address these negative effects, it is essential to boost the climatic adaptability by development of approaches which will have fewer negative effects (Nyang'au *et al.*, 2021). Water scarcity, unreliable rainfall makes technology intervention important for water and food production especially for maize production in ASALS of Kenya (Wolka *et at.,* 2018). The SWCs reduce surface run-off, improve soil structure, increasing infiltration due to increased soil cover (Berihun *et al.,* 2020).

Maize being among significant food crops, and staple food for majority of people in Kenya, it accounts for 40% of crop area and 51% of all staples grown (De Groote *et al.,* 2023). Although maize is important, its growth is hindered by both biotic and abiotic stresses which include poor fertility and frequent droughts (Simtowe *et al.,* 2021; Jones-Garcia *et al.,* 2021). The potential yield is about 6 to 8 ton per ha while the current yield is 1.0 ton per ha (Kiboi *et al.,* 2019). Therefore, in increasing maize production and adapting to climate change, SWCs have been developed to curb the change that pose risks to productivity. The production of maize is still more vulnerable to the increasingly frequent occurrence of climate variability, particularly during growing seasons when droughts and floods occur (Mumo *et al.,* 2021). Maize production is expected to reduce due to effects of climate change and the adaptability of soil and water maintenance technologies will be necessary (Bagula *et al.,* 2022).

From germination through maturity, maize experiences a great deal of sensitivity to drought since its germination depends on rain-fed systems therefore, it is necessary to come up with alternate soil moisture conservation techniques to lessen the consequences of drought stress (Uwizeyimana *et al.,* 2018). Improved agronomic techniques and soil and water conservation techniques would boost maize yields and improve soil quality, leading to a further expansion of agricultural acreage (Kim *et al.,* 2021). By creating water stress throughout its growth, frequent changes in rainfall patterns lower maize yields and their value including increasing crop unpredictability (Erkossa *et al.,* 2018). By preserving the soil's nutrient and moisture contents, lowering soil erosion and run-off rates, the use of traditional tillage, use of improved varieties of crops and SWCs can increase production (Bedeke *et al.,* 2019).

Stopping nutrients loss in the soil and water due to erosive processes, Soil and Water Conservation Practices (SWCs) offer good solutions. The potential yield of maize being about 6 to 8 ton per ha while the current yield is 1.0 ton per ha, SWCs adoption provides a potential solution to the issue, which will improve smallholder farmers' crop output and farm incomes (Adetoro *et al.,* 2021). Increased agricultural productivity and maize yields would result from the use of SWCs, increasing the amount of diverse food that people could access (Manda *et al.,* 2021). Although a number of these technologies have been advocated before, the speed at which implementation of the suggested SWCs is still minimal.

The foregoing situation where there is low adoption of SWCs is influenced by various factors such as socio-economic and institutional factors. The socio-economic factors include age, gender, education, land size, farmer’s perception demonstrating both positive and negative effects on adoption of SWCs on perennial crop production in

Ghana (Khama *et al.*, 2020). In addition, institutional factors such as group membership, access to credit, access to extension services and training are also taken into account making it necessary to understand how adoption of soil and water conservation (SWCs) methods are influenced by such factors. Therefore, this current study intended to investigate the existing gap on how the uptake of SWCs influenced by socio-economic and institutional factors could add to increased maize productivity in Tharaka Nithi County.

1.2 Statement of the Problem

Soil and water are basic resources for crop production; they contribute to increased maize crop yields. Lack of implementation of soil and water conservation technologies cause soil erosion and surface runoff that contributes to low fertility, poor crop production and loss of biodiversity. The current level of maize productivity is low at 1.0 ton per ha where the achievable potential is 6 to 8 ton per ha, this low yield is attributed by extensive soil fertility degradation in farms rising from the depletion of soil nutrients. To improve on productivity of maize, soil and water conservation practices are taken into account for increased production of agricultural systems which caters for concerns of low rainfall, soil erosion, degradation of land, water shortages and food insecurity. Despite, the promotion of improved soil and water technologies, farmers who practice maize farming do not use these practices in their farms resulting to reduced crop yield. The low adoption of SWCs could be attributed by both the socio-economic and institutional factors among other factors. Little information exists on these factors that influence adoption of these improved SWCs and how these technologies impact maize production. This study therefore determined how socio-economic and institutional factors affect the implementation of improved soil and water technologies in Tharaka Nithi County.

1.3 Objectives of the Study

1.3.1 Broad Objective

To analyze the socio-economic and institutional factors influencing adoption of soil and water conservation practices and its effect on maize production in Tharaka Nithi County.

1.3.2 Specific Objectives

i. To evaluate the socio-economic factors influencing the adoption of soil and water conservation practices among smallholder maize farmers in Tharaka Nithi County, Kenya.
ii. To determine the institutional factors influencing the adoption of soil and water conservation practices among smallholder maize farmers in Tharaka Nithi County, Kenya.
iii. To assess the levels and effects of adoption of soil and water conservation practices on maize yield in Tharaka Nithi County, Kenya.

1.4 Research Questions

i. What are the socio-economic factors influencing the adoption of soil and water conservation practices among small-holder maize farmers in Tharaka Nithi County, Kenya?
ii. What are the institutional factors influencing the adoption of soil and water conservation practices among small-holder maize farmers in Tharaka Nithi County, Kenya?
iii. What are the levels and effects of adoption of soil and water conservation practices on maize yield in Tharaka Nithi County, Kenya?

1.5 Significance of Study

Limited knowledge on soil and water conservation practices to adopt, results to poor crop yields and low soil fertility. Therefore, adoption of these technologies brings about improvement on soil and crop productivity. This research aimed at finding solution that incorporates smallholder farmers in agricultural production through SWCs to avoid soil deprivation. This would be a stepping stone for them to implement the policies and adopt the practices that fit them. The study findings add to the knowledge on adoption and the recommendations for using conservation practices are helpful to policymakers, farmers, agricultural officials and all other stakeholders. Further, it was meant to enhance adoption by creating awareness on the uptake of SWCs. This also, acts as a foundation for further research to take place, which will help to improve productivity and income-generating capability of the soil through the adoption of SWCs.

1.6 Scope of the Study

This study focused on Maara and Chuka Sub-Counties in Tharaka Nithi County assessing the socio-economic and institutional factors influencing adoption of soil and water conservation practices and their effect on maize production. Tharaka Nithi County was chosen because of its capacity to practice agriculture and its extensive literature on the solutions for SWCs that have been advocated. This study focused on maize farmers in Tharaka Nithi County on improved soil and water conservation technologies practiced and used on maize production during the growing period of 2021-2022.

1.7 Limitations

The farmers lacked farm records for previous years of maize production. This made it difficult for farmers to remember what quantity they attained in those years but it depended on farmers' honesty and memory for the responses. Therefore, most of the farmers interviewed provided the estimates. Strategic bias was also a challenge where farmers anticipated benefits from the research. However, they were informed that the acquired information and data was to be used only for academic purposes.

1.8 Assumptions of the Study

It was assumed that the farmers were willing to give the information required for the study. Also, the farming household's choice to adopt one conservation approach did not hinder the adoption of other strategies that were accessible.

1.9 Operational Definition of Terms

Adopter: A farmer who utilizes at least one of the technologies in practice on the operated maize farmland.

Adoption: The presence of any of the conservation practices or technologies at the farmers' fields.

Institutional factors: Constraints created by humans that need interactions such as farmer groups, extension and financial institutions.

Non-adopter: A farmer who has never implemented any of the SWC technologies in the maize farmland.

Production: Quantity in terms of bags and kgs produced in the farm.

Smallholder farmers: A farmer operating on a land less than 5 acres either leased or owned.

Socio-economic factors: Factors taken into account to describe an individual or family economic, physical and social status such as age, gender, income, occupation, farm size, farm topography.

Soil and water conservation practices: Methods a farmer uses in the field to prevent erosion and maintain soil fertility.

Soil erosion: Any form of soil degradation may it be water or wind.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of Soil and Water Conservation Practices

The natural mosaic of land uses on the surface of the earth, including cropland, pastureland, woodlands and forests depends on soil in both its natural and modified forms. Nearly 80% of Kenya's soil and land deterioration is attributable to desertification, and 88% of the nation's land mass is categorized as drylands (Karaya *et al.,* 2020). Soil erosion, rising population, and unpredictable weather patterns have recently hindered crop yield in Kenya's extremely erodible soils. In Kenya's highlands, soil erosion rates are increased by unrestricted land usage, forest logging on mountain ranges, and intense tropical precipitation (Watene *et al.,* 2021). About 20% of the country's whole farmland part has lost soil productivity due to water-induced soil erosion (Borrelli *et al.,* 2020).

Crop productivity depends on both land occupied and land management technologies used in production (AbdelRahman and Mohamed, 2023). According to recent projections, degradation will persist by 2050 as a result of a rise in the world's Gross Domestic Product (GDP), even though global population growth is anticipated to level off (Sterk *et al.,* 2020). The base of conventional agricultural methods is tilling and plowing the land to make a seed bed. However, it has been shown that these techniques severely harm soil, leading to its degradation of 20% of the globe’s agricultural land (Prăvălie *et al.,* 2021). Adopting suggested conservation management measures to restore degraded areas can help watersheds recover and result in better soil and water quality (Alagele *et al.,* 2019).

New paradigms are focused on preserving and improving the soil while increasing productivity, revenues, and environmental advantages are gradually replacing the conventional approach (Daryanto *et al.,* 2020). The majority of these strategies are founded on no-tillage techniques as well as the more general notions of conservation agriculture and sustainable land management (Kumara *et al.,* 2020). No tillage is beneficial in reducing several of the detrimental impacts of conventional tillage, including erosion, loss of organic matter, reduced biodiversity, and surface runoff (Ahmad *et al.,* 2020). These circumstances are changed to permanent soil cover, enhanced soil structure, increased levels of organic matter, increased water usage effectiveness, and enhanced soil biology and nutrient cycling (Shah *et al.,* 2019). When conventionally tilled soils are used, the improved soil moisture, aggregation, and organic matter quality of no-till soils frequently creates some level of production. Conservation management techniques are used to sustain crop productivity, improve soil quality, and protect the environment (Shah *et al.,* 2019).

De Moura *et al.* (2021), found ways that soil management practices, such using native trees and grasses, could improve local populations' quality of life while preserving their soils. Despite the information that has been amassed on various methods to control soil fertility in smallholder farms in Africa, farmers there are hesitant to accept these methods and frequently test and experiment with them (Di Prima *et al.,* 2018). This is a major concern where farmers perceive the technologies to be expensive and technical. According to Kansanga *et al.* (2021), the decisions made by smallholder farmers to use technology and to increase soil fertility are influenced by the overall benefits that would result from production. Smallholder farmers are at the center of soil fertility restoration operations. Adoption of simple and cost-effective soil and water technologies is hence a pertinent step towards improving food production.

In order to drastically limit soil loss and its effects, SWC structures serve two primary purposes. Not just soil particles but also vital plant nutrients and applied fertilizers must be lost in order for buildings to lessen their impact (Diop *et al.,* 2022). Due to the construction of barriers to prevent surface runoff, the SWCs are recognized as the initial line of defense. The majority of structures are designed to bench and lower runoff slopes, gradients, and velocities (Ejegue *et al.,* 2021). Reduced surface evaporation caused by the mulch effect, increased organic matter, greater infiltration, and precipitation retention are all ways that cover crops affect soil water content (Karuku, 2018; Qi *et al.,* 2020). Utilizing cover crop residues wisely can assist maintain proper infiltration rates, whether they are absorbed into the soil or placed to the soil surface (Çerçioğlu *et al.,* 2019).

A crucial stage of soil erosion process is runoff generation, which regulates the amount and duration of water that runs off the soil surface as well as the rates of soil detachment and sediment transport (Shojaei *et al.*, 2020). Agricultural productivity is negatively impacted by the loss of nutrients due to runoff and less vegetation cover (Touré *et al.*, 2020) but, runoff mitigation can be achieved by improving soil profile infiltration and limiting surface structural deterioration (Cerdà *et al.*, 2022). Soil fertility and nutrient management being key challenge in agricultural production and global food production thus, in order to protect against a soil water deficit in agricultural productivity, knowledge on runoff management, soil fertility loss and various conservation systems must be continued (Nyawade *et al.*, 2020).

2.2 Socio- Economic Factors Influencing Adoption of Soil Water Conservation Practices

2.2.1 Age

Age is a sign of maturity from which conclusions regarding individual's ability in making smart farming judgments are drawn. Meresa *et al.* (2023), argued that age was statistically significant for soil water conservation suggesting that the face of climate change, smallholder farmers were less likely to implement soil water conservation due to age. Therefore, younger farmers compared to older farmers used several soil water conservation techniques as climate change progresses. Ogunniyi *et al.* (2023), indicated that younger individuals were more likely than older people to attempt new things and possibilities because they are new to an industry therefore, the younger generation is more determined and likely to engage in production and farming practices that moderate climate change than the elder generation, which may make use of their combined production experience. Household-head age therefore can have an impact on SWCs, and this study aimed at showing if there was effect.

2.2.2 Level of Education

Education is a discrete variable that describes the quantity of formal education received by decision maker. Mango *et al.* (2017), showed that years spent in school was relatively connected with easier information access, the capacity to interpret and assess the technical and economic viability of conservation measures. The report contended that education might present chances for other means of support in non-farm activities. Kassa *et al.* (2021), study on factors influencing the adoption of SWCs in the northwest Ethiopian highlands, also reported that educated farmers were aware of how to prevent runoff by conserving soil and water. These educated farmers tend to understand the dangers of soil erosion hence they could have the tendency to spend more time and money on SWCs.

Ojo *et al.* (2020), discovered a favorable and positive effect of education on the use of climate change adaption tactics by Ethiopian smallholder farmers. Education was statistically significant and positively signed, indicating that farmers who obtained formal education were conscious on using more adaptation techniques to climate change compared to those with no formal education. Typically, farmers having greater levels of education were additionally mindful of climate change and the problems it raises. A farmer's level of education influenced how he or she adopted agricultural innovations. However, there is a knowledge gap on whether education has an impact on SWCs.

According to Mucheru-Muna *et al*. (2017) and Kimaru-Muchai *et al.* (2020) on the study to investigate the use of Zai pits for increased agricultural output in drier upper Eastern Kenya showed that the likelihood of putting water harvesting techniques into practice and adoption may have been influenced by the farmers' educational levels. According to this study, the majority of respondents without a formal education did not adopt. This was so because exposure to information through education increased awareness and encouraged the use of water harvesting technologies. Education improves farmers' capacities to better digest knowledge, embrace innovations and technology, and predict changes, increasing their likelihood of implementing various adaptation techniques., this study sought to find out how education affected uptake of SWCs.

2.2.3 Gender

Kagoya *et al.* (2018), on the study in the highlands of South Western Uganda reported that females were not expected to participate in SWCs because women are mostly involved in production as well as reproductive roles within a household. Due to their responsibilities, women do not have enough time to participate in extension programs concerning SWCs. Male-headed families had better access to information and were more accountable than female-headed households for developing conservation buildings. Therefore, the gender-division-of-labor situation was important and made it possible for SWCs to be adopted.

Amfo *et al.* (2021), findings revealed that gender was significant on the study of climate change, soil and water conservation on cocoa farmers in Ghana. It suggested that in contrast to the female farmers, male cocoa producers were more likely to use various methods of conserving soil water. Due to the traditional status of men in Ghana as household heads, male farmers have greater access than female farmers to resources on production, training programs, and knowledge on information. This is due to the fact that support to agricultural households is typically provided by family heads. In addition, Anang *et al.* (2022) reported that women in Ghana perform practically all household tasks and reproductive roles while men are more inclined to use technology that favors them in production decisions therefore this research aimed at investigating the connection between the uptake of SWCs and gender.

