SMALLHOLDER FARMERS' HOUSEHOLD SAVINGS AND THEIR INFLUENCE ON ADOPTION OF CLIMATE SMART AGRICULTURE TECHNOLOGIES IN NYANDO BASIN, KENYA

BY

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THESIS

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DECLARATION

This is my original work and has not been presented in any other university for a degree or any other award

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DEDICATION

I dedicate this work to my loving husband Vincent Akihanga, my son Lior Waki and my dear parents Daniel Gikonyo and Tabitha Njeri for their love, encouragement and unwavering support throughout my academic journey.

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ABBREVIATIONS AND ACRONYMS

AUAfrican Union

ADBAfrican Development Bank

CSAClimate Smart Agriculture

CCAFSClimate Change Agriculture and Food Security

CGIARConsultative Group for International Agriculture Research

GDPGross Domestic Product

FAOFood and Agriculture Organization of the United Nations

NEPADNew Partnership for African Development

NPCANEPAD Planning and Coordination Agency

NCCAP National Climate Change Action Plan

IPCC Intergovernmental Panel on Climate Change

ABSTRACT

Adoption of CSA technologies present an opportunity where smallholder farmers can not only be climate change resilient but also increase their agricultural productivity and incomes. Despite their proven benefits, the adoption rate of CSA technologies has been low mainly due to lack of credit access to small-scale farmers. Household savings has however been found to be an important budget item in rural households which farmers use to finance their farms. Evidence from literature point out that inadequate attention has been paid at household savings as a factor which has been established as a key contributor to farm investment in rural households which hinders development agencies from focusing on household savings as a strategy for scaling up CSA technologies .The study therefore compared the characteristics of households with savings and those without savingsin the study area, analyzed determinants of household savings and further examined the influence of household savings on adoption of individual CSA technologies and on the number of CSA technologies adopted by a household in Nyando Basin.The study tested the hypothesis that; there is no significant difference on demographic and socio-economic factors between savings households and households without savings, demographic, socio-economic and institutional factors have no significant influence on household savings among smallholder farmers and household savings has no significant influence on farmers' decision to adopt CSA technologies. Using stratified random technique, a sample 122 smallholder farmers was interviewed using structured questionnaires. Chi square statistic was used to compare the differences between the two groups while a Tobit model analyzed the determinants of household savings. Multivariate probit (MVP) model and Poisson model was employed to examine the influence of household savings on intensity to adopt CSA technologies. The findings revealed that smallholder farmers had a high propensity to save. More than half of the sampled households had savings. The major savings avenues were community groups, banks and home in that order. Age, sex, Financial literacy training, credit access and wealth index positively influenced household savings while total dependants and distance to cattle market had negative effect. MVP results showed that household savingshad a significant positive influence on adoption of agroforestry, improved breeds and greenhouse farming technologies while Poisson regression results revealed that household savingshad a positive and significant influence on the number of CSA technologies adopted by a household. In order to scale up adoption of CSA technologies through household savings, the study recommends for empowering of local community groups where most farmers save. This can be achieved through training on group management and financial literacy as it positively influenced household savings. There is also need for building capacity and of existing farmer groups training centers as well as widening their coverage. In addition, introduction of e-wallets can stimulate rural household savings. Future studies can widen the scope of household savings by accounting for non-monetary household savings.

Keywords: Climate Smart Agriculture technologies, Smallholder farmers' household savings, Nyando Basin

CHAPTER 1 : INTRODUCTION

1.1 Background information

Meeting nutritional and food security demands of world's population, which is expected to surpass ninebillion people by 2050, is a common objective shared by global development organizations, governments, and even individuals. Food production will accordingly need to increase by at least 70% by the year 2050 so as to match the food requirement of the growing and urbanizing populace (Thornton *et al*., 2018; FAO, 2009). In light of this, prioritization of the agricultural sector is key which is well articulated in the sustainable development goals (SDG 2) that aims at eliminating hunger, increasing food security and nutrition, and promoting sustainable agriculture by the year 2030. In Sub-Saharan Africa (SSA) the sector employs over 60% of the population and contributes approximately 30% of GDP. In Kenya, agriculture sector accounts for 28% of the country's GDP 65% of overall export revenues, while employing over 80% of the country's rural workers (World Bank, 2015).

Despite its critical role, the sector faces a number of obstacles, among them unstable and inadequate socio economic policies, market failures, poor infrastructure, financial inaccessibility, resource shortages owing to population pressure, environmental degradation and trade barriers (FAO, 2015; Atitianti *et al*., 2018; Karuku *et al*., 2017). These issues are further amplified by the impacts of climate change as this sector is primarily rain fed and also depends on climate (IPCC, 2014; Williams *et al*., 2015). The fifth assessment report of Intergovernmental Panel on Climate Change (IPCC) indicated the surface temperatures in Africa has risen by 0.5-2°C in the past 100 years and this was attributed to climate change. Rainfall patterns have also changed with shorter long-rainy seasons and longer short-rainy seasons and more frequent and intense floods (GoK, 2018). This jeopardizes historical agricultural productivity gains affecting smallholder farmers' food security, their income and livelihood (World Bank 2016). Much as agriculture is extremely vulnerable to climate change, the sector contributes significantly to this change accounting for 19- 29 percent of the global greenhouse gas (GHG) emissions (World Bank 2016; Vermeulen *et al*., 2012). It is therefore critical to have an agricultural sector that is not only climate resilient but also with low emissions in order to cushion over 70 percent of the world poor who mainly rely on the sector as the primary livelihood sources (World Bank 2016).

Based on this context, the concept of building resilient agricultural systems hasglobally been pushed to the forefront of agricultural policies. In Kenya for instance, agriculture is a major source of livelihood but is largely rainfed hence it is directly impacted by the impacts of climate change (Ochieng *et al*., 2016). The governmenttherefore came up with a framework titled National Climate Change Response Strategy (NCCRS) in 2010 which incorporates climate change in its development priorities. This was operationalized in 2012 through the National Climate Change Action Plan (NCCAP) which guided on the appropriate mitigation actions for six sectors including agriculture in line with SDG 13 of combating climate change and its impacts.Among this mitigation actions was adopting of climate smart agricultural practices (CSAP) that led to climate smart agriculture program (CSAP 2015-2030), in line withKenya vision 2030 with a vision of promoting climate resilient andsustainable agriculture that guarantees food security and contributes to national development goals.Substantial progress has been made in implementing these strategies with the aim of achieving the big four food security and nutritional security goal as noted in NCCAP 2018-2022.Adoption of Climate Smart Agricultural (CSA)technologiesoffer some unique opportunity for simultaneously tackling climate change concerns while still supporting agriculture industry growth and economic development.

The concept of CSA was developed by FAO with the goal of ensuringfood security through sustainable agricultural development in the face of climate change (FAO, 2013). Lipper *et al*., 2014 reported CSA as a strategy for reforming and reorienting agricultural growth in light of climate change.Climate Smart Agriculture (CSA) is not a universally applied practice, it involves evaluating the social, economic and environmental condition of a location then coming up with the appropriate CSA technologies (Williams *et al*., 2015). It comprises of three pillars notably; expanding agricultural output and incomes in a sustainable manner, adapting and creating resilience to climate changeand lowering or eliminating greenhouse gases emissions ifpracticable (GoK, 2017). The approach has received national and worldwide recognition as a critical response for adapting agriculture to climate change(FAO, 2013,World Bank 2015).

According to Lan *et al*. (2018), there are numerous CSA technologies that contribute to achieving climate resilient agriculture. However, technologies considered climate smart vary significantly across regions as CSA technologies are context specific depending on the vulnerabilities, constraints and characteristics of a given agricultural sector (Sova *et al*., 2018). Bhattacharyya*et al*. (2020) categorized the Climate Smart Agriculture Technologies on to six dimensions; carbon or energy smart, nitrogen smart, water smart, weather smart, knowledge or institution smart and crop smart technologies. Carbon smart technologieshelp the soil to store carbon and therefore prevent GHG emissions which include minimum tillage, organic and compost manuring, afforestation among others (Anuga *et al*., 2019). Weather smart technologies assist farmers in accessing timely weather information and therefore prepare for climate change events which include index based insurance and use of radios, television and mobile phones to access weather information (Shannon & Motha, 2015). Water smart technologies are water conservation technologies which help mitigate climate induced water stress (Quiroga *et al*., 2015) and include cover crops, mulching, contouring and terracing and rain water harvesting. Knowledge or institution smart technologies are practices which create awareness of climate events, sustainable agricultural practices and market prices of inputs as well as farm produce (Keshavarz & Karami, 2014). This could be through farmer to farmer knowledge sharing, smart farms and collective action groups. Nitrogen or nutrient smart technologies include planting of leguminous crops and precision fertilization while crop smart technologies involve practices like use of certified seeds, stress tolerant seeds, seeds and fodder banking(Anuga *et al*., 2019).Bhattacharyya*et al*. (2020) noted that as much as each dimension has its own set of unique technologies, they are interlinked with each other and they are applied together to yield the maximum benefits of CSA adoption.

Various organizations and policymakers have been working towards enhancing the adoption of these technologies in an effort of ensuring most smallholder farmers engage in agricultural practices which increase their productivity and also enable them to be climate resilient. CCAFS (climate change, Agriculture and Food Security) which is an international organization within CGIAR (Consultative Group for International Agriculture Research) promotes the use of these technologies in various countries in Africa. In East Africa, the organization has been able to establish six sites in four countries in East Africa. These countries include Kenya, Ethiopia, Tanzania and Uganda (Recha *et al*., 2017).Among the chosen cites in Kenya was Nyando Basin as it is a central point which represents regions which are experiencing extreme high rainfall during the rainy season and extreme drought during the sunny season and therefore the research findings in these area can be used and adapted in other regions with similar climatic zones (Förch*et al*., 2013).About 40% of the landscape of the Nyando Basin has been degraded by soil erosion and water runoff, forming deep gullies (Bernier et al. 2015). Climate change is evident in the region characterized by frequent droughts, irregular and unreliable rainfall, and extreme flooding during the wet season (Macoloo et al., 2013). As a result, agricultural production declines and farmers become more vulnerable to climate risks, affecting food security and household nutritional needs (Kinyagi et al., 2015). In this context, CCAFS identified agroforestry, greenhouse farming, improved breeds and water-harvesting as the most appropriate interventions in this area. The organization has partnered with other development agencies such as World Neighbors, Vi Agroforestry, Kenya Agriculture and Livestock Research Organization (KALRO) and Kenya Ministry of Agriculture and Livestock since late 2011 to develop and promote a portfolio of promising CSA interventions for Nyando. (Ojango et al., 2015).

Despite the potential adaptation, mitigation and productivity benefits associated with CSA interventions for smallholder farmers, their adoption requires a significant investment of time, labor and income, as well as acquisition of new skills may be required and this may inhibit adoption (Bernier et al., 2015).Apart from these investment costs there is a time gap between investments and realization of benefits od adoption. Therefore, it is important to cushion smallholder farmers on this period. Smallholder farmers fund these technologies using credit finance, money transfers from friend and relatives or the use of accumulated savings (Wattel *et al*., 2018). Credit finance is however a challenge to smallholder farmers because of lack ofcredit history and collateral while lenders find them unattractive because the high transaction costs are above the little loan amount required by smallholder farmers (Sadler *et al*., 2016). According to the Africa agriculture report in 2017, more than 50% of Africa population are in the agriculture sector but less than 1% of banking credit goes to this sector. The few with access to credit direct it to non-farm sector as farmers fear using their debt fundsto invest inunpredictable agricultural investmentsfor fear of losingcollateral (Hertz, 2009).In addition, the cost of internal sources of financing, such assavings, are cheaper compared to the cost of obtaining loans.(Abebe *et al*. 2018).

Household savings provide an opportunity for a smallholder farmerto overcome credit limitations by accumulating sufficient capital to invest in CSA technology adoption. It is known to be a key budget item among the rural households (kibet *et al*., 2009).Iyoha *et al*. (2003) and Rutherford (1999) observed that savings enhances well-being by supporting and growing rural businesses, and insuring households during crises. Savings in itself a strategy for managing risks and also a sign of the ability to repay loans.Savingscan help to cover investment cost as well as influencefarmers' risk behavior through providing mechanisms of dealing with risks and income variations which may motivate farmers on investing in CSA technologies (Wattel *et al*., 2018).According to FSD Kenya., 2016a, most farmers'finance their farms withsavings and also savings was found to be the most important risk management strategy.

1.2 Problem statement

Climate change and variability is a global problem which has affected especially the small scale farmers as it exposes them to both crop and livestock production risks, (Hardaker *et al*., 2015). Adoption of CSA technologies such as agroforestry, waterharvesting among others has been fronted as a sustainable strategy of addressing this problem, (FAO, 2013). In an effort to transform livelihoods under the changing environment, development agencies have promoted a number of CSA technologies globally. CCAFS (climate change, Agriculture and Food Security) which is an international organization within CGIAR (Consultative Group for International Agriculture Research) has specifically been promoting various CSA technologies in Nyando basin since the year 2011. However, to date, financial constraints has been a setback to the rate of adoption of these technologies.

Household savings has been found to be among the ways through which farmers finance their farms. Wattel *et al*.(2019) found that farmers in the study area self-finance their farms using savings while Kibet, 2009 noted household savings to be an important budget item among the rural households in Kenya. Despite this fact, a review of literature focusing on determinants of CSA adoption(Abegunde *et al*., 2019, Kurgat *et al*., 2020, Pagliacci *et al*., 2019, Awuni *et al*., 2018, Makate *et al*., 2018 and Aryal *et al*., 2018)reveals that inadequate attention has been paid at household savings as a factor influencing adoption. This hinders development agencies from focusing on household savings as a strategy for scaling up CSA technologies.

In addition, application of CSA technologies is location and context specific in regards to environment, social and economic situation of a place as noted by Abegunde *et al*., 2019. The author recommends for location specific studies on factors influencing adoption. Further the researcher recommends for future studies to consider and include other factors influencing adoption which is a research gap that this study seeks to fill.

1.3 Objectives and hypothesis of the study

1.3.1 Overall objective

The objective of this study was to analyze the determinants of household savings and its influence on CSA technologies adoption among smallholder farmers in Nyando Basin.

1.3.2Specific Objectives

i. To compare the socio-economic and demographic characteristics of smallholder farmers with savings and those without savings.
ii. To determine the influence of demographic, socio-economic and institutional factors on household savings amongsmallholder farmers.
iii. To assess the influence of household savings on the extent of adoption of CSA technologies among smallholder farmers.

1.4 Hypotheses

i. There is nodifference between the socioeconomic and demographic characteristics of smallholder farmers with savings and those without savings.

ii. Demographic, socio-economic and institutional factors have no influence on household savings among smallholder farmers

iii. Household savings has no influence on the extent of adoption of CSA technologies among smallholder farmers.

1.5 Justification of the study

Climate smart agricultural practices are a necessity to farmers if they have to overcome the impact of climate change. Financial constraints being one of the setback to their adoption calls for research on possible interventions in the area of financial avenues which farmers can utilize in order to be able to adopt these practices. The findings of the current study aim at informing policymakers and development agencies on the decision to consider household savings as an important strategy in scaling up of CSA technologies.Results on household savings patterns and factors influencing savings will provide vital information needed in designing appropriate strategies targeting to increase household savings. In addition, factors influencing household savings will be useful in formulating training targeting specific farmers' characteristics with the aim of encouraging increased savings rate and consequently investing in CSA technologies.The findings of this study will add to the existing body of knowledge on household savings and investments in CSA technologies. The study is also envisioned to contribute in achieving of sustainable development goal (SDGs) 1 aimed at eradicating poverty, 2 on zero hunger and goal 13 on mitigating climate change based on the benefits of increased adoption of CSA technologies.

CHAPTER 2 :LITERATURE REVIEW

2.1Introduction

This chapter reviews the relevant theoretical and empirical literature regarding household savings and CSA technologies. Empirical literature review is on determinants of household savings and factors influencing adoption of CSA technologies.

2.2The definition and concepts of Household savings

Savings refers to the part of income that is deferred for future consumption, investment or unforeseen events (Lidi *et al*., 2017; Uhuegbulem *et al*., 2016). It is important to individuals, households and the economy as a whole. Individuals value savings because unlike income it is what they have accumulated over time to cushion themselves against hard times, during emergencies and for investment purposes, Chowa *et al*., 2012. For an economy, savings provides finances necessary for investment purposes. Evidence points out that the rate of household savings is positively correlated to a country's high investment and growth rate (Attanasio & Banks, 2001). A country's domestic savings is more desirable for investment purposes to foreign aid and foreign direct investment as foreign aid and investment suppress domestic small scale enterprises through competition leading to decline in domestic investment and consequently lower rates of economic growth (Konya & Nyakwara, 2019).

Household savings forms the bulk percentage of domestic savings for developed and emerging economies (Njenga *et al*., 2018). However, in Sub-saharan Africa (SSA), the rate of formal savings by households has been low for various reasons such as low and irregular income and lack of access to financial services. The formal financial service providers find the rural population unattractive due to lack of physical infrastructure and the high account maintenance fees compared to their small deposits (Chowa *et al*., 2012). AGRA, 2017 reported that formal financial institutions are often beyond the reach of smallholder farmers. Some of the challenges cited are high transaction and travelling costs and where these exist, the high minimum balance and mandatory deposits discourage the farmers. The alternative savings instrument for the farmers if usually village savings and loans groups (VSLAs) which are not adequate and are often ineffective in their operations (AGRA, 2017).Despite these barriers, empirical literature points out that rural households in SSA actually save (Chowa *et al*., 2012; Wiliams, 2006)

Households save for various reasons and this can be grouped in to four savings motives; to smoothen unexpected losses of income, to smoothen and maintain a stable consumption pattern over time, to finance large lifetime expenditure and to ensure availability of resources during retirement and for bequest. This savings motives are supported by three major hypotheses which had a great contribution to savings literature.Relative income Hypothesis is credited to James Duesenberry (1949) in his book “Income, savings and the theory of consumer behavior". During this time John Keynes hypothesis that as income increases, an individual consume less and save more was dominant. However, further research showed that as aggregate income grew, aggregate savings did not grow proportionately over time which was explained by Duesenberry (1949) in the relative income hypothesis. He argued that the utility index of an individual is influenced by the ratio of their consumption to a weighted averageof other people's consumption.Relative income was assumed to be the average income of the neighboring households or the highest income that a household had attained in the recent past. He came to the conclusion that the overall savings rate is unrelated to overall income, and that an individual's tendency to save increases as their percentile position in the income distribution rises.

The second major contribution was in 1954 by Franco Modigliani and Richard Brumberg who proposed the life cycle hypothesis (LCH) and is anchored on the premise that consumption and savings levels of individuals reflect their age or stage in the life cycle. They argued that individuals spread their consumption evenly over their lifetime and therefore accumulate more savings during their early years in order to be able to maintain their consumption during retirement. Therefore, savings rate of a society is influenced by the age structure of its population.

The third major contribution was by Milton Friedman (1957) who developed the Permanent income hypothesis and argues that a change in consumption behavior is unpredictable since it is dependent on the expectation of an individual. The level of people's spending is in line with their long term average income expectations. The term permanent income denotes average income expected by a household in the long run. It assumes that in order to maintain a smooth consumption, households allocate their lifetime resources equally among each period of life and therefore consumption by a household in any period is based on its permanent income. Households save if their current income (transitory income) exceeds their permanent income so as to cushion themselves from lower incomes in future.

2.4 Climate smart agriculture (CSA) technologies

Most African economies rely on agriculture in poverty eradication and achieving food security. Research shows that over the past decade agricultural production has increased largely due to expansion in land area under cultivation with little change in production techniques (Williams *et al*., 2015). This is arisky affair, with climate change and variability. Climate Smart Agriculture (CSA) aligns to sustainable development goals (SDGs) with triple promise to: improve food security through increased agricultural productivity; help farmers in adapting to climate change; and reduction of greenhouse gasses emission from the agricultural sector (FAO, 2010, 2013). It is a localized mitigation and adaptation intervention and farmers are climate smart if they deliberately get involved in addressing local climatic concerns and in promoting a mix of adaptation, food security and livelihood solutions (Chandra, 2017).

Climate change has socio-economic consequences both at individual and national levels (Zougmore *et al*., 2016). By reducing agricultural production, climate change lowers household income limiting the capacity of a farmer to acquire physical assets (FAO, 2016). This translates to macroeconomic consequences like spike in agricultural commodity prices and food unavailability for the general population (FAO, 2015). This calls for action and political will to accelerate investments in adaptation and mitigation mechanisms to deal with climate change (FAO, 2010). Promotion of CSA practices is one way to deal with the long term effects of climate change as well as managing the risks associated with increased climate change and variability (Zougmore *et al*., 2016).

Milestones have been achieved inAfrica after CSA was included in the New Partnership for African Development (NEPAD) program on agriculture and climate change during the African Union (AU)conference in 2014. This facilitated the establishment of the African climate smart agriculture alliance whichin collaboration with other stakeholders is working to reach out to 25million households by the year 2025 (Williams *et al*., 2015). NEPAD Planning and Coordination Agency (NPCA) in partnership with FAO provides the necessary technical support to countries who are AU members in implementing the CSA program. African Union (AU) member states investing in CSA receive financial assistance from African Development Bank (ADB) and its partners.

