CLIMATE-SMART AGRICULTURE PRACTICES AND THEIR EFFECTS ON FARMERS' LIVELIHOODS IN SOY SUB COUNTY, UASIN-GISHU COUNTY, KENYA

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DECLARATION AND RECOMMENDATION

Declaration

This thesis is my original work and has not been presented in this university or any Other for the award of a degree

Signature…………………………………… Date: 30th July 2023

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This thesis has been submitted with our approval as university supervisors

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DEDICATION

This thesis is dedicated to my parents Mr. William Tirok and Mrs. Salome Baleon for their support during my studies, and my Role model and friend the late Prof John Mironga.

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ABSTRACT

Agriculture is considered to be "climate-smart" when farmers are in a position to adapt and sustainably mitigate climate risk and contribute to increasing food security. Climate variability poses serious economic challenges including low yields and high post-harvest losses leading to low income among farmers. The specific objectives of the study were to; to analyze perceived effects of climate smart agricultural practices on farmers' livelihoods in Soy sub-County, to determine the level of adoption of Climate Smart Approaches used to mitigate the effects of climate variability; evaluate the socio-economic factors influencing the adoption of Climate Smart Agriculture among the farming households and analyze the effects of Climate-Smart Agriculture (CSA) practices on farmers' livelihoods in Soy sub-County. A sample of 196 farming households was selected using systematic random sampling technique from Soy and Kipsomba wards. Primary data was collected using structured household questionnaires, and key informants' interview schedules. The collected data was analyzed by use of both descriptive statistics and inferential statistics. The study found out that the adoption of CSA practices is largely dependent on the household understanding of the benefits and the cost of individual CSA practices. Further, the study found that there is a significant relationship between the adoption of CSA and age and soil type. The benefit of adoption of CSA includes increased yields and raised farm income. The Government of Kenya is encouraged to enhance awareness on terracing and Agro forestry, the study also recommends the mainstreaming of gendered climate awareness on early planting and improved animal breads through demonstration plots and field days agricultural.

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LIST OF ABBREVIATIONS AND ACRONYMS

ASDS : Agricultural Sector Development Strategy
CSA : Climate-Smart Agriculture
DFID : Department for International Development
DTMA : Drought Tolerant Maize for African initiative
FAO : Food and Agricultural Organization of the United Nations
FDGs : Focus Group Discussions
GIAHS : Globally Important Agricultural Heritage Systems
GHGs : Green House Gases
GoK : Government of Kenya
IPCC : Intergovernmental Panel on Climate Change
ICRAF : International Council for Research in Agro forestry
KMD : Kenya Meteorological Department
KCSAIF : Kenya Climate Smart Agriculture Implementation Framework
MICCA : Mitigation of Climate Change in Agriculture
NIPB : National Institute for Plant Biotechnology
SDGs : Sustainable Development Goals
SLA : Sustainable Livelihood Approach
SLAF : Sustainable Livelihood Approach Framework
SPSS : Statistical Package for Social Science
USAID : United States Agency for International Development
WMO : World Meteorological Organization

CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

Climate-Smart Agriculture (CSA) practices aims to increase sustainable agricultural production by building resilience to climate variability and change. Adoption of CSA practices leads to improvement in food security and national development goals and aims to reduce Green House Gases (GHG) emissions (Steenwerth & Belina, 2008; Steenwerth et al., 2014). In 2010, at the First Global Conference on Agriculture, Food Security and Climate Change, the concept of Climate-Smart Agriculture (CSA) was presented and defined as agriculture that "sustainably increases productivity, enhances resilience, reduces greenhouse gas emissions, and enhances achievement of national food security and development goals (Lipper et al., 2014). Recent analysis indicates that although several CSA programs on-farm studies were successful, there is weak uptake of innovations, practices, and technologies (Palanisami et al., 2015). For example, new water management practices and technologies in India were adopted by only 12% of farmers in the last 40 years; similarly, adoption of mitigation options in agriculture is very low in the developing countries (Thornton & Lipper, 2014).

Climate-Smart Agriculture was adopted in Qinghai province China in joint contribution with Food and Agriculture Organization (FAO), International Council for Research in Agro forestry (ICRAF), and Chinese institutes including the Institute of Environment and Sustainable Development in Agriculture (IESDA) and the Northwest Institute of Plateau Biology (NIPB) (Deresa, 2009). The aim was to restore degraded grassland through sustainable grassland management. The implementation of approaches such as improved feeding, winter housing, post-farm processing, and marketing activities made CSA successful (Deresa, 2009).

Farmers in sub-Saharan Africa are vulnerable to climate variability given that (Deressa et al., 2008). Changes in crop cultivation suitability and associated agriculture biodiversity, reduction in input use efficiency, and prevalence of pests and diseases are some of the major effects of climate variability in agriculture (Rachmi et al., 2016). Despite vulnerability, African populations have recognized their ability to adjust to climate variability and practices to respond to threats and gain new opportunities (Funk & Brown, 2009). Adaptation choices that sustainably improve productivity, enhance resilience to climatic risk, and reduce greenhouse gas emissions are referred to as Climate-Smart Agriculture (CSA) technologies, practices, and services (Lipper et al., 2014). According to Cattaneo and Lipper (2016) the CSA was implemented in Tanzania on the southern slope of Mt Kilimanjaro under FAO's Globally Important Agricultural Heritage Systems Initiative (GIAHS). The approach succeeded since the income of the coffee farmers who were involved in the project increased by 25% within 3 years.

According to Lipper et al. (2014), since 2006, more than 100 new, drought-tolerant crop varieties and hybrids in East Africa have been developed and released across 13 countries by the Drought Tolerant Maize for Africa Initiative (DTMA). Each of these new varieties adapted to local requirements and is drought, pest, and disease resistant (Jain, 2007). In farm trials, the new varieties have yielded up to 35% more grain than those grown previously by farmers; the best hybrid out-yielded even the most popular commercial variety by 26% (Allan & Komar, 2006). Despite the various benefits of CSA technologies, the rate of adoption by farmers is fairly low (Pal, 2014). Several factors influence the extent of adoption of CSA technologies such as socio-economic characteristics of farmers, biophysical factors, and the new technologies (Deressa et al., 2011). The identification, prioritization, and promotion of available CSA technologies considering local climatic risks and demand for technology are major challenges for scaling out CSA in diverse Agro-ecological zones (Knowler & Bradshaw, 2007).

Farmers respond to climate variability phenomenon through two broad mechanisms which include mitigation and adaptation strategies and intending to moderate the adverse impact of climate variability (Allan & Komar, 2006). CSA in Kenya was first piloted in 2010 in collaboration with FAO Mitigation of Climate variability in Agriculture (MICCA) program to make agriculture knowledge based on what will take to put CSA into practice (Neate, 2013). Kenya Climate Smart Agriculture Implementation Framework (KCSAIF) 2018-2027 has been developed to provide guidelines for the implementation of CSA, strategies, practices, and technologies in Kenya, the implementations of CSA technologies have substantial potential to reduce climate variability impacts on agriculture (Schubert et al., 2021). According to Finger et al. (2007), adaptation measures such as changes in crop sowing dates and adoption of irrigation technologies can lead to higher yields. Several farm-level studies also suggest that adoption of CSA technologies can improve crop yields, increase input use effectiveness, increase net income and decrease GHG emissions (Jat et al., 2014).

In Uasin-Gishu County, farm produce is negatively affected due to Climate variability, maize farmers for instance have been adversely affected since they currently harvest 20 bags per Ha below the potential level of 40 bags per Ha (devolutionhub.or.k, 2013). Agriculture supports over 80% of households in Uasin-Gishu County in terms of income and food security (Wanjala & Njehia, 2014). About half of the inter-annual variability of agricultural production in Uasin-Gishu County is due to climate variability and between 5 to 10 % of global agricultural production is lost yearly due to unfavorable weather conditions (Wanjala & Njehia, 2014).

In Soy Sub-County there has been variation in climate evidenced variability in the onset and cessations of precipitation, extreme temperatures, variation in annual rainfall, number of rain days in a season, soil degradation, high winds, and the proliferation of diseases and pests. Hailstorms have also become more common especially in maize growing areas (Wanjala & Njehia, 2014). Consequently, experts, policymakers and other actors concerned with rural livelihoods and food security have recommended climate-smart agriculture (CSA) as a sure means of reducing the disparaging effects of climate variability in the smallholder farming sector (Lipper et al., 2014). Farmers in the sub-County have adopted various approaches to manage climate variability such as CSA.

1.2 Statement of the Problem

Agriculture is facing a myriad of challenges associated with climate variability. To address these challenges Kenyan government and the county government have advocated for different strategies Such as; sensitization of farmers on diversification of farming, early planting, and provision of subsidized fertilizers, the introduction of drought-resistant varieties, and provision of improved breeds of livestock. The National Climate Change Response Strategy (NCCRS, 2010) recommended that research is necessary for technological needs towards the improvement of agricultural yields. Soy sub-County is vulnerable to climate variability due to overreliance on rain-fed agriculture and poverty. There are possible ways of managing climate variability, including the adoption of Climate Smart Agriculture which is important in agricultural development in Soy Sub-County. However, the available information on the adoption of Climate Smart Agriculture and its effects on farmers' livelihood are scanty since it is a new concept (2018-2027), a gap that necessitated the study.

1.3 Research Objectives

1.3.1 Broad Objective

The broad objective of the study was to contribute to the understanding of Climate Smart Agriculture and its effect on livelihoods in Soy Sub-County Uasin Gishu County.

1.3.2 Specific Objectives

The study was guided by the following specific objectives;

(i) To analyze the perceived effects of Climate Smart Agriculture practices on farmers' livelihoods in Soy Sub-County.

(ii) To determine the level of farmers' adoption of Climate Smart Agriculture practices used to mitigate the effects of climate variability in Soy Sub-County.

(iii) To evaluate the farmers' socio-economic factors influencing the adoption of Climate Smart Agriculture practices among households in Soy Sub-County

1.4 Research Questions

(i) What are the perceived effects adoptions of Climate-Smart Agriculture practices on farmers' livelihoods in Soy Sub-County?

(ii) What is the level of adoption of Climate Smart Agriculture practices used to mitigate climate variability in Soy Sub-County?

(iii) What are the socio-economic factors influencing the adoption of Climate Smart Agriculture practices among households in Soy Sub-County?

1.5 Justification of the Study

Farmers in many parts of the world are increasingly adopting various CSA to mitigate the effects of climate variability (Scherr & Sthapit, 2009). The smallholder farmers in Soy Sub-County rely on rain-fed agriculture which has faced a lot of uncertainties due to climate variability. By providing information on the level of adoption of Climate Smart Agriculture practices and their effects on farmers' livelihoods, the findings of the study are expected to help smallholder farmers in making appropriate on-farm decisions in line with the expected climate conditions hence improving their livelihoods.

This study hopes to contribute to the academic debate on Climate-Smart Agriculture and climate variability adaptation, as well as wider climate variability, environmental, and development discourses. This study aimed to contribute to the growing literature on agricultural adaptation; in particular, it contributes to the understanding of factors that influence the adoption of improved technologies at the households' level. This allows evaluation of the role of household socioeconomic and institutional variables in determining farmers' choice of farming practices.

The study contributes to the realization of the *Big Four Agenda* in Kenya, in particular, the pillar on food and nutrition security (president.go.ke, 2014). Further, it provides information in the realization of Kenya′s Climate Smart Agriculture Implementation Framework (KCSAIF) 2018-2027, which envisions a Climate-Resilient and low carbon growth, sustainable agriculture that ensures food security and contributes to national development goals in line with Kenya Vision 2030 (devolutionhub.or.k, 2013).

Climate Change Act (2016) which outlines climate resilience and adaptive capacity to promote low carbon growth and to mainstream climate variability into planning processes while developing incentives to promote climate-resilient actions (devolution hub.or.k, 2013). The study is also relevant to Sustainable Development Goals (SDGs) goal number two which focuses explicitly on food by seeking to end hunger, achieve food security and improve nutrition and promote sustainable agriculture by the year 2030 (Lipper et al., 2014).

1.6 Scope and Limitations of the Study

The study was limited to Soy and Kipsomba wards due to the higher concentration of farmers practicing various agricultural activities in the sub-County. The study focused on three livelihood options in the study area including: mixed farming, formal and casual employment. The CSAs practices selected in the study area included: minimum tillage, crop rotation, terracing, agro-forestry, and mulching for crops, while for livestock; improved exotic livestock breeds and improved livestock nutrition were analyzed in the study since they were anticipated to be mostly adopted by farmers in the study area. There are many factors that influence agricultural production such as land size, soil nutrients, government policies, climate variability, pest, and diseases. However, in this study climate variability was considered the factor that has great effect on yields.

The study considered both large-scale and small-scale farmers. Primary data and secondary data were collected from august 2019 to January 2019. The study faced some challenges such as the absence of household heads during the administration of the questionnaires. The challenge was addressed by administering the questionnaire to the eldest person above 18 years who was present in the household during the questionnaire administration. The study also was faced with the challenge where some female respondents who were present during data collection period were not free to respond to some of the questions asked by the researcher. To compare the effects of CSA practices on crop yield for the farming households who had adopted and those who had not adopted the practices. Maize yields data (2017 and 2018) was collected. The two years recall period was chosen to increase accuracy of the information since farmers may not be able to recall with high degree of precision events that happened over two years ago.

1.7 Definition of Terms

Adaptation : Refers to the capacity of a system to adjust to a certain change. In this study, it refers to adjustments in livelihood systems or practices by smallholder farmers in response to actual or perceived climatic stimuli and their effects or impacts.

Adoption : It refers to the acceptance of a new product or innovation. According to this study, it is the process of implementing CSA techniques after being aware of the presence of the technologies in one's environment which is heavily affected by climate variability.

Agro-forestry **:** It is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms and bamboos) are deliberately used on the same land-management units with crops and livestock.

Climate Change : Refers to a long term shift in global or regional climate patterns.

Climate Smart Agriculture: Approaches for transforming and reorienting agricultural development under the new realities of climate change (Thornton & Lipper, 2014). In this study, CSA is operationalized to refer to approaches that contribute to enhancing the climate resilience of production, for example minimum Tillage, crop rotation, terracing etc.

Climate variability **:** Refers to variations in the seasonal rainfall characteristics: onset, cessation, amount, and the number of rainy days. In this study climate variability was operationalized to mean variation in rainfall characteristics**.**

Crop rotation **:** It is the practice of growing a series of dissimilar or different types of crops in the same land in sequenced seasons.

Farmers Wellbeing : it is the state of being comfortable, healthy, or happy. In this study, it was operationalized to mean farmers' welfare.

Food security **:** It is the physical, economic, social, and environmental access to a balanced diet and clean drinking water for every child-woman and man. In the study was operationalized to mean agricultural production.

Household head : This is the eldest person above the age of 18 years present in the household at the time of questionnaire administration.

Household : people who live within the same compound and have the same cooking arrangements.

Livelihood : Defined as stocks and flows of food and cash to meet basic needs (Chambers & Conway, 1992). Farming was considered as the main source of livelihood for most households in Soy sub-County.

Livestock breeding **:** It is the process of selective mating of livestock with desirable genetic traits to maintain or enhance these traits in future generations. It is operationalized to mean selective mating of cattle goats and sheep.

Livestock nutrition **:** it focuses on the dietary needs of animals in agriculture and food production. Livestock nutrition was operationalized to mean the supplementation and conservation of fodder and pastures for livestock

Minimum/Zero Tillage: This is a practice of minimizing soil disturbance and allowing crop residue or stubble to remain on the ground instead of being thrown away or incorporated into the soil.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter reviewed relevant literature on Climate Variability and Adaptation approaches, factors influencing adoption of Climate Smart Agriculture, effects of adoption of Climate-Smart Agriculture in agricultural decision-making, theoretical and conceptual frameworks.