2.2.4 Household Size

The adoption rate is influenced by the accessibility in agricultural labour because SWC establishment and maintenance require a lot of labor. A family's size and its economically active members have an impact on whether or not to invest in steps to protect water and soil. Willbroad *et al.* (2019), reported on the variables affecting the adoption and long-term application of water and soil conservation measures in the Bubaare Micro-Catchment of South Western Uganda, who argued that compared to households with bigger families, smaller family sizes were less likely to adopt SWCs because larger families can more readily afford to engage in labor for the design and execution of the SWCs. However, there was a gap on whether household size or members in the family influence adoption of SWCs.

Studies of Mwaura *et al.* (2021), involving the Highlands of Central Kenya on adoption intensity of selected soil-fertility management technologies, farmers' capacity to adopt technology required a lot of labor which was greatly hampered by labor shortages because majority of the farm labor was provided by family members. In comparison to smaller homes, larger households were more likely to adopt SWCs heavily. Similar to that, Darkwah *et al*. (2019) also concluded that larger households will have enough labor to adopt conservation practices and other adaptation strategies technology in Ghana. Information about technologies makes greater sense to the larger households compared to smaller ones.

2.2.5 Topography

The slope of land influences the adoption of SWCs because it is an indicator of soil and water loss from the farmland. Farmers who work on sloping fields are more aware of the possibility of soil loss than those who work on flat or vulnerable grounds. This suggests that farmers tending to susceptible fields are more likely to implement SWCs in their farms than farmers tending to erratic fields. The findings from the works of Wolka *et al.* (2018), on the effect of soil and water methods on crop output in Africa concluded that slope got a substantial effect on implementation of SWCs. The likelihood of erosion on the land increases with slope steepness. It is believed that the adoption of SWCs tends to be likely on steeper slopes.

Tsegaye *et al.* (2023), reported that an essential factor that influenced the likelihood of employing SWC technologies favorably was the slope of a plot. Where their farm plots were on steeper slopes, farmers tended to invest in conservation methods. Farmers might adopt conservation measures as soil erosion issues were easier to see on steeper slopes. Compared to farmers who cultivated gently or level sloping fields, farmers who farmed sloping fields sensed the threat of soil erosion better. It suggested that growers of sensitive fields were more likely to implement SWCs than growers of less vulnerable lands. This study aimed at finding out the effect on steeper slopes and less steeper ones.

2.2.6 Land Size

Findings of Balasha *et al.* (2023), observed that the size of the farm favorably influenced the use of conservation methods. The report revealed that large farms were far more likely to experience output losses due to improper conservation practices and to prevent these losses, producers engaged in conservation measures. Additionally, farmers with bigger sizes of farms have more capital and wealth, which suggests a reasonably strong ability to invest in SWCs. Chandio *et al.* (2018), study involving determinants of adoption of rice varieties in Pakistan, revealed that farm size was significantly involved in participation of improved seed technology. Large landholding farmers are open to implementing the agricultural techniques compared to small holding sized farmers. However, due to mixed effects, the research sought to establish the knowledge gap in Tharaka Nithi County.

Amfo *et al*. (2021), results revealed that land size had a significant and favorable influence on soil water conservation methods in Ghana. It revealed that as a farm grows, so does the number of conservation techniques used by cocoa growers to reduce the adverse effects of climate change. However, farm size has influence on cocoa yield suggesting that as farm size grows, SWCs are used, but productivity on the farm declines. Pello *et al.* (2021), on the factors affecting adaptation to climate change in Kenya by way of agroforestry, found that uptake of agroforestry technology was favorably and considerably impacted by the size of the size. This suggested that agroforestry adoption rises as the size of a farmer's farm increases. This is due to the scale-dependent nature of agroforestry technology. Therefore, unlike farmers with tiny pieces of land, those with larger pieces dedicated a portion of their land to testing the technique. The contradictions in the study enabled this research to find out how land as a variable affects use of soil and water methods.

2.2.7 Farmers' Perception on Soil Erosion

Batungwanayo *et al.* (2023), findings in Burundi showed that a key factor in determining whether farmers were willing to implement SWC practices was their awareness of soil erosion and rainfall patterns. Farmers' perspectives on climate change, the environment, and rain patterns affected their degree of concern, which influenced their drive to act and adopt various technologies to address difficulties caused by erosion, land degradation, and changes in rainfall patterns. Mekonnen *et al.* (2021), whose work was on integrated watershed management on soil quality in dry highlands of Northeast Ethiopia, the way farmers view soil and water conservation (SWC) techniques considerably influence how widely they are used. How farmers perceive the advantages of using SWCs in reducing erosion contribute to improvement of the implementation of SWC activities. This demonstrated that acceptance of SWCs is dependent upon perceptions of their efficacy. It was necessary to pinpoint the perception gap and how it affects the uptake of SWCs.

Following Sileshi *et al.* (2019) studies, farmers who were already aware of soil erosion difficulties on their plots used SWC techniques more than farmers who were uninformed about the problem, hence investing more in conservation measures. Mairura *et al.* (2022), on farm variables affecting Kenya's soil fertility management practices, smallholder views of soil fertility issues and technology adoption trends in Kenya were shown to be significantly correlated. This suggested that farmer views of soil fertility could affect adoption and as a result, raising farmer awareness of and sensitivity to their soil fertility can enhance farmer adoption of technology. In addition, Bayu and Eyayu, (2020), had similar findings and noted that farmers who considered soil fertility to be a difficulty and knowledge of the value of conservation structures were more likely to embrace conservation agriculture measures. Uncertainty exists regarding the impact on producers' awareness of soil erosion on the SWCs adoption in Tharaka Nithi County.

2.2.8 Land Tenure System

Land ownership security has favorable and unfavorable consequences on watershed usage and management, according to Katusiime *et al.* (2020). The literature mostly linked protected areas as a type of land tenure with successful conservation results when it came to forestry protection. Land tenure security is related to reduced deforestation regardless of the kind of landownership, accounting for any variations in assessment approach, location, and other factors. In addition, Alemu *et al.* (2023), analyzed that protected areas offer the presumptive security of land tenure. Secure land tenure affects soil and water conservation efforts by increasing household willingness to participate in costly and long-term conservation techniques such as stone bunds. The frequency and intensity of investments in preservation measures are also increased by secure land tenure. Jansen *et al.* (2023) compared the development of village institutions, opening markets, increasing population density, and securing land tenure higher level of funding for watershed conservation initiatives and possibility that appropriate watershed usage habits will be adopted. The impact on the system of land tenure was yet unclear.

According to Bizoza *et al.* (2021), the study results identified strongly showed direct significant association between Land Tenure Regulation (LTR) and land improving investment, particularly in terms of conservation. Though encouraging, not all cases were determined to have a meaningful impact. It is believed that rather than having a true causal effect, this is more likely to have a correlational effect. Terraces are one example of a soil conservation strategy that is challenging for individual investment because they are very expensive and rarely lucrative, in the early stages of their establishment. Despite the general tendency toward beneficial impacts of LTR, calls for greater research that takes responsibilities in particular institutional and economic contexts, potential bias, and land tenure systems.

Findings from Amfo *et al.* (2021), the study on land ownership the model for conserving water and soil was significant. This demonstrated that cocoa farmers on inherited or family land were hesitant to use various soil water conservation methods than farmers managing in the leasehold, sharecropping, or private land. The report showed that Ghana used a leasehold system of land ownership for farmers who do not own their own farms. While those who have cocoa farms under the system of inheritance typically view the farms as family assets, farmers who own cocoa fields under leasehold, sharecropping, or individual land tenure systems see farms as their own or private possessions. Farmers with private land ownership are therefore more business-minded and generally driven to use agricultural techniques that increase production, as well as measures to alleviate climate change. However, this research was necessary to determine what impact of tenure system and uptake of SWCs has.

2.3 Institutional Factors Influencing Adoption of Soil and Water Conservation Practices

2.3.1 Access to Information and Communication Channels

Awareness is considered important for research with information sources including extension services, having access televisions, mobile phones, magazines, radio and internet. Matere *et al.* (2023), noticed that uptake of soil and water conservation methods significantly impacted by access to information and advisories. It enabled farmers improve on the knowledge of possible effects of soil erosion and offered suggestions to increase the value of local climate data. Eanes *et al.* (2019), reported that farmers increasingly turn to private organizations for agricultural advice and information, such as agricultural retailers and agrovets, in context of soil and water conservation, has prompted creation of strategies and alliances with individuals and groups not generally involved in conservation.

Onyeneke *et al.* (2023), showed there was substantial effect of information access on climate change through Information, Communication and Technology (ICT) suggested that farmers implemented adaption techniques when they have access to information on climate change, possibly through radio, television, mobile phones, and other information sources, as opposed to farmers who only access conservation-oriented information. This suggested that raising farmers' adaptive capacity also entailed raising their consciousness of the negative effects of climate change. Farmers skilled in gathering information, incorporating new technologies into their operations, and maximize the use of that information. The study aimed at investigating how land ownership influenced SWCs adoption in Tharaka Nithi County.

2.3.2 Membership and Participation in Farmer Groups

Effectiveness of engaging farmers in member groups has impact on adoption of SWCs measures. Khanal *et al.* (2018), discovered a substantial direct and indirect association between farmers' active participation in group activities related to watershed management and the application of cover crops, a highly successful and well publicized method of nitrogen loss reduction for farms. Members of organizations helped farmers learn about good agronomic practices, and they give credit to productive inputs for facilitating the acceptance and spread of technology.

Farm-Based Organizations (FBOs) membership was significant and influenced cocoa production. Farmers in groups gain knowledge from one another's successes. Additionally, the majority of extension agents and organizations focus on farmer groups when disseminating agricultural knowledge and offering farmer training programs (Avane *et al.,* 2021). Most of the lending institutions like the banks, favor lending money and providing credit for inputs to groups of farmers as opposed to those who do not belong to a group (Avane *et al.,* 2021). They were predicted to enhance industrial processes and hence increase productivity. Therefore, compared to their counterparts, cocoa producers in groups were more productive.

According to Ariti *et al.* (2018), initiatives done by Non-Governmental Organizations (NGO's) in India were successful than those administered by the government because the NGO ensured a more energetic and efficient engagement of the population. As a result, participatory planning and implementation of interventions were successful. The effectiveness of initiatives for managing natural resources was determined by the involvement of rural residents and stakeholders' joint involvement in the design and execution of the SWCs therefore, participation facilitates information sharing, raises consciousness of the impacts of soil erosion, and facilitates pooling of resources together.

2.3.3 Access to Extension Services

From the study of Eanes *et al.* (2019), extension personnel and Natural Resources Conservation Services (NRCS), field days and demonstration opportunities would be organized and sponsored cooperatively by the personnel. Such occasions educated Crop Advisers (CAs) about both new and existing conservation projects if they were cooperatively arranged so that all parties share equal ownership. This gives extension staff the chance to present the most recent findings on different conservation methods, enabling CAs to obtain agricultural credit necessary for soil and water conservation and giving farmers and extension staff the chance to become more familiar with one another and to develop relationships based on trust. There was a positive attitude towards the adoption of SWCs and access to extension services and information.

Njenga *et al.* (2021), reported that having extension contact was positively significant impact on farmers' perceptions. It is crucial for farmers to have access to extension services so they may inquire about and get clarification on any difficulties they may be having when making an adoption decision. Farmers that interacted with extension agents more frequently learned more about the advantages of SWCs, its implementation strategies, and ongoing maintenance. Extension contacts and its frequency had a significant impact in adoption of technologies and ideas which increases the farmers' tendency to adopt SWCs than farmers with no extension contact.

2.3.4 Access to Training

Maja *et al.* (2023), examined the study on the factors affecting the SWCs adoption in eastern Ethiopia upper lands and found training to have favorable and positive impact on the uptake of SWCs. Farmers who took part in development agents' training on SWCs knew more about soil and water conservation practices than those who did not.

Farmers' training improved the likelihood that SWCs would be adopted, used, and put into effect. Since natural resource technologies require a lot of expertise, technical support is a key factor in acceptance. The adoption of conservation measures was adversely hindered by a lack of technical support.

Kumar *et al.* (2021), observed that there was a significant correlation with uptake of technologies through training. It was indicated that trained farmers employed soil and water conservation techniques more compared to untrained farmers. Farmers who participate in training get sufficient, current knowledge and technical support regarding how SWCs are implemented and why they are important. As a result, they increase their understanding of SWC participation and promote the implementation of conservation techniques. Contrary to this, Belachew *et al.* (2020), found that farmers had no access to all the necessary information therefore, adoption of check dams was negatively impacted by training since they did receive insufficient information hence could not adopt SWC technologies.

Chesterman *et al.* (2019), assessed how Ethiopian farmers put these practices into practice after receiving training on how to protect soil and water resources. They came to a conclusion that conservation measures implemented in Ethiopia's agricultural areas was positively impacted by the training component. The implementation of technologies for conserving soil water and the yield of cocoa were both significantly and favorably influenced by training. This indicated that recipients of farm management training were more likely than their untrained peers to use a variety of soil water conservation strategies and achieve higher yield.

2.3.5 Access to Credit

Abdul-Hanan (2017), reported in Northern Ghana that agricultural credits increased the intensity of soil and water techniques adopted by maize producers and this emphasized the significance of giving farmers loans to assist their investment in elements that increase productivity. Kumar *et al.* (2021), also noted that formal credit markets in agricultural countries did not operate successfully because of high material, lack of security and a moral hazard issue. Most of the farmers in degraded location lacked resources which had a substantial effect between the implementation on conservation practices and credit availability. This was because easy access to credit helped farmers overcome their cash-flow problems and buy better structures and inputs.

Van *et al.* (2022), found that despite efforts to improve farmers' access to credit, majority of households in Zambia remained credit-constrained. This limited access was ascribed to high interest rates and rigid loan restrictions. But most of households had title deeds which acted as collateral hence farmers were encouraged to invest in more environmentally friendly agricultural innovations which implied that farmers adopted the SWC technologies. There was knowledge deficit on whether credit would positively or negatively influence the adoption of SWCs. Therefore, this study aimed at knowing how access to or lack of financial assistance would affect the implementation of SWCs.

2.4 Analysis of the Effect of Adoption of Soil and Water Conservation Practices on Smallholder Farmer Maize Yield.

Impact evaluation examines the expected and unanticipated effects of a project's output on the intended users. Promotion of productivity enhances technologies like soil and water conservation practices uptake which is perceived to have significant impact on farmers' welfare and including all other actors at a value chain level (Atsiaya *et al.,* 2023). Impact assessment can be done before an intervention and after an intervention. The study analysis of Reed *et al.* (2017) on the ecosystem services impact on tropical forests, discovered that forests and trees improved crop yields. As a safety net for rural residents, forests and trees play a significant part in risk reduction. In regard to climate change and the projected impacts, this function is becoming more and more evident. A number of indicators are used for impact assessment for project intervention. These indicators include quantity of food produced, income and expenditure.

In regard to majority (90%) of the people in Kenya consuming maize as a staple food, it is a crucial crop for ensuring food security. Smallholder farmers who primarily grow it for income, have fewer resources to engage in soil and water management measures (Mutuku *et al.,* 2020). The level of maize grain productivity currently in Kenya is as low as 1.0 ton per ha where the attainable potential is 6 to 8 ton per hectare (Kiboi *et al.,* 2019). The main contributors to the difference in yield include irregular rainfall patterns, increased frequency of droughts, and extensive soil fertility degradation on farms caused by removal of soil nutrients without careful and effective soil and water management practices (Jena *et al.,* 2021). Continuous cultivation, alters physical and chemical properties, reduces soil aggregate and water retention stability increasing evaporation losses which heightens soil susceptibility to surface runoff. Jena *et al.* (2019), reported that minimum tillage together with other conservation agriculture measures change the distribution of carbon resulting in restoration of soil biological processes and being among the soil and water management technologies it increases maize yield due to its ability to increase water retention and water use efficiency through emphasis on soil and water conservation practices.

Anang *et al.* (2019), report on effects of adopting New Rice for Africa varieties (NERICAs) on household rice farmers in Ghana in terms of productivity, income, and poverty indices. They estimated the Local Average Treatment Effect (LATE) of NERICA adoption on income and poverty reduction among rice producers using instrumental factors. Nonvide *et al.* (2022) found that the dissemination of the NERICA variety had a strong, favorable, and significant effect on farm household income and wellbeing as evaluated by per capita spending and poverty alleviation. The findings implied that the adoption of NERICA types increased household per capita spending and income per cropping season, decreasing the likelihood that they will experience poverty. As a result, it was concluded that NERICA variety diffusion investment should be increased as a feasible policy tool to increase household incomes and decrease poverty, demonstrating the favorable effects of technology adoption.