Climate Smart Agriculture (CSA) has become an institutional concept for formulating agricultural policy amidst climate change (Taylor, 2018). Fourteen African countries, among them Kenya and Uganda in EastAfricahave adjusted their national agricultural and food security investments plans (NAFSIPS) to fit a framework proposed by FAO in collaboration with NPCA on investing and implementing CSA technologies (FAO, 2012).The framework proposes an improvement in agricultural research, technology dissemination and adoption. Consultative Group on International Agriculture Research (CGIAR, 2013),documented several success stories on climate-smart agriculture around the world. Among the successstories is where farmers in Sahel adopted water harvesting technology which lead to an increase in production to 400kg per ha in one season, adoption of drought tolerant maize variety by over two million farmers around the world increased the yields by 20-30% above what would have been achieved using the traditional varieties. The focus now is scaling up of successful interventions in order to reach out to more farmers.

Several studies (Mwungu *et al*. (2019), Beyene *et al*. (2017), Atitianti*et al*. (2018), Botha *et al*. (2015), Anuga and Gordon (2016), Radeny *et al*.,2018) have been conducted to determine whether the adopted CSA technologies are effective in boosting resilience and reducing the effects of climate change while simultaneously improving agricultural output and incomes, which are the goals of CSA adoption.The results have indicated that adoption of CSA technologies resulted in better livelihood outcomes such as agricultural incomes and food security which are among the indicators of resilience. For instance,Mwungu *et al*. (2019) showed a general positive impact on farm income after CSA adoption, however, he noted that adopting of some CSA combinations may result to a tradeoff where their adoption simultaneously increases incomes but also increases the labour costs. The study concluded that the goal of the farmer determines the combinations they chose. These results collaborate that of Beyene *et al*. (2017) and that of Atitianti*et al*. (2018), they noted that households that adopted CSA technologies earned 29% more income per ha compared to non-adopting households and also contributed to overall reduction in GHG emissions.Climate Smart Technologies (CSA) adoption has also been found to increase agricultural productivity resulting to food security and contributing to general household welfare (Botha *et al*. (2015), Anuga and Gordon (2016), Radeny *et al*. (2018). Khatri *et al*. (2016) noted that most farmers adopt CSA technologies based on their perceived economic benefits associated with a given practice and not necessarily to achieve all the three objectives including greenhouse gas reduction. Despite this fact, Saprota *et al*. (2015) argues that as much as these adaptation practices have economic benefits, most of them have greenhouse gases mitigation as a co-benefit hence are able to achieve all the three aims simultaneously.

2.5 Household savings and climate smart agriculture technologies

For agricultural investment to positively influence production and productivity, the investment made at the farm level by farmers are indispensable(Syed & Miyazako, 2013). Household Savings is the major source of investment fund in farming households and farm investment decisions are determined by the ability of a household to accumulate savings andthe amount saved (Syed & Miyazako, 2013). Household savings determines the level of innovation in implementing and usage of the latest technologies. It not only provides economic security in times of unexpected and irregular income periods but also facilitates wealth accumulation that enables households to respond to new opportunities (Wieliczko *et al*., 2020). Empirical studies on household savings and investment patterns have shown that savings positively influences adoption of agricultural technologies. For instance, Hohfeld &Waibel (2013) found that household savings positively influenced large agricultural investment. Nwibo & Mbam (2013) also reported that farming households save and invested mainly on adopting modern technologies like new varieties, improved breeds as well as purchasing agrochemicals.

2.6Climate smart agriculture in Nyando Basin

In an effort to overcome risks posed by weather extremes such as frequent floods and drought, the local communities have relied on indigenous knowledge based on trial and error. However, this approaches have often been ineffective and unsustainable due to incomplete information on changing climate extremes and the appropriate climate smart technologies (Ogada *et al*., 2020). Smallholder farmers on their own may therefore not be able to build strong adaptive measures as they require other players like input suppliers, local institutions, government departments and research organizations to mobilize and support them to build their resilience and adaptive capacity (Ogada *et al*., 2018). The Consultative Group for International Agriculture Research (CGIAR) on climate change, Agriculture and Food Security (CCAFS) in partnership with these key players has since 2011forecasted climate extremes in Nyando Basin, developed appropriate improved technologies, facilitated and mobilized farmers in the uptake of proven technologies (Aggarwal *et al*., 2018). Among the technologies which have been developed and promoted in Nyando Basin are, improved livestock breeds, agroforestry, water harvesting and greenhouse farming.The ultimate goal is to ensure that the smallholder farmers have sustainable food and nutritional security and enhanced household income (Kinyangi *et al*., 2015).

Improved livestock breeding programme was introduced by CCAFs in collaboration with World Neighbours and International, Livestock Research Institute (ILRI) with a goal of boosting productivity of small livestock like sheep, goat and chicken. Given the modest land holdings in Nyando, this intervention is appropriate because it requires less labor unlike cattle and gives women more power to manage the livestock and their incomes (Macoloo *et al*., 2013). This resulted in the introduction of Galla goats and Red Maasai sheep in Nyando that are cross-bred with local breedsin order to boostproductivity while poultry improvement involved introduction of early maturing and disease resistant indigenous chicken (Ojango *et al*., 2015). Galla goat is well adapted to dry lands, matures earlier with a longer productive life than local breeds and has a good milking ability while the Red Maasai sheep which is raised for meat is superior as it grows faster, is resistant to internal parasites and shows stronger tolerance to trypanosomes, drought and heat. The crossbreeds of Galla goats and Red Maasai sheep mature quicker compared to local breed and also command higher prices in the local markets (Kinyagi *et al*., 2015). Farmers receive extension services on good management practices from the ministry.

Agroforestry is a land management strategy in which trees and shrubs are planted alongside agricultural crops and pastures on the same piece of land. (Karuku, 2018). This has the ability to halt land degradation and therefore mitigate declining agricultural production and natural resource base and hence reduce rural poverty. Several agroforestry methods, such as fertilizer trees like *Calliandraspp*, *LeucenaLeucocephala*, and *Terminalia brownii*, have been successfully implemented in Kenya. In degraded fields, planting crops alongside these trees and using inorganic fertilizers can multiply agricultural output. Smallholder zero-grazing systems use fodder trees to augment or replace commercial feeds (Jama *et al*., 2006; Karuku, 2018). The trees introduced in Nyando basin targeted not only reducing soil erosion and enhancing soil fertility but also production of fruits (pawpaw, avocado, mango), fodder and fuel wood. This intervention also led to the promotion of Bee keeping as a livelihood diversification strategy for the rural community. Traditional bee keeping is labourintensive, dangerous and excluded women from harvesting due to the fear of bee stings. The average yield per beehive per year is only about 5kg. Improved beehives have been introduced as part of CSA innovations, and farmers have been trained to be more productive beekeepers. Artisans are taught how to make low-cost theft-proof bee hive, resulting in increased yields of up to 10kg per beehive in a single harvest, with three harvests each year. Women have also been actively involved in the practice(Macoloo *et al*., 2013).

Water harvesting is another CSA technology which is being promoted in Nyando Basin as rainfall in the area is increasingly unpredictable with long dry spells and intense rainfall in the rainy season leading to flooding. Farmers have traditionally relied on rivers and streams for water in the area, but this has become unreliable due to climate change. Households are incentivized to harvest water by investing in water harvesting pools and water pans through CSA technologies. The pools range in water capacity from 48000 to 100000 litres per family and can be used up to three months (Recha, 2017). Alongside this intervention, fish farming was introduced in the year 2014 through the department of fisheries with support from CCAF. Fish farming is an income generating activity and also improve nutritional value for the local community. Three smart farms (Onyuongo, Lower Kamula, and Obinju) have been established and are run by youth and women's organizations. Farmers have the opportunity to practice aquaculture skills such as selecting sites, water quality, constructing ponds, stock rating, predator control, how to harvest, preserve, market and do book keeping at these smart farms. (Recha, 2017). Farmers then construct their individual dams and stock them with fish which they can feed with locally available and affordable feeds like potato vines.Greenhouse farming was also introduced which has the advantage of savings water, protecting crops against floods and drought while also offering better control to pest and diseases. Farmers are taught greenhouse farming skills such as site selection, soil quality, water quality, harvesting processes, marketing, and bookkeeping at smart farms (Recha, 2017).

The uptake of CSA technologies in this region has since been on an upward trajectory (Ogada *et al*., 2020). For instance, investment in water harvesting technologies has been on the rise with almost 30% of the farmers reported to have constructed water pans with capacities of up to 48000-100000 litres per household. Similarly, adoption of improved livestock breeds has risen from 35% of the households in 2011 to about 57% in 2015. The uptake of agroforestry technology has also increased as farmers have been supported in setting up of tree nurseries which supply seedlings for planting. Sixty percent of these tree nurseries are owned by women which led to rise of at least 500,000 trees planted in farms between 2015 and 2017. Through agroforestry, households have even diversified to bee-keeping. Indeed, household welfare in the region has been positively impacted by adopting of

CSA technologies as reported by Ogada *et al*., 2018 who found that households that had adopted CSA technologies had superior diet diversity and were wealthier than non-adopters.

2.3 Factors influencing household savings and determinants of adoption of CSA technologies

Empirical literature has outlined the different factors influencing household savings. However, the focus of majority of these studies has been on developed economies and adopted a macroeconomic approach (Simleit *et al*., 2011). Teshome *et al*. (2013) focusing on factors influencing the savings of rural households noted that economic agents behave differently at the national and household level. The current study adopted a micro economic approach and used micro data in its analysis. Studies which followed the same approach identified demographic (age, sex, education, total dependants), socioeconomic (off-farm occupation, land size, wealth index) and institutional factors (distance to market, training, group membership, credit access) to influence household savings.

On the other hand, different factors influencing the adoption of CSA technologies have been identified from the reviewed literature. These variables have been categorized in to three classes as outlined in the stated hypothesis of this study (see section 1.4).

2.3.1Demographic Factors

Age of the household head

Age related savings motives significantly influence a household savings (Mirach & Hailu 2014). According to lifecycle hypothesis, a person is expected to save up to a certain point where they start dissaving as they grow old. Individuals build their savings during their earning years so that they can utilize them to smooth consumption on retirement (Adewuni *et al*., 2010). Obayelu , 2010 found that household heads within the age bracket of 45-65 years had the highest savings rate while those with more than 65 years having the lowest savings rate.Njunge (2011) found this variable to have a negative relationship on savings. The coefficient of age squared was negative implying that growing older by a year results in decrease in household's savings by roughly Ksh 2.63.

On the contrary, the knowledge intensive nature of CSA technologies may have a negative influence on older farmers. Nyong *et al*., 2007 noted that older farmers have over the years learnt about climate related shocks and therefore rely more on their indigenous knowledge as opposed to adoption of new technologies which may have steep learning curves. As much as older people may have accumulated physical and social capital which can enhance adoption, they are associated with loss of energy and being risk averse and therefore may not be willing to learn new skills, Atitianti *et al*., 2018. Older farmers are more rigid to shift from their traditional practices and adopt new technologies. On the other hand, young people are typically less risk averse and more willing to try out new technologies as noted by Mwangi and Kariuki, 2015. Kisaka- Lwayo *et al*. (2005) observed that younger farmers are more risk takers and therefore are willing to take up new ideas like CSA technologies. In the current study,agewas measured in number of years of the household head. It was hypothesized to have a positive influence on household savings but a negative influence on adoption of CSA technologies. Age squared was also included in order to assess the effect of age more accurately as the age of the household head increased and it was hypothesized to have a negative relationship on household savings and on adoption of CSA technologies.

Dependants

There is a number of factors which influence the aggregate savings of any household. Nayak (2013) observed that these variables differ between the rural and urban areas. Abdellhalek *et al*. (2009) indicated that while householdsize is a significant determinant of aggregate savings in the urban areas, the effect of household size on savings in the rural areas is insignificant. The reason for this is due to the fact that an additional member in rural areas does not affect a household's living and working condition. However, household size influence on savings is also determined by the composition of the households in terms of either dependants or productive household members. Total dependants are members of a household who are below 14 years and those above 65 years (World Bank, 2016). A rise in one household member will lead to a decline in household savings if that member does not bring any income to the household. Rehman *et al* (2011), in their study on savings concluded that bigger households have bigger expenditure and consequently reducing the amount saved by that household.

A common characteristic of smallholder farming is reliance on family and relatives labour for their farming activities (Anugaetal., 2019, Owusu *et al*., 2015). Household size is often used as a proxy for labour endowment where larger households are assumed to have more labour which has a positive influence on technology adoption (Kanyeji *et al*., 2020, Ndiritu *et al*., 2014). However, the age bracket of these household members matter as members who are below 14 years and those above 65 years are considered to be dependants and may not be actively involved in supplying of family labour, Kanyeji *et al*., 2020. Therefore, the current study expected total dependants to be significant but having a negative influence on household savings as well as on the adoption of CSA technologies.

Education

Education level is another factor whichhas been found to influence household savings as it is closely related to wealth accumulation in the long-run as income is expected to increase. Sawuya (2018) focusing on determinants of household savings estimated an Ordinary Least Square model and found that household savings increased as household heads advanced their education. The study further found that spouses who had advanced their education positively influenced the household savings which was attributed to improvement in literacy and numeracy levels. Gender, age, household location, household size and marital status were also identified to influence household savings. Zwane *et al*. (2016) using a panel data approach focused on factors influencing householdsavings in South Africa. Using a two stage least square (2SLS) method they found education level to have positively influence household savings. The study emphasized on the need for financial literacy in all education levels in order to instill a savings culture. Bernheim and Garrett (1996), Kibet *et al*. (2009) and Mwangi (2020) research in Kenya asserted that savings rates increase with education while Abdellhalek *et al*. (2009) found household's head literacy level as the key savings determinant in rural areas. The variable was expected to improve understanding and choice of a farmers savings pattern and was therefore hypothesized to positively and significantly influence a farmer savings.

On the other hand, Chiputwa *et al*., 2010 focusing on conservation agriculture technologies in Zimbabwe noted that CSA technologies are knowledge intensive. Therefore, educatedfarmers are more likely to adopt new technologies because they are likely to comprehend and interpret new technologies in a better way. Mwangi and Kariuki, 2015 noted that education improves the attitude of individuals and makes them more receptive and rational to be able to analyze the benefits and adopt new technologies. Gebresilassie and Bekele, 2015 who had similar results reported that educated farmers allocated more land to adoption of improved technologies.(Abdulai and Haffman, 2005) observed that farmers who were more educated are able to easily identify technologies which can improve their economic gains as such farmers have high ability to process information. In addition, education level increases the probability of access to financial assets by a household as it makes them more attractive to financial providers (Tu *et al*., 2015). In this study, education of the household head was measured on whether the farmer had formal or no formal education and was hypothesized to have a positive and significant influence on household savings and also on adoption of CSA technologies.

Sex.

The propensities to save between men and women differ due to their genderdifferences and also variations in their perceived risks and interests. Empirical findings on the relationship between household savings and the sex of the household head are inconclusive. Mirach and Hailu (2014) found that women's savings behavior was superior than men's. Abdelkhalek *et al*. (2009) also had the same finding and attributed this to that women save more with their children education in mind and therefore are able to better manage their savings between social needs, consumption needs and economic activities. The study however noted that when income increases, male headed households tend to save more and the results were therefore inconclusive. In contrast, Sawuya (2018) and Souksavanh (2013) found that savings levels of male headed house heads were higher than households managed by women. Gerrans and Murphy (2004) concluded that women have bigger chances of not savings due to their higher risk tolerance and that males have better chances of earning more than females hence more savings.

On the other hand, Gender issues in terms of gender roles, decision making and control of productive assets also plays a significant role in CSA adoption. Murray *et al*. (2016) focused on smallholder women farmers found that while efforts were being made to encourage adoption of CSA technologies, the women in the region were disadvantaged due to lack of capital, resources such as credit and land and might also lack power to make decisions of adopting these technologies.

The study concluded by emphasizing on the importance of factoring gender issues while developing and disseminating these technologies in order to ensure both men and women participate and benefit from adoption of such technologies. Gender differentials may also have an influence on the kind of technologies a household is likely to adopt based on resource requirement in terms of capital, land and labour. In sub Saharan Africa for instance, empirical studies point out that women-headed households have fewer resources than male-headed households. Ndiritu *et al*. (2011) focused on gender difference on agricultural technology adoption found that there is a higher likelihood of women managing farming plots in adopting soil and water conservation practices than adopting application of animal manure mainly because livestock are owned by men in the study region. Beshir, 2013 noted that male farmers are more resource endowed and hence have a high possibility of access to credit, information and productive assets compared to their female. This variable was measured in a dummy form with one representing male and zero value for female headed households.Based on this evidence, the current study hypothesized that sex of a household head can negatively or positively influence household savings but has a negative influence on adoption of CSA technologies.

2.3.2 Socio Economic Factors

Land size

According to the theory of factors of production, land is one of the important factors of production. It is assumed that holding all the other factors constant, landsize is directly proportional to output. Bealu, 2018 in Ethiopia found that one-hectare increase in land size increased household savings by Birr 34.83 since land size influences income which has a positive influence on savings. Mawia *et al*., 2021 confirmed this results as they found that an increase in size of maize plot increased the likelihood of household savings and attributed this to increased harvest and incomes which prompts households to choose to save. Mulatu, 2020 who had similar results argued that households with large farms require more finances to operate their farms and therefore they have to save in financial institutions in order to be able to access loans to finance their farm operations. They however noted that household size and composition can affect the influence on landsize on savings as family labour is required in order to make the farm productive.

On the other hand, building a sustainable and resilient agricultural system to climate change related shocks is more easily achievable if farmers are able to adopt multiple CSA technologies, Vera *et al*., 2017. Teklewold *et al*., 2013 and Aryal *et al*., 2018 noted that some of the technologies complement each other and would be more beneficial to farmers if adopted together. However, ownership of key factors of production such as landcan have an influence on the number of technologies adopted. Uaiene at al., 2009 noted that large farm sizes allow farmers to test different technologies which positively influences adoption. Land can be used as collateral in the credit market, increasing a household's purchasing power, Abeykoon *et al*. (2013).On the contrary, Mwangi and Kariuki, 2015 argued that small land sizes may encourage households to adopt new technologies which may increase productivity. The influence of land on adoption of CSA technologies is therefore inconclusive. The current study measured land as the number of acres of land possessed by a household. The variable was hypothesized to have a positive influence on household savings but having a positive or negative influence on adoption of CSA technologies.

Wealth Index

Wealth has been found to have a positive influence on household savings. Chowa *et al*., 2012 used the variable as a proxy for income citing the reason that in rural households, most individuals are seasonal earners and therefore find it difficult to recall the total amount earned in a year. Therefore, wealth is a more accurate measure as It can be verified on the spot. Following this line of thought, the current study hypothesized wealth index of a household to have a positive relationship on household savings. Itwas a continuous variable derived from using Principal Component Analysis (PCA). The key variables considered for computing the index were household assets, transport assets and farming assets. Abdul *et al*. (2013) found that the probability of a household head savings increased with increase in their asset value. He argued that household heads stand a better chance of savings once they have acquired property. The variable was therefore hypothesized to have a positive influence on household savings.

Off-farm employment

Off-farm employment was hypothesized to positively and significantly influence household savings. Household heads who have other incomes apart from farming are expected to save more from their off farm income. Kibet *et al*. (2013) found that businessmen saved more than farmers. Zeleke & Endris, 2019 also confirmed this results as they found that households with off farm employment were more likely to save than households whose main occupation was farming. The variable was therefore hypothesized to have a positive influence on household savings.

Total Livestock Units(TLU)

Total livestock holding may have a positive or negative influence of farmer adoption decision depending on the technology under consideration. For instance, Chiputwa at al.,2011 found the variable to have a positive influence on adoption of zero tillage technology and argued that since bigger herds of cattle require more labour and capital to manage them, farmers will likely adopt technologies which are labour savings like minimum tillage. On the contrary, the variable had a negative influence on crop rotation technology which was explained by that having many animals makes crop rotation a secondary enterprise and less of a priority area. Kanyeji *et al*.., 2020 found tropical livestock units to have a positive influence on adoption of intercropping and manure technologies and argued that many animals mean more feed requirements hence pushing farmers to intercrop in order to get the residues to feed their livestock. In addition, more livestock means more manure available to use in the farm. The influence of the variable on adoption of CSA technologies was therefore hypothesized to be indeterminate meaning it can have a positive or negative influence on CSA technologies adoption.