2.2 Climate Variability and Adaptation Approaches

Adaptation to climate variability refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (Albritton et al., 2001). Common adaptation methods in agriculture include the use of new crop varieties and livestock species that are better suited to drier conditions, irrigation, crop diversification, adoption of mixed crop and livestock farming systems, and changing planting dates (Knowler & Bradshaw, 2007). Adaption to climate variability is significant since it leads to reduction of flooding, erosion, reduction of pests, and diseases infestation (Altieri et al., 2015).

India has a long history of agricultural insurance schemes, starting with a pilot program for cotton farmers in Gujarat in 2003. This led to the Comprehensive Crop Insurance scheme in 2006, which was subsequently replaced by the National Agricultural Insurance Scheme (NAIS) in 2008 (Shirsath et al., 2017). Crop yields were independently checked each year on a sample of farms within a sub-district and farmers received pay-out if the yield were below a certain percentage of the long-term, average yield for the area. The scheme works reasonably well for widespread events such as drought and becomes relatively cheap to run since yields do not have to be checked on each farm. However, payouts tend to be delayed, taking up to 2 years to reach affected farmers. Therefore, weather-based crop insurance encourages farmers in India to invest in their crops boosting food security and resilience of smallholder product systems.

Climate-Smart Agriculture (CSA) requires farmers to use farming methods that make them more resistant to climate change and uncertainty (Zhao et al., 2023). Some of these methods are agroforestry systems, agroforestry systems, precision agriculture techniques, and improved water management. CSA helps farmers adjust to changing weather and keep up their farming output.

Changes in the climate often affect the amount and quality of water. Communities can deal with changing rain patterns and times when there isn't enough water by using water management techniques like collecting rainwater, using irrigation water efficiently, and conserving water.

In Sub-Saharan Africa, climate variability is set to hit the agricultural sector and cause untold suffering, particularly for smallholder farmers. To cushion themselves against the potential welfare losses, smallholder farmers need to recognize the changes already taking place in their climate and undertake appropriate investments towards adaptation (McLeman & Smit, 2006). Increased climate variability exacerbates production risks and challenges farmers' coping ability. Climate change poses a threat to food access for both rural and urban populations by reducing agricultural production and incomes, increasing risks and disrupting markets (Zougmoré et al., 2018). Young producers, the landless and marginalized ethnic groups are particularly vulnerable. The impact of extreme climate events can be long lasting, as risk exposure and increased uncertainty affect investment incentives and reduce the likelihood of effective farm innovations, while increasing that of low-risk, low-return activities (Dagdeviren et al., 2021).

Ecosystem-based adaptation places an emphasis on using ecosystems' inherent capabilities to help people adjust to climate change (Zougmoré et al., 2018). Green infrastructure can be established in metropolitan areas to reduce the effects of heatwaves and heavy rains, and restoration of wetlands can serve as natural flood buffers. Vulnerability to climate change can be mitigated through the design and construction of climate-resilient infrastructure. Buildings that can endure natural disasters, improved drainage systems for greater precipitation, and water purification plants that can adapt to varying water quality are all examples.

According to Komba and Muchapondwa (2018), farmers in Tanzania adopted irrigation, short-season crops, shifted sowing dates, and engaged in the planting of trees as measures to adapt to climate variability. Farmers adjust their farming calendar to adapt to climate variability (Kaplinsky et al., 2002). For instance, the pest that can be present in the soil can be eliminated when land preparation is done earlier since the scorching sun has been shown to kill pests, at the same time soil structure disturbance is minimized (Beddington et al., 2012).

According to Swanton et al. (2015), the poor performance of crops under rain-fed dependent cropping systems in Kenya can be avoided through timely planting in the semi-arid environment.

In addition, plant competition for their germination requirements such as nutrients in the soil and water is significantly reduced by practices such as weeding. Furthermore, when farmers practice weeding appropriately and more frequently help to control pests in which is controlled by the seasonal climate forecast information which is vital in making on-farm decisions on adaptation strategies (Recha et al., 2008). Other adaptive approaches include off-season production and weather-based insurance. Off-season production is where some farmers grow their crops at different periods of the year. When other farmers wait for their usual time of planting, enabling them to capture good market returns during scarcity and bring stabilization of prices in the market throughout the year (Gebey et al., 2010). Climate variability is already hampering agricultural growth. According to the Intergovernmental Panel on Climate Change (IPCC), climate change affects crop production in several regions of the world, with negative effects more common than positive, and developing countries highly vulnerable to further negative impacts. Increases in the frequency and intensity of extreme events such as drought, heavy rainfall, flooding and high maximum temperatures are already occurring and expected to accelerate in many regions (Maxwell et al., 2019).

Effective early warning systems can provide timely information about imminent extreme weather events such as hurricanes, floods, and heatwaves. Early warnings enable communities to prepare and take the necessary steps to mitigate potential risks and damages (Zhao et al., 2023). It is essential to disseminate accurate and localized climate information for effective decision-making and adaptation planning. CIS provides pertinent climate data to farmers, communities, and policymakers so they can make informed decisions about land use, crop selection, and disaster preparedness.

Enhancing social networks, community cohesion, and local institutions can improve climate variability resilience (Zougmoré et al., 2018). According to Zhao et al. (2023) strong social connections equip communities to respond collectively to climate-related challenges and recover more quickly from climate-related catastrophes. Diversifying sources of income and means of subsistence can reduce reliance on climate-sensitive activities. During agricultural downturns, promoting ecotourism, small-scale industries, and non-agricultural enterprises can provide alternative sources of income.

Incorporating climate considerations into development projects, such as infrastructure development, urban planning, and calamity risk reduction initiatives, can guarantee that investments are climate-resilient and resistant to the effects of climate variability (Singh & Singh, 2017). Promoting community-level knowledge sharing and capacity development is essential for effective climate adaptation. Training and awareness programs contribute to the development of local expertise and empower individuals to implement suitable adaptation strategies.

2.3 Adoption of Climate-Smart Agriculture Practices

Climate-Smart Agriculture is aimed at achieving global food security by enabling farmers to manage and create a viable agricultural system. Climate-Smart Agriculture supports farming communities to adapt to climate variability through building the resilience of agricultural livelihoods and ecosystems, and, wherever possible, to deliver the co-benefits of reduced Green House Gases GHG emissions (Zougmoré et al., 2014). Sultan et al. (2004) observed that farmers who are dependent on rain-fed agriculture prefer an adaptation to climate variability to be the best way of realizing sustainable agricultural output as humans may not stop variation of climate. The best approach to reduce the negative effects of climate variability is implementing the most appropriate adaptation technique (Singh & Singh, 2017).

Climate-Smart Agriculture practices help in transforming and reorienting agricultural systems to efficiently sustain development and ensure food security in scenario of variation of climate (Maguza-Tembo et al., 2017). The main objectives of CSA are: sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate variability; and reducing and removing greenhouse gas emissions, where possible CSA approach develops agricultural strategies to secure sustainable food security in light of climate variability (Mendelsohn, 2009). According to Lipper et al. (2014) CSA provides the means to help stakeholders from local to national and international levels identify agricultural strategies suitable to their local condition, CSA is one of the 11 Corporate Areas for Resource Mobilization under the FAO's Strategic Objectives, it is in line with FAO's vision for Sustainable Food and Agriculture and supports FAO's goal to make agriculture, forestry, and fisheries more productive and more sustainable.

According to Carpenter (2011), pest-resistant crops boost the climate-resilient of the farming system and have a high capacity to mitigate climate variability in London. Pest-resistant crops lessen the burden of farmers purchasing chemicals for controlling weeds; moreover, the chemicals they require to use are less toxic than previous generations of herbicides and pesticides (Levidow & Carr, 2007). A great advantage of pest-resistant crop varieties is that they facilitate weed control under reduced tillage, as they are not harmed by broad-spectrum herbicides for example; the canola variety of oilseed grape was introduced in Canada in 1995, and now accounts for about 95% of the national crop (Lal, 2004).

Zero tillage or minimum tillage is an approach that is practiced to conserve resources since it reduces the cost of production as compared to conventional tillage system (CS) with effects on soil moisture and temperature. Rainwater penetration in soil and the increase of the water storage in the soil profile is influenced by the amount and intensity of rainfall, water and soil temperature, slope and landform, hydro-physical properties, soil texture, and compaction. These soil properties are closely interdependent and are influenced by the tillage system (Zougmoré et al., 2014).

The adoption of a minimum tillage system reduces fuel consumption through less mechanized weeding and the necessity of ploughing land before planting (Ngoma, 2018). Terracing system is an approach that is significant since the participation of farmers in the initiative enabled them to value the indigenous agricultural technologies to guarantee their conservation while providing sustainable development conditions for present and future generations and controlling land degradation (Altieri, 2002). Crop diversification ensures differential nutrient uptake and use between two crops. For instance, the inclusion of nitrogen-fixing crops such as groundnuts, beans, and cowpeas will enhance soil fertility and nutrient supply to subsequent crops (Lal, 2004).

Crop diversification over time can be considered as a safety net on farmers' income if one crop is severely affected by climate extremes. Almost any agricultural practice or outcome currently qualifies as climate-smart, however, suggesting that CSA is a triple win for all without regrets, losers, and trade-offs. Thus, CSA can easily be appropriated for a wide range of conflicting agendas. The approaches that improve resource use efficiency through, higher productivity crop and livestock breeds, improved crop management, and animal husbandry can be considered as Climate-Smart Agriculture because they contribute to slowing the rate of climate variability (Shirsath et al., 2017). Virtually any agricultural practice that reduces exposure, sensitivity, or vulnerability to climate variability or change, for instance, water harvesting, terracing, mulching, drought-tolerant crops, index insurances, communal actions, are also climate-smart because they enhance farmers 'ability to cope with weather extremes. Likewise, agricultural practices that sequester carbon from the atmosphere, for example, Agro forestry, minimum tillage, reduce agricultural emissions like manure management, biogas plants, reduced conversion of forests and rangeland.

The implementation of CSA is faced with challenges such as high cost of innovation, inadequate research extension, and farmers linkages, limited experts with specialized training to handle such emerging issues as it entails innovation and adaptation, CSA is an emerging issue in agriculture that has attracted limited capacity of personnel with specialized training to handle such emerging issues, moreover, there is the inadequacy of integration of CSA related issues in technology development and dissemination (Kpadonou et al., 2017). As past encounter appears, prompt and uniform selection of innovations-in agriculture such as climate smart agriculture practices, is very uncommon. In most cases, the adoption behavior contrasts over financial bunches and over time. A few advancements have been well gotten while other changes have been embraced as it were an awfully little gather of agriculturists (Schottli & Jha, 2023).

2.4 Factors Influencing the Adoption of Climate-Smart Agriculture

Adaptation and vulnerability to variation of climate depend on; farm output, regional climate, and farmers' socio-economic characteristics. These factors interact with large regional differences across different regions (Chinasho et al., 2022). The most significant factors influencing the choice of a specific adaptation strategy include farming experience, level of education, farm size, gender, and farming experience (Assoumana et al., 2016). According to Kumari (2018) educated and experienced farmers in India are expected to have more knowledge and information about climate variability and the agro-economic practices that can be used to respond to climate variability. The decision to use more than one strategy in coping up with climate variability is influenced by the size of the farm. Thus large-scale farmers are more likely to adapt to climate variability because they have more capital and resources (Chalchisa & Sani, 2016). Adaptation to climate variability is planned when the actions that are taken are meant to reduce risks and utilize new opportunities brought about by global climate variability (Arnell et al., 2005).

According to Al-Hassan et al. (2013), informal credit and farmer-to-farmer extensions were the main factors influencing the choices of indigenous climate-related strategies among smallholder farmers in Northern Ghana. Further, the descriptive results revealed that few sampled farmers used short-duration crops and most of them altered the planting dates appropriately. According to Yegbemey et al. (2013) on farmers' climate variability adaptation decisions under various property rights in Benin found that access to credit positively and significantly influenced farming calendar adjustments. According to Igbalajobi et al. (2013) access to credit, years of formal education, access to information on climate variability, farming experience, and access to extension services positively influenced adjustment of planting date and growing of different varieties as adaptation measures in Nigeria. Gbetibouo (2009) examined the factors determining farmers' choice of adaptation strategies to climate change and variability in the Limpopo South African. The discoveries uncovered that whereas farming encounter, cultivate estimate, soil fertility, temperature, off-farm salary, perceived increasing temperature and extension services access emphatically affected farmers' choice of adjustment techniques; riches was found to apply negative impact on such decisions of farmers.

Changes in rainfall, instruction level of farmers and access to climate data was not significant. Deressa et al. (2009) reported that that an experienced farmer who lived in the Nile l of Ethiopia over a period of ten a long time was more familiar with climatic conditions within the region and effectively adjusted to the changing environment by embracing one of the traditional adjustment hones compared to the less experienced agriculturist. Although CSA methods are employed in several of Kenya's agro-ecological zones, only a small percentage of the population has adopted them. Low and medium adoption rates for climate-smart practices are connected to physical, institutional, and financial issues for both farmers and other agriculture value chain players.

Assessing farmers' adaptation to climate variability effects in Kyuso District in Kenya, (Kefa et al., 2012) found that the probability of farmers adapting to variability is influenced by age of the farmer, farm income, education, gender, access to climate information, household size, farming experience, access to credit, local agro ecology, access to irrigation water, distance to market, temperature and rainfall. Farmers simultaneously adopt several adaptation options at a time.

Ahmed (2014) asserts that the farmer's perceptions of these technologies and their features have an impact on the adoption of CSA methods. Smallholder farmers may be influenced by their social environment in terms of their subjective preferences for CSA technique aspects. We take into account the adoption of farmers' neighbors, their social contacts, and their effects on the rate at which different CSA approaches are adopted for these reasons. We also distinguish between behaviors that are short-term and long-term, whose dynamics can change, in our ABM models.

Knowledge of climate change and its effects on agriculture is a key driver of CSA implementation (Abid et al., 2015). Farmers that are aware of shifting weather patterns, an increase in the frequency of extreme events, and the need for sustainable methods are more likely to adopt CSA. Farmers must have access to CSA techniques, understand their advantages, and be aware of any potential difficulties (Sebatta et al., 2014). The distribution of knowledge about CSA techniques is greatly aided through training initiatives, seminars, and extension services. The study finds that smallholder farmers' CSA practices are positively impacted by education. This shows that education enables farmers to decide with knowledge and see opportunities for maximizing profits related to their farms. As a result, this element is necessary for the adoption and growth of CSA techniques among rural producers.

Farmers that have stable land tenure are more likely to make investments in CSA practices that will pay off in the long run. Producers may be deterred from making long-term investments by the insecurity of their land tenure. Secure land tenure and property rights are necessary for long-term investments in CSA (Ade & Bosede, 2016). Climate change and unpredictable weather are major risks to agricultural production and the rural livelihoods of smallholder farmers, according to (Murray et al., 2016), and farmers with secure land tenure are more inclined to adjust their agricultural techniques for long-term advantage. According to current predictions, worldwide annual rainfall will rise by the end of the century, but regional variations in precipitation's amount and severity will be large (Harvey et al., 2014; IPCC, 2014). Unless we dramatically reduce our annual emissions of billions of tons, GHG absorptions in the atmosphere will keep rising. Agriculture will be negatively impacted by these climate changes in a number of ways

(Arora, 2019; IPCC, 2014).