2.5 Theoretical Framework

Diffusion of innovation theory by (Rogers, 2010) was used in the study. The theory shows how the technology spread and at what speed, the knowledge decision and implementation of the innovation which confirms the outcome. According to the theory, people's decisions to adopt or reject an innovation are influenced by how those features are viewed, including advantages, complexity of the invention, compatibility and period. According to the argument, certain members of society embrace innovation and technology while others do not.

2.5.1 Diffusion of Innovation Theory

Adoption is a continual process that involves assessing the benefits received from early adopters. A choice to fully utilize an inventive as the topmost available course of action is also involved. Fundamental components of developing countries' initiatives to improve food security in general and agricultural modernization in particular are the proliferation of new technologies and agricultural innovations. It explains how, why, and how quickly new ideas and technologies spread, this study therefore, utilized the diffusion of innovation hypothesis (Dandedjrohoun *et al.*, 2012). This theory has four elements that explains; an innovation, communication, time taken to adopt and the social system. Under the interpretation paradigm of inquiry, it is believed that knowledge is not out there to be discovered, but humans purposely interpret their experiences and create meaning out of it (Rogers, 2010).

According to Rogers (2010), the innovative decision-making process has five unique phases: knowledge, persuasion, decision, implementation, and confirmation. Farmers gradually become aware of technological advancement through specific stages. The first level is the knowledge stage, during which farmers are informed of the latest strategy for SWCs and taught the workability of the strategy. The second level in this process is persuasion, where farmers' attitudes toward new technology is shaped through information sharing. Farmers commit to adopting technology in the third stage, the choice stage, using the knowledge they have acquired. The fourth stage is implementation, where farmers use or test the technology on their farms. The fifth level is confirmation, where farmers certify the success of the technology and even recommend it to their friends and neighbors.

Rogers (2010), separated the adoption process from diffusion process. The adoption phase primarily affects the individual whereas the diffusion process permeates society and groups. When a person initially learns about a new invention, they may not adopt it at all and this is the adoption process. On the other side, the diffusion effect is the cumulatively rising level of influence on a person to accept or reject an innovation (Mekuriaw *et al.,* 2018) resulting from the activation of peer networks about an innovation in a social system. An idea needs time to disseminate throughout a social structure, it does not happen all of a sudden. This idea makes it vital to comprehend how technologies and innovation sink in to a human. Whether a person truly accepts or disapproves a particular invention is a decision arrived at through a sequence of thinking and thought creating.

2.6 Conceptual Framework

A conceptual framework provides briefly an overview of the connections between the variables that were chosen for study in the issue statement, objectives, and research questions. By using a clear representation of the variables, the conceptual framework in this study provides an easily understood summary of the phenomenon being studied. The Figure 1 is a diagram that shows how dependent and independent variables relate to one another. The independent factors' influence on the dependent variables is shown by the arrows, which show the direction of influence. The uptake of SWCs and subsequent impact of adoption on maize yield and productivity is determined by socio-economic factors such as age, land size, gender and institutional factors such as access to training, membership and participation in farmer groups, access to extension services. Intervening variables are in the middle of influencing independent variables to dependent variables such as climatic factors, policy and governance where they influence these factors either directly or indirectly.

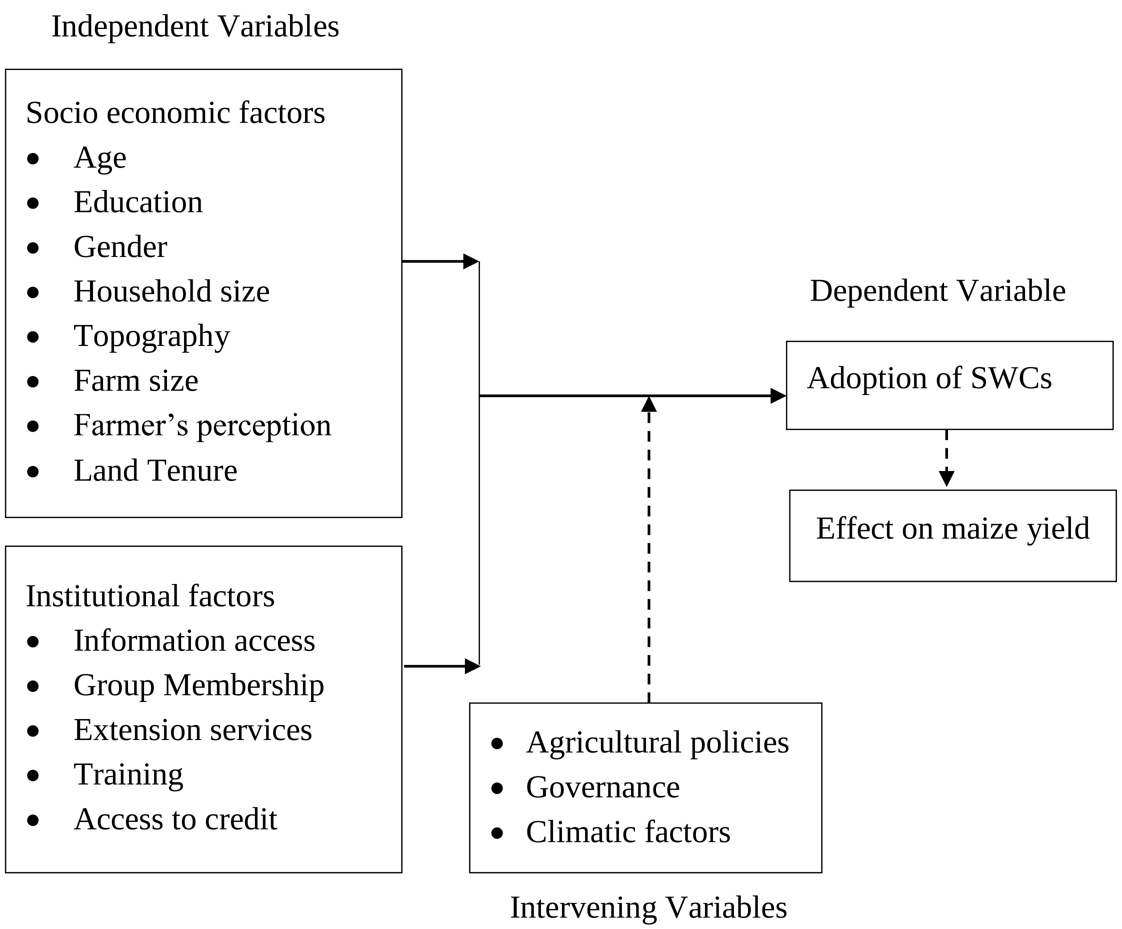

Figure 1: Conceptual Framework

Source: Author Conceptualization

CHAPTER THREE

METHODOLOGY

3.1 The Study Area

This study was conducted from November 2022 to February 2023 in Tharaka Nithi County (Figure 2**)**, which covers an area of 2609 km^2 and had a population of 393,177. Tharaka Nithi County was chosen because of its capacity to practice agriculture and its extensive literature on the solutions for SWCs that have been advocated earlier. It is located on the borders of Embu County to the south and south-west, Meru to the north and north-east, Kirinyaga and Nyeri to the west, and Kitui to the east and south east. The county lies between latitudes 00^{0} 07’ and 00^{0} 26’ South and between longitudes 37^{0} 19’ and 37^{0} 46’ East (Mugi-Ngenga *et al.,* 2016). Tharaka Nithi covers the Highlands (upper zone), that include Maara and Chuka which receives sufficient rainfall for agriculture with primary soil type being Humic-nitisols and having a clay concentration of 78%, and the Semi-Arid Zone (lower zone), which includes Tharaka North and Tharaka South sub counties (Mairura *et al.,* 2022) which has substantial ferrasol soils that are extremely eroded and infertile and receiving less than 700 mm of rainfall annually, and it is more ideal for livestock compared to growing crops. Tharaka Nithi County is a low-lying region, with an altitude between 250 and 1500 meters above sea level.

3.2 Research Design

Cross-sectional survey design was applied in this study to assess soil and water conservation practices and yield. This design was used since it is an observational study design that measures the outcome and the exposures (Kabubo-Mariara *et al.,* 2007) and can only gather information once to characterize how farmers in the study area perceived climate change and the adaptive techniques, they adopt to use SWCs. It was also employed due to its ability to directly compare numerous different factors, for this case socio-economic and institutional variables. Descriptive statistics was done since it is a scientific method that involves collecting data that enables the description of subjects or a situation. In this study descriptive statistics was useful in attaining information on the underlying determinants that are true and accurate.

3.3 Target Population

The study concentrated on smallholder farmers in Maara and Chuka Sub-Counties and four wards in the Sub-Counties that is Magumoni, Igambang'ombe, Muthambi and Mwimbi.

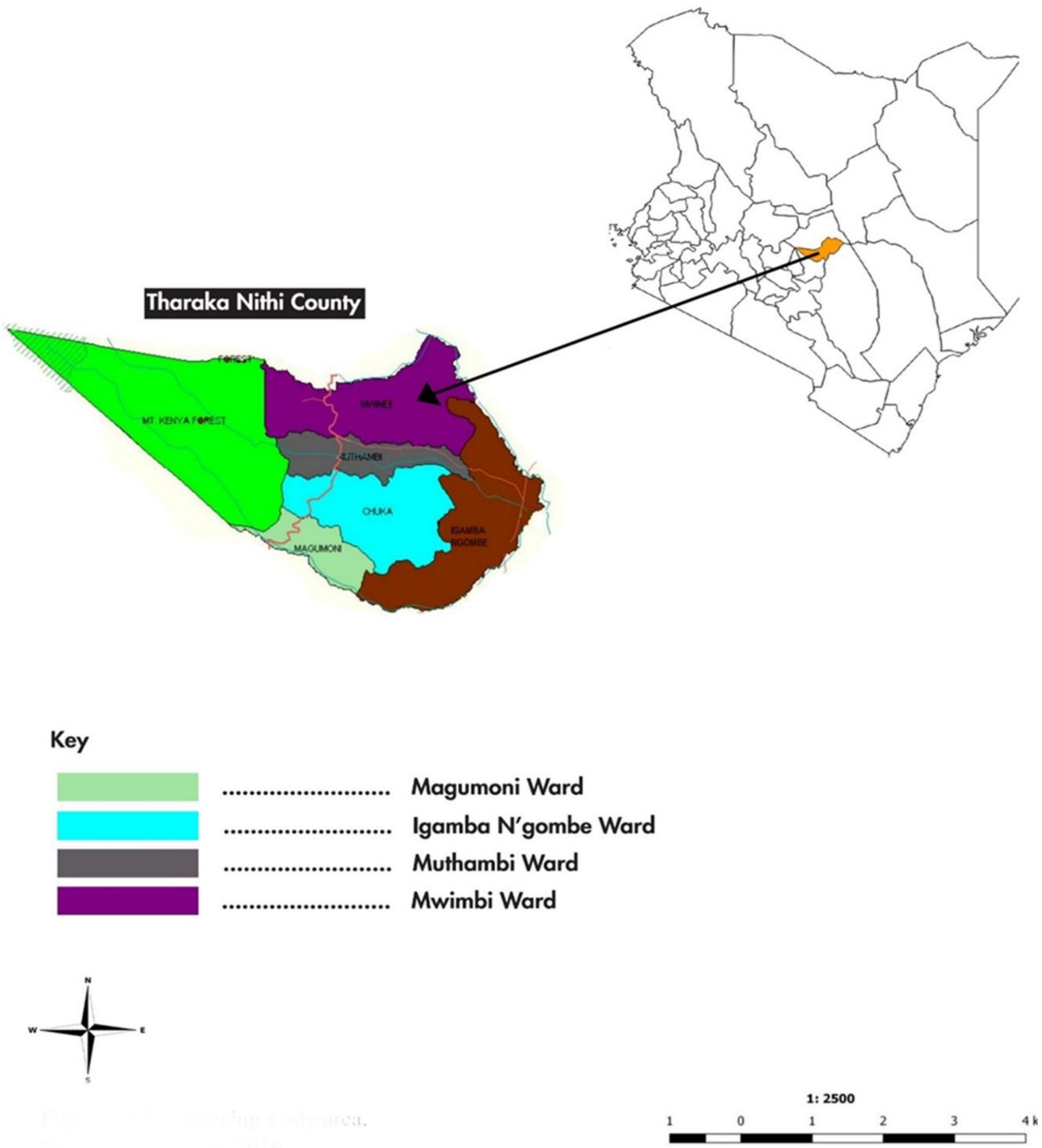

Figure 2: Map of the study area

Source: Geocurrent (2016)

Table 1: Population Distribution of Maara and Chuka Sub-County Respective Wards in Tharaka Nithi County.

Wards	Population	Households	Sample
Magumoni	39,657	1717	115
Igambang'ombe	36,240	1569	100
Muthambi	20,778	899	60
Mwimbi	24,598	1065	70
Total	121,273	5250	345

Source: KNBS (2019)

3.4 Sampling Method

Multi-stage sampling technique by Sedgwick (2015), was employed in choosing household sample in several stages. In the first stage, Tharaka Nithi County was chosen based on its potential for agriculture and on knowledge about technology being promoted to conserve soil and water in the area of study. The second stage involved, Maara Sub-County and Chuka Sub-County which was purposively selected due to their informed and varied climate change adaption techniques in the local agroecosystems of Tharaka Nithi County. In the third stage, two wards in each Sub-County; Maara sub-County (Muthambi and Mwimbi) and Chuka Sub-County (Magumoni and Igambang'ombe), were randomly selected. Respondent farmers obtained from the sampled wards were generated by the method of simple random sampling.

3.5 Sample Size

The study used the Cochran (1975), formula which is considered appropriate for larger populations. The Cochran formula is:

$$n_o = \frac{Z^2 * P * Q}{e^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where:

z is the standard normal confidence interval of 95% (z = 1.96)

e is the marginal of error at (0.05)

p is the percentage of the population which possesses the characteristics for adoption (0.6)

q is 1 – p (0.4)

$$n_0 = \frac{1.96^2 * 0.6 * 0.4}{0.05^2} = 369 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Thus, used was the sample size for finite population which is a correction factor, used to adjust or reduce the standard error to make it more accurate.

$$n = \frac{n_0}{1+\frac{(n_0-1)}{N}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3)$$

where:

N as the target population (5250)

$$n = \frac{369}{1+\frac{(369-1)}{5250}} = 345 \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (4)$$

According to Maguza-Tembo *et al.* (2017), the study therefore employed a 50:50 ratio of adopters and non-adopters with 10% of the calculated sample accounting for possibilities of non-response. Adopters were 158 while the non-adopters were 157.

3.6 Research Instrument

A semi-structured questionnaire was used to obtain primary data during the study (Appendix II). This research tool had both open-ended and close-ended questions and enumerators used it to administer the questionnaire verbally. The questionnaire gave insight and guided the farmers on the measures used for soil and water conservation. It was divided into socio-economic characteristics (age, gender, education, farmer's perception), land system characteristics (land size, land tenure system and land topography), soil and water conservation practices (intercropping, terraces, crop rotation, stone bunds), institutional factors (access to training, credit access, group membership and participation groups, access to extension services and access to information channels) and the effects on maize production.

3.7 Pilot Study

The pretest of the questionnaire was done in Kiegoi/Antobuchio ward, Igembe South Sub-County, Meru County targeting smallholder farmers living around the upper zone areas of Nyambene hills. The altitude of the area is 1700 meters above sea level. This area was selected due to similar ecological characteristics as the upper zones of (Chuka and Maara Sub-Counties) in Tharaka Nithi County. Tambwe *et al.* (2020), indicated that a sample size of between 10 to 30 participants is adequate for the pilot work, therefore this study focused on 15 smallholder farmers.