Shocks

Farmers who have been exposed to shocks such as floods appreciate what such risks pose to their agricultural enterprise and they are more willing to adopt the appropriate technologies which can make the resilient to these shocks. Abegunde at el., 2019 found that farmers who perceived climate change to have an adverse effect on their farming activities adopted more CSA technologies. Cassim *et al*., 2017 had similar results and reported that farmers who had reported an increase in frequency of floods twenty years prior the survey had a higher probability of adopting more CSA technologies. Abegunde *et al*., 2019 concluded that an increase in awareness of adverse effects of shocks such as floods on agricultural activities can enhance increases CSA adoption.Hassan and Nhemachena (2008) found that low rainfall made farmers adopt irrigation techniques. In the current study, shock was measured in terms of flood shock takingthe value of one for a household that had experienced floods in the past one year and zero if otherwise Households which had been exposed to flood shock were expected to adopt CSA technologies in order to cushion themselves against such occurrences in the future. The variable was therefore hypothesized to have a positive influence on adoption of CSA technologies.

2.3.3 Institutional Factors

Distance to the market

Distance to the market has been used as a proxy for access to market and financial institutions. Nwibo & Mbam (2013) found the variable to have a negative influence on savings and attributed this to the perishability nature of agricultural products and noted that farmers far from markets may suffer post-harvest losses hence deterring them from savings. Chowa *et al*., 2012 found distance to financial institution as one of the main barriers to savings in rural areas. He noted that even if financial institutions may exist, the transaction cost in terms of time, effort and money to access them may impede household savings. Therefore, expanding and ensuring easy access to financial services may be of benefit to both the financial providers and the users in the rural areas.

In the agricultural technology adoption studies, distance to the market is often utilized as a proxy for access to market and it influences adoption through transaction costs (Aryal *et al*., 2018, Kanjeji *et al*., 2020). Kessie at al., 2013 added that marker distance influences adoption through availability of information and access to technologies. According to Bashir (2013), market access affects the profitability of an investment in improved technology. If markets are not easily accessible to farmers, they may invest in an agricultural technology but not on large scale. This variable was measured as the distance to the cattle market in kilometers. It was hypothesized to have a negative influence on household savings as well as on adoption of CSA technologies.

Credit access

Improved credit access will mean farmers will reduce their future savings and be tempted to consume more as future needs can be easily met through borrowing. Mwangi, 2020 argued that in presence of credit access, the need to hold savings for precautionary measures such as emergencies becomes secondary. Terrones (2005) found the variable to have a negative influence on savings in industrial countries. On the other hand, Gonosa *et al*., 2020 who found the variable to have a positive influence on savings argued that access to credit enhances the productive capacity of a household leading to generation of more income which can encourage them to save. The influence of credit access on household savings is therefore inconclusive and the current study hypothesized that the variable can positively or negatively influence household savings.

On the other hand, the purchasing power of a household enhances their ability not only to purchase inputs required for new technology adoption but also to pay for extra labour which may be required for labour intensive technologies. Kwarteng at al., 2019 reported that credit access directly improves the purchasing power of households which positively influences adoption of new technologies. Mwangi and Kariuki, 2015 reported that credit access relaxes the liquidity constraint and boosts a household risk bearing behavior which increases their likelihood of adopting risky but more efficient technologies. Uaiene, 2011 noted that differential rates of credit access explain the differential rates of new technologies adoption among farming households.Access to credit enables a farmer to overcome capital constraint and may therefore increase the likelihood of investing in CSA technologies. On the contrary, it is possible that households that have access to credit channel them to other uses apart from agricultural investment. Hertz (2009) argued that the risk averse behavior of farmers makes them reluctant to invest their debt capital to risky farm investment for the fear of losing their collateral. Therefore, the influence of the variable on household savings and on adoption of CSA technologies was hypothesized to be indeterminate.

Training.

Training on financial issues has been found to have a positive influence on household savings(Liu *et al*., 2019). Barbić *et al*., 2016 assessing the relationship between financial literacy and savings plans towards retirement found that individuals without sufficient levels of savings for retirement had low levels of financial literacy. Chowa *et al*. (2012) and Mwangi (2020) attributed increased savings to financial education. Bealu, 2018 found the average savings of farmers who had trained to be higher than those who had not trained. He pointed out that financial training helps to not only create awareness and pass new ideas but also correct the misconceptions about savings. Gina *et al*., 2012 noted that availability of financial institutions is not enough to enhance individual savings but emphasized on financial education.

In an effort to steer adoption of CSA technologies, various policy instruments may be utilized by the government and development agencies. For instance, a voluntary scheme may be introduced where adoption of CSA technologies is financially supported through the rural development program. In such a case, factors other than financial ones drive the adoption of such practices. A study by Pagliacci *et al*. (2019) based on voluntary CSA schemes observed low adoption rate despite financial support. The study emphasized on the need to complement financial support by giving farmers accurate information and adequate training on CSA technologies. These findings are consistent with those of Tembo *et al*. (2016) who found household income to have no influence on CSA adoption but observed that being a leader in a farmers agricultural group meant having more access to CSA information and training, which raised the likelihood of adopting additional CSA technology. This implies that training a critical factor to uptake of CSA technologies.In the current study, training was measured by if a household had access or did not access financial and agricultural training in the last one year.It was hypothesized to have a positive relationship on household savings and also on adoption of CSA technologies.

Group membership

Group membership was coded as a dummy taking the value of one for membership and zero if otherwise. Akpan *et al*. (2011) observed that membership of a local association (MOA) was the strongest determinant of savings among agro-based workers in Nigeria.They attributed this to accumulation of social capital and networking which could lead to additional revenue sources resulting to increased savings. Bealu, 2018 noted that it is one of the channels through which farmers get to learn on new technologies which could yield more incomes leading to savings.

Kanyeji *et al*., 2020 noted that Membership to social groups facilitates social capital through collective action. This can have a positive influence on technology adoption as members share information and learn from each other (Migouna *et al*., 2011). Salifu *et al.,* 2012 found the variable to positively influence technology adoption and noted that group membership enables one to easily access extension services, credit facilities and acquire knowledge on new technologies. Kwateng *et al*., 2019 had similar findings and noted that information on new technologies in Ghana is mostly disseminated in farmer groups and therefore such farmers allocated more land to adoption of new technologies. Korir (2016) noted thatAgricultural groups provide social networking platforms where members can share new information and experiences like CSA technology. This study therefore hypothesized the variable to have a positive influence on household savings as well as on adoption of CSA technologies.

CHAPTER 3 : RESEARCH METHODOLOGY

3.1Conceptual Framework

Savings is an important budget item for rural households in Kenya (Kibet *et al*.,2009). In line with the reviewed literature, the study conceptualizes household savings to be influenced by demographic factors, socio economic factors and institutional factors as shown in Figure 3.1. Ellis, 2000 defined demographic factors as individual attributes which shape the productivity of householdsand include age, gender, total dependants, education level while Institutional factors explain why households behave differently and they include membership to a group, training on financial literacy, credit access and distance to the market. Socio economic factors include off-farm income, wealth index and number of plots. A household decision to save or not affect their ability to adopt CSA technologies which include; improved breeds, greenhouse farming, agroforestry and water harvesting. The study tests the hypothesis that household savings does not significantly influence the intensity of adopting CSA technologies.

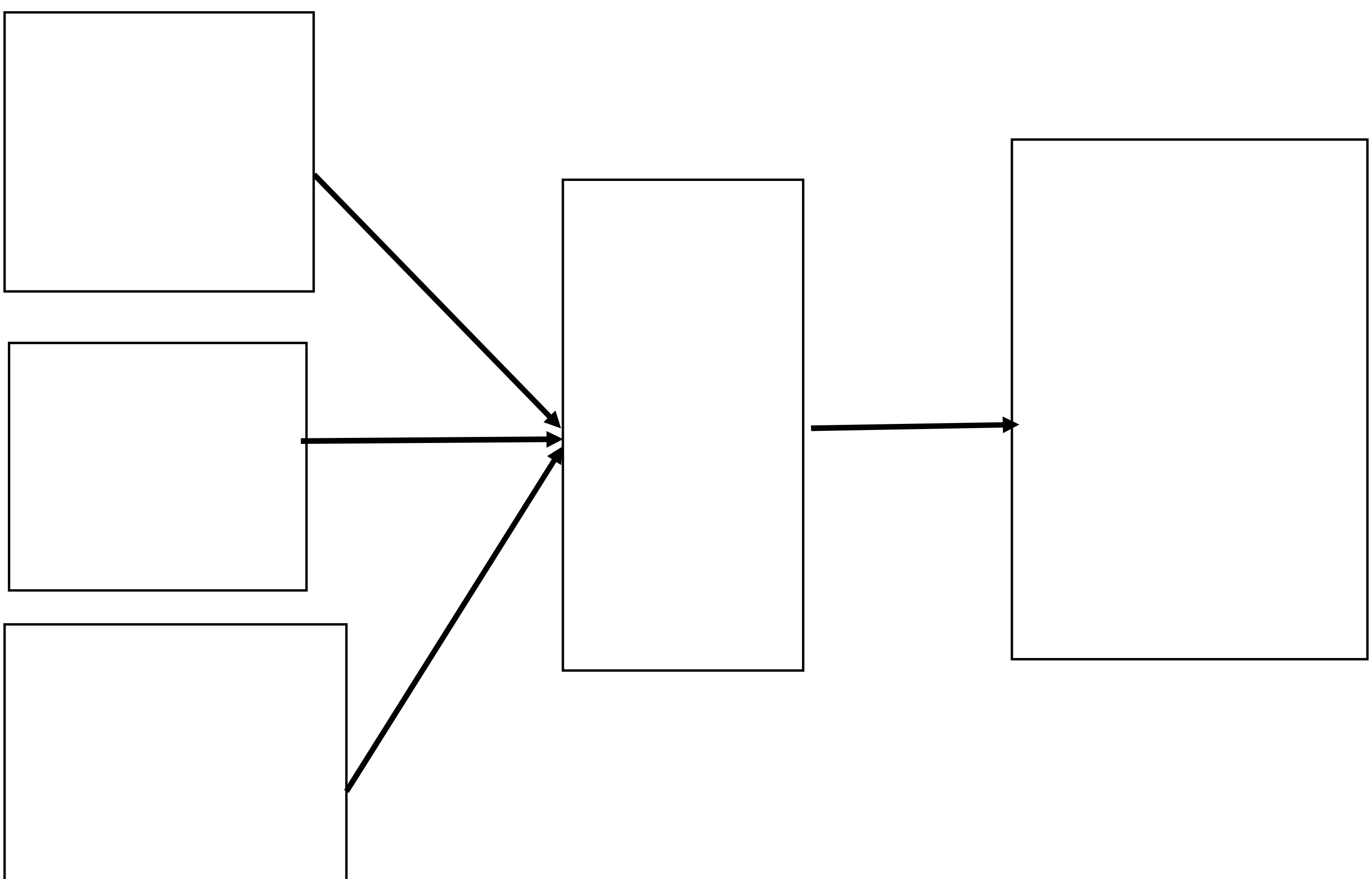

Figure 3. 1 :Conceptual framework showing linkages between household savings and adoption of CSA technologies

3.2Theoretical Framework

The decision of a household to adopt CSA technologies can be based on the two utility theories; the random utility theory (RUT) and the expected utility theory (EUT). The two theories are founded on the assumption that individuals are rational in decision making and they will choose alternatives which yield the maximum utility (Debertin, 2002). However, random utility theory assumes that the outcome of the choices made by individuals are known (revealed preference) as the choices are made in an environment of certainties. On the contrary, expected utility theory assumes that the outcome of the choices made is not known as choices are made in an environment of uncertainties and therefore individuals can only expect the outcome (stated preferences) (Mbugua *et al*., 2019). Given the erratic weather patterns in the study region, this study assumes that the outcome of the choices (CSA technologies) made by the farmers is not known. Therefore, the decision to adopt CSA technologies in the case on this study is based on expected utility theory (EUT).

Following the expected utility theory framework, a farmer's decision on savings and investing in a modern technology is based on the expected utility of the technology. Consider the ith farming household (i = 1,2….n) that must decide on either adopting or not adopting the available K^{th} CSA technologies(K= greenhouse farming, agroforestry, water harvesting, improved breeds). Let U_K represent the benefits associated with adoption of K^{th}CSA technology andU_0represent the benefits of not adopting any CSAtechnology.The farmer will decide to adopt the K^{th} CSA technology if the net benefit (B^*_{iK}) of adopting it is greater than that of not adopting, that is;

$$B^*_{iK} = U_K - U_0 > 0 \quad (3.1)$$

The net utility (B^*_{iK}) derived by a farmer from adopting a technology is a latent variablebut there are some farmer-specific attributes which can be associated with the decision a farmer makes. These attributes are socio-economic characteristic of the farmer, farm and institutional characteristics. The error term **(ε_i)** accounts for the unobserved factors.

$$B^*_{iK} = \beta_K X_i + \varepsilon_i \quad (3.2)$$

Where B^*_{iK}= latent variable associated with the benefits of CSA *k* and farmer *i*

β_K=vector of coefficient to be estimated

X_i = vector of independent variable

ε_i= error term

3.3Empirical data analysis

3.3.1 Objective one: To compare the socio/-economic and demographic characteristics of smallholder farmers with savings and those without savings.

Descriptive statistics was used to analyze the differences in socio-economic and demographic characteristics between households with savings and households without savings. Means, frequencies and percentages were computed and displayed in tables. Chi square was also estimated to analyze if the difference between the households with savings and households without savings was statistically significant.

3.3.2 Objective two: To identify the determinants of household savings among smallholder farmers in Nyando.

In estimating the factors influencing household savings, past studies have employed the binary logit and probit models (Negeri, 2017, Addai *etal*., 2017, Weliczko, 2020, Karaaslan *et al*., 2022). In this models, the explanatory variable is a dummy taking the value of zero or one depending on whether or not a household has savings. Therefore, the results of the model only explain the probability of a household savings versus a household not savings. According to Lynne *et al*., 1988, this does not provide much information about a household behavior as it only explains the probability that an individual made a certain choice and fails to take to account for the amount saved. As a result, the Tobit model has been preferred due to its advantages over the probit and logit models in that it accounts for both the discrete and continuous part of savings simultaneously (Maddala 1992, Johnston and Dandiro, 1997). The Tobit model is an extension of the probit model and it is one of the approaches used in analyzing censored data (Johnston and Dandiro, 1997). This model has been preferred in the previous related studies (Mirach & Hailu, 2014, Teshome *et al*.2013, Girma *et al*, 2013, Nigus, 2015, mulatu, 2020) due to the fact that household savings tend to be censored at the lower limit of zero (Gujarati, 2007)

In the current study, the dependent variable was household savings which takes the value of zero for some part of the sample and a positive continuous value for the rest of the sample. In this case therefore, a Tobit model (Tobin 1958) was appropriate. This model is usually applied where the dependent variable has a continuous distribution over positive values but has a positive probability of being zero. The suitability of this model on this kind of dependent variable is that it allows for censoring of outliers at both extremes. The presence of outliers can result in biased estimates and p-values leading to faulty conclusions (Moono, 2015). A Z-score was used to check for outliers in the amount of household savings. From the calculated Z-score, data points should fall within three standard deviations from the mean and any data point falling away from this was considered an outlier. The results showed two data points falling at four and nine standard deviations from the mean (see annex 6 highlighting the Z-scores for the various data points). After accounting for the two outliers, the maximum savings amount considered for the current study was Ksh 100, 000

(840USD) per month. The dependent variable was therefore censored from below and above; a lower limit of 0 and an upper limit of 100,000. The Tobit model specification is as follows;

$$S_i^* = \chi_i \beta + \mu_i, \qquad i = 1,2 \dots \dots n \qquad \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots 3.3$$

$$S_i = S_i^* \; if \; S_i^* > 0 \qquad \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots 3.4$$

$$S_i = 0 \; if \; S_i^* \leq 0$$

Where S_i is the observed amountof savings by a household

S_i^* is the latent variable which is not observed

β vector of unknown parameters to be estimated

χ_i vector of explanatory variables influencing household savings

μ_i is the error term

Following on the past empirical works [Kibet*et al*. (2009), Chowa *et al*. (2012),Teshome (2013), Mirach & Hailu (2014), Lidi *et al*. (2017), Sawuya (2018)] a number of relevant independent variables which are likely to influence household savings were identified together with their expected signs. Table 3.1 below presents the dependent and the explanatory variables used in estimating the Tobit model. These variables have been discussed and hypothesized at length in chapter two under subsection 2.3, page 13-23.

Table 0.1 : Description of explanatory variables influencing household savings

Variable	Description of the variable	Hypothesized sign
Dependent Variable		
Savings (svn)	Amount of household savings in Ksh	
Explanatory variables		
Demographic factors		

Age	Age of the household head in years	+
Age squared (Agesq)	Age of the household head in years squared	-
Sex	Sex=1 if the Sex of the household head male; 0 otherwise	-/+
Education (Educ)	Educ=1 if the household head has formal education; 0 otherwise.	+
Number of dependants (Nodpdnts)	Total number of household members below 14years and above 65 years.	-
Socio-economic factors		
Land size (Landsz)	Total land size in acres	+
Off farm occupation (offfarm_occ)	offfarm_occ =1 if the household head has other occupation apart from farming; 0 otherwise.	+
Wealthindex	Wealth index	+
Institutional factors		
Training	Training =1 if any household member attended financial training over the last one year; 0 otherwise	+
Group membership (Grpmbrship)	Grpmbrship =1 If the household head belonged to a farmer group; 0 otherwise.	+
Credit access (Crdtacc)	Crdtacc =1 if the household has an Outstanding loan; 0 otherwise.	+/-
Distance to market (Distmrkt)	Total distance to the nearest market in kilometers	-

The functional form of the estimated Tobit regression model was specified as follows;

$$S vn = \beta_0 + \beta_1 age + \beta_2 agesq + \beta_3 sex + \beta_4 educ + \beta_5 nodpdnts + \beta_6 Landsz + \beta_7 offfarm\_occ + \beta_8 wealthindex + \beta_9 training + \beta_{10} crdtacc + \beta_{11} grpmbrship + \beta_{12} distmrkt + Ui \quad \ldots\ldots 3.5$$

3.3.3 Objective three: Assessing the influence of household savings on the intensity ofadopting CSA technologies in Nyando Sub County

Different models have been used to analyze the adoption of agricultural technologies over the years. The decision to adopt is binary in nature where the dependent variable captures whether a household has adopted a CSA technology or not.In such a case a binary response model such as a probit or a logit model is appropriate as recommended by Wooldridge, 2016. A logit model is preferred to a probit model because it has slightly flatter tailsmeaning that the probit curve approaches the axes more quickly than the logit curve. It is also easily available in computer programs. However, in the current study, we analyze a situation where farmers face multiple options of CSA technologies and they can choose more than one technology simultaneously. Therefore, applying a univariate model would yield biased and inefficient estimates because of the various technologies under consideration. In addition, adoption of these technologies could be path dependent with the adoption of earlier technologies informing the adoption of subsequent technologies (Kpadonou *et al*., 2017). The applied model should therefore be able to account for this interrelationships as failure to correct for them can lead to inefficient and biased estimates (Kassie *et al*., 2013, Mulwa *et al*., 2017). To overcome this limitation, previous studies have applied the multivariate probit model (MVP) which accounts for joint decision making with potential correlation on the adoption decision meaning that adoption of the first technology can influence a farmer decision to adopt the subsequent technologies as these technologies can be substitutes or compliments. For instance, Tembo *et al*., 2017 while assessing the adoption of CSA technologies in Malawi found that all the CSA technologies under consideration had positive correlation meaning that these technologies complement each other when adopted.Mulwa *et al*., 2017 found most of the adaptation strategies complemented each other but the association between crop diversification and soil and water conservation technologies (SWC) was negative showing substitutability between the technologies. Timu *et al*., 2014 in Kenya found that there was interdependence in adoption of Gadam and Serena sourghum improved varieties as the correlation coefficient between the two varieties was positive. However, the correlation coefficient between the two improved varieties with the local Kimbeere variety was negative. Jerop *et al*., 2018 in Kenya found complementarity between adoption of pest and weed management and improved seed varieties, conservation tillage and pest and weed management and in adoption of group marketing and conservation tillage. Donkoh *et al*., 2019 in Ghana found the pairwise correlation coefficient between all the improved rice varieties to be positive indicating complementarity in adoption. Kurgat *et al*., 2020 in Tanzania found complementarity between adoption of chemical fertilizer and crop diversity, irrigation and crop diversity and agroforestry and crop diversity but found a negative relationship between adoption of irrigation and livestock diversity. Makate *et al*., 2018 in South Africa. based on this evidence, the current study therefore estimated a multivariate probit (MVP) in its analysis.

The general multivariate probit (MVP) model of adopting CSA technologies can be presented by a set of equation. following the expected utility formulation,let $U_k$represent the benefits associated with adopting Kth CSA technologies and U_o otherwise. The i^{th} farmer will adopt K^{th} CSA technology if the net utility $Y_{ik}$is greater than one such that $Y_{ik}=U_k-U_0>1$. The net utility (Y_{ik}) derived by a farmer in adopting Kth CSA technology is a latent variable that is derived from a set of observable factors and a multivariate normally distributed error term (Ɛ1).