Institutions and policies open to CSA can have a big impact on how widely it is adopted. Governments may provide financial incentives, subsidies, or insurance schemes to entice farmers to use climate-smart techniques (Harvey et al., 2014). An effective institutional framework can make it easier to access resources and credit. Policies that support CSA at the federal, state, and municipal levels can have a significant impact on adoption rates. Governments may provide financial incentives, subsidies, or insurance coverage to entice farmers to adopt climate-smart practices. Investments in CSA technology research and development may also be part of supportive policies

Adoption of CSA is negatively correlated with respondents' farmland's proximity to their home, which is statistically significant. As a result, farmers who crop far from their homes are probably less inclined to employ CSA practices. They may find it more challenging to conduct good and efficient management than their friends who live closer to their farms due to the stress that comes with distance. Distances can affect important components of agriculture, such as access to technology, expertise, and financial institutions, in addition to affecting market accessibility (Abegunde et al., 2020; Teklewold et al., 2013).

Another significant element that affected the implementation of CSA procedures in the study area was the size of the farms (Kom et al., 2020). According to this study, farmers who owned greater tracts of land used CSA practices more frequently, proving that incentivizing farmers to do so is a good thing. This outcome is in line with the conclusions made by Teklewold et al. (2013). The findings support those of Abegunde et al. (2020), who found that land fragmentation can be a barrier to CSA deployment. Farmer households with access to land and other resources will be able to put the innovations or techniques required for a successful agricultural enterprise into practice. Land is a fundamental component of agricultural output.

Farmers in the study area predict that climate change will have a severe influence on agricultural production, especially for heavy users. Additionally, this study suggests that farmers would implement more CSA techniques if they thought climate change had a large detrimental influence on crop production. This results is supported by Teklewold et al. (2013), Justin et al. (2017), and Abegunde et al. (2020). According to the study, farmers were more likely to use more CSA practices when they noticed an increase in flooding and changes in the amount of precipitation in their area. The fact that farmers who see the threat posed by extreme weather and shifting climatic trends also acknowledge the significance of CSA practices in boosting their resilience to climate effects means that this outcome is not at all surprising. According to the research on farmers' perceptions of climate change, CSA adoption in the region's farming system will rise in the future if farmers have sufficient understanding of climate change's detrimental effects on agricultural output.

2.5 Effects of Adoption of Climate-Smart Agriculture on Agriculture Decision Making

Agriculture is vulnerable to climate events. New technologies and production strategies among peasant farmers may be beyond their risk tolerance, given that failure may be catastrophic (Lipper et al., 2014). According to Gurjar and Swami (2019) there is a strong negative relationship in farming between household food security and innovation since there is a correlation between lack of innovation in farming practices and the number of food deficit months. This makes many poor households to be simply unable to save sufficiently to invest in high-return strategies. Stakeholders such as the World Bank, in collaboration with international Centre for Tropical Agriculture (CIAT) have begun to establish technical indicators in order to identify diverse strategies and compare them in terms of climate smartness (Castells-Quintana et al., 2018). These assess the technical potential of various agricultural techniques in terms of their ability to boost productivity, adapt, and mitigate climate change. Because of the wide range of effects of such tactics on people from various backgrounds, the indicators are weighted and quantified according to national and regional contexts, and may differ significantly from one country to the next (Benzie et al., 2018). In general, the indicators were scored from 1 (low potential) to 5 (high potential) in each area and assess positive improvements resulting from the application of CSA technologies.

The adoption of CSA contributes to climate variability adaptation and mitigation of greenhouse gases (GHGs), approaches such as agro forestry, zero tillage, and use of cover crops increase the amount of carbon sequestered in the soil (Comoé, 2013). The adoption of CSA can have long-term household benefits in terms of increased yields and make farming systems more resilient to variation in climate. The approaches generate positive benefits locally in terms of household and community level, as well as the public in reduced atmospheric carbon. However, adoption of many CSA practices has been very slow, particularly in food insecure and vulnerable regions in sub-Saharan Africa, the regions which have adopted the approaches increase their productivity as a result of improved soil characteristics and water retention (Giller et al., 2009). Agro forestry generates adaptation benefits through its impacts on reducing soil and water erosion, reducing yields variation, and improving water management. Agro forestry also contributes to carbon sequestration above ground and below ground, thereby contributing to GHG mitigation (Dhyani et al., 2020). Agro forestry has been practiced and succeeded in Indonesia, and Colombia, in Kenya it involves the planting of *the Grevillea* Agro forestry system and *shelterbelts* in Togo (Adenle et al., 2019).

Reduced or Zero tillage leads to minimized soil disturbance, increases water retention and improves soil structure and aeration, also reduces yield variability due to extreme weather events (Blanco-Canqui & Lal, 2009). Thus, zero tillage practice increases farm system resilience and improves the capacity of farmers to adapt to climate variability, moreover, such practices may reduce carbon losses that occur with ploughing and also sequester carbon through residue incorporation and reduced erosion (Shrestha et al., 2013). However, in many circumstances, farmers who adopt Zero tillage still periodically plough the land improving yields without compromising the gains in terms of resilience and adaptability, releasing stored carbon (Puig-Sirera et al., 2022). Zero/ minimum tillage has been practiced and succeeded in the following countries; wheat and Barley farming in Morocco, minimum tillage and direct planting in Ghana, and small-scale conservation tillage in Kenya (Kassam et al., 2019).

A cover crop can alleviate potential weed problems where herbicides are not available or accessible to poor smallholder farmers. Cover crops such as leaving residues on the field or improved fallows ensure that soil is not left bare after harvest and decomposes easily replenishing soil fertility (Matata et al., 2010). Continuous cover crops are significant to farmers since it helps in weed suppression and pest control. In terms of adaptation, the practices reduce erosion and enhance water retention which enhances resilience to drought. Population pressure and the need for continuous cultivation increases the rate of adoption of cover crops, however, due to the high rate of poverty in other regions high population pressure have instead led to the abandonment of cover crops and severe land degradation and where weeds and pests problems are greater (Showers, 2005).

CSA helps to improve food security for the poor and marginalized group through proper land management practices that build the resilience in agriculture and adaptive capacity of farmers' households to climate variability, while also reducing food waste (Azadi et al., 2021). CSA also improves the relationship between agriculture and poverty since agriculture is the main source of food, employment, and income for many people living in developing countries. Crop rotation, mulching, and minimum/ zero tillage are the components of conservation agriculture since they are approaches that aim at minimizing soil disturbances and minimizing bare and uncovered soil (Blanco & Lal, 2008).

The implementation of Climate-Smart Agriculture (CSA) can have a number of positive effects on agricultural systems, the environment, and rural communities. CSA techniques are intended to improve climate change resilience, increase agricultural sustainability, and reduce greenhouse gas emissions (Kassam et al., 2019). CSA practices assist farmers in coping with the effects of climate change, such as severe weather, droughts, and floods. By utilizing climate-resilient crop varieties, diverse agricultural systems, and water management techniques, farmers are better able to adapt to changing climatic conditions.

CSA can increase crop productivity and diversification, thereby boosting food production and dietary quality. By combining livestock and crops, CSA can generate more nutritious and balanced diets for rural communities. The CSA promotes the prudent utilization of natural resources such as soil, water, and nutrients (Azadi et al., 2021). Techniques such as precision irrigation, agroforestry, and conservation agriculture aid in preventing resource depletion and degradation.

Climate-Smart Agriculture techniques contribute to the reduction of greenhouse gas emissions from agricultural processes. For example, no-till agriculture and the use of cover crops can help sequester carbon in the soil, while improved animal management can help reduce methane emissions (Dhyani et al., 2020). CSA often involves farming practices that increase biodiversity. Crop rotation, integrated pest management, and agroforestry all contribute to the preservation of diverse ecosystems, which benefits agriculture and the environment.

In Kenya, it was estimated that the 2008-2013 droughts alone cause 23% of crop losses nationally (devolutionhub.or.k, 2013). The implementations of CSA technologies individually or in combination have substantial potential to reduce the effects of climate variability on agriculture. A meta-analysis of crop simulation under several climate situations found that farm-level adaptations can increase crop yields by an average of 7–15% when compared to without adaptation (Ngoma, 2018). Various studies show that the benefits of adaptation differ from one region to the other and with temperature and rainfall changes (Jones et al., 2007). Similarly, several farm-level studies also suggest that the adoption of CSA technologies can improve crop yields, increase input use effectiveness, increase net income and decrease GHG emissions (Shirsath et al., 2017).

The CSA is faced with challenges during the adoption; mulching is done in semi-arid regions where termites are abundant, surface mulch will be eaten by the termites limiting the benefits of CSA (Sanginga & Woomer, 2009). Zero/minimum tillage is affected by animals that graze in post-harvested lands, since animals remove the residue leaving too little residue to adequately cover the field and grazing may be sufficient, moreover grazing is too heavy to compact the soil, making planting with zero-tillage more difficult (Bot & Benites, 2005). The CSA practices require greater management skills than the traditional system, hence farmers require new approaches and more sophisticated systems, and farmers perceive the risk of adopting CSA as a key constraint to adoption in the African context (Mizik, 2021). Security of tenure may also influence the adoption of such practices to the extent that greater security increases incentives to invest for the long-run increase in yields and greater yield stability (Rashid, 2021).

Adapting to climate change can open up new market opportunities (Abegunde et al., 2020). Farmers now have a competitive advantage since businesses and consumers demand sustainable and ecologically friendly products more and more. Contour plowing and terracing, two CSA techniques, protect agricultural lands and towns downstream by halting soil erosion and lowering the likelihood of flooding (Teklewold et al., 2013). By giving excluded individuals the chance to earn an income, advancing gender equality in agriculture, and empowering women producers who frequently play a crucial role in food production CSA can have significant social consequences.

2.6 Effects of Rainfall Variability on Crop and Livestock Farming

Rainfall significantly affects how people live and how land is used (Marchant & Lane, 2014; Reid et al., 2015). Because of this, places with an average annual rainfall of at least 700 mm are likely to be dominated by rain-fed agricultural activities, while areas with low and/or highly variable rainfall regimes are typically dominated by pastoralism as the main means of subsistence (Ogutu et al., 2008). According to Megersa et al. (2014) rural poor pastoralists in developing nations are most susceptible to the effects of climate change and unpredictable rainfall. Multispecies husbandry has gradually supplanted cow pastoralism as a result of climatic change and variability (Watson et al., 2016). Although the degree of exposure varies locally, researchers and policymakers concur that rainfall variability in East Africa have had far-reaching effects and disastrous repercussions (Omondi et al., 2012).

In order to adapt to climatic and environmental changes, pastoralists have long varied their husbandry approaches and management methods (Megersa et al., 2014). They now have a wider variety of cattle, more grazing and browsing grounds, and pastures for both the dry and wet seasons (Ankrah et al,. 2023). As a result of labor-saving measures, pastoralist households are sometimes very large (Naess, 2012). In addition, pastoralists keep sizable herds to guarantee that enough animals endure to rebuild herds after a drought (McPeak, 2005). A growing human population, steady or dropping animal populations, and a declining area of rangeland are only a few of the constraints on this mix of adaptive techniques (Megersa et al., 2014).

Giridhar, K., & Samireddypalle (2015) reported that plant tissues lignify when precipitation variability rises, becoming less digestible, and changing in composition to include less appealing species. It may be more difficult for smallholders to manage feed shortages during the dry season as a result of these adjustments to manage changes in land use and cover that contain undesirable compositions of animal forage species (Thornton et al., 2009). The need for a thorough analysis of the effects of rainfall variability on traditional cow pastoralism and family food security arises from rising livestock mortality (Thornton et al., 2014).

Rainfall events are becoming less common in significant sections of central and north India, whereas they are becoming more often in peninsular, east, and north east India (Guhathakurta et al., 2011). Climate drivers, which occur at widely variable temporal (seasonal, annual, decadal, and multi-decadal) and spatial scales, have been related to inter annual variability in rainfall in Australia (Risbey et al., 2009; Nardone et al. 2010). The importance of rainfall to plants cannot be overstated since rainfall determines the amount of moisture in the soil that is eventually made available to plants (Mesike & Esekhade, 2014).

Climate variability, such as precipitation and temperature, affects crop growth stages and, as a result, affects agricultural yield. During the crop season, differences in seasonal rainfall timing make it difficult for farmers to choose the best time to sow crop seeds and apply agricultural inputs. Due to climatic variability, new issues are emerging, such as increased intensity of disease infestation in crops and growth of new crop diseases. Natural disasters, notably drought and flood occurrences, have become more common around the world (Thompson & Zhang, 2021). Distribution of crops and livestock in Kenya is influenced by geography (agro-ecological zones) distance to market, and cultural diversity of the Kenyan people. In Kenya, the agricultural value chain is influenced by financial services, value chain suppliers and supporting services. However, the type of interaction in the value chain depends on the type of value chain at play. It’s established that multi-national companies and government policy shape the agricultural value chain in Kenya (Recha et al., 2008).

According to Ogenga et al. (2018) Rainfall variability, characterized by irregular and unpredictable changes in the timing and amount of precipitation, has significant effects on both crop and livestock farming. As climate change intensifies, rainfall patterns are becoming more erratic, posing challenges for farmers worldwide. The rainfall variability such as insufficient or excess rainfall can lead to fluctuating crop yields (Dube & Pickup, 2001). Droughts can cause water stress, stunted growth, and yield losses, while heavy rains and flooding can damage crops, promote disease, and result in yield reductions. As a result, farmers may need to adjust their crop selection based on rainfall patterns. Drought-resistant or water-efficient crops become more desirable in areas with decreased rainfall, while flood-tolerant varieties may be preferred in regions experiencing more intense rainfall events.

Altered rainfall patterns can influence the prevalence and distribution of pests and diseases. Increased moisture might lead to the proliferation of certain pests and diseases, affecting crop health and yield (Kinda & Badolo, 2019). Farmers need to adopt appropriate water management practices to cope with rainfall variability. In regions facing water scarcity, techniques like rainwater harvesting and efficient irrigation become critical. Inconsistent crop yields due to rainfall variability can lead to price fluctuations in agricultural markets. This can impact farmers' income and food security. Heavy rainfall events can result in soil erosion, leading to nutrient loss and reduced soil fertility, which can negatively affect crop productivity. Unpredictable rainfall can cause delays in planting and harvesting, affecting the timing of farm operations and potentially reducing crop yields (Ogenga et al., 2018).

Rainfall variability affects livestock farming to great extent (Graef & Haigis, 2001). According to Rainfall variability influences the growth and availability of forage for livestock. Prolonged dry spells reduce pasture quality and quantity, leading to feed shortages. According to Kinda & Badolo (2019) poor pasture quality and limited water availability can lead to malnutrition and health issues among livestock. It may also make animals more susceptible to diseases. Insufficient rainfall can cause water scarcity for livestock, affecting their health and productivity. Adequate water sources become crucial during dry periods.

During prolonged dry spells, pastoralists and livestock farmers may be forced to move their herds in search of water and forage, leading to conflicts and resource competition. Rainfall variability can impact livestock reproduction rates and growth rates, affecting the overall productivity of livestock farms. Fluctuations in livestock productivity due to rainfall variability can lead to price volatility in the livestock market, affecting farmers' income (Teklewold et al., 2013).

Precipitation patterns can influence the occurrence and distribution of parasites and diseases (Kinda & Badolo, 2019). Increased moisture accelerate the spread of some pests and diseases, thus impacting crop health and output. Unpredictable precipitation also cause planting and harvesting delays, causing farm operations to be rescheduled and thus lowering crop yields (Ogenga et al., 2018). The fluctuation of rainfall has a substantial impact on cattle husbandry (Graef & Haigis, 2001). Precipitation variability affects the growth and availability of cattle feed. Prolonged dry times reduce pasture quality and quantity, resulting in feed shortages.