3.7.1 Validity Test

Validity is the extent to which analysis of the data and its findings truly reflect the phenomenon being investigated. It is also the degree to which a test achieves what it set out to achieve. According to In (2017), to ensure the results attained from the research meets all the requirements of the scientific research, the instrument was subjected to experts in the university since they have experience and expertise through validity of content.

3.7.2 Reliability Test

Reliability test shows how consistency with which a research tool provides findings or data after several trials. The Cronbach Alpha Co-efficient for this study was $\alpha = 0.7465$ where 15 items were put to a test to determine the reliability of the research tool (Table 2). According to Warner *et al.* (2022), Cronbach's co-efficient alpha of 0.7 is acceptable to measure internal consistency of how closely correlated items in a set were to show trustworthy results. Therefore, the questionnaire was adequate for use in this study.

Table 2: Results of the Cronbach Alpha Co-efficient

Items	Value
Average interitem correlation:	0.1641
Number of items in the scale:	15
Scale reliability coefficient:	0.7465

3.8 Data Collection

A semi-structured questionnaire was employed as the primary method for gathering and obtaining data. The semi-structured questionnaire obtained the primary information regarding the socio-economic, institutional factors and the effects of adoption of SWCs by the smallholder maize farmers in Tharaka Nithi County (Appendix II). The socio-economic factors included age, gender, education, land size and land topography. The institutional factors were access to information channels, membership and participation in farmer groups, access to training, credit access and access to extension services. Both qualitative and quantitative data were obtained from the study as shown by the plates of data collection (Appendix VI).

3.9 Data Analysis

The survey data was then coded, followed by a consistency check before statistical analysis procedure were done. Data entry was done on Microsoft excel and descriptive statistics was done using SPSS version 28.0 while the analysis was done on Stata software version 17.0. The coded data used statistical tools in descriptive statistics including mean, frequencies, percentages, non-parametric chi-squares and dispersion measures such as variances, standard deviation and ranges. To analyze the socio-economic and institutional factors determining the uptake of the SWCs, Multi-Variate Probit (MVP) model got applied while on the effects of adoption of SWCs on maize productivity, Propensity Score Matching (PSM) was employed.

3.9.1 Socio-Economic and Institutional Factors Influencing Adoption Among Small Holder Farmers on Soil and Water Conservation Practices.

Multivariate Probit Regression Model (MVP) as used by Donkoh *et al.* (2019), identified factors affecting the SWCs uptake using a set of socio-economic and institutional factors. This model's key benefit was that it made it possible to examine any potential relationships among the unobserved characteristics (error terms) and the adoption of various SWC measures. Using MVP, multiple binary dependent variables (yji) are considered and multiple latent variables or explanatory variables (y∗ji). The latent variable must be greater than zero in order for each binary observable variable to have a value of 1.

$$Y_{ji} = 1{,}0 \; if \; Y *_{ji} > 0 \; or \; otherwise \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$Y *_{ji} = X_{ji}\beta_{ji} + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (6)$$

where;

Y_{ji} is the dependent variable or any SWCs in practice for adopting SWCs.

$Y *_{ji}$ is the multiple latent variables or explanatory variables for not adopting SWCs.

X_{ji} observed characteristics or independent variables.

ε is the error term that captures unobserved characteristics.

β_{ji} parameter vectors estimated.

The study applied (MVP) where adoption of SWCs (dependent variables) was considered as discrete choices. The model was used to show how adoption of SWCs influenced the choices of socio-economic factors of the farmers. Farmers' opinions and criteria on decision of adoption was influenced by various variables. Table 3 shows the socio-economic factors that were used in analysis of adoption of soil and water conservation practices and their output.

Table 3: Description of Socio-Economic Variables Affecting the Adoption of Soil and Water Conservation Practices.

Variables	Explanation	Measurement	Expected sign
Dependent	Adoption of SWCs	Binary (1=adopted, 0=not adopted)	
Age	Number of years' household head has lived	Number of years	+/-
Gender	Being either a male or female	Dummy (male =1, female =0)	+/-
Education	Level of education	Number of years spent in school	+/-
Household size	Number of family members living in a particular homestead	Number of persons living in the household	+/-
Land size	Size of the land by the farmer	Acres	+/-
Land tenure system	Ownership of land	Dummy (1= with a title deed, 0= without a title deed)	+/-
Farmers' awareness on soil and water conservation	Fertility of the land	Dummy (1= farmer perceives the farm to be eroded, 0= does not perceive)	+/-
Topography	Slope of land	Dummy (1=steep, 0=otherwise)	+/-

Multivariate Probit Regression (MVP) model also allowed the possibilities of relationship between a number of factors that influence the dependent variables (SWCs), adoption of technology. MVP model showed how institutional factors affected the choice and adoption of SWCs on small-scale maize farmers.

Table 4 shows the description of institutional variables influencing the adoption of SWCs on small-scale maize farmers and their output.

Table 4: Description of Institutional Variables Affecting Adoption of Soil and Water Conservation Practices.

Variables	Explanation	Measurement	Expected sign
Group membership	Belonging to an association	Dummy (1= belong to a farmer group, 0= does not belong to any group)	+/-
Information sources and communication channels	Information sources owned by a farmer such as radio, television, mobile phone	Dummy (1=yes, 0=no)	+/-
Training	Farmer receiving farm management	Dummy (1= attended training, 0= did not attend any)	+/-
Access to extension services	Number of times in the past 12 months	Dummy (1= extension visits, 0=no extension visits)	+/-
Access to credit	Farmers receiving financial assistance	Dummy (1=received, 0=did not receive)	+/-

3.9.2 Effect of Adoption of the Soil and Water Conservation Practices on Maize Productivity.

Following the studies by Bello *et al.* (2020), Propensity Score Matching (PSM) model estimated the impact of adopting a technology on maize production where two groups were determined, adopters of a technology (T_i =1) and non-adopters of the technology (T_i =0). Propensity Score Matching is an econometric model used to measure an effect when there is no base line. Based on the propensity scores, those who adopted a technology (the treated group) were matched to those who did not (the control group), given by the equation below:

$$P(X_i) = prob\ (T_i = 1|X_i) \quad (0 < p(X_i) < 1) \dots\dots\dots\dots\dots\dots\dots\dots (7)$$

where;

X_i is a vector of adoption of technology control variables. If the $T_i's$ are independent over all(i) and the outcomes are independent of the adoption given X_i then the outcomes are also independent of adoption of technology given $p(X_i)$ as they would be if technology adoption was randomly done. To be able to calculate the propensity scores based on the ATT effect, the first condition is the balancing hypothesis where;

$$T|X|P(x) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . (8)$$

Observations with the same propensity scores, the distribution of pre-treatment characteristics must be similar in the treated and control groups. Each person has an equal chance of being assigned to a treatment, subject to the propensity score. The second condition is the Conditional Independence Assumption (CIA) given the propensity score

where;

$$Y_{1,}Y_0|\ T|X \rightarrow\ Y_1, Y_0, |\ T \quad P(X) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots .. (9)$$

If the pre-treatment variables do not confound assignment to treatment, then the propensity score does not confound assignment to treatment. The average treatment effect on the treated (ATT) measured the performance difference between the treatment and control groups. After computing the propensity score, the ATT τ effect was estimated as:

$$\tau = E(Y_{1i} - Y_{0i}|D_i = 1) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (10)$$

$$\tau = E\{E(Y_{1i} - Y_{0i}|D_i = 1, P(X))\} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots .. \ldots .. (11)$$

$$\tau = E\{E(Y_{1i} - Y_{0i}|D_i = 1, P(X)) - E\{Y_{0i}|D_i = 0, P(X_i)\}|D_i = 1\} \ldots \ldots \ldots \ldots .. (12)$$

where;

Y_{1i} is the result of a treated individual, which is maize yield for adopters

Y_{0i} is the outcome if the individual is the control group, the maize yield for non-adopters. Isolation of the control group, the treatment group with support, and the treatment group without support is carried out following the propensity scores matching test on the SWCs.

3.10 Ethical Consideration

This study entailed secrecy, preservation of privacy and confidentiality of respondent's data. This study complied with the Chuka University Institutional Ethical requirements with a recommendation letter (Appendix III) being obtained from the institution for permission to undertake the research. The researcher provided the respondents with introductory letter to inform them of what the study entailed (Appendix I). Additionally, the study took into account professionalism, confidentiality and anonymity, voluntary participation and respect. A permit from National Council for Science Technology and Innovation (NACOSTI) was acquired to facilitate collection of data in the area of study (Appendix IV).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Questionnaire Response Rate

The questionnaires were prepared, administered and responded by 318 smallholder maize farmers. Findings from the study presented 92.17% (318) of the respondents as the return rate of the administered questionnaires (Table 5). There was minor variance between the expected sample size and the achieved sample size because of the willingness of the respondents to respond to the questionnaire. According to Adeniran (2019), a response rate of 50% was satisfactory, 60% response rate was good, a 70% response rate and beyond was sufficient. Therefore, from this study 92.17% response rate was excellent for data analysis and reporting.

Table 5: Response Rate of the Respondents

Wards	Sample Size	Achieved Sample	Percentage
Magumoni	115	110	31.88
Igambang'ombe	100	100	28.99
Muthambi	60	50	14.40
Mwimbi	70	58	17.00
Total	345	318	92.17

4.2 Descriptive Statistics on the Socio-Economic Characteristics of Smallholder Maize Farmers

4.2.1 Gender of the Household Head

This study aimed at investigating the sex of the household head. The findings obtained from the study observed that 75.47% of the small-scale maize farmers who got involved in adoption of SWCs were males while 24.53% were females (Table 6). The study showed that most of the household heads were males probably because of the fact that family headship in the study location is primarily a male responsibility and that they are exposed to more of the farm resources compared to their female counterparts. The observed findings show that there may be gender inequality probably because most females did not own farms.

Table 6: Gender of the Household Head

Gender	Frequency	Percentage
Female	78	24.53
Male	240	75.47
Total	318	100

Similar results reported by Adzawla *et al.* (2019), on gender perspectives of climate change adaptation revealed that majority of those who responded were male and majority of female were involved in production in their own farms. Marie *et al.* (2020), who worked on farmer choices and determinants influencing the uptake of climate change adaptation technologies observed consistent results that homesteads headed by males were likely than female-headed households to put adaptation strategies into action. Findings from the study are in line with those of Jha *et al.* (2019) and Adetoro (2021), who indicated that farmers who were males adapted SWCs more because they had the privilege of having farm resources compared to female farmers.

4.2.2 Household Size, Average Age and Years of Schooling of the Maize Farmers

The findings from the study also identified maize farmers' household size, average age, and the years taken in schooling. Findings of this study show the average number of individuals living in a specific homestead was about 4 people with the least household having one member and a maximum of 10 members in other households (Table 7). The findings show that the farm could practice more SWCs because there was availability of labor from the household members. Findings obtained from the study agree with those of Innazent *et al*. (2022) on farm topology of smallholders integrated farming systems in India who analyzed that the average household size was 4 members. Mdoda *et al.* (2022) report had similar findings which revealed the mean household size was 4 persons in the households of irrigated spinach production in South Africa where farmers employed family members in the fields which was essential for increasing production and boosting profitability. The study findings of Kioko (2019), on the assessment of sustainable management practices in Kirinyaga County, Kenya reported inconsistent results that the household size was about 5 people which showed that large household sizes tend to practice more of the SWCs since there is provision of labour from large households with many family members present compared to the smaller ones.

Table 7: Maize Farmers Socio-economic Characteristics

Variable	Mean	Std. Dev.	Min	Max
Household Size	4.248428	1.789713	1	10
Age	48.03145	11.03045	26	98
Education	7.427673	4.330159	0	21

During the study, it was observed that the age mean of the decision maker was about 48 (±11.03) years with the years ranging from 26 (lowest) to 98 years (highest) [Table 7]. According to the findings, most of the respondents were 48 years which imply that smallholder farming was dominated by younger farmers. It is possible that farmers at this age were capable of engaging in farm decisions and this was a prime age of being involved in production. Results obtained from the study agree with the study findings of Mdoda *et al.* (2022) who conducted a report on the assessment of profit efficiency for spinach in South Africa, and revealed that the mean years a farmer has lived was 48 years which meant that younger farmers were more risk-takers contrary to older farmers who were not the risk takers. The findings obtained are similar to the study findings of Abubakar and Sule (2019) and those of Mellon *et al.* (2022) who revealed that the average years of the decision maker was below 50 and were able to make farming decisions on sustainable agricultural practices.

In regard to schooling years, the study findings show that the mean average years of schooling was 7 (±4.33) with some not attending school at all and highest being 21 years (Table 7). Education was a factor in adopting SWCs because literate farmers had the knowledge and know how on what methods to use in their farms. Study findings are in agreement with those of Faleye and Afolami (2020) who analyzed on climate smart agricultural practices among yam-based farmers in Nigeria and reported on the average years of schooling being 7, this meant that most farmers were literate and had the knowledge on the technologies to use on their farms. The findings of this study also agree to the study findings of Mdoda *et al.* (2022), who studied irrigated agriculture on spinach production in South Africa and concluded that the average schooling years was 7, which equaled to primary schooling indicating that farmers were literate and had the knowledge required.

4.2.3 Maize Farmers Level of Education

Further, from the findings attained, it was confirmed that most respondents (31.76%) attained standard eight or did not complete secondary education while 22.01% attained primary standard 1 to 6 and 7.55% did not attend school at all (Table 8). The study findings showed that most household heads were literate and had attained primary education. Based on these findings, it is possible that the farmers had capacity to grasp and use technical information putting them in a position to make informed decisions which boosts farming success. The study findings are consistent to those of Waaswa *et al.* (2022) who reported on climate- smart agriculture in potato production and observed that the farmers who obtained higher and standard education levels had the best prospects of making wiser judgements and rapidly embracing new farming technologies.

Table 8: Level of Education of the Maize Farmers

Level of Education	Frequency	Percentage
None/ Illiterate	24	7.55
Primary standard 1 to 6	70	22.01
Primary standard 7	59	18.55
Standard 8 or secondary form	101	31.76
Secondary form 4	48	15.09
College or higher	16	5.03
Total	318	100

4.2.4 Land Characteristics

4.2.4.1 Land Tenure System

This study sought to identify how small-scale maize farmers owned land. During the study, it was indicated that most (86.16%) of the maize farmers owned a farm and had title deeds, while 12.89% rented in, 0.63% rented out and 0.31% borrowed out (Table 9).

Table 9: Land Tenure System of the Maize Farmers

Land ownership	Frequency	Percentage
Owned	274	86.16
Rented/ Shared in	41	12.89
Rented/ Shared out	2	0.63
Borrowed out	1	0.31
Total	318	100

These findings of the study reveal that majority of the maize farmers produced the crop on land owned by the household heads and embraced SWCs as a way of curbing climatic risks. Based on the study findings, this was probably because owning land gave farmers the opportunity to adopt SWCs suitable in their own farms. Mogaka *et al.* (2021), obtained similar findings from a study on climate-smart practices in the West parts of Kenya and noted that majority of the maize farmers owned land therefore most of them could practice the SWCs. According to the findings of this study although land is scarce resource, not all farmers owned a piece of land. Land ownership is a consideration on agricultural production since it controls what kind of conservation practices are used.

4.2.4.2 Land Size

According to the study findings, the average land size was about 1.3 acres with some not owning any land at all and the maximum holding being 6 acres for maize production (Table 10). These study findings indicate that most maize farmers practiced small scale farming because farms are mostly fragmented resulting to less production due to the size of the agricultural area. These findings are in line with those of Otieno (2022), who studied on the factors and its impacts on the involvement of rural households in land markets, agricultural productivity, and food security in Siaya and reported that the average land owned was 1.3 acres due to tenure security of land fragmentation in the area.