$Y_{ik}{*}= \beta_k X_{i} + \varepsilon_{i}$.. 3.6

Where; Y_{ik}= The net utility derived by the i^{th} farmer on adopting k^{th} CSA technologies

$\beta_{k=}$ Vector of coefficients to be estimated

$X_{i\,=}$ Vector of explanatory variables

ε_i = Error term

As explained above, the farmer is faced with a dichotomous choice of adopting a technology if the expected utility of adopting is greater than that of not adopting as follows;

$$Y_{ik} = \begin{cases} 1 \text{ if } Y_{ik}^{*}>0 \\ 0 \text{ otherwise} \end{cases}$$

One of the assumptions of MVP is that the error terms are jointly distributed as a multivariate normal distribution with zero conditional mean, unitary variance and n x n correlation matrix of any two CSA technologies given as follows.

$$\Omega = \begin{bmatrix} 1 & \rho_{AW} & \rho_{AB} & \rho_{AG} \\ \rho_{WA} & 1 & \rho_{WB} & \rho_{WG} \\ \rho_{BA} & \rho_{BW} & 1 & \rho_{BG} \\ \rho_{GA} & \rho_{GW} & \rho_{GB} & 1 \end{bmatrix}$$

ρ(rho) is the pairwise correlation coefficient between the error terms of any two estimated adoption equations in the model such that;

ρ_{AW}=correlation coefficient between adoption of agroforestry and water harvesting technologies

ρ_{AB} = correlation coefficient between adoption of agroforestry and improved breeds technologies

ρ_{AG} = correlation coefficient between adoption of agroforestry and greenhouse farming technologies

ρ_{WA} = correlation coefficient between adoption of water harvesting and agroforestry technologies

ρ_{WB} = correlation coefficient between adoption of water harvesting and improved breeds technologies

ρ_{WG} = correlation coefficient between adoption of water harvesting and greenhouse farming technologies

ρ_{BA} = correlation coefficient between adoption of improved breeds and agroforestry technologies

ρ_{BW} = correlation coefficient between adoption of improved breeds and water harvesting technologies

ρ_{BG} = correlation coefficient between adoption of improved breeds and greenhouse farming technologies

ρ_{GA} = correlation coefficient between adoption of greenhouse farming and agroforestry technologies

ρ_{GW} = correlation coefficient between adoption of greenhouse farming and water harvesting technologies

ρ_{GB} = correlation coefficient between adoption of greenhouse farming and improved breeds technologies

The nature of the relationship between the adoption equations is given by the sign and significance of ρ. A positive correlation shows the technologies are complements with a negative sign showing substitutes. The assumption of joint decision in adopting different CSA technologies was tested using a likelihood ratio test (Wald test).

In as much as the results of MVP model shows the factors influencing the adoption of individual CSA technologies, farmers in the area adopt more than one CSA technology. It would be of interest therefore to understand factors influencing the adoption of multiple technologies. This prompted the current study to go further and analyze factors that influence the intensity of adopting CSA technologies. The intensity of adoption is measured by the number of CSA technologies adopted. Past empirical studies have estimated the intensity of adoption using an ordered probitmodel with an assumption that the number of technologies adopted is an ordinal dependent variable (Teklewould *et al*., 2013, Kpadonou *et al*., 2017, Tembo *et al*., 2017, Aryal *et al*., 2018, Abegunde *et al*., 2019, Kanyenji *et al*., 2020). In the current study however, the number of CSA technologies adopted did not have a natural ordering. CSA technologies with a natural ordering means that there is a particular order in which a farmer can adopt these technologies. For example, Ayarl *et al*., 2018 study in India applied an ordered probit model to analyze the adoption of five CSA technologies namely seeds of stress-tolerant varieties, minimum tillage, laser land leveling, site-specific nutrient management and crop diversification. In adoption of these technologies, the farmer had to first adopt laser land levelling which then facilitated adoption of minimum tillage as it is easier to practice minimum tillage on a laser leveled field. After this the farmer then planted the stress-tolerant varietieswhich was followed by adoption of site-specific nutrient management that involves the use of the leaf colour chart to manage and maintainthe required nutrients on the crop and finally crop diversification which involved integrating of legumes in to the cropping system. Based on this evidence, the current study employed a Poisson model which is a count data model with the underlying assumption that all the CSA technologies had an equal probability of being adopted.

The model assumes that the y_i takes non negative integer values and has a Poisson distribution. According to Green (2003) the probability density function of the model can be specified as follows

$$Prob\ (Y = y_i|x_i) = \frac{e^{-\lambda_i}\lambda_i^{y_i}}{y_i!}\ ,\ y_i=0,\ 1,\ 2,\ldots \qquad (3.7)$$

Where Y= the random variable that represents the number of CSA technologies adopted

y_i= a specific count value for the ith farmer,

x_i= independent variables influencing the number of CSA technologies adopted by the ith farmer

λ = the parameter to be estimated

The dependent variable for the MVP model was a farmer adopting a given CSA technology (1) or otherwise (0) while that of the Poisson model was the number of technologies adopted. The variables used in the two models and their expected signs are defined in table 3.2 below. These variables have been discussed and hypothesized at length in chapter two under subsection 2.3, page 13-23.

Table 3.2; Description of the variables used in the Multivariate probit and Poisson models.

Variable name	**Description of the variable**	**Hypothesized sign**

Demographic factors		
Age	Age of the household head in years	-
Sex	Sex=1 if the household head is male; 0 otherwise	-
Education of the household head (Educ)	Educ=1 if the household head had formal education; 0 otherwise	+
Socio-economic factors		
Household savings (hhsavings)	The amount saved by a household per month in Ksh	+
Land size (Landsz)	Total land size in acres	+/-
TLU	Tropical Livestock Units	+/-
Institutional factors		
Training	Training=1 if a household member had attended financial training over the last one year; 0 otherwise.	+
Group membership (Grpm)	Grpm=1 if the household head belonged to a farmer group; 0 otherwise.	+
Credit access (Crdtacc)	Crdtacc=1 if a household had an Outstanding loan; 0 otherwise.	+/-
Flood shock (Floodshck)	Floodshck=1 If a household had experienced floods in the last one year; 0 otherwise.	+
Distance to cattle market (Discatmrkt)	Total distance to the nearest food market in kilometers	-

The following empirical model was fitted in the data:

Multivariate Probit (MVP) Equation

$$\begin{Bmatrix} Improved\ breeds \\ water\ harvesting \\ Agroforestry \\ Water\ harvesting \end{Bmatrix} = \beta_0 + \beta_1 agehh + \beta_2 sexHH + \beta_3 educHH + \beta_4 hhsavings + \beta_5 landsz$$

$$+\beta_6 TLU + \beta_7 training + \beta_8 grpm + \beta_9 crdtacc + \beta_{10} floodshck + \beta_{11} discatmrkt + \varepsilon_{1..4} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots 3.8$$

Where $\varepsilon_{1..4}$ are the error terms for each of the equations and the independent variables are specified in table 3.2 above.

Poisson equation

$$y_1 = \beta_0 + \beta_1 agehh + \beta_2 agesq + \beta_3 sexHH + \beta_4 educHH + \beta_5 hhsaving + \beta_6 landsz$$

$$+\beta_7 TLU + \beta_8 training + \beta_9 grpm + \beta_{10} crdtacc + \beta_{11} floodshck + \beta_{12} discatmrkt + \varepsilon \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots 3.9$$

Where y_1 is the number of CSA technologies adopted, the independent variable are as specified in table 3.2 above and ε is the error term.

3.5 Study Area

Nyando Basin is located in the plains of Lake Victoria and lies within Kisumu and Kericho Counties in Kenya. It is a 10km by 10km block consisting of seven villages namely Kamango, Kobiero, Obinju, Kamuana, Chemildagey, Kapsorok and Tabet B. It is located between the coordinates 0°13’30’’S - 0°24’0’’S, 34°54’0’’E - 35°4’30’’E. Farming is the primary source of income with farmers practicing a mixed crop livestock system. It is also densely populated with more than 400 persons per square km. Poverty level is high with CCAFs endline survey report in the year 2021 showing that the households experiencing hunger for three to four months had risen up from 17% in the year 2011 to 43% in the year 2021 and that none of the households was completely food secure. This was attributed to prolonged dry spell and the effects of Covid-19 pandemic (Oganda *et al.*, 2021).

The area is characterized by scanty vegetation and deep gullies due to run off from seasonal rivers causing soil erosion. This has been escalated by climate change and variability with statistics showing increase in drought, floods and unpredictable rainfall (Macoloo *et al*., 2013). Nyando basin is deemed to be a focal area representing other regions experiencing weather extremes and therefore results generated from the area could easily be adapted to other similar regions hence prompting the current study in Nyando Basin.

The main source of livelihood is crop cultivation although it is mainly subsistence. Households in the region derive their incomes mostly from working on other people's farms, operating businesses and through remittances and gifts (Wattel *et al*., 2018). The area has three community based organizations (CBOs), that is Foko, Kapsokale and Necodep. These CBOs have many affiliated groups comprising of youth groups, women groups and mixed groups. The main activity of the groups issavings where members save a minimum of Ksh 50 per week. From these savings, members can borrow loans with a maximum loan amount of two times of one's savings. The loans attract a 10% interest rate with a grace period of three months. At the end of the year, the total group savings and the interest earned on loans is redistributed to the members in proportion to the total amount one has saved.

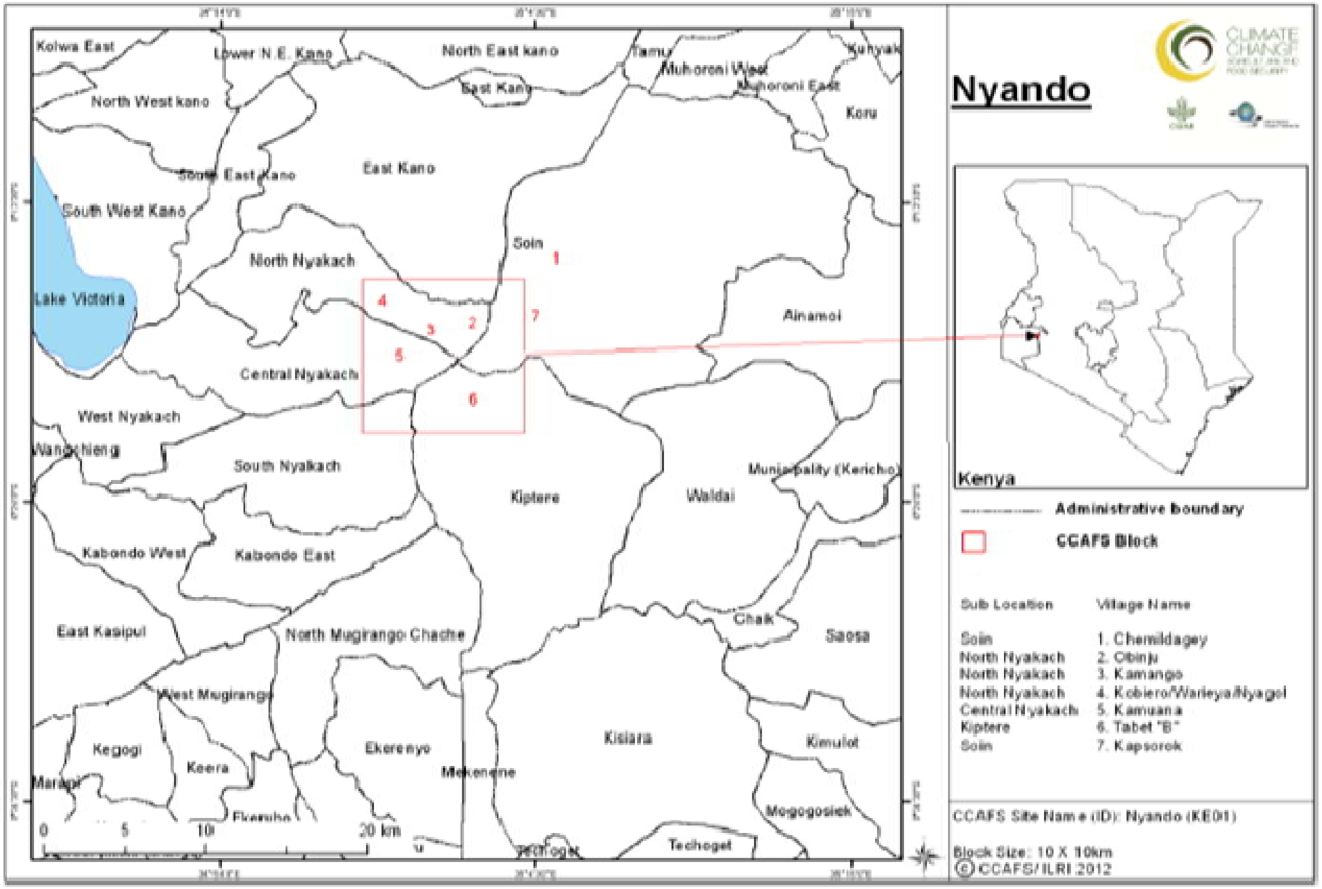

Figure 3. 2 Map of the study area: Geographical location of Nyando Basin

Source: Climate Change Agriculture and Food Security Site Atlas, Nyando/KatukuOdeyo,

3.6 Sampling design

A multistage sampling technique was utilized to obtain the required sample size for the current study. In the first stage, Kisumu and Kericho counties were purposively selected within the borders of Nyakach constituency and Soin constituency where CCAFS operates. In the second stage, households within seven climate smart villages (CSVs) and those out of CSVs that shared similar characteristics in terms of climate, soil conditions and agricultural practices. Households from the CSV villages were identified from the list of households participating in the CCAFS project while the list of non CSV households was obtained from the local administration. From the two lists obtained, the households to be interviewed were sampled using online researchrandomizer (www.randomizer.org).A total of 216 households from each of the two groups (CSVs and non CSVs) were randomly selected. In the last stage, stratified random technique was applied to select the individual households. Twelve strata were formed based on three criteria;

i. Location -Household is located in CSV and Household is not located in CSV
ii. Ownership of sheep/goat – household has no sheep or goat, has indigenous breeds only, has improved breed
iii. Crop and land management practice by household (low / high). A household was considered to practice low crop management if it did not use improved seeds, fertilizer, pesticide and to have high management if otherwise. Low land management households had not introduced ridges, terraces, hedges, intercropping, or planted a minimum number of trees per acre for the past 10 years. High land management households practiced otherwise.

This created 2(csv, non csv) x 3 (no sheep or goat, indigenous breed, improved breed) x 2 (low, high);2x 3x 2= 12 = 12 different strata as shown in the table below

Location	**Ownership goats/sheep**	**Crop/land management**
CSV	No sheep or goat	Low crop and land management practices
CSV	No sheep or goat	High crop and land management practices
CSV	Indigenous breeds	Low crop and land management practices
CSV	Indigenous breeds	High crop and land management practices
CSV	Improved breeds	Low crop and land management practices
CSV	Improved breeds	High crop and land management practices
No CSV	No sheep or goat	Low crop and land management practices
No CSV	No sheep or goat	High crop and land management practices
No CSV	Indigenous breeds	Low crop and land management practices
No CSV	Indigenous breeds	High crop and land management practices

No CSV	Improved breeds	Low crop and land management practices
No CSV	Improved breeds	High crop and land management practices

The main reason for the criteria used in selecting the 12 strata is that the study was focusing on upscaling of existing interventions. i.e. improved breeds and crop and land management practices in the study area.

The target sample was determined using the following formula (Cochran, 1977).

$$n = \frac{Z^2 p(1-p)}{e^2}$$

$$n = \frac{1.96^2 0.7(1-0.7)}{0.081^2} = 122.9593 \approx 123$$

Where n is the sample size, Z is abscissa of the normal curve (95% confidence interval) and its valueis found in statistical tables which contain the area under the normal curve (1.96). p is the estimated proportion of the desired attribute of adoption of improved breeds and practicing high crop and land management practices present in the population where in the current study it was about 70% and eis the desired level of precision at 0.081.

The respondents were selected based on the proportionate to size approach where stratum with more households had more respondents. Only 122 questionnaires out of the total 123 were used for analysis as one was dropped due to incomplete data.

3.7Data Collection and Analysis

Primary data was collected from small-holder farmers in Nyando Basin on the month of February 2019. The data was collected through semi structured questionnaires which were programmed in an open data kit (ODK) software to enable data collection using tablets. The enumerators were trained by ILRI staff on data collection and use of ODK tool. Primary data was collected through face to face interviews by interviewing the household head. However, in their absence, a household member with over 18 years who participates in decision making in the household. The use of ODK tool ensured that data was captured and transmitted to the central data base on real time basis which helped in minimizing errors and monitoring the process through the use of GPS fitted in the tool.

3.4Diagnostic tests for the model

3.4.1 Multicollinearity

It refers to a situation where there is presence of linear relationship among the independent variables, Koutsoyannis (1973). This leads to a type one error due to wide confidence intervals, Woodridge (2009). It becomes impossible to assess the impact of each explanatory variable on the dependent variable. In the variables included in the Tobit, Multivariate probit, and Poisson models, the presence of multicollinearity in the data was assessed using the Variance Inflation Factor (VIF) technique. As a rule of the thumb, if VIF Value of a variable exceeds ten it indicates presence of Multicollinearity Gujarati (2007). Such a variable can be excluded from the model. The results indicated absence of multicollinearity as the VIF values from all the variables included in the models were less than 10 (see Annex 2&3).

3.4.2 Heteroscedasticity

It exists when the variance of the dependent variables varies across data (Gujarati, 2004). It results in biased and inconsistent OLS estimates which are no longer best linear unbiased estimates (BLUE), (Woodridge, 2015). Its presence in the Tobit, MVP and Poisson models was tested using the Breusch Pagan Test. It tests the null hypothesis that the variance of the error term is constant across observations versus the alternative that error term variances are not constant across observations. The chi-square of 0.000 for the Tobit model and 0.0002 for the Poisson and the MVP model was statistically significant leading to the rejection of the null hypothesis of homoscedasticity and the conclusion that heteroscedasticity problem existed. Robust standard errors were therefore utilized to correct for this problem in the models. (See annex 4)

3.4.3 Goodness of fit

One of the limiting assumptions of the Poisson model is Equi-dispersion which requires the variance of the dependent variable to be equal to its mean meaning there is no over or under dispersion. This is tested using the deviance and Pearson statistic. The null hypothesis states that the variance is equal to the mean (equi-dispersion) versus the alternative hypothesis that the variance is not equal to the mean (over or under dispersion). A statistically significant result imply that the model is inappropriate as it will lead to the rejection of the null hypothesis (StataCorp, 2009).In the current study, the chi square value for both the deviance and Pearson statistic were statistically insignificant (Prob > chi2=1.0000). Therefore, we fail to reject the null hypothesis and conclude that there is equi-dispersion hence the Poisson model is appropriate.

goodness of fit

Deviance goodness-of-fit = 22.18564

Prob > chi2 (104) = 1.0000

Pearson goodness-of-fit = 21.88475

Prob > chi2 (104) = 1.0000

CHAPTER 4 : RESULTSAND INTERPRETATION

4.1Demographic, Socio-economic and Institutional characteristics of smallholder farmers with savings and those without savings.

Table 4.1 shows the different characteristics of households with savings and households without savings and the statistical significant differences between the two groups. Out of the 122 sampled households, 65% had savings while 35% did not have any savings. The average savings amount among the savings households was Ksh 20,558 with a maximum savings amount of Ksh 400,000. The results point out that households with savings had more productive members as compared to households without savings. Productive members of a households are those between the ages of 15 years and 64 years. These members not only can they contribute cash income for the household welfare but can also provide family labour which can have a positive impact on household savings. Lidi *et al*., 2017 pointed out that households with more actively working members are expected to save more.

Table 0.2 Comparison of characteristics of farmers with savings and those without savings.

Variables	Households with Savings (n=79)	Households without savings (n=43)	Total Sampled (n=122)		Significant Differences
		Means		t- ratio	P-value
Age	53.13	56.58	54.35	1.31	0.26
Household Size	6.18	5.51	5.94	-1.47	0.15
Number of dependants (household members below 14 years and those	2.76	2.86	2.80	0.33	0.74

above 65 years)					
Number of productive household members (household members between 15 and 64 years)	3.48	2.72	3.21	-2.07	0.04**
Land size in Acres	4.46	4.32	4.41	-0.09	0.93
Tropical Livestock Units (TLU)	5.95	5.2	5.69	-0.58	0.56
Wealth Index	0.72	-0.32	0	-4.34	0.00***
Distance to motorable road in KMS	0.60	0.70	0.64	0.61	0.37
Distance to food market in KMS	2.36	4.31	3.05	4.00	0.00***
Distance to cattle market in KMS	8.34	9.76	8.84	2.05	0.04**
	Percentages of Households			**z-ratio**	
Sex (Male=1)	83.54	76.74	81.15	-0.92	0.36
Formal education (Yes=1)	96.20	83.72	91.80	-2.40	0.02**
Off-farm occupation (yes)	44.3	30.23	39.34	-1.52	0.13
Credit access (yes)	79.75	41.86	66.39	-4.23	0.00***
Access to extension services (Yes)	74.68	41.86	63.11	-3.59	0.00***
Group membership (yes)	98.73	74.41	90.16	-4.31	0.00***
Experienced floods in the last one year(yes)	19.23	39.53	26.44	2.42	0.02**

Note: ***, ** = significant at 1% and 5%, respectively
Source: Survey data (2019). In all the tables and figures that follow, the source is survey data (2019) unlessotherwise stated.