According to Kinda and Badolo (2019), poor pasture quality and inadequate water availability might lead to animal malnutrition and health issues. It may also make animals more susceptible to disease. Water scarcity for livestock hurts the health and productivity of livestock. Pastoralists and livestock producers may be forced to relocate their herds in search of water and forage, which could lead to resource conflicts and violence (Dube & Pickup, 2001). Precipitation variability can alter animal reproductive and growth rates, affecting the total productivity of livestock farms. Teklewold et al. (2013) discovered that variations in livestock production caused by rainfall variability can contribute to price volatility in the livestock market, impacting farmers' income.

According to Graef and Haigis (2001), farmers must develop appropriate water management strategies to deal with rainfall variability. Rainwater gathering and proper irrigation become critical in water-stressed areas. Precipitation variability can lead to variable crop yields, which can cause price volatility in agricultural markets. Farmers' income and nutritional security may suffer as a result. Heavy rains can cause soil erosion, nitrogen loss, and decreased soil fertility, all of which can reduce agricultural output.

Soil moisture availability, rainfall volume, timing of onset and termination, and the length of the growing period all impact agricultural crop productivity from the perspective of rainfall variability (Bedane et al., 2022). Reduced crop yields can be attributed to erratic rainfall patterns because of their effect on the soil's ability to retain water. When it comes to solving the social and economic challenges faced by farmers who rely only on rainfall, having access to yearly and seasonal rainfall data is crucial. When organizing their work on the farm, most farmers rely on forecasts they've seen in the past. They may find it challenging to record the variability of rainfall and plan agricultural management strategies in a changing environment.

2.7 Summary of Knowledge Gaps

The adoption of Climate-Smart Agriculture (CSA) plays a key role in promoting resilience to climate variability, improvement of household income, and increase in agricultural productivity despite the prevailing adverse effects of climate variability hence farmers' wellbeing. Previous studies on the effects of adopting CSA did not come up with negative effects of CSA approaches; the current study analyzes both the negative and positive effects of CSA on farmers' livelihoods and environmental sustainability.

CSA has been proposed as a potential solution that could achieve the twin objective of improving agricultural production and climate goals and therefore improving the sustainability of communities and landscape. To qualify as CSA, agricultural practice must be context-specific and responsive to the priorities of the communities where they are introduced instead of proposing a generalized list of CSA practices. Previous studies considered producing a generalized list of CSA in the current study CSA practices were established through a process of interaction and exchange with various scientific and local knowledge sources. Farmers willing to adopt CSA on their farms are influenced by the availability of capital especially where the approaches to be implemented are expensive. This study assessed whether farmers in the study area can get extension or credit services that can support them in the implementation of the adaptive approaches especially CSA.

Farmers adopt adaptive approaches to different degrees and focused on general adaptation strategies, unlike the previous studies that focused on general climate variability adaptation strategies, the current study put more emphasis on CSA as an aspect of adaptation to climate variability, while examining institutional and socio-economic factors that explain factors influencing farmers' efforts while adopting CSA to manage climate variability in Soy Sub-County.

2.8 Theoretical Framework

This study was anchored on "The Sustainable Livelihoods Approach Framework (SLAF)" as the main theory. The sustainable Livelihood framework is used in assessing households' capacity to respond to and cope with perceived and actual hazards that constrain population livelihoods and identify ways of enhancing resilience (DFID, 1999). A livelihood framework is significant in this study since it is a tool used to define the scope and provide the systematic basis for livelihoods, through the identification of the main factors influencing livelihoods and the relationship between these factors. DFID (2012) developed a sustainable Livelihood Framework (SLAF) to understand better how people develop and maintain livelihoods. A SLAF is an integrated approach for assessing household assets and analyzing how they are linked to the livelihoods strategy and identifying constraints and opportunities to reinforce positive aspects and mitigate the challenges. SLF has five major components (Figure 2.1) which include vulnerability context, livelihood assets, transforming structures and processes, livelihood strategies, and livelihood outcomes, which are related through sequential relationships and feedbacks. DFID (2012) also provides a brief overview of these key elements of SLF and their linkages.

This study in the Vulnerability context adopted shocks, Trends, and seasonality. Shocks variables include Climate variability, increased labor cost, water availability, and low market prices. Trends in the study include; socio-economic and Bio-physical factors that influence the adoption of CSA. Seasonality underlines the shifts in prices of produce, employment opportunities, and food availability. The SLF provides an understanding of the vulnerability context of the poor farmers and how this can be addressed to achieve positive outcomes and determine the asset portfolio which entails access to accumulate, transfer and enable farmers to have sustainable livelihoods (Thiele et al., 2012).

In Livelihood Assets the study adopted Human Capital, Financial Capital, physical capital, and social capital. Financial capital is also important in the process of implementation of CSA. Social Capital is essential since information on the adoption of CSA flows through both formal and informal networks from the Crop officers to the farm households. Social capital includes the formal and informal networks and groupings such as government, NGOs, CBOs, agricultural extension, and meteorological services within the sub-Country. Households in different situations rely on different combinations of livelihood assets to construct livelihood strategies that are converted into livelihood outcomes (Ellis, 2000).

Livelihood strategies is adopted in the study since in the study area farmers adopt diverse livelihood activities which include farming and formal or casual employment which leads to improved livelihood outcomes that positively influence the various capitals. If most adaptive strategies are implemented, the vulnerability will greatly be reduced, income increased, food security improved thus improving the general wellbeing of the individual. It indicates that poverty is better understood by understanding the perspectives of the poor and how policies influence their vulnerabilities (Swift & Hamilton, 2001).

Transforming structures and processes-policies, institutions, and processes (PIPs) affect the viability and effectiveness of livelihoods positively or adversely. The PIPs adopted in the study comprises social, economic, and institutional context within which the poor pursue their livelihoods. The impact of PIPs is to enable or inhibit livelihood development by influencing people's access or ability to transfer assets, which in turn influences livelihood outcomes. Livelihood outcomes are relevant to this study in that farming should aim at achieving positive livelihood outcomes. The variables adopted from the livelihood outcome include; increased income, increased wellbeing, and improved food security. Transforming structures, processes and institutions include issues associated with participation, power, authority, governance, and laws.

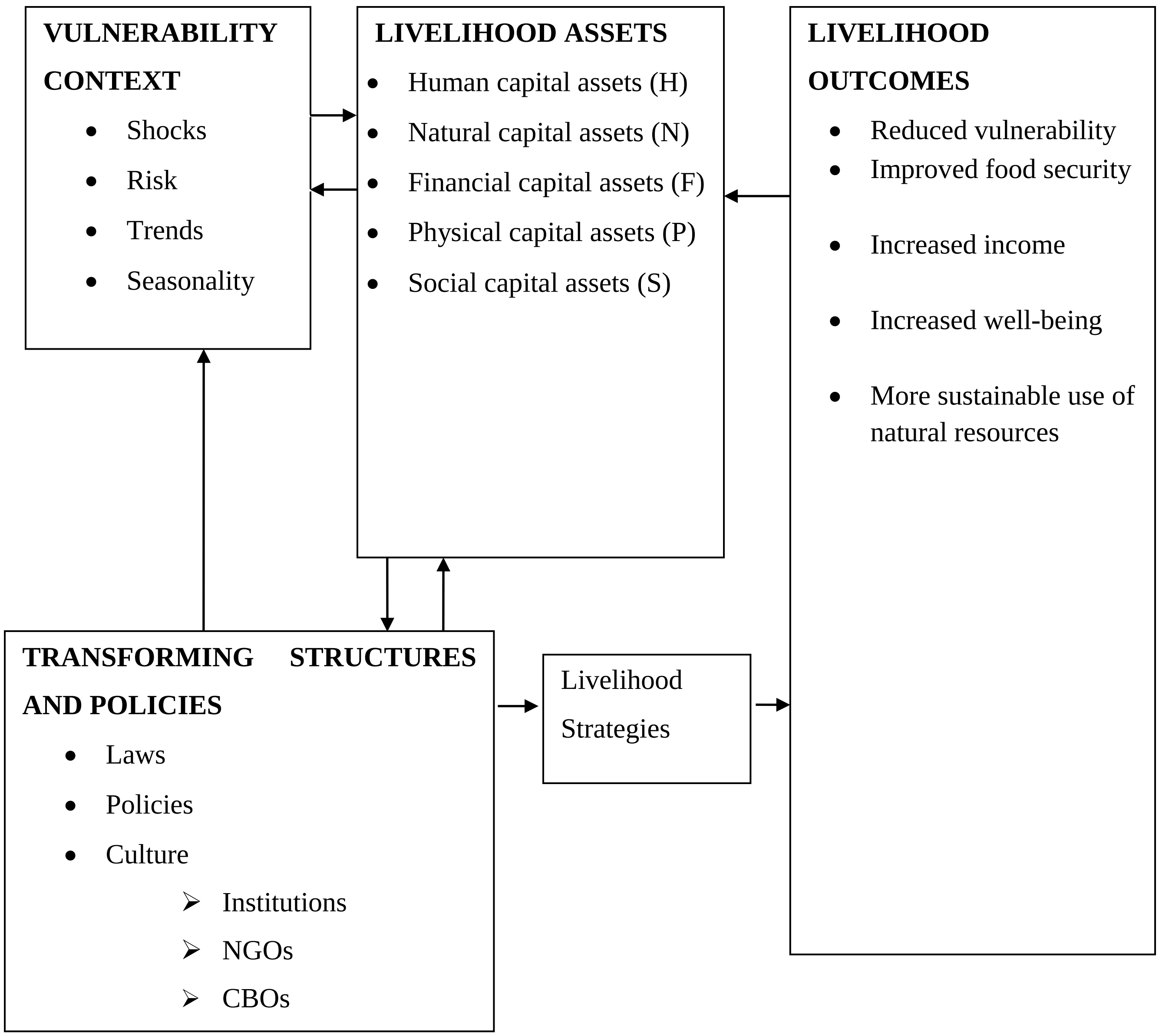

Figure 2.1: Sustainable Livelihood Approach Framework: Source: Adapted from DFID (1999)

2.9 Conceptual Framework

The conceptual framework (Figure 2.2) adopted for this study is derived from the synthesis of the literature. It defines independent, intervening, and dependent variables that provide guidelines for conducting the study and indicate that CSA approaches and their adoption determine the extent of livelihoods options.

In this study, the independent variables that influence the livelihood outcomes are; the adoption of CSA, where the indicators of CSA were Crop Rotation, Zero/ minimum tillage, Mulching, and Terracing. The intervening variable were; government policy, socio-economic and bio-physical factors, sub-variables include; age, gender, education, experience, slope, and landscape, these factors are conceptualized to influence the adoption of CSA. The dependent variables are the livelihoods and environmental outcomes which include; increased /decreased yields, income stability, and improved soil quality.

Agricultural decision-making depends mainly on the expected rainfall variation, rainfall amount, and the number of rainy days whose variation influences agricultural production. This calls for farmers to adopt Climate Smart Agriculture to reduce the harm likely to be caused by these variations. To adapt to Climate Smart Agriculture for adaptation, a farmer needs knowledge and information on the expected climatic conditions. The adoption of Climate Smart Agriculture practices is also influenced by lack of resources and constraints, making farmers have little or no control over the effects of climate variability. The constraints for instance include; experience, income, age, and perception. With these means available coupled with reduced constraints, farmers respond in a manner that can reduce the effects of climate variability.

The conceptual framework points to key variables to assist our understanding of the adoption of CSA and seeks to provide an understanding of the underlying causes and structures to shape climate variation effects (Paul, 2013). It is also a helpful scheme for action and decision-oriented by understanding adaptation measures, hence its adoption for the study.

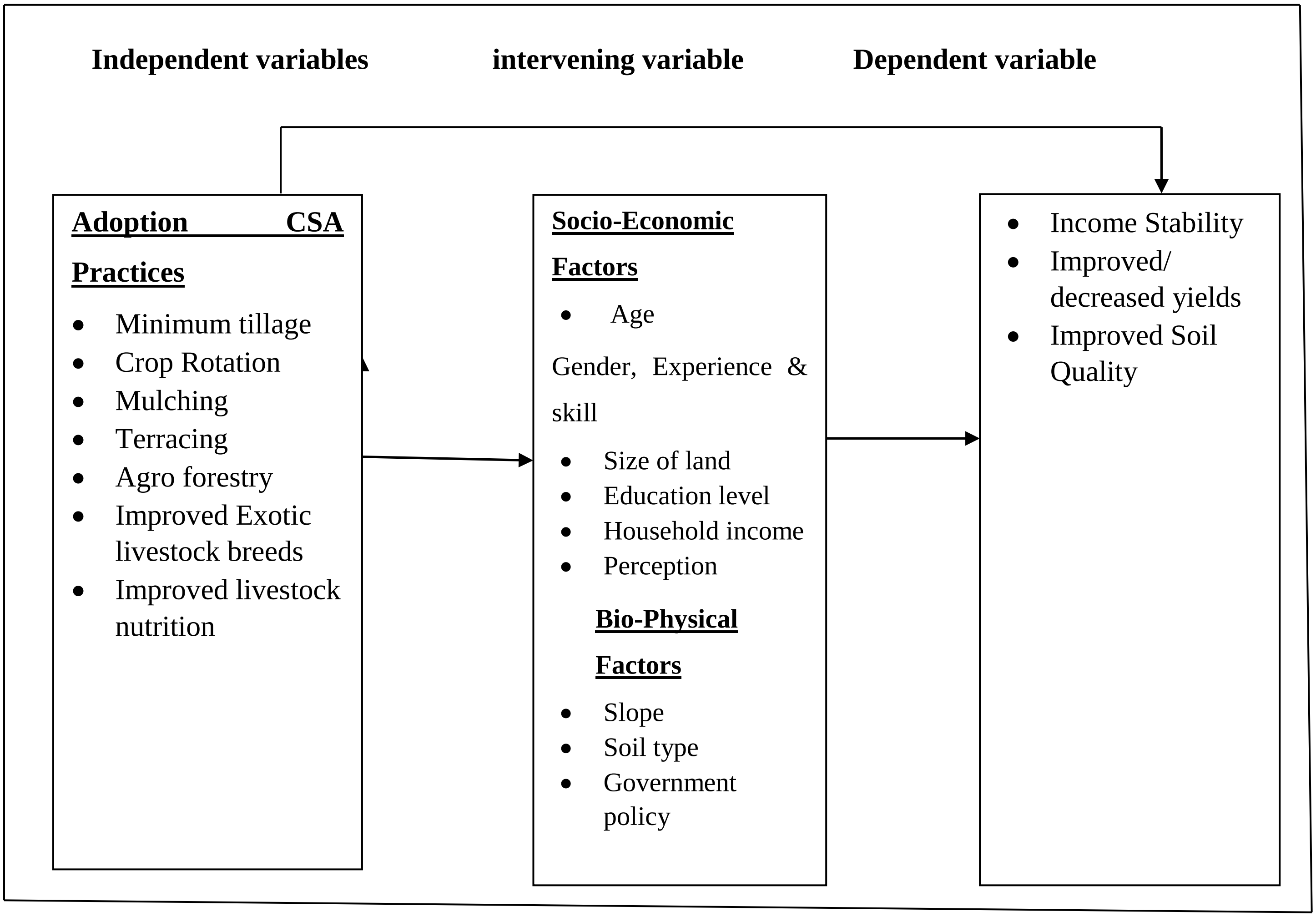

Figure 1.2: Conceptual Framework showing the interaction of independent and dependent variables

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents aspects of the study area, research design and target population, sampling procedure, sample size, data collection, validity and reliability and data analysis.

3.2 Location of the Study Area

The study was conducted in Soy Sub-County in Uasin-Gishu County Kenya. The sub-County lies between longitude 35° 8′ and 35° 19′ East and Latitudes 0° 45′ and 0° 56′ North (Figure 3.1). The area is bordered by the following; Turbo sub-County to the South West, Moiben sub-County to the east, Kapseret sub-County, and Kesses sub-County to the southeast. The sub-County occupies a total area of 682.4 Km^2 and is sub divided into seven administrative wards namely Ziwa, Segero-Barsombe, Kipsomba, Soy, Kuinet-Kapsuswa, Kapkures, and Moi'sbridge (Uasin Gishu county intergrated plan).