Table 10: Average Land Size for the Maize Farmers

Variable	Mean	Std. Dev.	Min	Max
Land Area	1.33	1.099483	0	6

4.2.4.3 Farmer Perception on Soil Erosion, Soil Fertility and Land Topography

The study sought to know the rate of awareness of farmers about soil erosion in their farms. Findings obtained from the study show that majority (58.18%) of the maize farmers perceived their land to be eroded experiencing soil degradation while 41.82% did not perceive their land of any erosion (Table 11). Further, the study showed that most maize farmers experienced erosion on the pieces of land which needed measures to prevent erosion. Kenee *et al.* (2020) reported inconsistent results which presented only 16.6% of farmers perceiving erosion to be severe and only 62.6% considered erosion to be a least cause. The study findings matched with those of Gonde and Kitila (2022) on the study of assessment of farmers' awareness towards SWCs in Western Ethiopia and noted a deterioration in soil fertility in most farms was due to continuous tillage, soil erosion and lack of sustainable measures to tackle soil degradation problem.

Table 11: Farmers Perception on Erosion, Fertility and Land Topography of Maize Farmers

Characteristics of land	Response	Frequency	Percentage
Awareness on Erosion	No	133	41.82
	Yes	185	58.18
	Total	318	100
Soil Fertility	Good	76	23.9
	Medium	228	71.7
	Low	14	4.4
	Total	318	100
Slope/ Topography	Gentle Slope (Flat)	120	37.74
	Medium Slope	177	55.66
	Steep Slope	21	6.60
	Total	318	100.00

The study results are also similar to those of Assaye (2020), who surveyed on farmer's awareness on soil erosion in Ethiopia and reported that when soil erosion reaches a certain critical level, some farmers start to notice its effects.

4.2.4.4 Soil Fertility

The study also investigated the fertility nature of the soil, and it was observed that 23.9% of the respondents had good fertile soils with top soil layer while 71.7% of the respondents had medium fertile soils and 4.4% had low fertile soils where maize did not do better (Table 11). These study findings meant that most farmers did not notice nutrient depletion from their farms until it became so critical that crops could not produce well due to the practice of continuous farming that led to nutrients depletion. Findings from the study matched the findings of Mulwa *et al.* (2017) which concluded that crop failure is less likely to occur on fertile soils compared to medium and less fertile ones.

4.2.4.5 Land Topography

The study findings aimed at investigating the land topography and how it affected the adoption of SWCs. It was observed that 37.74% of the respondent's land was flat or gently slopy, 55.66% had medium sloping land while 6.60% of the land was steep (Table 11). Findings of this study show that most of the maize farmers were owners of flat and medium sloping land meaning that most of them did not perceive their land to be steep. Findings attained from the study are in line to the study findings of Gessese *et al.* (2022), whose study examined the adoption and intensity of SWCs in Ethiopia where 38% of the land was gentle and moderately slopy while less than 15% was steep and observed that households who owned gentle or steep slope farm plots used physical procedures to prevent erosion. The findings attained from the study are inconsistent to the study findings of Arega *et al.* (2022), who studied on farmer's psychodynamics in integrated SWCs in Ethiopia and stated that the topography's role in accelerating soil erosion through soil degradation was minimal.

4.3 Descriptive Statistics of Institutional Factors on Maize Farmers

4.3.1 Group Membership of Maize Farmers

The study aimed at identifying how group membership influenced the adoption of SWCs. The study findings reveal that majority (68.24%) of the maize farmers belong to a congregation group which was either a mosque or a church (Table 12). A congregation group is important since most people go for worship and it is possible that it is where most farmers get farming information from. Further, the study also noted that about 22.96% of maize farmers belonged to savings and credit group (Table 12). The ability to obtain loans and other farm inputs is based on belonging to a savings and credit group because it enables information sharing. Consistent results were obtained by Kimbi *et al.* (2022), whose study analyzed how credit and saving group membership boosted contract farming among sorghum farmers in Tanzania and reported that farmers readily communicated on agricultural knowledge and also obtained financial resources through these groups in order to purchase production inputs.

Table 12: Group Membership of the Maize Farmers

Group Membership	Frequency	Percentage
Group Member	225	70.75
Non-Group Member	93	29.25
Total	318	100
Type of group		
SACCO	73	22.96
Merry Go-Round	106	33.33
Cooperative Union	3	0.94
Seed Production Group	3	0.94
Water's Association	134	42.14
Marketing Group	2	0.63
Women Association	18	5.66
Youth Group	1	0.31
Congregation Group	217	68.24
Nyumba Kumi	42	13.21
Forests' Association	99	31.13

From the study, it was also revealed that the rate of participation of maize farmers in cooperative unions, seed production group, marketing group and youth group was relatively low, at below 1% (Table 12). This was probably because each organization had its own motivation and goals. Rokhani *et al.* (2020), analyzed the factors of participation in sugarcane farmers contract farming in Indonesia and obtained similar findings which reported that cooperatives and agricultural associations participation was low due to pooling of resources together to boost operational efficiency and economies of scale.

4.3.2 Access to Extension Services, Training and Information Channels of the Maize Farmers

This study sought to find out how extension and training influenced the uptake of SWCs. The findings show that 76.10% of the maize farmers needed extension services, training and information while 23.90% did not need any extension services (Table 13). From those who needed extension services, training and information, only 37.19% received the services while 62.81% did not received the services (Table 13). The study findings imply that extension contact was low because of limited extension officers who give information and trainings to small-scale farmers. Bashir *et al.* (2018) examined a study on the smallholder farmer implementation of cowpea technologies in Nigeria and reported consistent results that extension agencies expectations to play in the diffusion and acceptance of technology was undermined by farmers' lack of contact with extension agents. Verdicts from the study agreed to the findings of Oyetunde-Usman *et al.* (2021), who surveyed the factors of adoption on multiple workable agricultural practices in Nigeria, and reported that access to extension services was below its peak making farm households perceive a high adoption risk for sustainable agricultural practices.

Table 13: Access to Extension Services by the Maize Farmers

Access to Extension Services	Response	Frequency	Percentage
Willingness to Access	Willing to Access	242	76.1
	Not Willing to Access	76	23.9
	Total	318	100
Those who Accessed	Not Accessed	152	62.81
	Accessed	90	37.19
	Total	242	100
Source of Extension Services	Government extension service	34	37.78
	Spouse	2	2.22
	Farmer Coop or groups	11	12.22
	Neighbor	2	2.22
	Model/lead farmers	30	33.33
	Other farmers	5	5.56
	NGOs	2	2.22
	Research center	1	1.11
	Radio/TV	3	3.33
	Total	90	100

During the findings, it was also observed that 37.78% of maize farmers got extension services from government agencies, 33.33% attained information from farmer to farmer while 12.22% got information from farmer groups and co-operatives (Table 13). The study findings show that most farmers attained their information from the government extension services probably because it was less costly compared to other organizations. Similar to this study Madaki *et al.* (2022), concluded that farmers were more conscious of climate change if they received meteorological information from government extension officers which was perceived to be cheaper or less expensive compared to other sources of information. The study findings are also in line to the study analyzed by Adi *et al.* (2021), on the determinants influencing tobacco and sugarcane growers' engagement in farmer groups and associations in Indonesia and reported that sugarcane farmers participate more in cooperatives while tobacco farmers were involved in associations. Dembele *et al.* (2019) analyzed the studies on adaptation approaches to climate change among grain farmers in Mali and reported inconsistent results that NGOs were a major source of information on the impact of climate change.

Further, the study also sought to find out the reasons for extension services and training. The findings of this study reveal that 15.11% of the maize farmers received information for new varieties of maize, 8.2% on new varieties of legumes and 8.98% on field pest and disease control (Table 14). The study findings showed that these reasons were outside the main purpose of soil and water management probably because they needed advice and information on what varieties of maize to plant on their farms, what new varieties of legumes to intercrop and what field pests and diseases to control for better productivity compared to information on SWCs.

The study findings also show that farmers got information for SWCs such as intercropping, irrigation, minimum tillage, tree planting and, soil and water management at 8.13%, 4.78%, 3.99%, 5.42% and 7.7%, respectively (Table 14). This information on SWCs was very low which showed that extension agents did not focus or give enough information to the farmers, hence low adaptation of the practices. The findings of this study disagree with those of Amengor *et al.* (2022), who studied on perception awareness and adoption of drought tolerant maize in Ghana and concluded that the adoption rate of the technology was 15.8% since they had access to extension information and services.

Table 14: Reasons for Extension Services, Training and Information of the Maize Farmers

Reason for Extension	Frequency	Percentage
New varieties of maize	212	15.11
New varieties of legumes	115	8.2
Field pest and disease control	126	8.98
Soil and water management	108	7.7
Crop rotation	143	10.19
Intercropping	114	8.13
Minimum tillage	56	3.99
Leaving crop residue in the field	40	2.85
Irrigation	67	4.78
Output markets and prices	69	4.92
Input markets and prices	58	4.13
Collective action	33	2.35
Livestock production	60	4.28
Family health	58	4.13
Tree planting	76	5.42
Forest management	68	4.85

The study also sought to know how the maize farmers interacted with or visited the extension agents. It was observed that, farmers on average contacted the extension agent for information two times with a minimum of at least one and a maximum of 10 times (Table 15). From the findings of this study, low contact of extension agents was probably due to the limited availability of the extension officers. This implied that there was insufficient extension service delivery in terms of SWCs dissemination in the area and also in terms of field days and field demonstrations.

Table 15: Extension Contact of Maize Farmers

Variable	Observation	Mean	Std. Dev.	Min	Max
Extension Contact	90	2.0556	1.41708	1	10

The findings obtained from the study, matched the studies analyzed by Gikunda *et al.* (2022) on effective uptake of climate smart agriculture strategies in Mbeere North, Kenya and indicated that extension agents were not doing enough to spread a varied range of climate smart agriculture methods to farmers since they had not received any information about climate-smart.

4.3.3 Maize Farmers Access to Credit

The study sought at investigating how access to financial assistance influenced adoption of SWCs. The study findings demonstrated that 39.94% of maize farmers required credit while 60.06% did not need any credit (Table 16). Based on this study findings, it is possible that it was difficult for small scale farmers to apply for credit since collateral was needed by the financial agents. The study findings also show that out of those who needed credit, only 58.27% applied for the credit while 41.73% never applied for credit assistance (Table 16). There is a possibility that most of the farmers applied for credit so as to manage daily activities in the farm.

The findings obtained from the study agreed with the findings of Kimathi *et al.* (2021), on the adoption of resilient potato varieties and its determinants on smallholder farmers in Meru County, Kenya who reported that access to financial assistance was typically accompanied with extension services and usage of SWCs for climate change adaptation. Findings from the study are inconsistent with those of Nsele *et al.* (2022), who examined the variables impacting urban farmers’ long-term adoption of new practices in the Democratic Republic of the Congo and reported that only 22.8% of the respondents accessed credit.

Table 16: Access to Credit of the Maize Farmers

Credit Accessibility	Response	Frequency	Percentage
Willing to Access Credit	Not Willing	191	60.06
	Willing	127	39.94
	Total	318	100
Those who Applied	Never Applied	53	41.73
	Applied	74	58.27
	Total	127	100
Source of Credit	Money lender	16	20.78
	Farmer group/co-operatives	1	1.3
	Merry go round	31	40.26
	Microfinance	6	7.79
	Bank	3	3.9
	Relative	15	19.48
	Saving and Credit Group	2	2.6
	Shylock	3	3.89

It was demonstrated from the study that most of the maize farmers (40.26%) attained their finances from merry go round while 20.78% attained from money lenders (Table 16). The study findings show that informal sources of agricultural loans were most prevalent in the area because it was possibly easy to access them compared to other sources like the banks, microfinance and saving and credit groups who needed collateral. Findings obtained from the study are consistent to the findings of Teye *et al*. (2022) whose study was on the effects of agricultural finance on technology adoption, agricultural yield in Ghana on rice farmers and reported that 67% of women believed lack of collateral prevented them from obtaining loans to adopt rice technology.

During the study, it was observed that the formal credit institution sources such as the banks, credit cooperatives and SACCOs were few for farmers seeking for credit. Mulume *et al.* (2022), whose study analyzed on farmers' credit access in the Democratic Republic of Congo on youth tomato growers reported consistent results that inadequate financial policies, the incorrect perception of the risk and the absence of collateral was to blame for the region's dominance of informal sources of agricultural financing.

Table 17: Purpose of Credit Acquisition

Purpose of Credit	Frequency	Percentage
Buying seeds	56	16.62
Buying fertilizer	80	23.74
Buy herbicide and pesticides	53	15.73
Buy farm equipment/implements	22	6.53
Invest in transport such as bicycle,	19	5.64
Buy oxen for traction	5	1.48
Buying livestock for fattening	12	3.56
Invest in irrigation system	14	4.15
Invest in minimum tillage	9	2.67
Non-farm business or trade	20	5.93
To pay land rent	8	2.37
Buy food	10	2.97
Non-food consumption needs	26	7.72
Medical expenses	1	0.29
School fees	2	0.60

The study also aimed at investigating the main purpose for the credit acquired. The findings obtained from the study show that most of the maize farmers attained credit but used the credit for other household expenses like buying seeds, fertilizer, herbicides and pesticides at 16.62%, 23.74% and 15.73%, respectively rather than adoption of SWCs (Table 17). From the study findings, credit used for the purpose of soil and water conservation practices was below peak at 4.15% which was for investing in irrigation system and at 2.67% for minimum tillage (Table 17). Findings on the purpose of credit matched the study results examined by Mulume *et al.* (2022) who studied on tomato farmers in Congo and noted a large diversion of credit to household activities other than farming.

4.4 Levels and Adoption of Soil and Water Conservation Practices on Maize

4.4.1 Practice of Intercropping

The study purposed to investigate the intensity of intercropping as implemented by the maize farmers as a SWCs. The findings show that majority of the farmers practiced intercropping at 67.3% while 32.7% of the farmers did not intercrop maize with any other crop (Table 18). This was probably because most maize farmers had limited pieces of land and needed to utilize the land with more crops since they had some knowledge on intercropping for more productivity. The findings attained from the study are in agreement from the research work by Binacchi *et al.* (2022) whose analysis on the potential of conservation agriculture to increase cowpea nitrogen fixation farm lands of Eastern Kenya indicated that majority of farmers practiced intercropping and that soil moisture content decreased under maize and cowpea intercropping relative to maize alone.

Findings obtained from the study also matched those of Wafula and Kelvin (2022), who studied the effect of water harvesting, and fertilizer application technologies on nutrient uptake and their effects on maize and beans production in Machakos County, Kenya and reported that there was higher grain yield of 1.64 t/ha from bean-maize intercropping system and lowest yield of 0.44 t/ha from sole beans. The findings in this work contradict the study results analyzed by Musyimi *et al.* (2022), whose study on the effect of ridging and intercropping on sorghum yield in dry and less dry lowlands of Makueni County in Kenya reported that cowpea grain yield decreased when it was intercropped with sorghum, which was attributed to sorghum's shadowing effect on the cowpea. Therefore, it is possible that not every crop that is intercropped with another would bring about a positive impact in this case, increase in yield of the particular crop.

Table 18: Practice of Intercropping and Irrigation

Practice	Response	Frequency	Percentage
Intercropping	Never Practiced	104	32.7
	Practiced	214	67.3
	Total	318	100
Irrigation	Never Practiced	185	58.18
	Practiced	133	41.82
	Total	318	100

4.4.2 Adoption of Irrigation

The study purposed at finding out how irrigation influenced the adoption of SWCs. It was determined by this study that 41.82% of the maize farmers practiced irrigation while 58.18% had no form of irrigation on their farms (Table 18). Findings obtained from this study observed that majority of the farmers did not practice any kind of irrigation on the farm possibly due to limited water availability and water scarcity, expensive structures to lay irrigation and insufficient knowhow to practice irrigation. Similar findings were reported by Sezen *et al.* (2022) who analyzed a study on the growth productivity of peanut under irrigation water management practices in Turkey and reported that depending on the rate of recurrence, regimes and volumes of irrigation, peanut output declined as irrigation application water was reduced. Alotaibi *et al.* (2021) examined the adoption of sustainable water management practices in Saudi Arabia and reported similar findings that use of waste water and industrial treatment in irrigation was low which was probably caused by insufficient information on farmers about safe use of waste water.