There was a significant difference in wealth index between the two groups. Households with savings had a higher wealth index compared to households without savings. These results are consistence with that of Mumin *et al*, 2013 in Ghana who reported that the probability of a household head savings increases by 0.792 with a percentage increase in their asset values. The study noted that once assets are acquired, a household stands a better chance of savings.

The distance to markets was used as a proxy for access to market and financial institutions such as commercial banks and loans and savings associations. Households closer to markets are expected to easily access financial institutions as well as have better returns on their production due to reduced transaction cost hence better savings status. On average, households with savings traveled s 2km and 1km less to food and cattle market respectively compared to households without savings. The differences was statistically significant at 1% and 5% respectively. This suggests a possible strong positive relationship between access to markets and financial institutions and household savings. Mulatu, 2020 and Mawia *et al*., 2021 found distance to a financial institution to be a major barrier to savings.

Although in general, access to formal education was high among the small scale farmers in the region, there was an observable significant difference between the two groups. About 96% of households with savings had access to formal education compared to 84% of households without savings. These findings concur with Beisland & Mersland (2012) who found education to be a key factor influencing savings in Uganda. Mulatu, 2020 had the same findings in Ethiopia and argued that education enables farmers to be rational in their savings decisions and it also enhances their farm management skills which has a positive impact on their farm output leading to more incomes and savings.

In terms of group membership, households with savings had significantly higher levels at 99% compared to households without savings at 74%. Group membership enhances social capital through collective action. These results are consistent with that of Bealu, 2018 in Ethiopia. Analysis of credit access showed that households with savings had higher access as compared to households without savings. The difference was statistically significant at 1%. This results can be justified by the earlier finding that majority of those who had saved were in groups with further analysis showing that the main activity of these groups was savings and giving credit.

Extension services were accessed by 75% of households with savings compared to 42% of households without savings. The difference was statistically significant at 1%. These results are consistent with those of Mawia *et al*.,2021 in Uganda who found that most of the households without savings reported not to have attended any training on savings. The study therefore pointed out on the need for financial training to enhance savings mobilization. 40% of households without savings reported to have experienced shocks in terms of floods while only 19% of households with savings experienced floods. The difference was statistically significant at 5%. Shocks may have a negative impact on savings as households may be forced to spend their savings in order to cushion themselves against their adverse effects. Mumin *et al*., 2013 in Ghana observed that households that did not experience any shocks in the past two years were more likely to save than their counterparts who experienced the shocks.

4.1.2 Savings avenues

The major savings avenue for savings household in the study area was community groups (77%) with 18% savings in banks and only 5% kept their savings at home. The community groups have a policy where members make weekly deposits which they are loaned based on their total contributions. Members acquire loans at low interest rates than non-members. At the end of the year, the accrued interest and the principal contributions is shared out among members. This finding was in consonance with Nwibo & Mbam (2013) who observed that farmers prefer mobilizing their savings through community groups because they are able to access loans which may not be possible in formal financial institutions due to lack of collateral. Mawia *et al*., 2021 in Uganda found that most households (40%) saved in village savings and loans associations (VSALa) compared to only 13% who saved with commercial banks. The study cited bank access barriers such as high bank charges and financial illiteracy as the reason for low savings with the banks.

4.1.3Reasons for households savings

Households save for varying reasons depending on their priorities. Figure 4.3 below shows the various reasons for savings by the smallholder farmers in the study area. The main reason for household savings in the study area was to access loans. Most financial institutions give credit on condition that one has some savings with them. The amount of Savings is used for credit rating a borrower and the loan extended is based on the percentage of savings one has.These results are in agreement with that of Mulatu, 2020 in Ethiopia who found that most smallholder farmers saved in order to access credit as savings was a precondition of accessing a loan. However other studies found the main reason for savings was to earn interest from the money saved (Mawia *et al*., 2021) and to meet unexpected expenses like illnesses (Lidi *et al*., 2017).

The second main reason for savings in the study area was to purchase food. The region is popular with drought and floods hence farmers save for food as a precautionary measure in the advent of such events. Farmers also saved for agricultural reasons such as to buy certified seeds, purchase livestock and fertilizers respectively. However, a few households saved for livestock management like veterinary services, growing fodder, construction of animal sheds. This is because most of the farmers in the region practice open grazing where animals graze in fields which are not fenced and most of them keep indigenous breeds. Water management practices considered under this study was construction of ridges and bunds to control the speed of surface run-off, mulching and purchase of water storage facilities like tanks and only 3% of the farmers had saved for it. A few of the farmers had saved for ceremonies such as funerals as such events are communal where villagers do a fund raiser to offset the expenses.

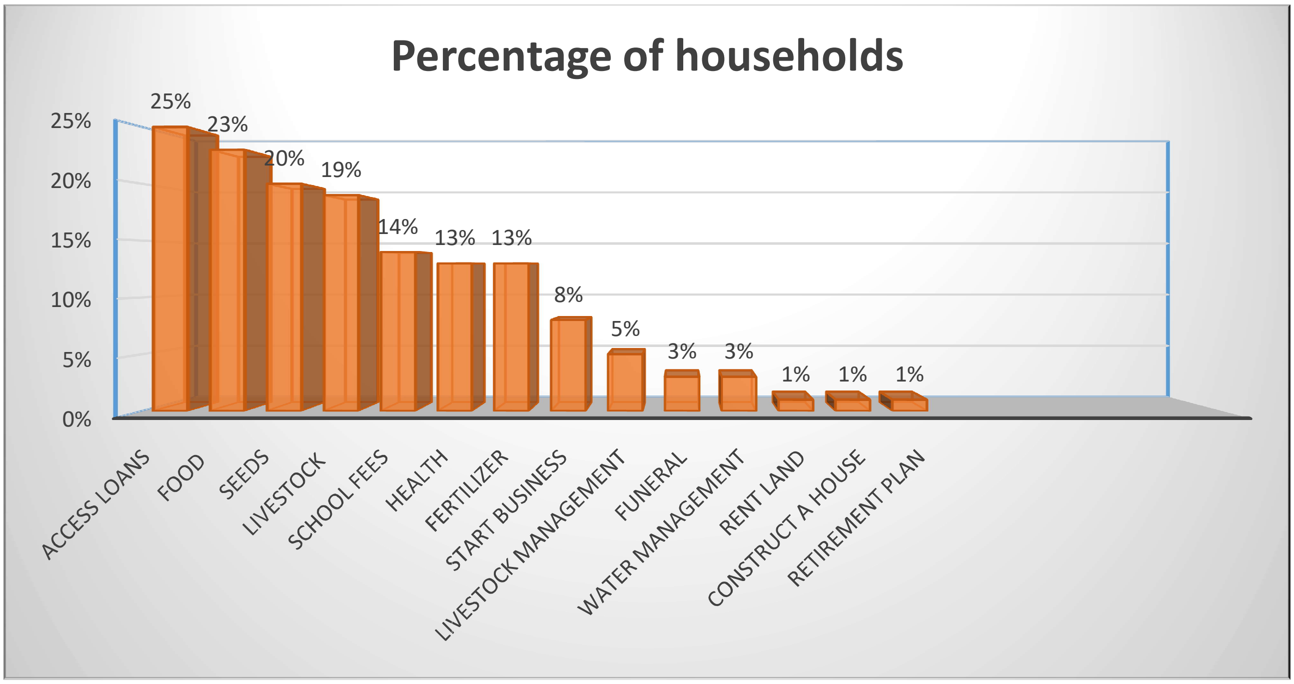

Figure 4.1: Reasons for savings in Nyando Basin (Feb, 2019).

4.2 Factors influencing household savings of smallholder farmers'

Table 4.2 below presents the results of the Tobit model indicating the factors which influence the savings performance of households in Nyando Basin. The overall significance of the model as measured by the F-statistics showed that the model is significant at 1 percent level (Prob > F = 0.0045).This implies that all the independent variables were jointly significant in explaining the variation in the dependent variable at less than 1% significance level, showing the goodness-of-fit of the model. Out of the twelve variables that were tested, eight were significant with five being positive and three negative.

Table 0.3: Determinants of household savings among smallholder farmers.

Variable	Coefficient.	Marginal Effects
Demographic factors		
Age of the respondent (years)	**572.737 **** (271.253)	301.910 (142.201)
Age of the household head square	**-5.431 **** (2.414)	-2.863 (1.272)
Sex of the household head	**11644.05 *** (6107.845)	6137.996 (3210.466)
Formal education(yes=1)	10203.6 (8969.311)	5378.686 (4745.278)
Total dependants	**-2833.512*** (1601.897)	-1493.646 (850.454)
Socio-economic factors		
Off-farm occupation(yes=1)	690.964 (5138.076)	364.232 (2701.925)
Total land size in acres	752.538 (0.322)	396.69 (354.177)
Wealth Index	**2193.57***** (732.560)	1156.31 (374.593)
Institutional Factors		
Distance to market (km)	**-1150.988*** (610.405)	-606.727 (324.759)
Financial literacy training	**12548.21***** (4409.993)	6614.611 (2337.956)
Group membership	1304.564 (20509.16)	687.682 (10804.6)

Credit access	**13423.37 *** (7227.689)	7075.943 (3782.115)

Log pseudolikelihood = -895.60822; F (12, 110) = 2.59; Prob > F = 0.0045; n = 122

Note: ***, **, * = significant at 1%, 5% and 10%, respectively
Figures in parenthesis are Robust Standard Errors

As expected the age of the household head had a positive influence on savings at 5% level of significance. However, the level of savings increases as the age of the household head increases up to a certain point where as the household head grows older, the level of savings of a household starts to decrease. This is shown by the age squared variable which is negative and statistically significant at 5% level. The marginal effects show that as individuals get older by one year, it increases the level of savings by Ksh 302 but as they grow older the savings level decreases by Ksh 3. These results are consistent with the lifecycle theory of savings which states that individuals save up to a certain age where they start dis-savings due to retirement and old age. This is in contrast with the findings of Nigus (2015) in Ethiopia who argued that the elderly may actually save due to the risk of huge health bills and the need to leave inheritance for their children and relatives.

As expected, the sex of the household head was found to have a positive influence on household savings. The results of the marginal effects show that being a male-headed household increases the level of savings by Ksh 6,138 at 10% level of significance. These results are consistence to that of Sawuya (2018) in Uganda who argued that female head of households have less time to devote to cash income generating activities which are likely to increase their savings because they have to attend to household chores like fetching water, collecting firewood and childcare. However, this is contrary to the finding of Milach & Hailu (2014) in Ethiopia and Abdelkhalek *et al*. (2009) in Morocco who analyzed savings determinants of rural households. They noted that women have a better savings behavior than men as they are more conservative in their investment decisions. They are able to balance between savings regularly and meeting their social needs, consumption needs and economic activity.

Credit access had a positive influence on household savings at 10% level of significance. This means that access to credit by a household increases their savings levels. Marginal effects indicate that a household accessing credit increases the savings level by Ksh 7,076. This could be explained by the fact that most farmer groups in Nyando engage in savings and credit among other activities. These findings are in consonance with that of Gonosa *et al*., 2020 in Ethiopia who stated that credit access enhances the productive capacity of a household enabling them to generate more cash income which motivates them to save. They however contradict that of Kibet *et al*., 2009 who found the variable to have a negative influence of farmers in Kenya. They observed that most of the savings was used for consumption purposes and therefore an increase in credit access would positively influence consumption but have a negative influence on savings unless such credit is given with restriction on how it will be used.

The total number of dependants in a household had a negative influence on household savings. This implies that the more the number of dependants a household had, the less the level of savings. The marginal effects show that an addition dependant in a household decreases the level of the household savings by Ksh 1,494. These findings are in support with that of Lugauer *et al*. (2019) in China, Kibet *et al*. (2009) in Kenya and Rehman *et al*. (2011) in Pakistan who reported that households with fewer dependants had higher savings rates., The dependants were defined as those individuals in the household below 14 years and those above 65 years. They are involved more on household activities than productive workforce and they increase the level of household expenditure (Chua *et al*., 2016).

The coefficient of wealth index as per the priori expectation was significant at 1% level and positively related to farming household savings. This implies that the wealthier a farmer is, the higher the savings levels. The wealth index was computed using household assets, transport assets and farming assets. Marginal effects result show that a unit increase in household asset index by a household increases the level of smallholder farmer savings by Ksh 1,156. This could be explained by the fact that wealthier households can be able to engage in productive investment outside the farm and can easily access credit for investment and accumulate capital in terms of savings. This finding concur with that of Chowa *et al*. (2012) who reported the variable to be positively related to savings of rural households in Uganda. Households financial and productive assets were used to calculate the wealth index. The author argued that household wealth is a better predictor of savings than household income in rural households as income does not provide a necessarily reliable measure of wellbeing because rural households are mostly involved in informal labour markets which are often seasonal and highly variable. However, wealth represents what household have accumulated over time and is more permanent therefore providing a more accurate and steady depiction of long-term living standards.

Training on financial literacy bore a positive coefficient and was statistically significant at 1%. The marginal effect indicated that financial literacy training increases the level of smallholder farmer savings by Ksh 6,615. These findings are in conformity with that of Chowa *et al*. (2012)

who reported a positive relationship between financial education and household savings among the rural households in Uganda. Similarly, Teshome *et al*. (2013) in Ethiopia found that training participation increases the likelihood of savings performance and emphasized on the need for training in order to encourage rural households to save.

As anticipated, distance to the market was found to have a negative and significant influence on savings at 10% level of significance. This suggests that the further a household is from the market decreases their savings levels. The marginal effects show that a unit increase in distance reduces the level of smallholder farmer savings by Ksh 607. This may be explained by that most financial institutions are located around markets hence farmers closer to markets can easily access them. This further can be explained by that households closer to markets can easily sell their surplus which can enhance savings. Obalola *et al*. (2018) analyzing determinants of savings among smallholder farmers in Nigeria had similar results and attributed this to closeness to financial institutions hence increasing the likelihood of savings some part of their income.

4.3 Factors determiningthe intensity of household adoption of CSA technologies in Nyando Basin

To address the third objective, Chi square test was applied to show if there was any significant difference in technology adoption between households which had savings to those without as shown in table 4.3. Out of the four CSA technologies which were being promoted in the study region, agroforestry was the most adopted where70% of the sampled farmers practiced it. This was followed by improved breeds (41%), water pan (30%) and greenhouse farming (8%) respectively. From the results, only 8% of households with savings had adopted greenhouse farming and none on the households without savings had adopted this technology with the difference being statistically significance at 5%. Improved breeds and agroforestry was practiced by both groups with a higher percentage of savings households practicing agroforestry (52%) compared to (19%) among the households without savings and the difference between the two proportions was significant at 1% level. Among the 41% of the households who had adopted improved breeds 33% had savings while 8% had no savings and the difference was also statistically significant at 1% level. Water pans were adopted by 16% of households with savings while 13% of the adopters had no savings and this result did not have any statistical difference. Various factors have been attributed to the reasons why farmers adopt a given technology more than other technologies. Cassim *et al*., 2017 found most households to have adopted soil and water conservation technologies as compared to other technologies and attributed this to extension information focusing more on this practice, on the other hand Ojoko *et al*., 2017 noted that farmer's perceived climate change impact on their farms influence their choice of CSA practices. The current study shows that household savings also has an influence on the choice and level of adopting CSA technologies. Encouraging rural household savings could be an important policy strategy to enhance increased uptake of CSAs.

Table 0.4 : Adoption rates of individual Climate Smart Agriculture (CSA) technologies between households with savings and households without savings.

CSA Technologies	Pooled sample (% households)	With savings (% households)	Without savings (% households)	Chi square Value
Greenhouse farming	8.20	8.20	0.00	0.015**
Water pan	29.51	16.39	13.11	0.169
Improved breeds	40.98	32.79	8.20	0.003***
Agroforestry	70.49	51.64	18.85	0.002***

Level of significance: 1%***, 5%**, 10%*

4.3.1 Intensity of adoption of CSA technologies between households with savings and households without savings.

The results from table 4.4 clearly indicate that the adoption rates of CSA technologies differ across the savings and non- savings households. Most of the households adopted one technology. However, more savings than non-savings households adopted two CSA technologies, and none of the households without savings adopted more than two technologies. The Chi-Square estimate indicate a significant difference at 1% on the intensity of CSA technology adoption between the savings and non- savings households.

Table 0.5 : Difference in number of Climate Smart Agriculture technologies adopted between households with savings and households without savings.

Number of Technologies adopted	Pooled sample	Number of savings households	Number of households without savings	Chi square Value
1	72	36	36	
2	35	28	7	
3	9	9	0	
4	5	5	0	
Total	121	78	43	0.001***

The mean in the number of CSA technologies adopted among the savings households was 1.76 while that of households without savings was 1.16. The difference in the means was statistically significant at 1% level. This underlines the potential of rural household savings as an important policy strategy that can enhance increased uptake of CSA technologies in an effort to make smallholder farmers climate change resilient.

4.3.2 Multivariate probit (MVP) model results for factors influencing adoption of specific CSA technologies

The results from Table 4.5 below shows the likelihood ratio test (Chi-Square (6)=13.9525**) was significant at five percent level thus rejecting the null hypothesis of zero association amongst the covariance of the error terms in the equations. This implies that the adoption of the four CSA technologies is not mutually independent but there is substitutability and complementability in their adoption. This result validates the use of the MVP model and points out that using a univariate regression (ordinary logit or probit model) to assess the influence of household savings on adoption of CSA technologies would yield inefficient and biased estimates. There was a negative and significant correlation between adoption of agroforestry and water harvesting, water harvesting and greenhouse farming technologies, meaning that farmers adopted these technologies as substitutes. The adoption of improved breeds and greenhouse farming had a positive and significant correlation indicating that farmers adopted the two technologies as compliments.

Table 0.6 : Complementarities and substitutability of CSA technologies.

	Agroforestry	Water harvesting	Improved breeds	Greenhouse farming
Agroforestry	1			
Water harvesting	-0.374*** (0.139)	1		
Improved breeds	0.114 (0.134)	-0.162 (0.140)	1	
Greenhouse farming	0.174 (0.320)	-0.346** (0.168)	0.201** (0.191)	1

Notes: Robust standard errors in parenthesis
Likelihood ratio test of regression interdependence, Chi-Square (6) =13.9525**
N=121, Statistical significance at *P<0.1, **P<0.05, ***P<0.01

Table 4.6 shows that the Wald Chi-Square Wald (chi2(44) = 285.06, Prob > chi2 = 0.0000) for the overall significance of the model was significant implying that the independent variables used in the model explain significant portion of the variations in the dependent variables.Household savings had a significant and positive relationship on adoption of agroforestry, improved breeds and greenhouse farming technologies. This can be explained by that adopting of these CSA technologies may require some cash income for employment of labour and to purchase the necessary tools for adoption like greenhouses and the improved breeds. In addition, adoption of CSA technologies has been found to be influenced by the risk attitude of farmers. For instance, Musyoki *et al*., 2022 found that smallholder farmers risk attitude had a significant influence on adoption of CSA technologies such as stress tolerant livestock in Nyando Basin. Mao *et al*., 2017, in China cited that risk averse farmers are reluctant to adopt profitable but high risk new technologies while the few who are risk takers benefit from adopting such technologies. Wattel *et al*., 2018 while analyzing financing for CSA technologies by smallholder farmers in Nyando Basin stated that household savings is a form of risk management strategy as it provides mechanisms of dealing with risks and income variations which may encourage farmers to adopt risky CSA technologies.