3.2.1 Topography and Climate

Soy sub-County is situated on a plateau with altitudes falling gently from 2,700 meters above sea level to about 1,500 meters above sea level. Soy sub-County enjoys bi-modal rainfall seasons with an annual rainfall ranging between 900 to 1200 mm. The sub-county has a cool and temperate climate, with annual temperatures ranging between 8.4 °C and 27 °C. The wettest season in the region is experienced between April and May while the driest season is between January and February. Approximately 218 km^2 of its land is underwater, swamps, and rocks.

3.2.2 Soils Characteristics and Ago-Ecological zones

According to Jaetzold et al. (2009), most of the agricultural area has upland soils called Acrisols, phaeozems, and Nitisols which are developed through igneous rocks. These soils are well-drained deep with humid topsoil. The soils are moderate to high fertility and hence, suitable for the growth of a variety of crops. The sub-County has three agro-ecological zones they include Upper Highland Zone dominated by Nitisols soils, Upper Midland Zone dominated by Acrisols, and Lower Highland Zone dominated by Ferralsols with patches of Gleysols in between (Jaetzold & Schmidt, 2003).

MAP OF THE STUDY AREA

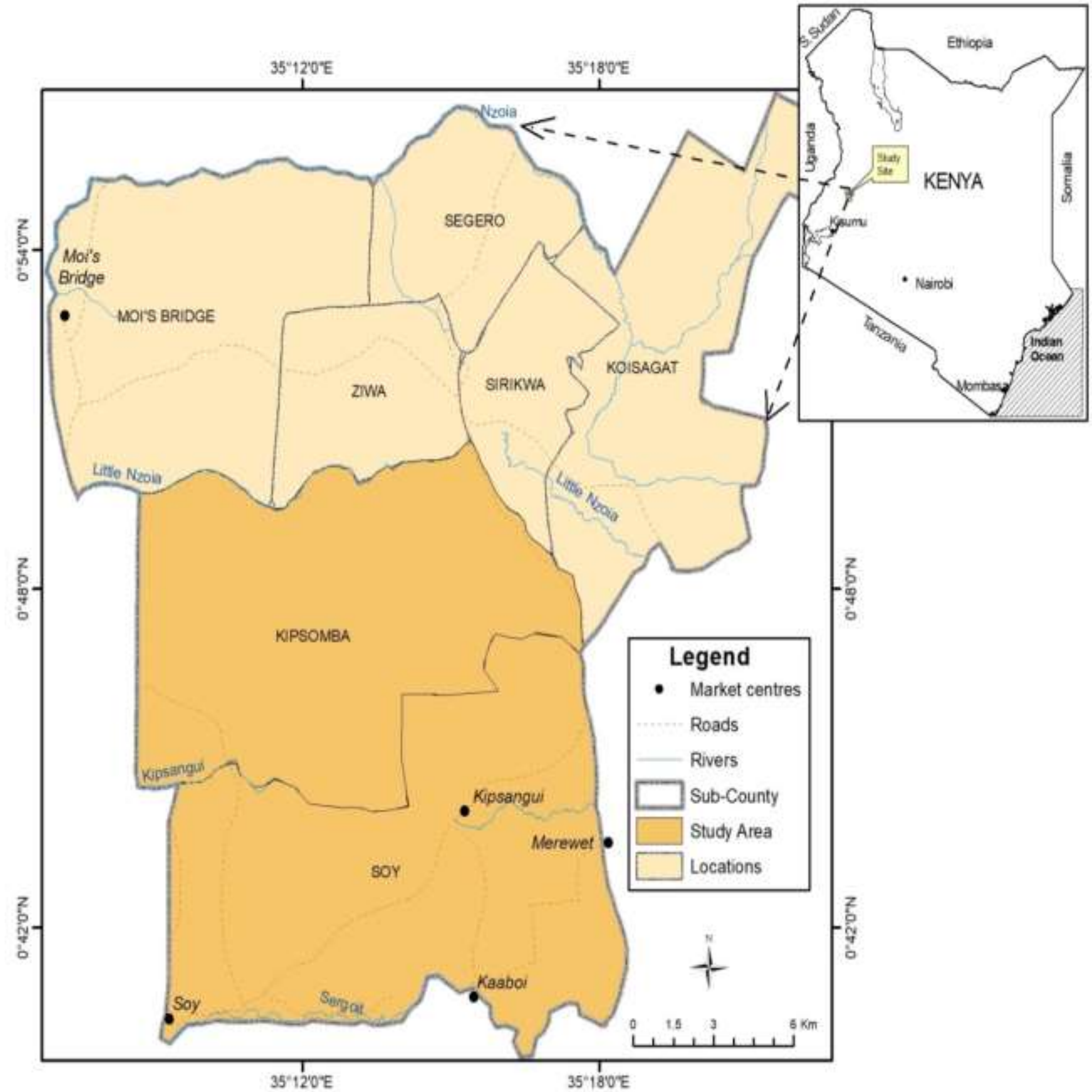

Figure 2.1: Map of Study Area showing the study sites, source; Kenya Topographical GIS shape files, modified using ArcMap).

3.2.3 Demographic Characteristics of the Study Area

According to the 2019 census, the population of soy sub-county was 229,094 people, land area of 768.0 square kilometers; administratively the study area is divided into eight wards. The area is a cosmopolitan region occupied by Kalenjins, luhya, luo, kikuyu, Turkana among others. Farming is the main economic activity in Soy Sub-County.

3.2.4 Agricultural and Economic Activities

The main economic activity in the study area is agriculture. The current total land under agricultural production is approximately 13,490 ha (Baraza et al., 2008). The total number of maize farmers is approximately 166,635 and about 2,603.2 km^2 is arable land and hills. The current total land under agricultural production is approximately 13,490 ha, various food crops (Maize, Beans, Irish potatoes, and horticultural crops do well in highly arable land in the study area (Baraza et al., 2008). Soy sub-County have reasonably large farm sizes and mechanized farming, Agriculture is the mainstay of the economy contributing 80% of total rural household income and food security (Nyamwamu, 2016).

3.3 Research Design

The study adopted a survey research design since it enables the researcher capture wider audience within a short time. This was used to collect primary data on the level of adoption of Climate-Smart Agriculture in the management of climate variability by farmers in Soy Sub-County. Information collected was on farmers' adoption of CSA and factors influencing adoption of CSA in Soy Sub-County. Survey research design is ideally suitable for describing the characteristics of large populations. With this design, many questions can be asked about a given topic giving considerable flexibility to the analysis (Neuman, 2007). Key Informant Interview (Appendix II) were used to supplement the information obtained from sub-county agricultural offices and administrative leaders, which is useful in the responses obtained during the collection of quantitative data.

3.4 Target Population

The study targeted all farming households in Soy sub county, Uasin Gishu County. According to the Kenya National Bureau of Statistics (2019), Soy sub-County comprises 88,956 farming households; Kipsomba ward has 5343 farming households while Soy ward had 3560 farming households.

3.5 Sampling Procedure and Sample Size

A multi-stage sampling method was used to obtain an appropriate sample size for the study. First, Uasin-Gishu County was purposively selected from the forty-seven counties in Kenya because it has a wide variety of farming practices involving crop and livestock farming. Secondly, Soy sub-County was purposively selected among the six sub-counties (Soy, Turbo, Moiben, Ainabkoi, Kapseret, and Kesses) because it has a mixture of both large scale and small-scale farmers compared to the other sub-counties in Uasin-Gishu, within Soy Sub-County there are seven wards namely; Kuinet-Kapsuswa, Kipsomba, Mois'bridge, Ziwa, Soy, Koisagat-Kapsang, and Segero-Barsombe. Using a simple random technique two wards were sampled (Kipsomba and Soy).

There are 88,956 farming households in Soy Sub-County, out of which 5343 are found in Kipsomba ward and 3560 are from soy ward respectively (Baraza et al., 2008).

Sample size was determined by use of proportionate sampling as specified by Kothari (2004) formula for finite population;

n= $z^2 . p . q . N / e^2(N-1) + z^2 . P . Q$ ………………………………………………….... (1)

Where: N = the population size,

n = sample size,

p = the sample proportion (q = 1-p),

Z= the standard variant at a given significance level (α = 0.05) and

e= acceptable error (precision).

Using p=0.5 as the proportion of farmers with off-farm investments ("n" will be the most conservative sample and will give the desired precision).

Z=1.96,

p=0.5 and an acceptable error of 7 % (e).

q= the weighting variable and is computed as 1-P.

The sample was determined as;

n= (1.962 x 0.5 x 0.5 x 88,956) / (0.07^2 x 88,955) + (1.96^2 x 0.5^2) ≈ 196

Therefore, from the equation, the desired sample size was 196 respondents. These were obtained as 5443/ 8903 x 19 = 119.22 ≈ 119 for Kipsomba ward and 196-119= 77 for Soy ward. The Key informants were; two crop officers, two National Cereal Board Officers, two Meteorologists, and one Environmental Officer and documentation of the adopted approaches to provide rich qualitative information to support hard data from the key informant interviews.

3.6 Data Collection

Primary data was collected using questionnaires (Appendix I), and Key Informant Interview schedule (Appendix II). Household questionnaires were administered to selected households targeting household heads to obtain primary data on adoption of Climate Smart Agriculture practices and farmers' socio-economic characteristics which include; experience, gender, education level, income, and access to extension services. Questionnaires were also used to gather data effects of CSA on agricultural production and climate variability information. Besides the questionnaires, Key Informant Interviews and Focus Group Discussion were also conducted. Six Key Informants were chosen purposely to give insight information on adaptive approaches, agricultural production, rainfall amount, and distribution in Soy Sub-County.

Secondary data was used to complement the survey data. The secondary data was obtained from records available in sub Soy Sub-County department of agriculture which include: the interventions of the national and county government to improve farmers’ livelihoods and information on climate variability.

3.7 Validity and Reliability

The data collection instruments for this study were questionnaire and interview schedule. The instruments were validated by use of content validation determined by an expert judgment as well as consultation with my supervisors at Egerton University. The questionnaire being the main tool of data collection was pre-tested in the neighboring Moiben sub-County which exhibits almost similar climatic characteristics to the study area. At the end of each day during data collection, the filled interview schedules and questionnaires were counter-checked to ascertain that all questions are answered.

Reliability was tested to determine the extent to which any measuring procedure yields the same results on repeated trials (Neuman, 2007). To test the reliability of the questionnaire, which was the main instrument, pre-testing was done using approximately 20 respondents picked from the neighboring Moiben sub-county which has similar agro-ecological characteristics to the study area. The piloted questionnaire was then subjected to the Cronbach alpha (α) test and yielded

Coefficients of 0.853 coefficients. This is very reliable according to Mugenda and Mugenda (2003).

3.8 Data Analysis

Data collected was first edited and checked for errors and omissions. The data was then coded and keyed into a computer. Both descriptive and inferential statistics were used to analyze data using SPSS version 20 software. Thematic analyses were used to analyze all qualitative data of KII (Braun & Clarke, 2006). Information on rainfall variability according to respondents was presented use five-point liker scale since it was an ordinal data (Jameson, 2004). Regression was used to determine relationships between the adoption of CSA and socio-economic factors influencing farmers in Soy Sub-County. Multiple regression analysis was employed to determine the strength of causal relationships between dependent and independent variables. Regression coefficient is a measure represented as a value between 0.0 and 1.0, where a value of 0.1 indicates a perfect fit and is thus a highly reliable made for future forecast, while a value of 0.0 would indicate that the model fails to accordingly model the data at all.

$$\acute{Y}= \beta_0+\beta_1 \chi_1+\beta_2\chi_2+ \beta_3\chi_3+\beta_4 \chi_4+\beta_5\chi_5+ \beta_6\chi_6 +\Sigma ij \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Where:

Y is the dependent or criterion variable (CSA)

β_0 is the constant value,

X_1, $X_2 X_3$, $X_4 X_5$ and X_6 are the independent variables; experience, age, gender, education, slope, and soil type respectively.

β_1, $\beta_2\beta_3$, β_4, β_5 and β_6 are the regression coefficients and,

ε_{ij} is the error component with a mean of zero because normality has been assumed.

Y= -1.722 -0.115 Exp - 0.192 Age - 0.009 Age- 0.007 Edu + 0.045 Slope + 0.530 Soil Type

3.9 Ethical Considerations

Before the study was conducted a permit was obtained from National Commission for Science Technology and Innovation (NACOSTI) (Appendix III). Permission was also sought from the office of County commissioner and agricultural office within the study sites. All the respondents were assured of the confidentiality of the information provided during the study.

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results and discussion on the socio-economic characteristics of the respondents. The information is important to help understand the characteristics of the population under study. Also the chapter presents result and discussions on the level of adoption of CSA practices used to mitigate the effects of climate variability, socio-economic factors influencing the adoption of CSA practices among households and the effects of CSA on farmers' livelihoods in Soy Sub County.

4.2. Social-economic Characteristics of the Respondents

This section presents results on socio-economic factors influencing the adoption of CSA among farming households in Soy Sub County. Socio economic characteristics of the farming households discussed are Gender, education level, age, household head, farming practices, size of land under cultivation.

4.2.1 Gender of the Household Head

The finding in Figure 4.1 shows that 53.06% of the respondents were male-headed households, while female-headed households were 46.9%. This implies that the majority of the farming households in Soy Sub County had the male household head this could be because male respondents are more informed than the female. Despite most households being headed by a male, it was noted that the number of women were more than men involved in the quality and quantity of agricultural yields. On account of the gender division of assigned the responsibility of ensuring their household food needs are adequately met. Therefore, study concludes that both male and female gender in Soy Sub-County are involved in farming and are likely to practice CSA practices. These contradicts the findings by Lipper et al. (2014) that female headed households tends to play an important role as food producers, managers of natural resources, income earners and caretakers of household food security.