4.4.3 Practice of Crop Rotation

This study shows that 85.22% of maize farmers practiced crop rotation with various number of crops while 14.78% did not crop rotate maize with any other crop (Table 19). The study findings show that most farmers practiced rotation with the goal of protecting soil quality and soil fertility and that also it was monotonous to only plant one type of crop. The study findings are in agreement with those of Dang and Hung (2022), who determined the impacts of crop rotation on maize fertility and reported that crop rotation was a technique for increasing soil fertility and diversifying crop yield.

Further, Turyahabwe *et al.* (2022), studied on factors affecting the uptake of SWCs by small holder farmers in Eastern Uganda and reported similar findings that over half of the farmers in the area used crop rotation, which decreased soil erosion and increased crop yield. The study findings are in contrast with those of Mcharo and Waswa (2022), who studied effect of gender differentiated adoption of SWCs by farmers in Kenyan agricultural highland catchment and reported that crop rotation was hardly used which was attributed to the tiny farm sizes, which made it economically unfeasible to rotate the main crop. Debie and Ermias (2020) had similar findings which reported that legume and cereal crop rotation was the top alternate method to maintainable land management practices in Ethiopia.

Table 19: Adoption of Crop Rotation and Terraces

Practice	Response	Frequency	Percentage
Crop Rotation	Not Adopted	47	14.78
	Adopted	271	85.22
	Total	318	100
Terraces	Never Adopted	142	44.65
	Adopted	176	55.35
	Total	318	100

4.4.4 Adoption of Terraces

Findings of this study observed that 55.35% of the maize farmers practiced terracing while 44.65% did not have any terraces on the farms (Table 19). These findings indicate that farmers practiced terracing mostly on steep slopes, on hills and highland areas to prevent runoff and erosion. Similar results were reported by Destaw and Fenta (2021) on climate change adaptation among rural farmers in Northern Ethiopia who reported that producer’s top goal to lessen the influence of soil erosion and surface runoff on produce output was highland area terracing. The report also indicated that climate change adaptation technologies were location specific, implying that they were adopted depending on the topography of the area. Findings obtained from this study agreed to the work analyzed by Mairura *et al.* (2022), on the study of farm factors affecting soil fertility in Tharaka Nithi County, Kenya who reported that terraces were frequently used in maize. This was possibly because maize is a significant food and income crop that was planted in numerous conservation agriculture techniques.

4.4.5 Use of Mulching

These findings of the study aimed at examining mulching influence to the uptake of SWCs. Findings obtained from this study show that most (71.38%) of the maize farmers did not practice mulching while 28.62% practiced this SWCs (Table 20). It was observed that farmers did not practice mulching probably because they never had enough crop residues to cover the ground so as to retain the soil moisture and enhance soil structure. Turyahabwe *et al.* (2022), examined soil and water conservation practices by smallholder farmers in Eastern Uganda which reported inconsistent results that only 40% of the farmers in that area practiced mulching which prevented the soil from splash erosion.

In addition, findings obtained from this study contradict the report findings of Xianchen *et al.* (2020), who studied how different types of mulch affected tea production in China and reported that mulching increased water use efficiency and low erodibility was seen due to the use of high organic residues. Li *et al.* (2021) had similar findings which reported that mulching was practiced less depending on local conditions, cost and type of material indicating that hedgerow mulches, controlled soil and water loss better than living mulches.

Table 20: Practice on Mulching and Minimum Tillage

Practice	Response	Frequency	Percentage
Mulching	Never Adopted	227	71.38
	Adopted	91	28.62
	Total	318	100
Minimum Tillage	Not Adopted	306	96.23
	Adopted	12	3.77
	Total	318	100

4.4.6 Practice on Minimum Tillage

Minimum tillage was examined on how it affected the adoption of SWCs. The findings obtained from this study revealed that 96.23% of the maize farmers did not practice minimum tillage while 3.77% of the farmers practiced (Table 20). These finding was probably because of lack of knowledge on minimum tillage and farmers being used to convectional tillage. Hapemo Ngullie *et al.* (2022), whose study was on effect of tillage on soil properties with pigeon peas production reported inconsistent results that minimum tillage enhanced the physical state of the soil which outperformed convectional tillage. Findings attained from this study disagree with the report of Fikirie (2021), whose findings reported that the practice of no tillage was at 36% in coffee growing areas of Ethiopia and was used to moderate the effect of termites and soil acidity. Similarly, Olowa *et al.* (2019) studied the factors affecting adoption of SWCs among fluted pumpkin producers in Nigeria and reported that minimum tillage was not predominant in the area because of shortage and fragmentation of land hence majority of the farmers not practicing it.

4.4.7 Adoption of Stone Bunds

The study sought to determine how stone bunds were adopted on maize farms. Findings obtained from the survey, show that majority (88.36%) of the maize farmers practiced no stone bunds while 11.64% had adopted them on their farms (Table 21). Based on the observations, majority of maize farmers did not adopt stone bunds probably because farmers found it hard and tiresome to place the stones on the farm edges. Goba *et al.* (2022) whose work evaluated farmer's awareness on soil erosion and management SWC measures in southwest part of Ethiopia reported inconsistent results that stone bunds were adopted at only 48% and they assisted in reducing erosion by water on the farms, and that the use of these physical measures to conserve soil and water, increased soil fertility and subsequently improved agricultural productivity.

Table 21: Adoption of Stone Bunds and Grass strips

Practice	Response	Frequency	Percentage
Stone Bunds	Not Practiced	281	88.36
	Practiced	37	11.64
	Total	318	100
Grass Strips	Not Practiced	209	65.72
	Practiced	109	34.28
	Total	318	100

4.4.8 Planting of Grass Strips along Contour Lines

Findings obtained from the study found that 65.72% of the maize farmers did not plant grass strips along contour lines while 34.28% did the planting on their farms (Table 21). The study findings observed that the use of grass strips was probably low due to inadequate awareness of the farmers on the types of grasses to plant, labor required for management and that this uses land meant for food production. It is possible that grass plantings along contour lines act as a vegetative live barrier, that reduces surface runoff and erosion hence conserving water and soil within the farm. The study findings are inconsistent with those of Birhan and Tekalign (2022) who studied sustainable agriculture using technology to conserve soil and water in Central Ethiopia and reported that grass strips were one of the methods used to prevent surface runoff as a vegetative measure and was adopted at 45.5% and also noted that the farmers used grass strips to control grazing of the animals in their farms.

4.5 Econometric Analysis on Socio-Economic and Institutional Factors on Adoption of Soil and Water Conservation Practices Using Multivariate Probit Model

A Multivariate Probit (MVP) Model was employed to determine the factors that affected the use of SWCs for maize production. Multivariate Probit model estimated correlated binary outcomes, which extended to more than two dependent variables. This study identified eight soil and water conservation (SWCs) as dependent variables which farmers were likely to adopt and nine independent variables (household size, gender, land size, education, topography, perception on soil erosion, extension and training, membership, access to credit) whereby there were three continuous variables (land size, household size, education) and six dummy variables (gender, topography, perception, membership, extension and credit access) [Table 22].

The model analysis showed that size of the farm had a positive association and was significant on intercropping and irrigation at 1% (Table 22). These study findings indicate that as land size increased, the maize farmers practiced more of intercropping and rotation probably because land as a resource allows intercropping and rotation as SWCs to be practiced. Bekele *et al*. (2021) reported similar findings which indicated that land size was positive and significant with adoption of intercropping and that there was likelihood of adopting SWCs as land size increased. Adusumilli and Wang (2018) also had similar findings, and reported that land size variable was positively significant on irrigation for farmers who believed in water conservation and preserving land moisture. Further, the study findings also reveal that farm size had a negative relationship on grass strips adoption and was significant at 5 % (Table 22). These study findings show that as land size increased, the adoption of grass strips decreased. Findings obtained in this research agree with the study results of Belachew *et al.* (2020), whose report noted that increase in land size negatively influenced adoption of grass strips.

The study findings show that gender variable had a significant factor and a negative association on intercropping with P-value at 5% and mulching with a P-value at 10% (Table 22). The findings of this study observed that more females practiced intercropping and mulching as opposed to their counterparts possibly because females are known for farm activities compared to men and this influenced the decision of adopting SWCs. This study findings, coincides with those of Sileshi *et al.* (2019), whose report concluded that female household heads were more concerned with production and believed it was their duty to combat land degradation which lowers crop output to ensure that their families had access to food than their male counterparts.

Further, findings of the study on household size (number of members living in a specific household) also was investigated. These study findings show that household size had a significant and a positive association with stone bunds and rotation at a P-value = 5% (Table 22). These study findings found that the more people living in a certain home, the greater they are likely to adopt stone bunds and rotation probably because large households have the ability to offer labor to the farm. The findings obtained from the study, agree with the study findings of Gessese *et al.* (2022) who found a positive significancy at 5% and that the likelihood of households adopting SWCs was higher for larger families than it was for the other households due to being more labor-intensive.

During the study, education variable (number of schooling years for the decision maker) was investigated. The findings of this study show that the average education level had a significant factor and a negative relationship with minimum tillage and stone bunds on maize farms at 1% and 5%, respectively (Table 22). This study findings, showed that being an educated farmer did not give a better understanding of adopting minimum tillage and stone bunds in conserving soil and water. This was probably because educated farmers did not focus on the farm possibly as they did more off-farm work compared to farm activities. The findings from this study agree to the study results of Bapfakurera *et al.* (2020), who noted a negative relationship on uptake of conservation practices in Rwanda indicating less-educated farmers who work off-farm, were better suited to participate in the uptake of soil and water conservation techniques than educated ones.

Further, the study also investigated how perception of a farmer towards erosion influenced adoption of SWCs. The study findings indicated that perception had a positive association and a significant P-value at 1% on crop rotation and terraces and also a P-value at 10% on stone bunds (Table 22). The study findings show that the farmers who adopted crop rotation, terraces and stone bunds were more likely to avoid soil erosion and maintain soil structure and fertility. This was possibly because farmers already were aware of soil erosion in their farms making it easy to adopt SWCs. The study findings are consistent to the research analyzed by Yifru *et al.* (2022) on farmer's opinions, perceptions and consciousness of the issue of soil loss and reported that awareness of erosion issue helped them implement newly adopted SWCs. The findings of this study also agreed with those of Dilebo and Tizazu Toma (2017) who reported that perception of a farmer was positive and significant indicating that farmers' perceptions of SWCs shows how best they implement them. In addition, the study findings also show how farmers perceived soil erosion had a negative association and a significant P value at 1% on intercropping and irrigation (Table 22). These findings show that the farmer's interest to curb erosion decreased the adoption of intercropping and irrigation.

Further, the findings attained from the study show that slope of land or topography of the land was positively significant and affected the adoption of intercropping, grass strips and stone bunds at 5% (Table 22). The study findings show that farmers were more likely to use intercropping, stone bunds and grass strips on steeper slopes that seem vulnerable to fast surface runoff possibly because these SWCs were a long-term investment for slopy lands. Findings obtained from this study are consistent to the results of Naazie *et al.* (2023) whose report concluded that farmers who had land on steep slopes had the ability to invest in conservation measures compared to those on less steep slopes. Further, the findings on slope of land also negatively and significantly affected the practice of crop rotation at 5% (Table 22). The study findings indicate that few farmers adopted rotation on steep slopes probably because farmers concentrated on practices to curb surface runoff on steep lands rather than less slopy ones.

Table 22: Multivariate Probit Results

Variable	Intercropping	Terraces	Mulching	Grass Strips	Minimum Tillage	Stone Bunds	Crop Rotation	Irrigation
	Co-efficient	Co-efficient	Co-efficient	Co-efficient	Co-efficient	Co-efficient	Co-efficient	Co-efficient
Land Size	0.334*	0.074	-0.017	-0.160**	-0.131	-0.176	0.188	0.206*
House head Gender	-0.457**	0.092	-0.360***	0.024	-0.131	-0.030	-0.040	-0.033
Education	0.006	-0.0002	-0.017	-0.016	-0.144*	-0.065**	0.029	-0.030
Perception	-0.705*	0.884*	0.239	-0.296	0.074	0.452***	1.112*	-0.471*
Slope/Topography	1.183**	-0.464	-0.445	0.843**	0.563	0.586**	-0.836**	0.098
Extension/ Training	-0.781*	0.154	0.540*	-0.695*	0.283	0.164	0.787*	-0.078
Group Membership	0.893*	-0.417**	0.448**	0.224	-0.348	-0.467	0.594**	0.594*
Credit	-0.487*	-0.073	0.135	0.107	0.336	0.415***	-0.041	0.305
Household size	0.09	-0.049	-0.049	0.043	0.038	0.141**	0.137**	0.081

*, ** and *** represented 1%, 5% and 10%, respectively. Number of observations = 318, Wald chi2 (88) = 296.22, Log likelihood = -1041.8635, prob > chi2 = 0.0000, Likelihood ratio test of rho = 0, chi2 (28) = 165.7

Extension and training as a variable on adoption of SWCs had a negative association on intercropping and grass strips at 1% significant level from the study (Table 22). The study findings meant that the more the farmer attained extension services, the less he or she practiced intercropping and grass strips as SWCs. This was possibly because there were not enough extension agents who worked in agriculture to extend to farmers' knowledge on SWCs. Ghali *et al.* (2022) made similar revelations that access to extension service and training influenced the uptake of SWC practices negatively due to limited availability extension agents. Further, the findings of this study also observed that access to extension and training affected the practice on of rotation and mulching positively and significant at 1% (Table 22). These study findings show that the probability to adopt mulching and rotation by the household head who obtained knowledge on extension, training and information was high. The findings obtained from the study matched those of Yaseen *et al.* (2023) and noted that extension service access was positive and significant so as to promote adoption of sustainable agricultural output on oil-palm cultivation. The findings obtained from this study agree with the study findings of Johnson *et al.* (2018) whose report showed that extension services access was positively significant with the likelihood of adopting maintenance of vegetation in Nigeria.

Further, the study aimed at determining how belonging to a group or association influenced adoption of SWCs. The study findings observed that membership variable was positive and significant for intercropping and irrigation (P-value at 1%) and rotation and mulching (P-value at 5%) [Table 22]. The study findings indicate that farmers in a group were likely to use these practices because of the knowledge and information gained from the group. The study findings agree with the study results of Mengistu *et al.* (2019), whose report noted that farmers belonging to a group, cooperative and associations were likely to implement the soil and water conservation measures more than those who were not members because training was a motivating factor for employing conservation measures.

The study findings on credit access had a significant factor and a negative association on intercropping (P-value =1%) [Table 22]. The study findings observed that those with access to credit practiced less intercropping than those with no access. This was possibly because farmers diverted their use of financial assistance to other expenses rather than practicing SWCs. Findings of this study matched the results of Anang *et al.* (2022) whose analysis concluded that majority of soybean farmers lacked access to finances, which prevented them from adopting SWCs that increase the level of productivity. This was also due to all the long application procedures needed to acquire credit.

Further, the findings obtained in this study also show that credit access was substantial and had a positive association on stone bunds (P-value = 10%) [Table 22]. This study findings, meant that those with access to credit practiced more stone bunds compared to those who had no access. This was probably because stone bunds needed financing for installation since they are labor intensive. Findings attained from this study disagree with the studies analyzed by Maré *et al.* (2022), on credit significance on sustainable agricultural intensification in Burkina Faso and reported that, how farmers use loans may account for the variations in outcomes. The findings of this study also matched with the report of Ullah *et al.* (2022) who concluded that agricultural credit access had a significant factor and influenced by recommended wheat varieties implying that as credit improved for those who acquired it, the possibility of adopting improved wheat varieties in Pakistan also increased.