Table 0.7 : Factors affecting adoption of Climate Smart Agriculture (CSA) technologies

Variables	**Agroforestry**	**Water Harvesting**	**Improved breeds**	**Greenhouse Farming**
Demographic factors				
Age of household head	-0.011(0.011)	0.001(0.011)	-0.003(0.010)	-0.023(0.014)
Sex of the household head	0.282 (0.374)	-0.506(0.365)	0.235 (0.368)	**-0.956*(0.512)**
Formal education (yes=1)	**-1.268**(0.657)**	-0.138(0.602)	-0.313(0.542)	**2.492***(0.662)**

Socio-economic factors				
Log of household savings	**0.023*(0.038)**	-0.006(0.035)	**0.071**(0.035)**	**0.159**(0.071)**
Log of land size	**0.441**(0.214)**	-0.228(0.206)	0.210(0.189)	**1.269***(0.434)**
Tropical Livestock Unit (TLU)	**-0.082***(0.023)**	0.020 (0.017)	0.047(0.033)	**-0.076**(0.039)**
Credit access	0.147 (0.353)	-0.241(0.298)	0.293(0.291)	0.430(0.823)
Experienced flood in the past one year(yes=1)	-0.041 (0.335)	-0.353(0.331)	-0.067(0.327)	-0.793(0.566)
Institutional factors				
Agricultural training(yes=1)	**1.303***(0.308)**	**-0.588** (0.303)**	**0.926**(0.292)**	**5.554***(0.801)**
Group membership	-0.326 (0.466)	0.226(0.549)	-0.550(0.602)	**3.890***(1.046)**
Distance to cattle market(km)	0.034 (0.042)	-0.053(0.038)	0.076 (0.038)	**0.203**(0.0072)**

Log pseudo likelihood = -196.88934, Wald chi2(44) = 285.06, Prob > chi2 = 0.0000, n=121,

Note; Robust standard error in parenthesis, Statistical significance at *P<0.1, **P<0.05, ***P<0.01

Among the demographic factors, the sex of the household head had a significant and negative influence on adoption of Greenhouse farming technology. This means that female headed households were more likely to adopt greenhouse farming technology compared to male headed households. This can be attributed to the fact that, in the study area, greenhouse farming is done in groups where extension workers train farmers in groups and then the group members come together to contribute and provide labour to start and run the greenhouse. These groups are mostly women dominated which can have an influence on adoption of greenhouse farming technology. Bernier at al., 2015 found that once the women in Nyando Basin are aware of CSA technologies, a higher proportion of women than men take up these technologies. Musafiri *et al*., 2022 who found a negative relationship between household gender and technology adoption argued that women are targeted by most agricultural empowerment programs therefore enhancing good agricultural practices among women. These findings contradict that of Omoro, 2014 who found that more male than female headed households to have adopted the technology in Kisii and Nyamira counties in Kenya.

Formal education had a negative and significant influence on adoption of agroforestry technology but a positive and significant influence on adoption of greenhouse farming technology. A possible explanation may be due to differences in nature of the technologies in terms of technical know- how in their implementation where greenhouse farming is more knowledge intensive than agroforestry technology. Education enhances an individual's ability to collect, process and utilize new information, Chilot *et al*., 2015. Another explanation may be that farmers in the study area have been practicing agroforestry for a longer time and therefore as people get educated, they practice more of greenhouse farming as they consider it a more modern method of farming. Chilot *et al*., 2015 pointed out that due to the decreasing land holding and the motivation for higher productivity, educated farmers are moving to more recent cropping systems.

Land size had a positive and significant influence on agroforestry and greenhouse farming technologies adoption at 5% and1% level of significance respectively. This finding suggest an increased likelihood of adopting agroforestry and greenhouse technologies with increased land size. These findings collaborate that of Kpadanau *et al*.,2017 in Burkina Faso who reported that farmers with large land holding are more likely to adopt agricultural technologies. The study states that households with large land holding are likely to be wealthier and therefore they can afford the initial investments costs and inputs required in adopting these technologies. Lalani *et* *al*., 2016 also argued that the capital and assets owned by large scale farmers enable them to adopt practices requiring high investment cost. Mwangi and Kariuki, 2015 however noted that farmers with small land sizes tend to adopt land savings technologies such as greenhouse farming which contradicts the results of the current study.

Tropical livestock units (TLU) had a negative relationship on adoption of agroforestry and greenhouse farming technologies. This implies that farmers with more livestock units are less likely to adopt agroforestry and greenhouse farming. This results can be explained by that of Kurgat *et al*. (2020) in Tanzania who noted that some practices like livestock diversity are more often practiced alone as smallholder farmers consider other agricultural technologies as substitutes and therefore trade them off with livestock keeping. These farmers are therefore likely to trade off greenhouse farming and agroforestry technologies for livestock farming.

Among the institutional factors, training had a positive and significant relationship on adoption of agroforestry, improved breeds and greenhouse farming technologies. However, this variable had a negative influence on adoption of water harvesting technologies. This implies that farmers who receive more training are more likely to adopt agroforestry, improved breeds and greenhouse farming technologies but are less likely to adopt water harvesting technology. The positive relationship may be due to that training is an added input to adoption as it enhances transfer of knowledge, skills and attitudes to farmers as noted by Azumah *et al*., 2018. On the other hand, Aryal et., 2018 focusing on farming households in India attributed the negative relationship of training on technology adoption on extension officers focusing their training more on the other technologies.

Group membership had a positive and significant influence on adoption of greenhouse farming technology. This finding is supported by our earlier argument that in the study area, this technology is mostly practiced by members in a group where they contribute resources like capital and labour to start and run the greenhouse. Diallo *et al*., 2020 noted that groups have become important platforms of promoting CSA technologies in most farming communities. They serve as contact points through which CSA intervention programs can easily reach to a big group of farmers at one point and time. Group membership enhances sharing of information among the group members about market access, financial services as well as providing informal insurance systems in times of crisis which can be an incentive to technology adoption (Kanyeji *et al*., 2020, Maindi *et al*., 2020). Kagongo *et al*., 2021 in Kenya added that membership in farmer groups which engage in giving credit and marketing of produce enables the members to access such services which increases their adaptive capacity and consequently adopting CSA technologies.

The distance to the cattle market had a positive and significant influence on adoption of greenhouse farming technology. This suggest that the nearer a farmer was to the cattle market, the less likely they were to adopt this technology. These results contradict most of the other studies which have found the variable to have a negative influence on technology adoption due to increased transaction cost and lack of market information which influences farmer's investment decisions (Kanyeji *et al*., 2020, Maindi *et al*., 2020, Aryal *et al*., 2018, mulwa *et al*., 2017, Nambiro & Okoth (2013). A possible explanation for the positive relationship could therefore be because households closer to cattle markets are likely to focus more on livestock farming unlike households far from the cattle markets who are likely to focus more on crop farming and therefore adopt greenhouse farming technology to enhance their productivity.

4.3.3 Factors influencing the intensity of adoption of climate smart agriculture (CSA) technologies

Table 4.7 presents the results of the Poisson model; the chi-square value of the model was significant at 1% indicating that the independent variables taken together influence the number of CSA technologies adopted. Out of the 12 variables which were fitted in the model 8 were statistically significant. Household savings positively and significantly influenced the number of CSA technologies adopted at 1% level of significance. This confirms FSD Kenya, 2016a report that most farmers self-finance their farms with savings and that savings is an important strategy for coping with risks in rural areas. According to Wattel *et al*. (2018), Nyando basin has a range of financial service providers but they have limited outreach as they mostly work through agro-dealers in the value chain. The findings are consistent with those of Hohfeld and Waibel 2013 who found that savings positively influenced the amount invested in agriculture among the small scale farm households in Thailand. This can be explained by a study by Twumasi *et al*., 2019 in Ghana who reported that an increase in savings increases the probability of a smallholder farmer access to credit as well as the amount one can borrow. Farmers not only use savings as a source of collateral in the credit and savings community groups but it also reflects their net worth in the credit market (Akudugu, 2016; Twumasi *et al*., 2019). Theophilus *et al*. (2019) in Ghana also recommended for encouraging farmers to adopt a good culture of savings where they develop a habit of savings regularly in order to improve their credit access. Encouraging rural household savings could therefore be an important policy strategy that can enhance increased uptake of CSA technologies.

Table 0.8 : Results of determinants of intensity of adoption of CSA technologies in Nyando Basin

Variables	Coefficients	t-value	p-value

Demographic factors			
Age of household head	**-0.013 (0.007)****	-1.96	0.050
Age of the household head square	0.00008 (0.00006)	1.28	0.199
Sex of the household head	-0.152 (0.104)	-1.47	0.143
Formal education (yes=1)	-0.266 (0.162)	-1.64	0.101
Socio-economic factors			
Log of household savings	**0.031***(0.009)**	3.56	0.000
Log of land size	**0.173***(0.060)**	2.88	0.004
Tropical livestock units (TLU)	**-0.014* (0.008)**	-1.85	0.065
Credit access	**0.153 (0.093)***	1.65	0.100
Experienced flood in the past one year(yes=1)	**-0.170 (0.092)***	-1.84	0.065
Institutional factors			
Agricultural training(yes=1)	**0.446 ***(0.075)**	5.92	0.000
Group membership	-0.085 (0.120)	-0.71	0.478
Distance to cattle market(km)	**0.029 (0.010)****	2.96	0.003

Log pseudo likelihood = -152.55504, Wald chi2(12) = 79.46, Prob > chi2 = 0.0000, N=121, Note; Robust standard error in parenthesis, Statistical significance at *P<0.1, **P<0.05,***P<0.01

The age of the household head had a negative influence on adoption intensity at 5% level of significance. This implies that older farmers are less likely to adopt more CSA technologies compared to young farmers. This results contradicts that of Challa and Tilahun (2014) who found the variable to have a positive influence on climate change related technologies. However, Wekesa *et al*. (2017) confirmed the results of this study and argued that older farmers are more risk averse and have a short term planning horizon hence are less likely to implement more strategies. Cassim *et al*. (2017) who had the same results added that older farmers mostly rely on indigenous knowledge acquired over time than adopting modern farming practices.

The coefficient of training has a positive influence on the number of CSA technologies adopted and is statistically significant at 1%. The possible justification may be that training enhances skills and farmers who are knowledgeable about climate change are likely to adopt technologies which would mitigate them against such effects. Farmers are also likely to adapt technologies which they have full information about. Similar results have been documented by Wango (2012) who found the variable to have a positive relationship on farmers' cultivating improved sorghum variety. Maumbe and Swinton (2000) had similar results and stated that training enhances farmer's knowledge and skills and helps them to make innovative decisions.

The number of CSA practices adopted by a household was further influenced by land size which was positive and significant at 1%. Ownership of bigger land sizes increased the likelihood of adoption of more CSA technologies. Similar findings were reported by Wekesa (2017) who found that bigger farm sizes were strongly correlated with increased adoption of CSA technologies as the fixed input provides farmers with opportunities to experiment different CSA technologies. This results however contradicts that of Awuni *et al*. (2018) who found the variable to have a negative relationship with adoption of improved rice production technologies in Ghana which he attributed to labour constraints as households could not mobilize the required labour in application of the technologies.

As expected, TLU variable was found to have a negative but significant relationship with the number of CSA technologies adopted. This suggests that ownership of more livestock units could actually reduce the adoption of more CSA technologies. This results are consistent with that of Kurgat *et al*. (2020) who noted that some practices like livestock diversity are more often practiced alone as farmers consider other agricultural technologies as substitutes and therefore trade them off with livestock keeping. This result contradicts that of Issahaku and Abdulai, 2019 who found the livestock ownership to have a positive influence on adoption of climate smart practices among smallholder farmers in Ghana.

Credit access had a positive and significant influence on the number of CSA technologies adopted at 10% level of significance. The finding upholds the study of Mwangi and Kariuki, 2015, Maindi *et al*., 2020 and Mulwa *et al*., 2017 that alluded that credit access stimulates technology adoption by removing of cash income constraints and also enhancing a household risk bearing ability. Households that had experienced floods had a negative and significant influence on the number of CSA technologies adopted. This results contradict that of Abegunde *et al*., 2019 and Cassim *et al*., 2017.

Based on the proxy for market access, the coefficient of distance to cattle market had a positive and significant influence on the number of CSA technologies adopted. This means that the further a household is from thecattle market increases the number of CSA technologies they are likely to adopt. These results suggest that households who sold their cattle to more distant markets adopted more CSA technologies than those who sold to nearby markets. A possible explanation could be due to price differentials where distance markets fetch higher prices compared to near markets which include open air markets which may be characterized by middlemen exploiting the farmers leading to low prices. Higher returns favors technology adoption as it increases the purchasing power of households. These results contradict that of Ghimire and Huang (2015) on adoption of improved maize varieties among rural farmers in Nepal.

CHAPTER 5 : SUMMARY,CONCLUSIONS AND POLICY RECOMMENDATIONS

5.1: Summary

- The study examined the influence of household savings on smallholder farmers decision of adopting CSA technologies in Nyando Basin in Kenya. The area was chosen because of the high prevalence of drought and floods due to climate change as well as introduction of various CSA technologies by non-governmental organizations aimed at helping the farmers to be climate change resilient.The CSA technologies under study were agroforestry, improved breeds, water harvesting and greenhouse farming.
- The study specifically aimed at comparing the socio-economic and demographic characteristics of smallholder farmers with savings and those without savings, determine the influence of demographic, socio-economic and institutional factors on household savings among smallholder farmers and lastly assess the influence of household savings on the intensity of adoption of CSA technologies among smallholder farmers.
- The study utilized primary household data collected through questionnaires in Open Data Kit and administered to 122 households. Chi square statistic was used to compare the characteristics of households with savings and those without savings while a Tobit model analyzed the determinants of household savings. A multivariate probit model was employed in assessing the influence of household savings on adoption of individual CSA technologies while a poison model assessed the influence of household savings on the intensity of CSA technologies adopted.
- Among the factors which were found to influence household savingsincluded; age, sex of the household head, total dependants, distance market, credit access, financial literacy training and wealth index.

- Among the four CSA technologies which were considered in the current study, agroforestry was the most practiced technology followed by improved breeds, water-pan and greenhouse farming respectively. There was a statistical significant difference between savings households and households without savings on adoption of agroforestry, improved breeds and greenhouse farming technologies
- The results of the MVP model revealed that household savings positively and significantly influenced the adoption of agroforestry, improved breeds and greenhouse farming technologies. In addition, the Poisson model results pointed out that household savings had a positive and significant influence on the number of CSA technologies adopted. Other factors which were found to significantly influence the number of CSA technologies adopted by a household were agricultural training, log of land size, credit access and distance to cattle market with positive influence while age, TLU and flood shocks negatively influenced the number of CSA technologies adopted by a household.

5.2 Conclusions

Comparison of characteristics of farmers with savings and those without savings.

- There was a statistical significant difference between households with savings and households without savings in terms of formal education, credit access, wealth index, distance to market, number of productive members of the households, access to extension services, group membership and experience of floods. As compared to non-savings households, savings households were wealthier, more educated, had more productive members of the household, had more access to credit and extension services and were nearer to the markets.

- Contrary to the traditional assumptions that rural farming households are too poor to save due to low productivity, the results of the current study confirm that smallholder farmers have the capacity to save as more than half of the households in the study area had savings. Most of the savings households channeled their savings to community groups showing the importance of this groups in mobilizing household savings. The major reason for the farmers to save in community groups was in order to access loans which is based on one'ssavings rate and at lower interest rates than non-members.

Determinants of smallholder farmers household savings.

- Age and sex of the household head, total dependants, distance to market, financial literacy, credit access and wealth index were found to have an influence on household savings. These findings demonstrate that wealthier households are more likely to save. Additionally, improvement of market access as proxied by distance to the market can enhance smallholder farming household savings. Finally, there is need to train smallholder farmers on financial literacy in order to increase their knowledge on the importance of savings.

Influence of household savings on adoption of climate smart agriculture technologies

- The analysis of the influence of household savings on adoption of individual CSA technologies and the number of CSA technologies adopted clearly validate the positive and significant influence of household savings on adopting CSA technologies. This calls for innovative ways of mobilizing smallholder farmerssavings in order to scale CSA technologies adoption. Other control variables such as age, TLU, credit access, flood shock, agricultural training, land size and distance to the market significantly influenced the adoption of CSA technologies. Such factors should also be considered when designing policies to promote adoption of CSA technologies by smallholder farmers.

5.3: Recommendations

- Based on the findings from the current study, Household savings has the potential of increasing the intensity of adopting CSA technologies. The study therefore recommends for householdsavings to be considered as an important strategy for scaling climate smart agriculture adoption. The study proposes for specific measures aimed at enhancing household savings as follows:
    1) Most of these savingsis channeled to the local community groups. This suggests the need for strengthening the local farmer groups where most farmers save and also encouraging farmers to join these groups. In promoting this farmer groups, institutions for extension delivery could establish collaborations with the groups where lead farmers could be equipped with important skills like on group management which they would then train their group members. This would encourage more farmers not only to join groups but also be actively involved in group activities like savings.
    2) In addition, distance to the market has been found to have a negative influence on savings. This underscores the need for development agencies to introduce e-wallets to small holder farmers in an effort to mobilize rural household savings. This model has been found to stimulate savings among smallholder farmers in West Africa through a system called myAgro as documented by AGRA, 2017. In this model, farmers do not have to travel to deposit their savings as they simply purchase scratch cards in their local shops (just like for credit top up) and then

send the code in the system and a deposit is made. The micro deposits accumulate for a given time where farmers can now be able to invest in CSA technologies. The system goes further to partner with financial institutions where they connect qualifying farmers to access credit for their agricultural activities.

3) The study findings further suggest that education level did not have any significant influence on household savings or on intensity of adopting CSA technologies. However, financial literacy and agricultural training had a significant and positive influence on household savings and adoption of CSA technologies. Therefore, even though small-holder farmers may lack formal education, training them on financial issues and CSA practices may actually enhance their savings levels and uptake of CSA technologies. Projects aimed at scaling up of CSA technologies should target training farmers on financial issues so as to broaden their financial literacy including savings and also disseminating sufficient knowledge on CSA practices which could provide incentives towards intensification of CSA practices. This could be achieved through appropriate collaboration between the local groups and relevant stakeholders such as institutions for extension delivery and non-governmental actors who can lender their expertise on financial issues to the members. Regular agricultural training seminars should be organized where the importance of savings for agricultural investment should be emphasized. In addition, there is need for building capacity of the existing farmers training centers as well as expanding their coverage to ensure that distance is not be a limiting factor for farmers to attend trainings.

4) Market access was central on household savings and intensity of adoption of CSA technologies. Therefore, farmers should be assisted with innovations and incentives that canimprove their market access. This could be accomplished through policies that can help rural poor farmers develop higher levels of social capital such as cooperative societies. This would significantly improve market access and return on investment, resulting in the buildup of savings and as a result, investment in CSA technologies.

- Finally, the results point out that farmers take improved breeds and greenhouse farming technologies as complements. Therefore, promoting and creating ways of enabling farmers adopt these technologies as a package can stimulate the adoption of both technologies. This will also solve the problem of partial adoption and ensure that farmers achieve the maximum benefits of adoption both economically and environmentally.

5.4: Suggestions for future research

- Future studies can widen the scope of household savings by accounting for non-monetary household savings. In addition, further studies can consider other CSA technologies which have not been included in the current study. This will help to come up with all-inclusive policy interventions in regard to scaling out of CSA technologies.

REFERENCES

Abdelkhalek,T.,Arestoff,F.,Freitas,N.M. And Mage,S.(2009). "A microeconometric analysis of households'savings determinants in Morocco". The African Review Journal of Money, Finance and Banking.

Abdulai, A., and Huffman, W. E. (2005). The diffusion of new agricultural technologies: the case of crossbred-cow technology in Tanzania. American Journal of Agricultural Economics, 87(3), 645-659.

Abdul-Hanan, A., Ayamga, M., and Donkoh, S. A. (2014). Smallholder adoption of soil and water conservation techniques in Ghana. *African Journal of Agricultural Research. 9*(5), 539-546. DOI: 10.5897/AJAR2013.7952

Abegunde, V. O., Sibanda, M., & Obi, A. (2019). Determinants of the Adoption of Climate-Smart Agricultural Practices by Small-Scale Farming Households in King Cetshwayo District Municipality, South Africa. Sustainability, 12(1), 195. https://doi.org/10.3390/su12010195

Abeykoon, M.N.D.F., Weerahewa, J., & Silvia, G.L.L.P. (2013). Determinants of market participation by indigenous poultry farmers: A case study in Anuradhapura district in Sri-Lanka. Tropical Agricultural Research, 24(4), 347-361

Abebe, G., Tekle, B., &Mano, Y.(2018). "Changing Savings and Investment Behaviour: The Impact of Financial Literacy Training and Reminders on Micro-businesses," Journal of African Economies, Centre for the Study of African Economies (CSAE), vol. 27(5), pages 587-611.

Adeyemo, A.C., and Bamire R. A. (2005).Savings and Investment Patterns of Cooperatives Farmers in Southwestern Nigeria. Journal of Social Sciences. 11 (3): 183 – 192.

African Union (2014). Report of the chairperson of the NEPAD heads of state and government orientation committee. Assembly of the Union. Twenty-Third Ordinary Session. 26-27 June 2014. Malabo, Equatorial Guinea. http://africacsa.org/introducing-the-africa-csaalliance-ascaa/

AGRA. (2017). Africa Agriculture Status Report: The Business of Smallholder Agriculture in Sub-Saharan Africa (Issue 5). Nairobi, Kenya: Alliance for a Green Revolution in Africa (AGRA). Issue No. 5

Akpan, S., Udoh, E., and Aya, E. (2011) . "Analysis of Savings Determinants among Agro-based firm Workers in Nigeria: a Simultaneous Equation Approach", Research on Humanities and Social Sciences, www.iiste.org, Vol.1,

Akudugu, M. (2016). Agricultural productivity, credit and farm size nexus in Africa: a case study of Ghana. Agricultural Finance Review. 76, (2), 288-308. 10.1108/AFR-12-2015-0058.