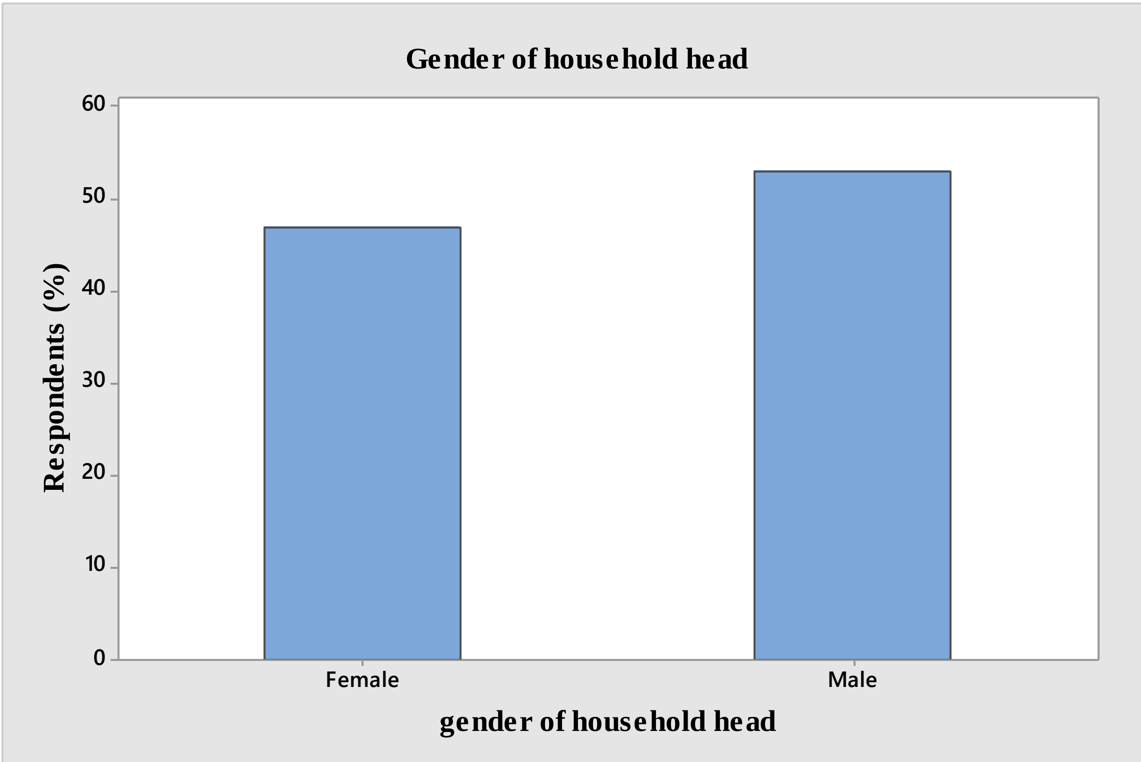

Figure 3.1: Genders of the Household Head in Soy sub-County

4.2.2 Education level of the Household Head

The education level of the household head enables the household to acquire useful knowledge on appropriate farming techniques due to the ability to read and comprehend information related to climate variability and agricultural activities. Formal education can enable one to gain employment, which is a source of income that can be used in the implementation of the various adaptation strategies to climate variability such as CSA practices. The findings in Figure 4.2 show that 10% of the sampled households had no formal education, 35% had attained primary education and below while 47% of sampled residence had attained secondary education and 18% had attained tertiary education. These results imply that most farmers had attained formal education which empowers the household head to engage in income-generating activities. The economic activities gained because of education may act as alternative sources of livelihoods and adaptation strategies to climate variability. According to earlier study by Tatesse et al. (2013) in eastern Ethiopia, the more educated the household head is the more he/she is likely to implement adaptation strategies to climate variability.

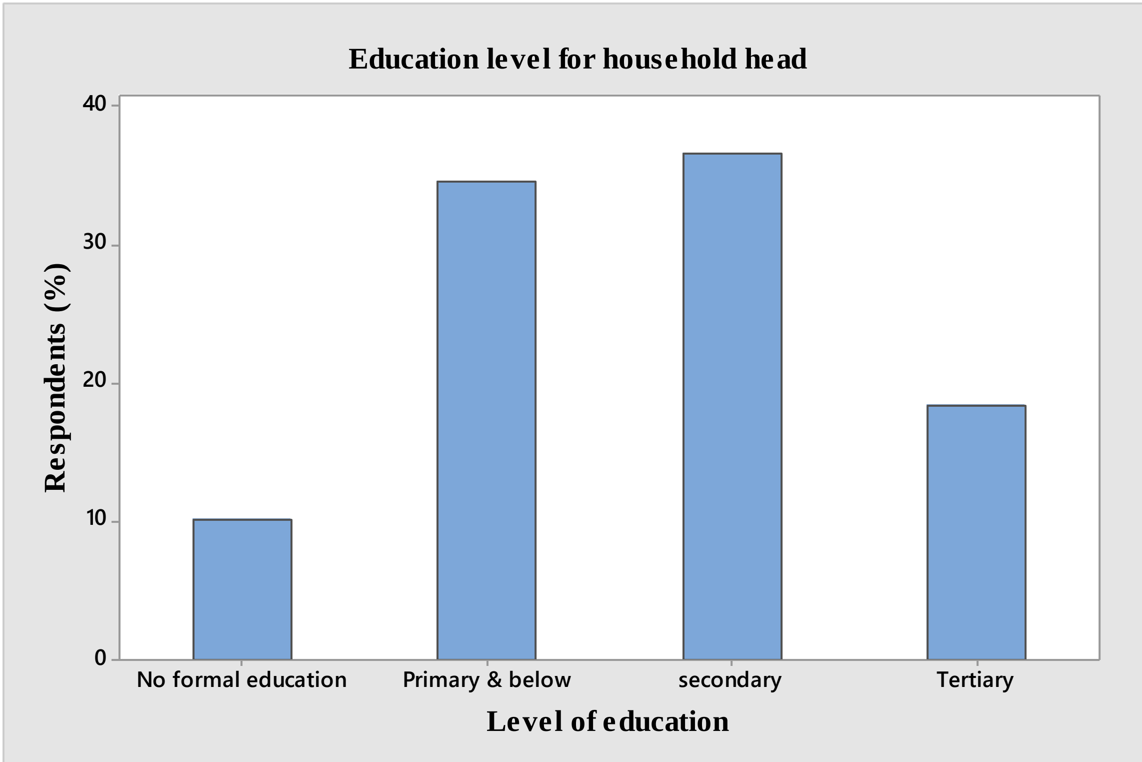

Figure 4.2: Level of Education of Household Heads in Soy Sub-County

4.2.3 Age of the Household Head

The findings in Table 4.1 revealed that 36.22% of the respondents were aged between 36 and 50 years, 30.6% between 26 and 35 years, and 29.08% were aged 50 years and above. The results indicate that majority of the farmers are in their prime age and are in a position to make a vital decision regarding the implementation of CSA which is among the adaptive strategies to climate variability. The study findings are consistent with earlier study by Ishdorj and Higgins (2015) in Congo suggesting that the higher the age of the household head the more stable the economy of farm household because older people have relatively richer experiences of farming activities and adaptive strategies, as the age increases farmers acquire more knowledge and experience on how to adapt to adaptive strategies (Beyene & Muche, 2010).

Table 4.1: Age of the Household Head in Soy sub-County

Age	Number of Respondents (%)
18-25	40.8
26-35	30.6
36-50	36.22
Above 50	29.08
Total	**100**

4.2.4 Household Head Farming Experience in Soy Sub-County

Farming experience of the household is significant to farming activities regarding the choice of approaches used to mitigate the effects of climate variability. It is important in creating awareness of social economic and environmental factors influencing the adoption of CSA practices. The findings in Table 4.2 shows that 41.35% of the respondents have been involved in farming activities for over 20 years, followed by 23.46% who have been involved in farming between 10 and 15 years, 20.40 % have been involved in farming for between 5 and 10 years and only 14.79 % have been farming for only 5 years and below. This implies that majority of the respondents are experienced in farming activities. These findings are consistent with the earlier findings by Cahn (2007) who argued that farmers with experience are more aware of farming production and how It influences farming households" livelihoods in their areas. Moreover, their expertise, knowledge, and skills had been influenced by their experiences.

Table 4.2: Household Head Farming Experience in Soy sub-County

Years of farm Experience	Number of Respondents (%)
1 -5	15.30
6-10	20.40
11-15	12.24
15-20	15.30
Above 20	36.80
Total	**100**

4.2.5 Source of Household Income

The findings in Table 4.3 show that 47.95% of the respondents' practices farming, 39.29% engage in casual employment, 12.75% had formal employment. The results indicate that though all respondents sampled and interviewed were farmers, a number of them had other sources of livelihoods and practice farming as secondary source of livelihoods. This implies that the main source of sampled household respondents is farming while employed as a complementary source of livelihood. The higher number of households whose primary source of income is farming shows how significant farming is in Soy Sub County and importance of CSA in increasing production.

Table 4.3: Occupation of the Household Head

Occupation	Number of Respondents (%)
Farming	47.95
Formal employment	12.75
Casual employment	39.29
Total	**100**

4.2.6 Household Farming Practices

The findings in Table 4.4 indicate that all the farmers in the study area (61.22%) plant maize as their main food crop, 30.12% planted beans, and 8.66% planted sorghum. This shows that apart from planting maize farmers also grow other crops. Growing different varieties of crops within a given season increases the probability of harvestings since even if one crop fails the farmers will still depend on the others as source of livelihood.

Table 4.4: Household Farming Practices

Crops	Number of Respondents (%)
Maize	61.22
Beans	30.12
Sorghum	8.66
Total	**100**

4.2.7 Land under Cultivation

The findings in Table 4.5 shows that 12.75% of the respondents cultivate between 1 and 5 acres, 31.63% cultivate between 5 and 10 acres, 21.93% of the respondents cultivate between 10 and 15 acres of land, 25.51% cultivate between 15 and 20 acres of land and 8.18% of the respondents cultivate more than 20 acres of land. Thus majority (31.63%) of the sampled respondents operated farms in the range of 1-5 acres. This small farm size was attributed to the increasing population which has occupied relatively large areas in the study area, large size of land enables high production in an area with majority of respondents having less than scores, this shows that CSA is the only viable option to increase production. These findings concur with the earlier findings by Neate (2013) who reported that, large farm size household can produce more and offers the opportunity for livelihood diversification.

Table 4.5 Land Size under Cultivation

Land size under cultivation	**Number of Respondents (%)**
1 -5	12.75
5-10	31.63
10-15	21.93
15-20	25.51
Above 20	8.18
Total	**100**

4.2.8 Households Practicing Livestock Keeping

The results in Table 4.6 show that majority of farming households (86.7 %) keep livestock, while 13.27% practice crop farming. This implies that most of the respondents practice mixed farming. Crop-livestock interaction ends up being a complimentary adoption approach where farmers rely on livestock to produce manure while the crops provide the livestock with fodder. Besides, livestock is considered a means of security and means of coping during crop failure and other calamities; the practice is in line with CSA policies since animal manure can be utilized to enhance carbon sequestration and soil fertility. This finding is consistent with research findings by Marenja and Barrett (2007) who argued that manure and fertilizer inputs are complementarities because of the beneficial interactive effects of manure on fertilizer effectiveness. Similarly, Jama et al. (2007) showed that positive results can be achieved using inorganic fertilizer and manure in western Kenya.

Table 4.4: Respondents Practicing Livestock Keeping

Household Response	Number of Respondents (%)
Yes	86.73
No	13.27
Total	**100**

4.2.9 Types of Livestock Kept

The findings in Figure 4.3 show that 57% of the respondents keep cattle, 35% of the respondents keep sheep, 6% kept goats while 2% of the respondents kept poultry. Based on this result, it's clear that in the period when there is maize failure households source food from other regions. This finding concurs with those of Kang'ara (2001) in Embu who noted that livestock contributes to households' economy in different ways such as a source of supplementary food.

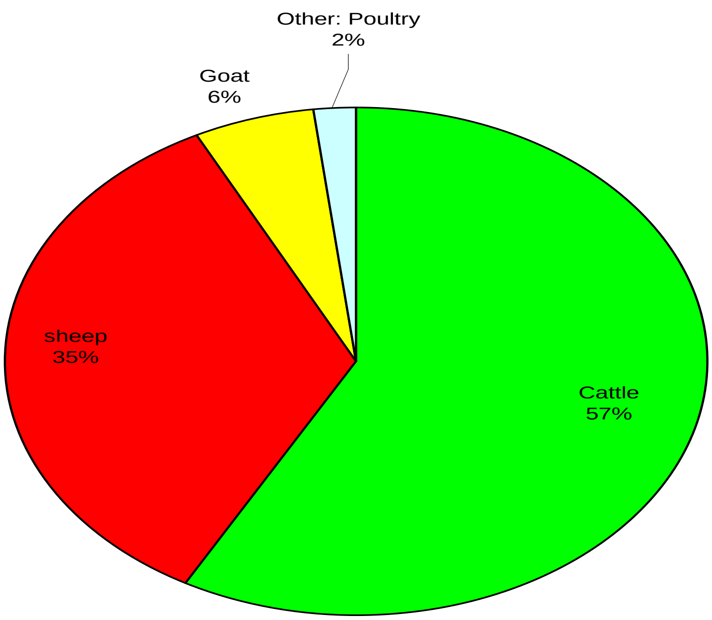

Figure 4.3: Types of Livestock Kept in Soy Sub-County

4.2.10 Mode of Feeding the Livestock

The findings in Table 4.7 shows that most livestock keepers (84.7%) of the respondents in the study area feed their livestock using conserved fodder and conserved forage (64.8%) while 1.5% feed their livestock with irrigated pastures and 1.5% with irrigated fodder. This implies that most farmers prefer conserved feeds to graze in vast rangelands. This is due to lack of grazing land since most of the land has been used in crop farming, this result contradicts the earlier findings of Adewumi and Olafadehan (2010) who observed that livestock keepers with access to vast rangeland rarely supplement their stock but depend entirely on range pasture.

Table 4.5: Mode of Feeding Livestock

Feeding mode	Conserved fodder (%)	Conserved forage (%)	Irrigated pastures (%)	Irrigated fodder (%)
Yes	84.7	64.8	1.5	1.5
No	16.3	35.2	98.5	100.0
Total	**100**	**100**	**100**	**100**

4.2.11 Livestock Feeding Places in Soy Sub-County

Cattle keepers in the study area were also asked where they feed their cattle and it was noted (Table 4.8) that most farmers (69%) feed their livestock in public land, 13% of the respondents feed their livestock in paddocks and 18% feed their livestock in stalls. This implies that most farmers keep their livestock in communal land; this could be because of the low number of cattle per respondent which is meant for consumption not commercial. This result concurs with the earlier findings by Kosgey et al. (2008) that most small-scale farmers keep animals in order to satisfy family needs rather than purely as an economic enterprise.

Table4.6: Livestock Feeding Places

Livestock Feeding places	Number of respondents (%)
Paddocks	13
Public land	69
Zero grazing units	18
Total	**100**

4.2.12 Services Given by Ministry of Livestock in Protection against Diseases

Livestock keepers were asked to name the support they access from the government. The findings in Table 4.9 shows that 14.8% of the livestock keepers access the service of adequate disease surveillance, 17.3% access disease control, 62.2% access regular vaccination, 5.7% of the livestock keepers indicated that vaccination was done only when there is an outbreak of diseases and 1.02% of the livestock keepers indicated that mostly the government of Kenya values the vaccination of their livestock since it prevents spread of diseases.

Table4.7: Services Offered by the Ministry of Livestock in Protection against Diseases

Services offered by the Ministry of livestock	**Number of respondents (%)**
Adequate disease surveillance	14.8
Disease control	17.3
Regular vaccination	62.2
No action	1.02
Only vaccination when there is a disease outbreak	5.7
Total	**100.0**

4.2.13 Duration of Adoption of Climate-Smart Agriculture Practices

The findings in Table 4.10 shows that, most of the farmers 49.5% have adopted CSA for more than 6 years, 16.8% had adopted between 4 and 6 years, 15.8% between 2 and 4 years, 13.8% had adopted CSA practices 1 and 2 years and only 4.1% had not adopted CSA practices at all. The level of adoption differs from a practice to a practice based on their age, gender, and landholding size, and income level. Farmers who have not adopted the CSA practices hinted in FDGs that they lack evidence of how innovations can be practically incorporated into agricultural systems. They require to identify ways in which farmers can achieve synergies and minimize trade-offs in implementing multiple interventions on real farms. The results supports the findings by Williams et al. (2015) who reported that although CSA practices are employed in several of Kenya's agro-ecological zones; only a small percentage of the population has adopted them. Low and medium adoption rates for climate-smart practices are linked to infrastructural, institutional, and financial issues for both farmers and other agriculture value chain players.