4.6 Econometric Analysis on Adoption of Soil and Water Conservation Practices on Maize Yield Using Propensity Score Matching

Propensity Score Matching (PSM) model determined the effect of adoption of SWCs on maize yield. PSM thereafter, applied binary logit model to determine propensity scores and number of blocks for the treated and controls making sure the predicted mean propensity ratings for adopters and non-adopters were the same. The propensity scores estimated then used matching algorithms (Nearest neighbor, Radius and Stratification) to compute the Average Treatment Effects and the Common Support Graphs (Appendix V). The adopters and non-adopters estimated Average Treatment Effects (ATT) which measured the impact on maize yield. The participants or treatment group included the adopters of SWCs whereas the non-participants or control group were the non-adopters. The effect of the SWCs was given by the difference (Average Treatment Effect) in maize productivity between the participants (adopters) and non-participants (non-adopters) of SWCs, with or without treatment (Table 23).

From the study findings, land size co-efficient was positive which showed that it was statistically significant at 1%, 5% and 10% on intercropping, irrigation and rotation, respectively (Table 23). The study findings observed that as the land size increased, more farmers practiced intercropping, irrigation and rotation on maize farms and this was probably as a result of land being a great resource in production. The findings attained from the study, agreed to the studies done by Wordofa *et al.* (2020) concluding that land area was positively significant and increased the likelihood of utilizing better structural SWCs. From the study findings, land size as a variable also had a negative co-efficient and was significant (P- value=5%) on grass strips (Table 22). This study findings, indicates that as land size increased, the practice on grass strips as a SWCs decreased. This was possibly because grass strips are labor intensive to establish therefore, waiting for grasses to grow and cutting them is difficult. In addition, grass strips also take land meant for food crop production.

The household size variable for labor force (average number of people residing in a homestead) also got investigated. The study findings show that household size had a positive co-efficient which was significant (P- value=5%) on intercropping and irrigation (Table 23). The study findings indicate that the more people present in a household, the greater intercropping and irrigation was practiced on maize farming probably because household members provided labor force in the farm. Findings from this study matched the study results of Mazumder *et al.* (2023) whose report revealed a solid and favorable association between the number of active household members which increased conservation farming practices in Bangladesh. The study findings also show that household size had a negative co-efficient and was significant at a (P-value= 10%) on terraces (Table 23). Findings of this study showed that the greater number of people in a household, the less terraces were practiced probably because slope of land had to be steep to practice terraces and that they were also expensive to lay.

The study findings on age as a variable had a negative co-efficient with significance at 10% on rotation and irrigation (Table 23). The observed study findings show that younger households practiced rotation and irrigation more compared to the older people. In other words, the negative co-efficient indicates that as age increased by one, the adoption of rotation and irrigation as SWCs decreased. This was possibly because young people have energy and are fit to do crop production and adopt SWCs. Gedefaw *et al.* (2018) and Alemu *et al.* (2023), examined the study of household determinants in implementing sustainable soil and water conservation practices in Ethiopia and reported similar observations that older household heads may be less enthusiastic in constantly adopting SWC practices since they were more likely to be bodily unfit and hesitant to change.

The findings obtained in this study are in agreement with the study results of Chelang'a *et al.* (2023), who found age to be negative and significant for the implementation of good agricultural practices and reported the possibility of younger farmers adopting sustainable farming practices compared to older farmers on adoption of global gap on French beans farmers in Kenya. The findings of this study also show that age was positively significant (P-value=5%) to mulching indicating that as age increased by one, the older people practiced mulching more (Table 23). Similarly, the results of Islam *et al.* (2021) concluded that age plays an important role and was positively significant in applying techniques to climate change in Bangladesh.

Education as a variable was also to be investigated from the study. The findings of this show significance and a negative association on minimum tillage (P-value=1%), stone bunds and irrigation (P-value=10%) [Table 23]. The study findings show that the more educated a farmer was, the less they practiced minimum tillage, stone bunds and irrigation on maize farms. This was probably because educated farmers mostly worked off-farm therefore doing agriculture was much less. These findings on education agree with the results of Mairura *et al.* (2021), whose findings found education to be negative and influenced adoption of SWCs indicating that as the level of education for a person increased, the less they were likely to adapt the SWCs. The study findings obtained disagree with the report of Checco *et al.* (2023), whose findings concluded that education indicated the human capital factor hence positively associated with the improved rice varieties observing that the more the number of years spent in school, the higher the farmer's ability to gather data and technology acquisition to solve production problems.

Further, access to extension and training variable had a positive impact on mulching and rotation at 1% significance level (Table 23). The findings signify that if a farmer accessed extension, information and training, the more they practiced mulching and rotation on their maize farms. This was probably because farmers who acquired extension services and training gained knowledge from extension officers who made it easier for them to practice mulching and rotation. The findings attained in this study are consistent to the study results of Asfew *et al.* (2023) whose findings noted that farmers' interactions with extension agents were more motivated to implement better soil conservation practices. Further, the findings attained in this study also presented extension services access to have a negative effect on intercropping and grass strips at 1% significance level (Table 23). These findings showed that the more a farmer had information the less they practiced intercropping and grass strips probably because extension agents had scanty and less information on SWCs making it difficult for farmers to practice. Findings of this study contradict the study report of Kogo *et al.* (2022) which concluded a positively signed influence on access to extension and training on maize farmers in the west parts of Kenya.

Based on the study findings, belonging to a group was positive and significant on intercropping (P-value= 1%), mulching, grass strips (P–value =5%) and irrigation (P-value= 10%) [Table 23]. The study findings show that a farmer belonging to a group practiced intercropping, mulching, grass strips and irrigation more than those who did not belong to any group. This was possibly because farmers who belonged to a group had information and had interacted with other farmers therefore gaining ideas and information of adopting technology. The findings obtained from the study agree with study findings of Njenga *et al.* (2021) who found belonging to a group was positively significant to mulching, because farmers learned about the finest technology, exchanged ideas and shared experience through group membership.

Findings attained from this study also show that group membership had a negative association and had a significant factor on terraces and stone bunds at 1% and 10%, respectively (Table 23). These study findings show that those who did not belong to any group practiced terraces and stone bunds more than their counterparts. This was probably because laying terraces and stone bunds are expensive therefore, belonging to a group did not give farmers the advantages to adopt them. Similarly, Oduniyi *et al.* (2022) studies found that membership was negative and significant on adopting suitable land management technologies in South Africa.

This study also sought to investigate how adoption of SWCs impacted the maize yields. The study findings show that four SWCs adopted had significant effect on maize yield across all three-matching algorithms (Nearest neighbor, Radius, Stratification). From the study findings of Cherotich *et al.* (2019), who examined the effect of financial knowledge on women in Kenya showed that performance (ATT) was determined by matching the treated and control groups. The findings of this study therefore show that the Average Treatment Effect (ATT) on intercropping was positive and significant at 5% with an approximate range of 290 kgs to 375 kgs per hectare increase relative to maize farmers who never practiced intercropping in their farms (Table 24). This was probably because intercropping was an easy practice to do and there were available legumes to intercrop with maize.

Table 23: Logit Regression, Estimation of Propensity Scores Results

	Intercropping	Terraces	Mulching	Grass Strips	Minimum Tillage	Stone Bunds	Rotation	Irrigation
Variable	Co-efficient	Co-efficient	Co-efficient	Co-efficient	Co-efficient	Co-efficient	Co-efficient	Co-efficient
Land size	0.4985*	0.1599	-0.0319	-0.3282**	-0.1692	-0.2939	0.4295***	0.2757**
Household size	0.1954**	-0.1208***	-0.0944	0.0716	-0.0984	0.1331	0.1459	0.1499**
Gender	-0.664**	0.1297	-0.5992***	0.1415	-0.1591	0.0912	-0.0698	-0.0953
Age	-0.01019	-0.0043	0.0243**	-0.0182	-0.003	-0.0133	-0.0269***	-0.0198***
Education	0.00602	-0.0174	-0.0337	0.00053	-0.2997*	-0.0829***	0.0003	-0.0555***
Extension	-1.2268*	0.1292	1.123*	-0.9809*	0.6718	0.0307	1.3745*	0.0129
Membership	1.6594*	-0.9232*	0.7233**	0.6086**	-0.4418	-0.9675***	0.7057	1.162*
Credit Access	-0.8243*	-0.0261	0.242	0.1177	0.854	0.7246***	0.0964	0.3337

*, **and*** represents significance level at 1% ,5% and 10%, respectively.

Intercropping = (Log likelihood= -167.13332, LR chi2(8)= 67.73, Pseudo R2= 0.1685, prob>chi2= 0.0000), Terraces= (Log likelihood= -209.54297, LR chi2(8)= 18.11, prob>chi2= 0.0204, Pseudo R2= 0.0414), Mulching= (Log likelihood= -174.97666, LR chi2(8)= 30.81, prob>chi2= 0.0002, Pseudo R2=0.0809), Grass strips= (Log likelihood= -192.10318, LR chi2(8)= 24.65, prob>chi2= 0.0018, Pseudo R2= 0.0603), Minimum Tillage= (Log likelihood=-41.874843, LR chi2(8)=18.44, prob>chi2= 0.0181, Pseudo R2=0.1805), Stone bunds= (Log likelihood=-106.67207, LR chi2(8)= 15.36, prob>chi2= 0.0526, Pseudo R2= 0.0671), Crop Rotation= (Log likelihood= -116.39392, Lrchi2(8)= 33.61, prob>chi2= 0.0000, Pseudo R2= 0.1262), Irrigation= (Log likelihood= -192.53713, Lrchi2(8)= 47.23, prob>chi2= 0.0000, Pseudo R2= 0.1092)

Number of observations = 318

Results obtained from the study agreed with the report of Takam-Fongang *et al.* (2019) who confirmed that average treatments were positive and significant on adoption of improved maize varieties in Cameroon increasing the maize yield. Additionally, findings of this study also observed that minimum tillage ATT was negative and significant at 1% on maize yield where there was decrease of about 248 kgs to 690 kgs per hectare from those who practiced minimum tillage than those farmers who did not practice on their farms (Table 24). This was possibly because soil erosion was so intense and soil lost fertility which brought decrease in maize production. Results from the research work of Ojo, T *et al.* (2021) concluded inconsistent results on adoption of SWCs having a positive ATT with a significant impact on productivity of rice in Nigeria.

Further, the study findings also show that stone bunds had a negative ATT but significant at 1% with a decrease in maize production ranging between 50 kgs to 287 kgs per hectare on those that adopted stone bunds compared to those who did not (Table 24). This was probably due to water carrying away nutrients that could have improved maize production. Results obtained from this research disagree to the study outcome of Ahmed *et al.* (2017) whose report indicated that the adoption of technology was positive and improved maize productivity leading to significant gains in consumption for the adopters than the non-adopters in Ethiopia. Further, these study findings also show irrigation was positively significant at 1% with an increase in maize production ranging between 270 kgs to 725 kgs per hectare than those farmers who did not adopt irrigation in their farms (Table 24).

Findings from this study agree to those of Teklu *et al.* (2023) whose report noted that row planting had increased climate resilience capacity for the adopters therefore, it had more noticeable effect for adopters than non-adopters. Further, results obtained from this study indicate adoption of terraces and crop rotation having a negative ATT and decreased production but was insignificant (Table 24). In addition, the study outcome also shows that the adoption of mulching and grass strips had a positive ATT and increased production but was not significant (Table 24).

Table 24: Average Treatment Effect on the Treated (ATET) Group on Maize Yield

SWCs	Matching Algorithm	Treated	Control	ATT	Std. Err.	T-statistic
Intercropping						
	Nearest Neighbor	214	62	375.706	260.743	1.441
	Radius	214	103	291.741	168.643	1.73**
	Stratification	213	104	365.558	199.942	1.828**
Terraces	Nearest Neighbor	176	86	-246.028	227.401	-1.082
	Radius	176	142	-72.72	191.506	-0.38
	Stratification	176	142	-74.774	178.804	-0.418
Mulching	Nearest Neighbor	91	60	382.934	240.604	1.592
	Radius	91	216	253.715	231.548	1.096
	Stratification	91	216	313.008	229.425	1.364
Grass strips	Nearest Neighbor	109	71	227.725	316.842	0.719
	Radius	109	209	219.206	202.906	1.08
	Stratification	109	209	217.157	142.233	1.527
Minimum tillage	Nearest Neighbor	12	10	-248.75	359.715	-0.692
	Radius	12	206	-268.685	114.314	-2.35*
	Stratification	12	206	-698.398	274.106	-2.548*
Stone bunds	Nearest Neighbor	37	29	-51.946	109.391	-0.475
	Radius	37	249	-265.233	92.429	-2.87*
	Stratification	37	249	-287.335	87.237	-3.294*
Rotation	Nearest Neighbor	271	40	-94.491	327.216	-0.289
	Radius	271	45	-57.64	254.482	-0.227
	Stratification	271	45	-24.37	342.11	-0.071
Irrigation	Nearest Neighbor	133	73	271.511	247.562	1.097
	Radius	133	185	727.734	199.679	3.645*
	Stratification	133	185	562.435	223.395	2.518*

*, ** and *** represents significance level at 1%, 5% and 10%, respectively.

CHAPTER FIVE
SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of the Findings

The main aim of this study was to determine the socio-economic and institutional characteristics on adoption of soil and water conservation practices and their effects on maize production in Tharaka Nithi County, Kenya. This study applied the cross-sectional research design to acquire data and get to understand how the socio-economic and institutional factors influence the adoption of soil and water conservation practices and their effects on maize yield among small scale maize farmers in Tharaka Nithi County. This study involved a sample size of 318 smallholder farmers through multistage sampling technique where maize producers involved both adopters and non-adopters of the soil and water conservation practices (SWCs). A semi- structured questionnaire gathered information in the area of study. Multivariate Probit (MVP) model was utilized in analyzing the first and second objective while Propensity Score Matching (PSM) model was used on the third objective to measure Average Treatment Effects (ATT) that gave results on impacts of the maize yield.

The first objective investigated the socio-economic factors influencing the adoption of soil and water conservation practices (SWCs) in Tharaka Nithi County. Multivariate Probit model analysis done to accessed the association between the factors and the adoption of soil and water conservation practices. Eight conservation practices were put into account (intercropping, terraces, mulching, grass strips, minimum tillage, stone bunds, crop rotation and irrigation) while socio-economic factors were also considered (land size, gender, household size, household head age, education). In regard to socio-economic characteristics, the area under maize had a significant (P-value =1%) and a positively associated with farmers' adoption of intercropping and irrigation. Additionally, land also showed a significant (P-value=5%) with a negative influence on grass strips adoption. Gender had a significant (P-value=5%) on intercropping and (P-value=10%) on mulching with negative relationship to their adoption. Household size was significant with (P-value=5%) and a positively related on adoption of stone bunds and crop rotation. Education variable had a significant (P-value=1%) on minimum tillage and a (P-value=5%) on stone bunds but with a negative relationship on adoption.

The second objective investigated the influence of institutional factors on adoption of SWCs in Tharaka Nithi County. Multivariate Probit model also analyzed the association between three institutional factors (Extension services access, information and training, Credit access and Group membership) and the adoption of SWCs. The MVP model shows that access to extension and training was significant (P-value=1%) and a negative correlation with intercropping and grass strips while extension service access was significant (P-value=1%) and a positive association on mulching and crop rotation. Membership was significant (P-value=1%) and a positive relationship on intercropping and irrigation, also membership had a significant (P-value=5%) but a negative association on rotation and mulching. Access to credit was significant (P-value=10%) and a positive relationship on stone bunds, also access to credit had a significant (P-value=1%) but a negative influence on intercropping.

The study further sought at determining the impact or effect of adoption of soil and water conservation practices on maize production. Logit regression model estimated the propensity scores which further matched the treatment and control groups using matching algorithms of nearest neighbor, radius and stratification. The logistic model showed that land area (P-value = 0.002<0.01, P-value = 0.053<0.1, P-value = 0.021<0.05, P-value = 0.016<0.05) had significant influence on intercropping, crop rotation, irrigation and grass strips, respectively. The land area co-efficient on intercropping, crop rotation and irrigation were positive which meant that as the land size increased, the adoption of the practices increased. Land co-efficient on grass strips was negative which indicated as land size increased, grass strips adoption decreased. Household size (P-value = 0.015<0.05, P-value = 0.040<0.05, P-value = 0.081<0.1) had significant influence on intercropping, irrigation and terraces, respectively. The household size co-efficient was positive which meant that the higher the individuals living in a homestead, the greater they practiced intercropping and irrigation. The household size co-efficient was also negative on terraces suggesting the more people were in the household, the less they practiced terraces.