Antonakis, J., Bendahan, S., Jacquart, P., &Lalive, R. (2014). Causality and endogeneity: Problems and solutions. *The Oxford handbook of leadership and organizations*, *1*, 93-117.

Anuga, S., Gordon, C., Boon, E., and Surugu, J. (2019). Determinants of climate smart agriculture (CSA) adoption among smallholder food crop farmers in th Techman Municipality, Ghana. Ghana Journal of Geography, 11(1).

Awuni, J.A., Azuma, S.B., Donkoh, S.A.(2018). Drivers of adoption intensity of improved agricultural technologies among rice farmers. Evidence from northern Ghana. Rev. Agric.Appi. Econ. 21(2), 48-57

Aryal, J.P., Rahut, D.B., Maharjan, S., and Erenstein, O. (2018c). “Factors affecting the adoption of multiple climate-smart agricultural practices in the Indo-Gangetic plains of India”, Natural Resources Forum, Vol. 42 No. 3, pp. 141-158.

Attanasio, O. P., & Banks, K. (2001). The assessment: Household savings—Issues in theory and policy. Oxford Review of Economic Policy, 17, 1-19. doi:10.1093/oxrep/17.1.1

Barbić, D. (2016). “Logistic regression analysis of financial literacy implications for retirement planning in Croatia”, Croatian Operational Research Review, 7(2), 319-331.

Bhattacharyya, P., Pathak, H., Pal, S. (2020). Dimensions of Climate-Smart Agriculture. In: Climate Smart Agriculture. Green Energy and Technology. Springer, Singapore. https://doi.org/10.1007/978-981-15-9132-7_3

Bealu, T. (2018). “Determinants of savings behavior among rural households in case of Boricha Woreda, Sidama zone, Southern Ethiopia” International Journal of Recent Scientific ResearchVol. 9, Issue, 11(E), pp. 29748-29752, November, 2018.

Beisland, L. A., & Mersland, R. (2012). The use of microfinance services among economically active disabled people: Evidence from Uganda. Journal of International Development, 24, S69–S83.

Bernheim, B.D., Garrett, D.M., (1996). The Determinants and Consequences of Financial Education in the Workplace: Education from a Survey of Households. Working Paper No. 5667.CambridgeMA: National Bureau of Economic Research.

Bernier, Q., Meinzen-Dick, R., Kristjanson, P., Haglund, E., Kovarik, C., Bryan E, Ringler, C., Silvestri, S. (2015). Gender and Institutional Aspects of Climate-Smart Agricultural Practices: Evidence from Kenya. CCAFS Working Paper No. 79. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available online at: www.ccafs.cgiar.org

Beshir, H. (2014). Factors Affecting the Adoption and Intensity of Use of Improved Forages in North East Highlands of Ethiopia. American Journal of Experimental Agriculture 4(1): 12-27, 2014

Bola, A. A., Diagne, A., Wiredu, A. N., & Ojehomon, V. E. (2012). Wealth status and agricultural technology adoption among smallholder rice farmers in Nigeria. International Journal of Sustainable Development, 05(2), 97–114.

Brata, A.G. (1999). Household Savings Behavior: The case of rural industry in Bantul. *CSIS*, 28(1): 75-86.

Cameron, A. C., and Trivedi, P. K. (2001). Essentials of count data regression.*A companion totheoretical econometrics*, *331*.

case of Multan District. Pak. J. Soc. Sci. 30 (1):17 – 29.

Cassim, O.J., Chakufwa, E. W. and Timika S. V. (2017). Understanding the factors affecting adoption of subpackages of CSA in Southern Malawi. International Journal of Agricultural Economics and Extension ISSN 2329-9797 Vol. 5 (2), pp. 259-265,

CGIAR. 2013. Climate-Smart agriculture success stories from farming communities around the world. Montpellier: CGIAR. [Google Scholar]

Challa, M.,& Tilahun, U. (2014). Determinants and Impacts of Modern Agricultural Technology Adoption in West Wollega: The Case of Gulliso District. *Journal of Biology, Agriculture and Healthcare*, 4(20): 2224-3208

Chandra, A. (2017). Climate-smart agriculture in practice: insights from smallholder farmers, Timor-Leste and the Philippines, Southeast Asia PhD Thesis, School of Earth and Environmental Sciences, The University of Queensland. doi:10.14264/uql.2017.880

Chiputwa, B., Langyintuo, A.S., & Wall, P.C. (2010). Adoption of Conservation Agriculture Technologies by Smallholder Farmers in the Shamva District of Zimbabwe: A Tobit application. *Research Papers in Economics*.

Jerop, R., Dannenberg, P., Owuor, G., Patience, M., Kimurto, P., Willkomm, M. and Tups, G. (2018). Factors affecting the adoption of agricultural innovations on underutilized cereals: The case of finger millet among smallholder farmers in Kenya. African Journal of Agricultural Research. 13. 1888-1900. 10.5897/AJAR2018.13357.

Chilot, Y.,Atnafe, Y., and AwHassan, A. (2015). A Multivariate Analysis of Factors Affecting Adoption of Improved Varieties of Multiple Crops: A Case Study from Ethiopian Highlands. Ethiopian Journal of Agricutral Sciences. 25. 29-45.

Chowa, G.A.N., Masa. R., Ansong, D. (2012). Determinants of savings among low income individuals in rural Uganda: Evidence from assets Africa. Advances in Applied Sociology, 2(4):280-291.

Chowa, G. A., Masa, R. D., & Sherraden, M. (2012). Wealth effects of an asset-building intervention among rural households in Sub-Saharan Africa. Journal of the Society for Social Work and Research, 3, 329-345. doi:10.5243/jsswr.2012.20

Chua, N. E. A., Kiong, S. K. L., Villa, K. H. M., & Paguta, R. B. (2016). A Tobit Analysis of the Determinants and Potentials of Savings in the Case of Payatas Households. Information Management and Business Review, 8(3), 47-57. https://doi.org/10.22610/imbr.v8i3.1331

Coenders, G., &Saez, M. (2000). Collinearity, heteroscedasticity and outlier diagnosis in regression. Do they always offer what they claim? New approaches in applied statistics, 16, 79-94Economics Letters, 99:585-590.Economics, Stern School of Business, New York University: 1-63.85

Moussa Diallo1, M., Aman, N.J.,Adzawla, W. (2020). Factors influencing the adoption of climate smart agriculture by farmers in Ségou region in Mali

Lugauer, S., Ni, J., Yin, Z. (2019). Chinese household savings and dependent children: Theory and evidence,China Economic Review, Volume 57, https://doi.org/10.1016/j.chieco.2017.08.005.

Donkoh, S.A., Azumah, S.B., & Awuni, J.A. (2019). Adoption of improved agricultural technologies among rice farmers in Ghana: a multivariate probit approach. *Ghana Journal of Development Studies*.

Ellis, F. (2000). The determinants of rural livelihood diversification in developing countries. Journal of Agricultural Economics, Oxford University Press, Oxford, Uk Export Processing Zones Authority. (2005). Horticultural Industry in Kenya

FAO. 2010. Climate smart agriculture: policies, practices and financing for food security, adaptation and mitigation. Rome: Food and Agriculture Organization

FAO. 2012. Identifying opportunities for climate-smart agriculture investments in Africa. http://www.fao.org/docrep/015/an112e/an112e00.pdf

FAO. 2013. Climate-Smart Agriculture Sourcebook. Rome (available at www.fao.org/ docrep/018/i3325e/i3325e00.htm).

FAO. 2015. Climate Change and food security, risks and responses (http://www.fao.org/3/a-i5188e.pdf)

FAO. 2016. Climate change and food security: risks and responses. Rome: Food and Agriculture Organization of the United Nations.

Feder, G., Just, R. E., and Zilberman, D. (1985).Adoption of agricultural innovations in developing countries*:* A survey. *Chicago: The University of Chicago*

Förch, W., Sijmons, K., Mutie, I., Kiplimo, J., Cramer, L., Kristjanson, P., Thornton, P., Radeny, M., Moussa, A., andBhatta, G. (2013). Core Sites in the CCAFS Regions: East Africa, West Africa and South Asia, Version 3.CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen,Denmark. Available online at: www.ccafs.cgiar.org

Gerrans, P., Clark-Murphy, M.(2004). Gender differences in retirement savings decisions, Journal of Pension Economics and Finance 3, 145-164

Njenga, G.,Onuonga, S.M.and Sichei, M.M. (2018). Institutions effect on households'savings in Kenya: A ranked ordered multinomial/conditional probit model approach. Journal of Economics and International Finance. 10. 43-57. 10.5897/JEIF2018.0896.

Gina, A.N. C.,Rainier ,D. M. and David, A. (2012). "Determinants of Savings among Low-Income Individuals in Rural Uganda:Evidence from Asset Africa ." Scientific Research. Online in SciRes.

Ghimire, R., Huang, WC. Household wealth and adoption of improved maize varieties in Nepal,a double-hurdle approach. Food Sec. 7, 1321–1335 (2015). https://doi.org/10.1007/s12571-015-0518-x

Gebresilassie L, Bekele A (2015). Factors determining the allocation of land for improved wheat variety by smallholder farmers of northern Ethiopia. Journal of Development and Agricultural Economics 7(3):105-112.

Gonosa, A.,Bargissa, B., Tesfay, K. (2020). Factors' Affecting the Motives of Rural Households' Savings Behavior in North Bench District, Bench Maji Zone of Southern Ethiopia. Journal of Economics and Sustainable Development www.iiste.orgISSN 2222-1700 (Paper) ISSN 2222-2855 (Online) Vol.11, No.17, 2020 31

Government of Kenya (2018). *National Climate Change Action Plan (Kenya): 2018-2022*. Nairobi: Ministry of Environment and Forestry.

Greene, H. W. (2003). Econometric analysis (5th Edition). Upper Saddle River, New Jersey: Prentice Hall Publishers.

Greene, H. W. (2007). Functional form of heterogeneity in models for count data. *Department Of*

Greene, H. W. (2008). Functional form for the negative binomial model for count data.

Greene, H.W. (2007). Econometric analysis: *Pearson Education Inc. New York* University

Gujarati, D. N., & Porter, D. C. (2009). Basic Econometrics. Fifth edition. McGraw-Hill Publishers, New York, NY: USA

Gujarati, D.N. and Sangeetha (2007) Basic Econometrics. Tata McGraw-Hill, New Dehli, India.

Gujarati, D. (2004). Basic Econometrics. Fourth edition. McGraw-Hill Publishers, New York, NY: USA

Gulnur, M. and Fatma, T. (1996). "Differences In Household Savings Behavior: Evidence From Industrial and Developing Countries", *The Developing Economies*, XXXIV-2

Hardaker, J.B., Lien, G., Anderson, J.R., & Huirne, R.B.M. (2015). Coping with risks in agriculture, 3rd Edition. *Applied Decision Analysis*.

Hanchane, S., & Mostafa, T. (2010). Endogeneity problems in multilevel estimation of education production functions: an analysis using PISA data. Centre for Learning and Life Chances in Knowledge Economies and Societies. LLAKES research paper, Recuperado.

Halefom, Y. (2015). "Determinants of household savings in Gedeo zone, Southern Ethiopia". Journal ofEconomics and Sustainable Development, 6 (7).

Harris, J.M., Blank, S.C., Erickson, K. & Hallahan, C. (2010). Off-farm income and investments in farm assets: A double-hurdle approach. Selected Paper prepared for presentation at the *AAEA, CAES, and WAEA Joint Annual Meeting*, Denver, Colorado, July 25-27, 2010, 19pp.

Hausman, J. A. (1978). Specification tests in econometrics. *Journal of the econometric society*, 1251-1271

Hertz, T. (2009). "The Effect of Nonfarm Income on Investment in Bulgarian Family Farming" *Agricultural Economics*, Vol. 4, No. 2, pp. 161–176.

Hohfeld, L. and Waibel, H. (2013). Investments of Rural Households in Northeast Thailand and the Future of Small Scale Farming. Journal of International Agriculture 52 (2013), No. 3: 217-236

Holden, S., Shiferaw, B., and Pender, J. (2004). "Nonfarm Income, Household Welfare, and Sustainable Land Management in a Less-favored Area in the Ethiopian Highlands"*Food Policy,* Vol. 29, pp. 369–392

Issahaku G and Abdulai A 2019 Adoption of climate-smart practices and its impact on farm performance and risk exposure among smallholder farmers in Ghana. Australian Journal of Agricultural and Resource Economics. doi:10.1111/1467-8489.12357

Imbens, G., and Wooldridge, J.M. (2007). "Control Function and Related Methods." NBER Summer Lecture Series 6.

Iyoha, M., Oyefusi, S. A. and Oriakhi, D. E. (2003). An introduction to modern Macroeconomics. Mindex publishing, Benin City, Nigeria.

Jama, B., Eyasu, E., Magosti, K. (2006). Role of agroforestry in improving food security and natural resource management in the dry lands: a regional overview. Journal of the Dry lands 1(2): 206-2011. Justin, C.O., Wiliams, C.E. and Vera, T.S. (2017). Understanding the factors affecting adoption ofsubpackages of CSA in Southern Malawi.International Journal of Agricultural Economics and Extension ISSN 2329-9797 Vol. 5 (2), pp. 259-265.

Kangogo, D., Dentoni, D., and Bijman, J. (2021). Adoption of climate-smart agriculture among smallholder farmers: Does farmer entrepreneurship matter?,Land Use Policy,Volume 109,105666,ISSN 0264-8377,https://doi.org/10.1016/j.landusepol.2021.105666.

Katungi, E., Machethe, C.L., and Smale, M. (2007), Determinants of social capital formation in rural Uganda: Implications for group-based agricultural extension approaches, African Journal of Agricultural and Resource Economics, 01, (2), 24

Karuku, G.N. (2018). Soil and water conservation measures and challenges in Kenya; International Journal of Agronomy and Agricultural Research.

Karuku, G. N., Kimenju J. W. & Verplancke H. (2016). Farmers' perspectives on factors limiting tomato production and yields in Kabete, Kiambu County, Kenya, East African Agricultural and Forestry Journal, 82:1, 70-89

Kea, T., and Kim, M. (2012). "Individual, Institutional, and Structural Determinants of Household Savings Decisions", *Utrecht University*, Working Paper: April 2012.

Keshavarz, M., & Karami, E. (2014). Farmers' decision-making process under drought. *Journal of arid environments*, *108*, 43-56.

Kibet, L.K., Mutai, B.K., Ouma, D.E., Ouma, S. A., & Owuor, G. (2009). 'Determinants of household savings: Case study of Small holder farmers, entrepreneurs and teachers in rural areas of Kenya', Journal of Development and Agricultural Economics, 1(7) 137-143

Kinyangi J, Recha J, Kimeli P, Atakos, V. (2015). Climate-smart villages and the hope of food secure households: Preliminary results from climate change adaptation and mitigation initiatives in the Nyando climate-smart villages. ILRI, Nairobi Kenya: Climate Change, Agric. Food Security, (CCAFS)

Kisaka-Lwayo, M., Darroch, M.A.G., & Ferrer, S.R.D. (2005). Analysis of risk attitudes of smallholder crop farmers in Umbumbulu district, Kwazulu-Natal, South Africa. African Crop Science, 7(2), 909-914

Kleinbaum, D. G., Kupper, L., & Muller, E. (1998). Applied Regression Analysis and Other Multivariate Methods.2nded., PWS-Kent, Boston, Mass.

Korir, J.K., (2016). Factors influencing intensity of adoption of Integrated Pest Management package and pesticide misuse in the control of Mango Frit Fly in Embu East Sub-County, Kenya.

Koutsoyannis, A. (1973). Theory of Econometrics.Macmillan Education Ltd.

Kpadonou R A, Owiyo T, Barbier B, Denton F, Rutabingwa F and Kiema A 2017 Advancing climate-smart-agriculture in developing drylands: Joint analysis of the adoption of multiple on-farm soil and water conservation technologies in West African Sahel. Land Use Policy, 61, 196-207. doi:10.1016/j.landusepol.2016.10.050

Lugauer, S., Jinlan, N., and Zhichao, Y. (2019). "Chinese household savings and dependent children: Theory and evidence". *Economics Faculty Publications*. 70. https://digitalcommons.unomaha.edu/econrealestatefacpub/70

Lalani, B., Dorward, P., Holloway, G., & Wauters, E. (2016). Smallholder farmers' motivations for using Conservation Agriculture and the roles of yield, labour and soil fertility in decision making. Agricultural Systems, 146, 80–90.

Lan, L., Sain, G., Czaplicki, S., Guerten, N., Shikuku, K.M., Grosjean, G., *et al*. (2018). Farm-level and community aggregate economic impacts of adopting climate smart agricultural practices in three mega environments. PLoS ONE 13(11): e0207700. https://doi.org/10.1371/journal. pone.0207700

Lidi, B.Y., Bedemo, A., Belina, M. (2017). Determinants of savings behavior of farm households in rural Ethiopia. The case of Benishangul Gumuz regional estate. Journal of Economics and Sustainable Development. Volume 8, No13, pg 27-37.

Liu, F. (2019). "Professional financial advice, self-control and savings behavior", International Journal of Consumer Studies, 43(1), 23-34

Mawia, H., Simtowe, F., & Rahut, D. B. (2021). Choice of savings instruments among rural women maize farmers: evidence from Uganda.

Macoloo, C., Recha, J., Radeny, M., Kinyangi, J. (2013). Empowering a local community to address climate risks and food insecurity in Lower Nyando, Kenya. Case Study prepared for Hunger • Nutrition • Climate Justice • 2013 | A New Dialogue: Putting People at the Heart of Global Development. Dublin, Ireland: Irish Aid.

Maindi, N. C., Osuga, I. M., and Gicheha, M. G.(2020). Advancing climate smart agriculture: adoption potential of multiple on-farm dairy production strategies among farmers in Murang'a County, Kenya. Livestock Research for Rural Development. Volume 32, Article #63. Retrieved January 28, 2021, from http://www.lrrd.org/lrrd32/4/izzac32063.html

Makate, C. (2019). Effective scaling of climate-smart agriculture innovations in African smallholder agriculture: A review of approaches, policy and institutional strategy needs. Environmental Science and Policy. 96: 37-51. Doi: 10.1016/j.envsci.2019.01.014

Makate,C.,Makate, M.& Nelson Mango, N. (2018). Farm householdtypology and adoption of climate-smart agriculture practices in smallholder farming systems ofsouthern Africa, African Journal of Science, Technology, Innovation and Development, 10:4, 421-439, DOI: 10.1080/20421338.2018.1471027

McKune, S., Poulsen, L., Russo, S., Devereux, T., Faas, S., McOmber, C., and Ryley, T.(2018). Reaching the end goal: Do interventions to improve climate information services lead to greater food security? Climate Risk Management, Volume 22, 2018, Pages 22-41.

Maumbe, B. M., and Swinton, S. M. (2000). "Why Do Smallholder Cotton Growers in Zimbabwe Adopt IPM? The Role of Pesticide-Related Health Risks and Technology Awareness" Paper presented at the American Agricultural Economics Association meetings, Tampa, FL. July-Aug. 2000.Google Scholar

Mbugua,M., Nzuma, J., & Muange, E. (2019) Social networks and expost risk management among smallholder farmers in Kenya, Development Studies Research, 6:1, 30-39, DOI: 10.1080/21665095.2019.1573149

Mbindah, B.(2017). Assessment of Climate Change Scenarios on Onion Yields Under Different Soil Fertility Regimes Using Aquacrop Model in Ugenya, Siaya County. MSc Thesis. Department of Land Resource and Agricultural Technology, University of Nairobi

Mbindah, B., Karuku, G., Gachene, C. (2018). Simulating Climate Change Impacts on Onion (Allium cepa) Yields under Varying Soil Fertility Management Practices in a Sub Humid Region of Kenya. In print Manuscript numberISWCR_2018_45. International Soil and Water Conservation Research

Mirach, T.H. and Hailu, Y.M. (2014). Determinants of household savings in Ethiopia: a case of north Gondar zone, Amhara regional state, European Centre for Research Training and Development UK (www.eajournals.org) Vol.2, No.4, pp.37-49

Moono, L. (2015). An Analysis of Factors Influencing Market Participation Among Smallholder Rice Farmers in Western Province, Zambia.

Mignouna, D. B., Manyong, V. M., & Rusike, J. (2011). Determinants of adopting imazapyr-resistant maize technologies and its impact on household income in Western Kenya. AgBioforum, 14(3), 158–163.

Murray,U., Gebremedhin, Zewdy, G., Galina,B., and Charles, S. (2016). Smallholder Farmers and Climate Smart Agriculture: Technology and Labor-productivity Constraints amongst Women Smallholders in Malawi. Gender, Technology and Development. 20. 10.1177/0971852416640639.