Table 4.8: the Length of Time at Which Farmers have Adopted the CSA Practices

Length of time	**Number of respondents (%)**
Not adopted	4.1
1-2 yrs	13.8
2-4 yrs	15.8
4-6 yrs	16.8
Above 6 yrs	49.5
Total	100

4.3 Farmers Perception on Rainfall Variability in Soy Sub-County

The results in Table 4.11 show that the majority (85%) of the respondents agreed that in the study area rainfall variation interferes with agricultural production in their land 62% of the interviewed respondents agreed with the statement that it always rains during the long rainy season from March to August every year while most of the respondents (54%) disagreed that the rainfall in the study area is very reliable and predictable and rains never fail, 51% of the respondents disagreed with the statement that it always rains during the short rainy season from September to December every year. The results suggest that the farming households in soy sub-county experience rainfall variability. This result was supported by results obtained from key informant interviews where the participants indicated that the main indicator of change in rainfall pattern was mainly attributed to an increase in the frequency of extreme events which are prolonged drought and change in rainfall amount. Therefore, since it is evident that there is variation in rainfall in Soy Sub County there is need for the adoption of Climate Smart Agriculture practices to cope up or mitigate its effects of climate variability. This result concurs with the earlier findings by Karanja (2017) that rainfall pattern has changed over the years and gives farmers no time to recover from effects of climate variability.

Table 4.9: Rainfall Variability According to the Respondents

Statement	SA	A	NC	DA	SDA	Total
The rainfall in the area is very reliable and predictable. Rains never fail	43 (21.93%)	42 (21.42%)	5 (2.55%)	52 (26.53%)	54 (27.55%)	196 **(100%)**
It always rains during the short rainy season from September to December every year	45 (22.95%)	38 (19.38%)	2 (1.02%)	60 (30.61%)	51 (26.02%)	196 **(100%)**
It always rains during the long rainy season from March to August every year	62 (31.63%)	56 (28.57%)	2 (1.02%)	42 (21.42%)	38 (19.38%)	196 **(100%)**
Rainfall variation in my land always interferes with agricultural production	166 (85.5%)	26 (13.2%)	4 (2.04%)	0 (0.0%)	0 (0.0%)	196 **(100%)**

SA= Strongly Agree; **A**= Agree; **NC**= No comment; **DA**=Disagree; **SDA**= strongly disagree

4.4 Adoption of Climate Smart Agriculture Practices

This section presents the results of the level of adoption of CSA practices used to mitigate climate variability. The findings in Table 4.12 shows that 50.51% of the respondents adopted minimum tillage, where most of them prefer tilling to conserve soil 53.06% of the respondents practice Agro forestry, 44.38% adopted terracing, 58.67% practiced crop rotation practice, and 28.06% adopted mulching while most farmers with 93.36% adopted the change in planting dates. For the farmers who kept livestock, 82.14% adopted improved livestock nutrition while 94.40% prefer improved livestock breeds. The most preferred Climate Smart Agriculture practice is the change in planning dates where farmers could follow the strategy of either early planting (EP) at rainfall onset or late planting (LP) two weeks after onset rains, farmers showed their preference in early planting since it leads to higher germination rate of up to 90%. While the least adopted practices were; Agro forestry, Minimum Tillage, Terracing, Mulching. The lowly adopted CSA practices could be due to lack of awareness of the practices and their benefits. The majority of farmers could also have had few years of farming experience.

Table 4.10: Adoption of Climate-Smart Agriculture Practices

CSA Practices	Number of the respondent (%)
Minimum Tillage	50.51
Crop Rotation	58.67
Terracing	44.38
Agro-forestry	53.06
Change in planting dates	93.6
Mulching	28.06
Improved livestock breeds	94.40
Improved livestock nutrition	82.14
Totals	**100**

4. 4.1 Ranking of Climate Smart Agriculture Practices in Soy Sub County

The researcher ranked the Climate Smart Agriculture practices according to the most used approach to the lowly adopted approach. The highest number of the respondents adopted the practice of improving their livestock breeds (94.40%); according to key informants; "Uasin Gishu county government offers subsidized artificial insemination services for livestock farmers, this encourages them to improve on their breads." Leguminous fodder production and fodder crop residues provide cattle with a rich diet and improve the quality of the manure, which, when added to the soil, increases crop and fodder productivity.

The majority of the respondents (93.36%) admitted that the planting dates have changed, this could be because of climate variability which could be solved by the adoption of Climate Smart Agriculture practices which is an immediate and direct way to help smallholder farmers ensure their farm-based livelihoods in the face of the increasing stresses posed by climate variability is to focus on helping them use farm management practices based on agro-biodiversity and ecosystem services that provide adaptation benefits. Most of the livestock keepers (82.14%) had changed their livestock nutrition where most of the farmers are purchasing Lucerne and star grass for support of on-farm fodder production to improve milk in a sustainable manner adoption of CSA practices and their implementation of agricultural practices to cope with climate variability.

Among the sampled farming households 58% admitted that they practice crop rotation, in this case, farmers plan to sow specific crops on the same field for a period of 2 or more years. The succeeding crop may be of different species (grain crops followed by legumes) or variety from the previous crop. According to key informants' crop rotation is an important practice for carbon sequestration. Rotating to a different crop improves the physical, chemical, and biological environment of soil and reduces pests and diseases, which produce large amounts of biomass and residue for incorporation in the soil for carbon sequestration (Page et al., 2020).

Fifty-three percent of the sampled farmers plant crop and trees at the same time which aid conservation on the farm. Integrating trees with livestock production leads to increased carbon in the soil, which can compensate for part of the livestock-related emissions. Agro forestry can increase tree density on the farm and limit burning, and soil and water conservation can reduce soil erosion and improve agricultural productivity on hillsides. The main sources of tree seedlings were from private nursery operators and sometimes Grevillia (*Grevillea robusta*) and African mahogany (*Khaya anthotheca*) most farmers plant the trees on farm boundaries or terraces banks. Improved soil fertility due to biomass transfer, soil moisture retention, and nitrogen-fixation.

The study indicates that 50.51% of the sampled farmer practiced Minimum Tillage. Most farmers applied direct seeding where they grow crops without mechanical soil disturbance after the harvest of the previous crop. No-tillage and involves slashing the weeds and previous crop residues or spraying herbicides for weed control, and seeding directly through the mulch using direct seeding implements. Through the practice, all crop residues retained and amendments are either broadcast on the soil surface or applied during seeding.

According to the sampled farming households, 44.38% had prepared Terraces in their farms. The practice of terracing was perceived by farmers as the most beneficial practice in terms of increased yield but the least affordable and the most time-consuming CSA practice. According to farmers, the main barriers to the adoption of terraces were cost and insecure land tenure. Farmers also said they were unsure whether terraces would lead to higher productivity in the short term. The labor-intensiveness of terracing was addressed through collective action. During focus group discussions, farmers highlighted that terracing allows unusable land on slopes to be turned into a productive land.

The study indicates that 28.06% of the sampled farmers practiced mulching in their farms. The adoption of the practice was the lowest meaning there is a problem in the dissemination of the practice by officers in the study area. The data also showed that wealthier households were more likely to practice mulching. Perhaps this could be linked with the tendency of more affluent households to practice gardening, which requires inputs and tools and access to markets. On the other hand, farmers not owning land seem to adopt mulching as it is a temporary, easy, and low-cost practice. According to key informant (crop officer) mulching plays an important role in conservation tillage. Mulching also reduces evaporation losses, increases infiltration, and helps the building-up of biological micro flora and soil organic matter (SOM), therefore improving long-term soil structure and fertility.

4.5 Factors Influencing Adoption of Climate Smart Agriculture Practices

Six socio-economic characteristics of farmer's (independent variables) were hypothesized to influence the adoption of climate smart agriculture in the study area. The results in Table 4.13 showed that most of these variables negatively influenced the rate of adoption of CSA except slope and soil type which positively influence its adoption. Consequently, at 95% confidence interval, age significantly influenced the rate of adoption of Climate Smart Agriculture (p=0.029, t=-21.777, CI=0.05). This meant that, age of farmers influences the adoption of CSA practice among households in Soy Sub-County. This results supports the findings in Tesfaw, (2013), who concluded that farmers' age was detrimental in market participation as the head of the household becomes older, he/she is less likely to adopt the CSA practices although they are not capital and labor intensive. These illustrate the decline in preference and adoption of CSA practices by the older farmers.

On the other hand, the soil type positively influenced the farmers' adoption of Climate Smart Agriculture practices (p=0.042, t=0.530, CI=0.05). The soil type in study area positively influence the rate of adoption of CSA by farmers in that the physical and chemical properties of soil in Soy Sub-county favours the adoption of CSA as an alternative approach to other practices that are reliant on adequate rainfall. Moreover, the land topography in the area positively influenced the adoption of CSA although it was not significant at 95% confidence interval (p=0.056, t=0.045, CI=95%). This illustrate that the general low land elevation in study area was relatively favourable to CSA practices such as minimum tillage, drought resistant crops, crop rotation etc.

Other socio-economic variables such as gender of the head of household, experience and education had no significant statistical effect on the adoption of CSA (p>0.05). These findings corroborates with findings by Apata et al. (2009). While Apata et al. (2003) identified that a number of socio-economic characteristics such as gender, age of household head, farming experience, occupation, and source of livelihood influenced the level of understanding and implementation of agricultural technologies, in other study among arable food crop farmers in southwest Nigeria, Apata et al. (2009) reported that gender of the household head had no significant relationship with adaption strategies.

Table 4.11: Social Economic Factors Influencing Adoption of Climate Smart Agriculture Practices

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	-1.722	.941		-1.829	.319
Experience	-.115	.012	-.705	-9.241	.069
Age	-.192	.009	-1.209	-21.777	.029
Gender	-.009	.001	-.296	-6.162	.102
Education	-.007	.002	-.102	-3.130	.197
Slope	.045	.004	.958	11.317	.056
Soil type	.530	.035	.413	15.155	.042

4.6 Effects of Adoption of Climate-Smart Agriculture practices on farming households

This section sought to analyze the effects of CSA on farming households in Soy sub -County. The findings in Table 4.14 show that 88.7% of the respondents indicated that with the adoption of the CSA practices there were positive effects as evidenced by the increased yields. Moreover, 73% of the farming households indicated the adoption of CSA leads to increased income, 8% of the farming households disagreed that adoption of CSA leads to the creation of employment, 95.91% of the farming households also that the adoption of CSA can control pest in farms, while 1% also that the adoption of CSA control weeds in the farms. This result indicates that CSA can be an effective approach for improving food security and alleviating poverty in rural areas. The results concurs with the study by Mudhara et al. (2021) who concluded that the factors such as the home head's education, labor size, and the implementation of CSA all had a substantial impact on household income.

Table 4.12: Effects of adoption of Climate Smart Agricultural Practices in Soy sub-County

Benefits of CSA	**Number of respondents (%)**
Increased yields	88.77
Increased income	73.46
Employment creation	7.65
Able to control pests	4.08
Able to control weeds	0.06
Totals	**100**

4.7 Household Farm Yields in Soy Sub-County

The researcher was interested in finding out the household farm yield in 2017 and 2018 amongst farmers who have adopted the CSA practices and those who had not adopted the practices. In the year 2017 as indicated in Table 4.15, 12.55% of the respondents harvested 10 bags and below, those respondents that harvested between 10 and 20 bags were 6.69%, while 13.38% of the respondents harvested between 20 and 30 bags of maize. According to survey results shown in the table above farmers who had not adopted CSA practices, 83% of the maize growers harvested 10 bags and below, 5.43% of the respondents harvested between 10 and 20 bags of maize, 9.20% of the respondents had harvested between 20 and 30 bags while 17.57% harvested above 30 bags. These results generally imply that the adoption of CSA practices leads to high yields in the farms since the yields of the farmers who had adopted the CSA practices are higher than for those who had not adopted the CSA practices. This finding is consistent with research finding by Sardar et al. (2021) who argued that farmers who adopted a full set of CSA practices gain higher yield 32% and 44% kg/ha, and higher farm income 45% and 48% US$ per ha than non-adopted farmers for cotton–wheat and rice-wheat crops, respectively.

Farmers in the study area also planted beans in 2017, those who had adopted Climate Smart Agriculture practices 2% of the respondents harvested between 0 and 10 bags per ha, 11% harvested between 10 and 20 bags per ha, and there was no respondent harvested above 20 bags per ha. Respondents who had not adopted Climate Smart Agriculture practices; 6% harvested between 0 and 10 bags of beans per ha, 2% of the respondents harvested between 10 and 20 bags of beans per ha. These suggest that the production of beans in the study area is low and this could be because of unreliable climatic conditions. Sorghum in 2017, 2% of the respondents harvested between 0 and 10 bags, while no respondent harvested above ten bags per ha. This suggests that sorghum is not doing well in the study area may be due to ecological conditions that are not favorable.

Table 4.13: Household Farm Yields for the Year 2017

Number of bags in 90 Kgs	Farmers who Adopted CSA (%)	Farmers who did Not Adopted CSA (%)
MAIZE		
0-10	12.55	0.83
10-20	6.69	5.43
20-30	13.38	9.20
Above 30 bags	34.30	17.57
BEANS		
0-10	2	6
10-20	11	2
20-30	0	0
30 bags and above	0	0
SORGHUM		
0-10	2	1
10-20	3	2
20-30	0	0
30 bags and above	0	0

The results on Table 4.16 shows that in 2018 No respondent harvested 10 bags and below of maize per ha, 2.17% of the respondents harvested between 10 and 20 bags per ha, 19.56% of the respondents harvested between 20 and 30 bags per ha and 41.3% of the respondent harvested above 30 bags. Among the respondents who had not adopted the CSA practices, 1.08% harvested 10 bags and below, 3.26% harvested between 10 and 20 bags, 14.67% harvested between 20 and 30 bags of maize per ha, and 17.93% of the respondents harvested above 30 bags.

On the other hand, the respondents who planted beans, 15% of the respondents harvested below 10 bags of beans per ha, 6% of the respondents harvested between 10 and 20 bags per ha and no respondent harvested more than 20 bags of beans per ha. 2% of the sampled farmers harvested between 0 and 10 bags and 3% of the respondents harvested between 10 and 30 bags per ha, no farmer admitted to harvest above 20 bags of sorghum. This suggests that the adoption of CSA practices leads to the production of higher yields, moreover the production decreased in 2018 despite the adoption of CSA practices, this may be because of the effects of climate variability. This result concurs with the earlier study by Hamin and Fashal (2019) who concluded that climate variability and food security are related in light of the truth that Climate variability influences the general national food security.

Table 4.15: Household Farm Yields for the Year 2018

Number of bags in 90 kgs per ha	Number of farmers who adopted CSA	Farmers who did not adopt CSA
MAIZE		
0-10	0%	1.08%
10-20	2.17%	3.26%
20-30	19.56%	14.67%
Above 30 bags	41.30%	17.93%
BEANS		
0-10	15%	8%
10-20	6%	5%
20-30	4%	4%
Above 30 bags	0%	0%
SORGHUM		
0-10	4%	2%
10-20	5%	3%
20-30	0%	0%
30 bags and above	0%	0%

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of findings, Conclusions and recommendation of the study. It identifies recommendations based on the research findings.

5.1.1 The Level of farmers' Adoption of CSA Practices to Mitigate Climate Variability

The first objective of this study determined the level of adoption of CSA used to mitigate climate variability in Soy Sub County. The study revealed that in the study area farmers have adopted different CSA practices with the aim of mitigating climate variability. The results showed that 96.9% (188) of the sampled farming households had adopted CSA practices while only 4% (8) had not adopted the CSAs practice. Climate Smart Agriculture practices accounted for half of the total cropland area in the sample in the 2018/2019 farming season. Majority of the respondents practice mixed farming (crop farming and livestock keeping). The level of adoption differs based on the combination of the CSA practices and their potential benefits for adaptation to climate variability. According to the farmers the area is experiencing climate variability evidenced by variation of the Rainfall. The study further found that the rains are not reliable and predictable and this has influenced farmers' their cropping systems, grazing patterns, production and the adaptation strategies to climate variability.