The age (P-value = 0.019<0.05, P-value = 0.099<0.1, P-value = 0.044<0.05) had influence on crop rotation, irrigation and mulching respectively. The age co-efficient was negative on crop rotation and irrigation which meant that as age increased, less people practiced crop rotation and irrigation meaning young farmers were more active in adoption than older people. Education (P-value = 0.001<0.01, P-value = 0.051<0.1, P-value = 0.055<0.1) was negatively significant on minimum tillage, stone bunds and irrigation, respectively. This showed that the more educated a farmer was, the less they adopted minimum tillage, stone bunds and irrigation. Extension was also examined (P-value = 0.001<0.01, P-value = 0.004<0.01, P-value = 0.001<0.01, P-value = 0.000<0.01) on intercropping, mulching, grass strips and crop rotation, respectively. The extension co-efficient on intercropping and grass strips was negative which meant that farmers who contacted extension officers practiced less of intercropping and grass strips. The extension co-efficient also was positive on mulching and crop rotation. The membership co-efficient was positive on intercropping, mulching, grass strips and irrigation which meant that belonging to a group ensured more farmers adopted the practices. The membership co-efficient was also negative on terraces and stone bunds. Access to credit had a positive co-efficient on stone bunds (P-value = 0.057<0.1) and a negative co-efficient on intercropping (P-value = 0.004<0.01).

Further, PSM analyzed the Average Treatment Effects (ATT) on the conservation practices that measured the impact on maize yield. The mean average of maize increment on intercropping was a range of about 290 kgs to 375 kgs per hectare and significant at 5%, minimum tillage decreased maize production at an approximate range of 248 kgs to 690 kgs per hectare but significant at 1%, adoption of stone bunds decreased maize yield by about 50 kgs to 287 kgs per hectare but significant at 1% and adoption of irrigation as a SWCs increased maize production at an approximate range of 270 kgs to 725 kgs per hectare and significant at 1%. This meant that when intercropping and crop rotation were adopted there was increase in productivity and high income. In addition, adoption of terraces had a negative impact and was insignificant on maize productivity with a decrease range of 70 kgs to 245 kgs per hectare, mulching as a practice increased maize production by about 250 kgs to 380 kgs per hectare but insignificant, grass strips increased maize yield with a range of about 200 kgs to 230 kgs per hectare but not significant while crop rotation decreased maize production with about 20 kgs to 90 kgs per hectare but insignificant. This meant that terraces, mulching, grass strips and crop rotation as SWCs adopted by maize farmers were insignificant.

5.2 Conclusion

Findings of this study concluded that the effect of land size, gender, household size, slope, education, soil erosion perception, group membership and extension services were significant with positive or negative association with the number of soil and water conservation methods practiced in order to curb erosion and increase maize production. Land size, household size, farmers' perception, topography of the land, extension services, group membership and access to credit were significant and had a positive influence on the adoption of SWCs. Gender and education were significant and had a negative influence on the adoption of soil and water conservation practices (SWCs).

The overall adoption rate of soil and water conservation practices (SWCs) was average. This was because SWCs adopted depended on the topography of the land and also it was contributed by factors like land size, age, gender, education, group membership among other socio-economic and institutional factors. The adopters had an increased rate of improving yields in comparison to non-adopters who did not observe most of SWCs. This clearly indicated that for effective adoption of SWCs and increase in maize production, several factors needed to be taken into account to advocate more adoption.

Maize small scale farmers return on productivity was increased by adopting intercropping and irrigation. The adoption of intercropping and irrigation was significant and had a positive Average Treatments Effects (ATT) indicating increase in maize yield. Additionally, minimum tillage and stone bunds as SWCs adopted were significant but decreased maize production. The Average Treatments Effects (ATT) on minimum tillage and stone bunds was negative indicating a production reduction in maize yield.

5.3 Recommendations

From the conclusions in the study, the following recommendations were made:

i. The government and other stakeholders are to focus and organize more training for the smallholder maize farmers and especially the younger farmers since the aging farmers are less likely to use the practices. This will not only help in increasing adoption of SWCs but also improve on crop production from young farmers.

ii. Government should place a high priority on maximizing the potential for production of maize smallholder farmers by promoting group formation, subscription and involvement. Group membership will increase on interaction with various farmers therefore gaining knowledge on SWCs.

iii. Maize small-scale farmers are urged to practice and explore soil and water conservation methods like irrigation and intercropping to avoid usage of practices that may decrease production and location-specific targeted policies from agricultural extension agents to avoid use of wrong practices in different areas increasing awareness on the importance of adopting SWCs.

iv. To increase maize yields, stakeholders and policy makers should also encourage campaigns that outline the economic benefits of SWCs so as to increase their adoption and thereafter positively impact crop yield.

5.4 Suggestion for Further Research

This study suggests that future research to include:

i. This study only focused on eight SWCs practiced on maize production therefore future research, can look into more technologies on different types of crops to examine the impact on adoption.

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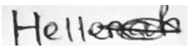
APPENDICES

Appendix I: Introductory Letter

Dear Sir/Madam

My name is Hellenah Mwendwa Gitonga, a student at Chuka University pursuing a Master of Science Degree in Agricultural Economics. I am carrying out academic research on "analysis of socioeconomic and institutional factors influencing the adoption of soil and water conservation practices and its effects on maize production." The aim of this research is to fulfill the academic requirement of award of degree at Chuka University. I kindly request you to answer the questions truthfully and honestly. All the responses attained will be treated with confidentiality, information will be used to meet the goals and objectives of the study and results will be presented to design other researches in the future. Thank you for participating.

Yours faithfully,



Gitonga Mwendwa Hellenah

Appendix II: Survey Questionnaire

Sub-county …………. Ward ………. Interview date ………… Questionnaire number …...

Part 1: Smallholder Farmer Socio-Economic Factors

1. Gender of the respondent

   1.Male

   0. Female

2. Gender of household head

   1. Male

   0. Female

3. What is the age (years) of the household head ………………………………?
4. What is the number of schooling years of the household head ……………………?
5. Level of education (Tick appropriately)

None/ illiterate	
Primary standard 1 to 6	
Primary standard 7	
Primary standard 8	
Secondary form 4	
College or higher	

6. How many people have been living in the homestead for the last 12 months, …………………?

Part 2:

7. **Farming system characteristics**

   7.1 Do you own any farming land? 1. yes_   0. no_

   7.2 If yes, how much total land do you own? (acres), ……………………………....

   7.3 Do you have a title deed?   1.yes   0. No

   7.4.1 if yes, who in the household owns this land?

Household head	
Spouse	
Household head and spouse jointly	
Son	
Daughter	
Other	

7.5 Do you farm in the forest rented/ lease/ own areas

Forest rented	
Leased areas	
Own land area	

7.6 If yes, how many acres ……………………

7.7 How many acres are under maize……………

Part 3: Soil and Water Conservation Practices

8. What is the slope of your farming plot?

Flat	
Fairly steep	
Steeper	

9. During your farming years, have you experienced any form of erosion in your farmland?

1. Yes

0. No

9.1 How do you perceive your farm to be in terms of fertility?

Fertile	
Less fertile	
Not fertile	

9.2 Have you practiced or adopted any conservation method to curb erosion?

1. Yes

0. No

9.3 If yes, what conservation method did you use?

Grass Strips	
Terracing	
Mulching	
Crop rotation	
Intercropping	
Irrigation	
Stone Bunds	
Minimum Tillage	

10. Who in the farm initiated the method?

Household head	
Spouse	
Household head and spouse jointly	
Son	
Daughter	
Other	

11. Who in the household makes the decision of what crop to be planted (maize)?

Household head	
Spouse	
Household head and spouse jointly	
Son	
Daughter	
Other	

12. What quantity of maize in kgs do you plant on your farm? Indicate …………………

13. Have you practiced or adopted any soil and water conservation method on maize production?

1.Yes

0. No

13.1 If yes, which one?

Grass Strips	
Terracing	
Mulching	
Crop rotation	
Intercropping	
Irrigation	
Stone Bunds	
Minimum Tillage	

14. From your opinion, is there any benefit associated with the practice?

1. Yes

0. No

14.1 If yes, what are some of the benefits?

i)……………………………………………………….

ii)……………………………………………………….

iii)………………………………………………………

iv)………………………………………………………

15. How many bags/kgs did you get from your maize production during the last 12 months, after the soil and water conservation method? ....

15.1 Compared to the last 12 months and the previous years, how has your production been?

Increased	
No significant change	
Declined	
Don't know	

Part 4: Research and Extension Services

Access to information and communication channels

16. Did you receive any information on soil and conservation methods in the last 12 months?

1. Yes 0. No

If yes, fill the following table, if No, skip the question

	17.1	17.2	17.3	17.4	17.5
Sources of information (use the information source code)	What kind of information did you get from the source? (Use code)	Did you get the information at the right time? 1.yes 0.no	Did you apply the information given? 1.yes 0.no	Were there any terms for provision of information? (use code)	How many times was the information provided in the last 12 months?

Information source 1. Television 2. Radio 3. Mobile phone (sms, social media) 4. Brochures 5. Newspapers 6. Other (Specify)

Kind of information 1. Inputs 2. Government initiatives/ projects 3. NGO projects and initiatives 4. Good soil and water conservation methods 5. Hybrids/ varieties 6. Climate/ weather 7. Other (specify)

Terms of provision of information 1. Free 2. Paid 3. Subscription 4. Other (specify)

17. Are you a member of any group? (self-help group, farmer groups, chama)

1.yes 0. no

17.1 If yes, are you an active participant?

1. Yes 0. No

17.2 Is there any information provided in those groups concerning soil and water conservation practices? 1.yes 0.no

If yes, 17.2, who provides the information?

Members	
NGO	
Government	
Other(specify)	

17.3 Who initiated this group?

Members	
NGO	
Government	
Other(specify)	

17.4 Are there any benefits associated with being in a membership group?

Yes	
No	
Don't know	

Extension services/training

18. Did you get any extension advice on soil and water conservation methods and maize production? 1. Yes 0. No

18.1 Did you participate in field day? 1. Yes 0. No

18.2 If yes, 18.1, how many times have you participated? Indicate……………

18.3 Home distance to the center of field day in walking hours? Indicate…………….

18.4 Did you get any training on soil and water conservation method on maize production? 1. Yes 0. No

18.5. If yes, 18.4, the number of trainings you have participated? Indicate ……………

18.6 If yes 18.4 did the training include practical demonstration? 1. Yes 0. No

18.7 What are the areas of training did you participate?

i. ……………………………………………………………….

ii. ………………………………………………………………..

iii. ……………………………………………………………….

iv. ………………………………………………………………

Access to Credit

19. In the last 5 years, did you borrow/receive any credit or financial help?

1. Yes 0. No

19.1If yes, where did you get it? Tick appropriately

Banks	
Microfinance institutions	
Saccos	
Community groups	
Family/ Neighbours	
Mobile phones	
Other(specify)	

19.2 For what purpose did you use this loan?

i. ………………………………………………..

ii. …………………………………………………

iii. …………………………………………………..

19.3 From your opinion, did this credit help you in solving matters of soil and water conservation? ………………………..

19.4 If yes, explain how?...

Thank you for taking the time to respond to the questions and participating in the study

Appendix III: Chuka University Ethics Approval Letter

CHUKA UNIVERSITY

Knowledge is Wealth *(Sapientia divitia est)* Akili ni Mali

CHUKA UNIVERSITY INSTITUTIONAL ETHICS REVIEW COMMITTEE

Telephones: 020-2310512/18
Direct Line: 0772894438

P. O. Box 109-60400, Chuka
Email: info@chuka.ac.ke,
Website: www.chuka.ac.ke

REF: **CUIERC/ NACOSTI 304**
TO: Hellen Mwendwa Gitonga

3rd August, 2022

Dear Sir/madam

RE: Analysis of Socio-Economic and Institutional Factors Influencing Small Holder Farmers Adoption of Soil and Water Conservation Practices in Maize Production, Tharaka County, Kenya

This is to inform you that *Chuka University IERC has* reviewed and approved your above research proposal. Your application approval number is *NACOSTI/NBC/AC-0812*. The approval period is 3rd August, 2022 to 3rd August,2023.

This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by *Chuka University IERC*.
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to *Chuka University IERC* within 72 hours of notification
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to *Chuka University IERC* within 72 hours
v. Clearance for export of biological specimens must be obtained from relevant institutions.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days upon completion of the study to *Chuka University IERC*.

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://research-portal.nacosti.go.ke and also obtain other clearances needed.

Yours sincerely

Dr. Benjamin Kanga
SECRETARY

Chuka University is ISO 9001:2015 Certified...

Inspiring Environmental Sustainability for Better Life

Appendix IV: NACOSTI Research License

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 416240

Date of Issue: 14/November/2022

RESEARCH LICENSE

This is to Certify that Miss.. Hellenah Mwendwa Gitonga of Chuka University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Tharaka-Nithi on the topic: Analysis of Socio-Economic and Institutional factors Influencing small-holder farmers adoption of soil and water conservation practices in maize production, Tharaka Nithi County, Kenya. for the period ending : 14/November/2023.

License No: **NACOSTI/P/22/21985**

416240

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

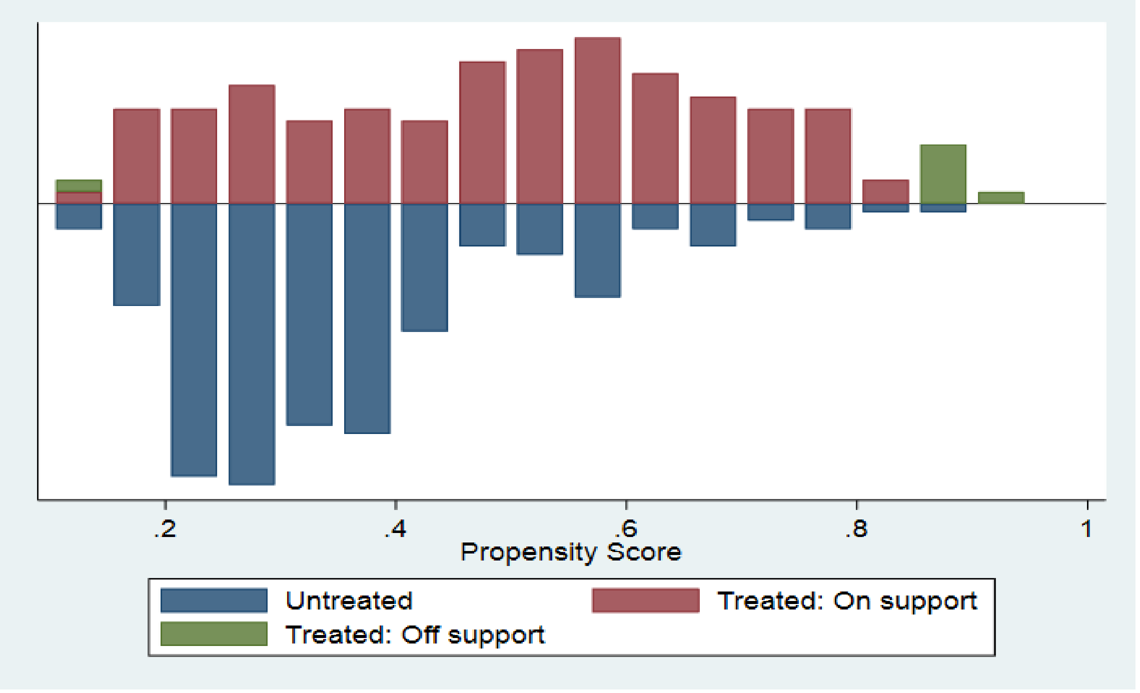
NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

See overleaf for conditions

Appendix V: Stata Output of Data Analysis for the Common Support Graph

Common Support Graph on Intercropping

Common Support Graph on Irrigation



Common Support Graph on Minimum Tillage

Common Support Graph on Stone Bunds

Appendix VI: Plates showing Data Collection