According to the key informant, most of the farmers in the study area rely on rain-fed agriculture; delayed onset rains and variation of rainfall lead to lower crop yields and potentially result in reduced income and food insecurity if the uptake of certain approaches such as CSA is not taken into account. Farmers in the study area are also able to access weather forecasts information concerning the onset of rainfall and drought through various means especially the radio. However, the weather forecast becomes irrelevant to farming activities since farmers claimed that information from the forecast is less reliable.

5.2.2 Farmers' Socio-economic Factors Influencing the Adoption of Climate Smart Agriculture among Households in Soy Sub-County

The second objective of this study assessed farmers' socio-economic factors influencing the adoption of Climate Smart Agriculture among households in Soy Sub-County. The study established that the intensity of farmers adopting of Climate Smart Agriculture practices is positively influenced by farmers' age. The study further found that the gender of the household head is not statistically significant in influencing the adoption of CSA practices. The biophysical factors such as soil type also influence farmers in adapting to Climate Smart Agriculture practices.

5.2.3 The Effects of CSA on Farming Households' Livelihood in Soy Sub County

The third objective of this study assessed the effects of climate Smart Agriculture practices on farming household livelihoods in soy Sub County. The study established that the main benefits of the adoption of CSA practices are, increased yields (88.77%), growth in farm income (73.46%), and increased food output. It also indicates that farming households can be an effective part of the response to climate variability. This is an indication that CSA can be a useful approach for mitigating climate variability, building more resilient livelihoods, improving food security, and alleviating poverty. According the key informants, most important achievement of the adoption of CSA is the integrated soil fertility through the increase of the soil organic matter status of the soil. According to the study findings the soil management practices for CSA include; minimum tillage, agro-forestry, and crop rotation through compost, crop residues, and green manure. The practices also prevent the washing away of nutrients by erosion and better retention of soil moisture. Agro forestry leads to reduced soil and water erosion, increased yields of food, fodder, and fuel; however, adoption of agro forestry worries farmers in that the introduction of some trees on farms can affect the growth of crops hence reducing their productivity.

5.3 Conclusions

Majority of the farming households in Soy Sub-County have adopted the CSA practices. The most preferred CSA practices by farming households were; changing planting dates for crops and improving livestock breeds for livestock. The results also indicated that the farmers' preference to adopt CSA practices is influenced by the cost of technology and implementation and their benefits to the adaptation of climate variability. Climate variability which was measured in this study by, fluctuation of rainfall pattern and increase in the occurrence of drought negatively affect crop yield and livestock production in the study area where farming households depend on rain-fed agriculture.

The Socio-economic factors examined in the study area; slope and soil type positively influence the adoption of CSA practices while education, experience, and age do not significantly influenced the adoption of the CSA practices by the farming households in Soy sub-County. The study reveals that some socio-economic and location-specific variables have significant effects on farmers' priorities on the adoption of CSA practices. Even though farmers in Soy sub-County are aware of climate variability, its impacts and have adopted CSA practices and other adaptation strategies, crop production in the region continues to decline. There is a need therefore to increase farmers' capacity to better adapt to the effects of climate variability to ensure sustainable agricultural productivity, improved livelihoods, and food security.

The adoption of CSA practices positively and negatively influences the livelihoods of farming households in Soy Sub-County, the main achievements of the adoption of CSA is the increase of farm yields, yield stability due to the soil being well-drained, and having raised farm income due to reduced farming activity, for instance, minimum tillage where farmers can avoid ploughing of land and just go for direct planting or plant after harrowing their land. However, the adoption of some CSA practices such as agro forestry had a negative effect where the planting of trees affects some of the growth of crops on the farm. Farmers need to advance in ways in which will lead them to strengthen the flexibility of farming communities and their livelihoods bring about this development through the introduction of useful climate-resilient and low carbon emission agricultural practices in farmer's land and adopting an extensive vision of agricultural growth that directly link farmers with policies and programs which will enable them to have suitable incentives to adopt new practices. Kenya has quite a lot of potential for CSA, but it needs to be explored extensively. CSA practices promotion requires concerted action from multiple actors to allow for context-specific approaches to be designed and implemented. Although the country has traditional agricultural practices as well as research-based programs and techniques that have CSA qualities, CSA practices promotion requires concerted action from multiple actors to allow for context-specific approaches to be designed and implemented.

5.4 Recommendations

Given the foregoing conclusion, this study makes the following recommendations targeting policy and future research:

I. Agro forestry and terracing were among the least adopted CSA practices despite their contribution on climate change mitigation and soil erosion control. Therefore, I recommend that agricultural extension officers to enhance awareness of the benefits of agro forestry and use of terracing to the farmers to increase adoption of this strategies in Soy Sub-County.

II. I recommend the department of agriculture and ministry of gender to enhance inclusivity for both men and women in agricultural activities in Soy sub county main streaming of gendered climate smart agricultural practices. Farmers need to be engaged in the planning of CSA, and work jointly with technical specialists and extension workers to identify CSA practices that are suitable to local conditions which could mitigate the climate variability.

III. Since majority of the households indicate that adoption of CSA leads to increased yields and income, I recommend enhanced awareness through farmers' field day and demonstration plots to reach those farmers who have not yet adopted CSA practices in Soy Sub-County to enable the sub-County realize food security.

5.5 Suggestions for Further Research

This study suggests the following for further research:

I. This study suggests research that can facilitate a more understanding of the clear meaning of climate variability to farming households as a major constrain to better agricultural production in Soy Sub-County. Climate variation was the focus of this study with an assumption that farming households were in a position to conceptualize well the meaning of climate variability which was not the case as noted during the study.

II. More research should be done to find out why bio-physical factors does not significantly influence the adoption of Climate Smart Agriculture practices in order to improve improved agricultural production in Soy Sub-County and suggest appropriate adaptation measures.

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APPENDICES

Appendix I: Questionnaire for Farmers

I am a student at Egerton University pursuing a degree of Master of Arts in Geography. This purpose of this questionnaire is to collect data on the adoption of Climate Smart Agriculture practices and their implication on farmers' livelihoods. You are requested to fill the questionnaire to help realize the study objectives. Your responses will be highly appreciated and treated with utmost confidentiality.

Questionnaire No.…………………………... Date of interview……………………

WARD……………………………………...

Please tick (√) the appropriate response or give a brief comment where applicable

<u>Part A: Personal details</u>

1. Name (Optional): ……………………………………………………………...

2. Gender

Male ☐ Female ☐

3. Highest level of education:

A. None ☐
B. Primary and below ☐
C. Secondary ☐
D. Tertiary ☐

4. Age bracket

A. 18-25 ☐ B. 26-35 ☐ C. 36-50 ☐ D. Above 50 ☐

<u>PART B: Crop Farming and Farming Characteristics</u>

7. What is the total size of your land (in acres)

1-5☐ 6-10 ☐ 11-15 ☐ Above 20 ☐

8. What is the size of your farm under cultivation (in acres)?

1-5 6-10 ☐ 11-15 ☐ Above 20 ☐

9. What is the main crop that you grow on your farm?

(a) Maize

(b) Beans

(c) Wheat

(d) Pyrethrum

(e) Peas

11. For how many years have you practiced farming? A. 1-5 years B. 5-10 years

C. 10-15 years D. Above 20 years

12. Respond to the following statements about rainfall variability

Statement	Response				
	SA	A	NC	DA	SDA
The rainfall in the area is very reliable and predictable. Rains never fail.					
It always rains during the short rain season from September to December every year.					
It always rains during the long rain season from March to August every year.					
Rainfall variation in my land always interferes with agricultural production.					

KEY: SA= Strongly Agree; **A**= Agree; **NC**= No comment; **DA**=Disagree; **SDA**= Strongly Disagree

<u>PARTC: LIVESTOCK FARMING</u>

13 Do you keep livestock?

A. Yes B. No

13. If yes which bread of livestock do you keep?

(a). Cattle

(b). Sheep

(c) Goat

(d) None of the above

(e) Others specify……………………………………

14. How do you feed your livestock?

(a). Using conserved fodder ☐

(b) Using conserved forage ☐

(c). Using irrigated pastures ☐

(d) Using irrigated fodder ☐

(e) Others specify…………………………………………

15. Do you feed your livestock with any of the following fodder crops?

(a) Napier grass ☐

(b) Rhode grass ☐

(c) Desmodium ☐

(d) Lucerne ☐

Others specify………………………………

16. Where do you feed your livestock?

(a). In paddocks ☐

(b) In communal land ☐

(c) In stalls ☐

17. What services does ministry of livestock do to ensure that your livestock are protected against diseases?

(a). Adequate disease surveillance ☐

(b). Disease control ☐

(c). Regular Vaccination ☐

(d). Intensify surveillance and control emerging livestock pest and diseases ☐

Others specify…………………………………………………………………….

PART D: Adoption and implications of CSA in Adaptation to Climate Variability

18. Do you practice any of the following CSAs shown in the table?

CSA approaches	Yes	No
Minimum Tillage		
Crop Rotation		
Terracing		
Agro-forestry		
change in planting dates		

Mulching

Improved livestock breeds

19. For how long have you adopted the above CSA approaches?

(i) Not adopted

(ii) 1- 2 years

(iii) 2- 4 years

(iv) 4-6 years

(v) Above 6 years

(20). what is the **MAIN benefit** of applying the practice stated above in your farming practice

(i) Increased yields

(ii) Increased income

(iii) Employment creation

(iv) Able to control pests

(i) Able to control weeds

(ii) Others (specify)……………………………………………………………………

(21). what is/are the main challenge in implementing CSA practices?

(i) Water availability

(ii) Inadequate and unreliable weather forecast information

(iii) Availability of market

(iv) Increased labor cost

(v) Availability of credit facilities

(vi) Inadequate knowledge on their application at farm level

(vii) No challenge encountered

(viii) Others (specify)……………………………………………………………………………

(22). Crop yield (indicate number of 90 kg bags per acre)

Crop variety	2017	2018
Maize		
Beans		
Sorghum		
Other		

(specify)…………………………………

23. What should be done to improve the adoption of Climate Smart Agriculture?

A. encouraging farming group ☐ B. Sensitization of farmers ☐

PART E: LIVELIHOOD OPTIONS AND INCOME

24. What is your main occupation?

A. Farming ☐ B. Formal employment ☐ C. Casual employment ☐

25. How many hours do you work a day?

A. 1-2 hours ☐ B. 3-4 hours C. 5-6 hours ☐ D. 7-8 hours ☐ E. Above 10 hours ☐

26. What is the average household monthly income?

Income category	Tick one category	Indicate the average amount in KES
Below KES 10, 000		
KES 10, 001 – 15, 000		
KES 15, 001 – 20, 000		
KES 20, 001 – 25, 000		
Above KES 25,000		

27. How has been your welfare since you adopted the CSA approaches?

A. Reduced Welfare ☐ B. Improved Welfare ☐ C. No changes ☐

28. What are the changes in the qualities of the soil of the farm where the CSA approaches have been adopted? A. fertility improved ☐ B. Reduced soil fertility ☐ C. No changes ☐

Appendix II: Key Informant Inter View Schedule

Interview No. ………… Location ……………………………... Date……………………
The Key Informants:

i. **Crop officers**

ii. **Meteorologist**

<u>**Interview Schedule**</u>

Name…………………………………………...Occupation…………………………….

<u>**Section 1: Meteorologist (To provide daily rainfall data for the period (2013-2018)**</u>

1. Kindly describe the rainfall pattern in Soy Sub-County for the last 5 years in terms of rainfall amount, cessation, and rainfall onset.

<u>**Section 2: Crop officers**</u>

2. Please give a summary of food crop production of Soy Sub-County yearly of the years 2017 and 2018.
3. Explain the impacts of climate variability on farming practices in Soy Sub-County for the last 5 years.
4. What are the best Climate Smart Approaches that can be implemented in order to enable farmers to adapt to the varying patterns of rainfall and temperature affecting food production in Soy Sub-County?
5. Explain the main constrains that hinders farming households from adapting the Climate Smart Approaches in Soy Sub-County?
6. In your own view, how has the government, NGO'S and CBO'S assisted farming households in Soy Sub-County in order to adapt to adaptive approaches such as CSA in order to improve on the food security and their livelihoods?
7. Does the terrain of the land affect farm yields in the sub-county?
8. How do farmers advised to manage steepness of their land to avoid soil erosion?
9. Does the type of soils in soil sub-county holds water or it allows infiltration?
10. How has the government policy been cascaded in Soy Sub-County?
11. How often do farmers request for soil testing?
12. How often is vaccination done?
13. Do you provide subsidized seeds of animal feeds?

Appendix III: Introduction Letter

EGERTON

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OFFICE OF THE DIRECTOR GRADUATE SCHOOL

Ref: NM14/12115/17 Date: 29th August, 2019

The Director General
National Commission for Science Technology and Innovation,
P. O. Box 30623-00100
NAIROBI.

Dear Sir,

RE: REQUEST FOR RESEARCH PERMIT – MR. FRANKLINE KIPROTICH YATICH REG. NO. NM14/12115/17

This is to introduce and confirm to you that the above named student is in the Department of Geography, Faculty of Environment & Resource Development Management, Egerton University.

He is a bona-fide registered M.A. student in this University. His research topic is **"Assessment of Climate Smart Agriculture and their Effects on Farmers' Livelihoods in Soy Sub County, Uasin-Gishu County, Kenya."**

He is at the stage of collecting field data. Please issue him with a research permit to enable him undertake the studies.

Your kind assistance to him will be highly appreciated.

Yours faithfully,

DIRECTOR, BOARD OF POST GRADUATE STUDIES
30 AUG 2019

Prof. Nzula Kitaka
DIRECTOR, BOARD OF POSTGRADUATE STUDIES

NK/en

"Transforming Lives Through Quality Education"

Appendix IV: Research License

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **340777**

Date of Issue: **24/October/2019**

RESEARCH LICENSE

This is to Certify that Mr.. FRANKLINE YATICH of Egerton University, has been licensed to conduct research in Uasin-Gishu on the topic: ASSESSMENT OF CLIMATE SMART AGRICULTURE AND THEIR EFFECTS ON FARMERS' LIVELIHOODS IN SOY SUB COUNTY, UASIN-GISHU COUNTY, KENYA for the period ending : 24/October/2020.

License No: **NACOSTI/P/19/2274**

340777

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Appendix V: Snapshot of abstract page of publication

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Effects of Climate Smart Agriculture Practices on Household Livelihoods in Soy Sub-county Kenya

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This study sought to analyze the effects of adoption of Climate Smart Agriculture practices on farmers' livelihoods in Soy sub County Kenya.
Study Design: The study adopted a cross-sectional descriptive survey research design, specifically use of household questionnaires, and interviewing key informants were used to come up with both quantitative and qualitative data.
Place and Duration of Study: the study was conducted in two sites in Soy sub-County Kenya: Soy and Kipsomba ward. The study was conducted in the period October –December 2019.
Methodology: Structured household questionnaires (N-196) and interviews with Key informant (N-6) were conducted in two agro-ecological zones. Descriptive statistical analysis was used .while results from key informants were used to collect valuable data that was useful in checking the validity of responses obtained through the use of questionnaires.
Results: The study found that 88.7% of the farming households that had adopted CSA practices led to increased yields, 73.46 % of farming households felt that the adoption led to increased income, 7.65 % felt that it has led to employment creation, 4.08 % felt that the adoption led to control of pest and 0.06 % felt that it led to control of weeds. This is an indication that the adoption of Climate Smart Agriculture practices can be the useful approach for mitigating climate variability effects, building more resilient livelihoods, improving food security and alleviating poverty.
Conclusion: in order to improve on the climate variability adaptation smallholder farmers need to adopt more of CSA practices to turn around the of food insecurity threats. The study concludes that the adoption of Climate Smart Agriculture practices positively and negatively influences the livelihoods of farming households in Soy sub- County.

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