Mulatu, E. (2020). Determinants of Smallholder Farmers' Savings: The Case of Omo Microfinance Institution in Gimbo District of Kaffa Zone, Southern Ethiopia. International Journal of Accounting, Finance and Risk Management, 5(2), 93–105

Mwaura, S., Muluvi, A., and Mathenge, M. (2013). African Leafy Vegetables and Householdwellbeing in Kenya; a disaggregation by gender.Current Research Journal of Social Sciences 6(4): 82-94, 2014 ISSN: 2041-3238, e-ISSN: 2041-3246

Mwangi M, Kariuki S (2015). Factors Determining Adoption of New Agricultural Technology by Smallholder Farmers in Developing Countries. Journal of Economics and Sustainable Development 6:5

Mumin Y.A., Razak, A., Domanban, P.B. (2013). Analysis of household heads' decision-to-save with financial institutions in Ghana. Asian Economic and Financial Review. 3. 1466-1478.

Nayak, S.(2013). “Determinants and pattern of savings behavior in rural households of western Odisha”, A thesis submitted for the partial fulfillment of the master degree in development studies. National Institute of Technology, India, 25-28

Ndamani, F., Watanabe, T. (2016). Determinants of farmers’ adaptation to climate change: a micro level analysis in Ghana. Scientia Agricola 73(3):201–208. https://doi.org/10.1590/0103-9016-2015-0163

Ndiritu, S.W., Kassie, M.,& Shiferaw, B.(2011). Adoption of agricultural technologies in Kenya: How does gender matter? Paper presented at the 28th International Conference of Agricultural Economists, 18–24 August, Rafain Convention Center, Foz Do Iguacu, Brazil.

Nhemachema, C. & Hassan, R. (2007). Micro-level Analysis of Farmers‟ Adaptation to Climate Change Change in Southern Africa. IFRI discussion paper No.00714. International Food Policy Research Institute, Washington, DC.

Nkonya, E. J., Pender, P., Jagger, D., Sserunkuma, C., Kaizzi and Ssali, H.(2004). “Strategies for Sustainable Land Management and Poverty Reduction in Uganda”. IFPRI Research Report No.133. IFPRI, 2033 Kstreet, NW Washington, DC 20006-1002, USA.

Nwibo, S.U. and Mbam, B.N. (2013). Determinants of savings and investment capacities of farming households in Udi Local Government Area of Enugu State, Nigeria. *Research Journal of Finance and Accounting* 4(15): 59 -68.

Nyong A, Adesina F, Elasha BO (2007). The value of indigenous know ledge in climate change mitigation and adaptation strategies in the African Sahel. Mitig. Adapt. Strat. Glob. Change 12:787-797.

Obalola, T.O., Audu, R.O., Danilola, S.T. (2018). Determinants of savings among smallholder farmers in SokotoSouth Local Government Area, Sokoko State, Nigeria. Acta Agric. Slov. 2018, 111, 341–347. [CrossRef]

Ochieng, J., Kirimi, L., & Mathenge, M. (2016). Effects of climate variability and change on agricultural production: the case of small-scale farmers in Kenya. NJAS - Wageningen Journal of Life Sciences. doi:10.1016/j.njas.2016.03.005.

Odoemenem, I.U. (1992). Funding Agriculture through Cooperatives. The case of Anambra State Village Adoption Scheme (ASVAS), Nigeria. Quarterly Journal of International Agriculture, Germany, Vol.31 No.1. January-March, pp. 25-35.

Odoemenem, I.U., Ezike, K.N.N., Alimba, J.O. (2005). Assessment of Agricultural Credit

Odoemenem, I.U., Ezihe, J.A.C., and Akerele, S.O. (2013).Savings and Investment Pattern of Small-Scale Farmers of Benue State, Nigeria. *Global Journal of Human Social Science Sociology and Culture,* 13(1): 7-12.

Ogada, M.J., Radeny, M., Recha, J., Riba, A., Auma, J., Solomon, D. (2021). CCAFS Endline Synthesis Report: Nyando, Kenya. CCAFS Report. Wageningen, the Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

Ojango, J.M.K., Audho, J., Oyieng, E., Recha, J., Muigai, A. (2015). Sustainable small ruminant breeding program for climate-smart villages in Kenya: Baseline household survey report. CCAFS Working Paper no. 127. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

Ojoko, E., Akinwunmi, J., Yusuf, S., & Omobowale, O. (2017). Factors influencing the level of use of climate-smart agricultural practices (CSAPs) in Sokoto state, Nigeria. Journal of Agricultural Sciences, Belgrade. 62 (3) 315-327. 10.2298/JAS1703315O.

Osondu, C., Obike, K., & Ogbonna, S. (2015). savings, income and investment patterns and its determinants among small holder arable crop farmers in umuahia capital territory, abia state nigeria. 3. 51-70.

Pagliacci, F., Defrancesco, E., Mozzato, D., Bortolini, L., Pezzuolo, A., Pirotti, F., Pisani, E., Gatto, P. (2019). Drivers of farmers' adoption and continuation of climate-smart agricultural practices. A study from northeastern Italy. Science of The Total Environment.710. 136345. 10.1016/j.scitotenv.2019.136345.https://doi.org/10.1016/j.scitotenv.2019.136345.

Person Howells**,** P., and Bain, K. (2007). Financial Markets and Institutions. Pearson Education Limited Http://www.custominsight.comEducation limited publishers

Poulton, C., & Kanyinga, K. (2014). The Politics of Revitalising Agriculture in Kenya. Development Policy Review, 32, s151-s172. http://dx.doi.org/10.1111/dpr.12080

Quiroga, S., Suárez, C., & Solís, J. D. (2015). Exploring coffee farmers' awareness about climate change and water needs: Smallholders' perceptions of adaptive capacity. *Environmental Science & Policy*, *45*, 53-66.

Raghu, P. T., and Manaloor, V. (2014). Factors influencing adoption of farm management practices in agro-biodiversity hotspots of India: An analysis using Negative Binomial Count Data model. *Journal of Natural Resources and Development, 04: pp 46 – 53*

Reardon, T., Berdegue, J., Barett, C.B., &Stamoulis, K. (2007). Household income diversification in to ryral nonfarm activities. In transforming the rural nonfarm economy. S. Haggblade, P. Hazell and T. Reardon, eds. Pp. 115-140. Baltimore, MD, John Hopkins University Press.

Recha, J., Okila, W., and Nindo ,W. (2017). Coping with unpredictable rainfall patterns in Nyando

Recha, J. (2017). Supporting small-scale fish farms for climate risk management in Nyando

Recha, T. O., Gachene, C. K. K., &Claessens, L. (2017). Adapting Nyando smallholder farming systems to climate change and variability through modeling. African Journal of Agricultural Research, 12(26), 2178-2187.

Rehman, H.U & Muhammad, Z.F. (2011). Savings Behavior among Different Income Groups in Pakistan: A Micro Study. International Journal of Humanities and Social Science. 1.

Republic of Kenya. (1965). African Socialism and its Application to Planning in Kenya. Sessional Paper No. 10: Nairobi: Government printer**.**

Republic of Kenya. (1974). National Development Plan. Nairobi: Government printer.

Rosenzweig**,** M. (2001). "Savings Behaviour in Low-Income Countries," *Oxford Review of Economic Policy*, **17**, 40–54, 2001.

Rutherford, S. (1999). The Poor and Their Money, Oxford University Press, U.S.A.

Sadler, M.P., Millan, A.A., Swann, S.A., *et al*. (2016). Making Climate Finance Work in Agriculture. Washington: World Bank Group.http://documents.worldbank.org/curated/en/986961467721999165/Making-climate-finance-work-in-agriculture

Salifu A, Funk RL, Keefe M, Kolavalli S (2012). Farmer based organizations in Ghana. U.S.A.: International Food Policy Research Institute. Retrieved from http://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/127387/file name/127598. Pdf

Sameroynina, Y. (2005)."Consumption and Savings Behavior in Russia" The Economics of Savings. Edited by Gapinski JH, Kluwer Academic Publishers, London.

Sawuyah, N.(2018). Micro Analysis of the Determinants of Household Savings: Empirical Evidence from Uganda. International Journal of Innovative Research and Development. Volume 7, Issue 1, Page Number 312-322, 2018

Senthilkumar, P. (2017). "A Study on Investment Pattern and Awareness of Farmers in Pollachi Thaluk", International Journal of Interdisciplinary Research in Arts and Humanities, Volume 2, Issue 1, Page Number 4-8, 2017

Sharma, V. P., & Kumar, A. (2000). Factors influencing adoption of agroforestry programme: a case study from North-West India. Indian Journal of Agricultural Economics, 55(3), 500–510.

Shannon, H. D. and Motha, R. P. (2015). Managing weather and climate risks to agriculture in North America, Central America and the Caribbean. Weather Climate Extremes, 10: 50-56Sijmons, K., Kiplimo, J., Forch, W., Thornton, P.K., Radeny, M., Kinyangi, J. (2013). CCAFS Site Atlas-Nyando/KatukOdeyo. CCAFS site atlas series. The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark.

Simleit, C., Gavin, K., &Ferdi, B. (2011). The determinants of household savings in South Africa. Journal for Studies in Economics and Econometrics. 35. 1-20.

Sova, C. A., G., Grosjean, T., Baedeker, T. N., Nguyen, M., Wallner, A., Jarvis, A., Nowak, C., Corner-Dolloff, E., Girvetz, P., Laderach, and Lizarazo. M. (2018). "Bringing the Concept of Climate-Smart Agriculture to Life: Insights from CSA Country Profiles Across Africa, Asia, and Latin America." World Bank, and the International Centre for Tropical Agriculture, Washington, DC.

Syed, S., Miyazako, M. (2013). Promoting investment in agriculture for increased production and productivity. FAO 2013. Available online: http://www.fao.org/3/a-az725e.pdf

Taylor, M. (2018**)**. Climate-smart agriculture: what is it good for?, The Journal of Peasant Studies, 45:1, 89-107, DOI: 10.1080/03066150.2017.1312355

Hailemariam, T., Menale, B., &Bekele, S. (2013). Adoption of Multiple Sustainable Agricultural Practices in Rural Ethiopia. Journal of Agricultural Economics. 64. 597–623. 10.1111/1477-9552.12011.

Temesgen F, Emana B, Mitiku F, Gobana E (2017). Application of multivariate probit on determinants of sesame farmers market outlet choices in Gimbi District, Ethiopia. African Journal of Agricultural Research 12(38):2830-2835.

Terrones, M., Carderelli, R. (2005). "Are Savings and Investment Trends Fuelling Global Imbalances?" IMF Survey - 2005. Vol.34, No.17, Washington DC, IMF.

Tembo, F.M., Mangison, J., Edris, A.K., and Kenamu, E.(2017).Determinants of adoption of multiple climate change adaptation strategies in Southern Malawi: An ordered probit analysis. Journal of Development and Agricultural Economics,Vol. 9(1), pp. 1-7.

Teshome, G., Kassa, B., Emana, B. and Haji, J. (2013). 'Determinants of rural household savings in Ethiopia: The case of East Hararghe zone, Oromia regional state', Journal of Economics and Sustainable Development, 4 (3), 66-75.

Talent, Z., Lorraine, G., & Mokadi, M. (2016). The Determinants of Household Savings in South Africa: A Panel Data Approach. International Business & Economics Research Journal (IBER). 15. 209. 10.19030/iber.v15i4.9758.

Tran, N.L.D., Rañola, R.F., Ole Sander, B., Reiner, W., Nguyen, D.T. and Nong, N.K.N. (2020). "Determinants of adoption of climate-smart agriculture technologies in rice production in

Vietnam", International Journal of Climate Change Strategies and Management, Vol. 12 No. 2, pp. 238-256. https://doi.org/10.1108/IJCCSM-01-2019-0003

Trentacoste, M. F. (2000). Statistical models of At-Grade intersection accidents. U.S. Department of Transportation, Federal Highway Administration: 1-59.

Tu, T.T.T., Viet, N.Q., &Loi, H.H. (2015). Determinants of access to rural credit and its effects on living standard: Case study about poor households in Northwest, Vietnam, *International Journal of Financial Research, 6(2), 218-230*

Theophilus, K.A., Robert, A. & Paul, S.M. (2019). Determinants of the extent of adoption of maize production technologies in Northern Ghana. African journal of agricultural research. 14. 819-827. 10.5897/AJAR2019.13912.

Uaiene RN, Arndt C, Masters WA (2009). Determinants of Agricultural technology adoption in Mozambique. Discussion paper.

Vermeulen, Sonja, J., Bruce, M.C., and John S.I. (2012). "Climate Change and Food Systems." Annual Review of Environment and Resources 37: 195–222

Waaswa, A., Nkurumwa, A.O., Kibe, A.M. *et al*. (2021). Understanding the socioeconomic determinants of adoption of climate-smart agricultural practices among smallholder potato farmers in Gilgil Sub-County, Kenya. Discov Sustain 2, 41. https://doi.org/10.1007/s43621-021-00050-x

Wamalwa, I.W. (2017). Adoption of Climate Smart Agricultural Practices among Small Scale Farmers of Kitutu and Nyaribari Chache in Kisii County, Kenya.
Wellbeing in Kenya: A Disaggregation by Gender.

Williams, T.O., Mul, M., Cofie, O., Kinyangi, J., Zougmore, R., Wamukoya, G., Nyasimi, M., Mapfumo, P., Speranza, C.I., Amwata, D.,*et al* (2015). Climate Smart Agriculture in the African Context—Background Paper. In Proceedings of the Feeding Africa Conference—Unlocking Africa's Agricultural Potentials for Transformation to Scale, Dakar, Senegal, 21–23 October 2015

Winkelmann, R. and Zimmermann, K. F. (1995). Recent developments in count data modeling: Theory and application. *Journal of Economic Surveys*, 9(1):1-24.

Wooldridge, J. M.(2009). "On estimating firm-level production functions using proxy variables to control for unobservables," Economics Letters, Elsevier, vol. 104(3), pages 112-114, September

Wooldridge, J. M. (2015). Introductory Econometrics: A Modern Approach (5th Edition). Nelson Education.

Wooldridge, J. M. (2002). Econometric analysis of cross sectional data. Massachusetts Institute of Technology, USA: 1-1064.

WorldBank. (2016). "Agriculture & Rural Development."http://data. worldbank.org/topic/agriculture-and-rural-development

Zakaria, A., Alhassan, S.I., Kuwornu, J.K.M. *et al*. (2020). Factors Influencing the Adoption of Climate-Smart Agricultural Technologies Among Rice Farmers in Northern Ghana. Earth Syst Environ 4, 257–271 (2020). https://doi.org/10.1007/s41748-020-00146-w

Zeleke, A. T., & Endris, A. K. (2019). Household savings behavior and determinants of savings in financial institutions: The case of Derra District, Oromia Region, Ethiopia. Research Journal of Finance and Accounting, 10(23), 2222–2847

Zougmoré, Robert, Traoré, A.S. and Mbodj, Y.(2015). Overview of the Scientific,Political and Financial Landscape of Climate-Smart Agriculture in West Africa. Working Paper No.

118. CGIAR Research Program on Climate Change, Agriculture and Food Security. Available online at: www.ccafs.cgiar.org
Zuze, S.B.(2012). Factors That InfluenceSavings of Small Scale Tea Farmers in Kericho Town, Kenya

APPENDICES

Appendix 1: Household survey Questionnaire

Survey instrument for Nyando Basin

Introduction

Good morning/afternoon. I am coming from the University of Nairobi and doing a study with VU University, The Netherlands, and CCAFS East Africa and with the permission from the local government. The aim of the study is to get insights on household savings patterns and how it affects adoption of CSA technologies in this region specifically agroforestry, greenhouse farming, water harvesting and improved breeds. The results of the study will inform policy on use of household savings in scaling CSA technologies.

You have been selected randomly from a list of farmers and your responses will be treated with utmost confidentiality. The interview will take approximately one hour and your participation is voluntary.

The respondent will either be the household head, spouse or any household member who is over 18 years of age and participates in the family decision making.

Do you consent to participate in this research? [1=yes 0=no] if no move to the next household.

Section A: Background information

Interviewer name (code A)
County: 1 = Kisumu, 2 = Kericho [_____]
Location (code B)
Sub location (code C)
Village
CCAFS hhid
codeA:1 =Josephine Wandaho Njogu, 2=Naomi Wanjiru Gikonyo, 3=Elly Musembi Kyalo, 4=Margaret Ochieng, 5=Victor Rutto, 6= Anthony Musyimi, 7=Alex Birir
code B: 1=JIMO EAST, 2=NE NYAKACH, 3=PAP ONDITI, 4=KAPLELARTET, 5=KAPSOROK, 6=SOIN, 7=SOLIAT
code C: 1=JIMO EAST, 2=AGORO EAST, 3=AWACH, 4=KABODHO EAST, 5=OLEMBO,

S1Bq1 Nameoftherespondent:
S1Bq2 Respondentgender: Male=1/Female=0 [_]
S1Bq3 Relationshipofrespondenttohouseholdhead(code a): [____]
S1Bq5 Householdtype (code c):[____]
S1Bq6 Household member numbers
a) Respondent relationship 1 = Household head, 2 = Spouse, 3 = Other family member, 4 = Other non-family member **c) Household type** 1 = Male headed, with wife or wives, 2 = Male headed, divorced, single, widowed, 3 = Female headed, divorced, single, widowed, 4 = Female headed, husband away, husband makes most household/production decisions, 5 = Female headed, husband away, wife makes most household/production decisions, 6 = Child headed (under 16)/orphan, 96 = other, specify ____

HHmember no.	FIRST NAME (***Startwith head***)	Gender:Male=1/ Female=0	Age (years)	Highest levelof education attained (**codeA**)	Primary occupation **(code B)**	Secondary occupation **(code B)**	Relationto HH (**code C)**	Maritalstatus**(>12yrs**) **(code D)**
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

CodesA:1= No formalschooling,2=Primaryincomplete,3=Primarycomplete,4= Secondaryincomplete,5= Secondarycomplete,6=Tertiary/universityincomplete,7= tertiary/Universitycomplete,8=Adulteducationincomplete,9=Adulteducationcomplete, 10=Don't know
Codes B: 1=farming crop, 2=farming livestock, 3=salaried employment, 4=self-employed off-farm, 5=casual laborer on-farm, 6=casual labored off-farm, 7=school/college, 8=non-school child, 9=herding, 10-household chores, 11=other, specify
Codes C:1=Householdhead, 2=Spouse, 3=Son/daughter, 4= Parentlivingwithson/daughter, 5=Son/daughterin-law, 6=Grandchild, 7=other relative, 8=Hired worker9=Other, specify______
Codes D: 0=single, 1=married, 2=widowed, 3=divorced, 4=other, specify

Section B: Household Savings patterns

Do any of your household members have savings? *Yes=1, No =2.*

If yes, kindly fill the table below

Who in the household has savings? *See (A)*	What is the amount of the savings? (KShs)	Where are the savings kept? *See (B)*	What is the annual interest rate received?	What are savings used for? *See (C)*

A. Who has savings 1=husband, 2=wife, 3=joint husband/wife, -66=other, specify	B. Where are savings kept? 0=at home, 1=bank, 2=relative, 3=friend, 4=input supplier, 5=trader, 6=processor, 7=community group, specify name, -66=other, specify	C. Use of savings 1=food, 2=health, 3=funeral, 4=wedding, 5=seed, 6=fertilizer, 7=livestock, 8=water management, 9=livestock management, -66=other, specify

Section C: Investment in CSA Technologies

Have you adopted any Climate Smart Agriculture Technology? 1= yes 0= no

If no, what could be the reason?

1=haven't heard about it, 2=High cost/expensive, 3=Not interested, 4= others (specify)

If yes, kindly fill the table below

Ranking .	**Technology adopted** 1=Agroforestry, 2=Livestock breeding program(galla goats, red Maasai sheep), 3=Greenhouse farming, 4=Water harvesting, 5=others(specify)	**Source of information about the technology** 1=Government extension officers 2=Community Based Organization, 3=Family member, 4=Other Farmers, 5=Research center (e.g. CCAFS), 6=Filed days in Demonstration plots	Reason for investing in the technology	Year started	Total Investment since starting
1					
2					
3					
4					
5					

Section D: Household Assets

Household items

Item no	NameofAsset	Do you own this?	Total number owned	If you would sell [..] how much would the UNIT fetch (KShs)
1	Cooker/GasStove			
2	Refrigerator			
3	Radio/cassetteplayer			
4	Television			
5	Generator			
6	Pressing iron			
7	Fan			
8	Computer			
9	Blender			
10	Deepfreezer			
11	Wallclock			
12	Bed			
13	Buckets			
14	Pots			
15	DVD Player			
16	Mobilephone			
17	Sofaset			
18	Sewing Machine			
19	Mosquitonets			
Transport assets				
1	Car/Truck			
2	Motorcycle			
3	Bicycle			
4	Cart (animal drawn)			
Farm implements				
1	Tractor			
2	Fishingequipment			
3	Grinding machine			
4	Hoes			
5	Sickle			
6	Cutlasses			
7	Wheelbarrow			
8	Files			
9	Spades/shovel			
10	Ploughs			
11	Sprayer pump			
12	Water pump			
13	Other - locally			

14	Other			
Food items			Total kg/number	
1	Maize			
2	Sorghum			
3	Beans			
4	Peas			
5	Potatoes			
6	Sweet potatoes			
7	Cassava			
8	Nuts			
9	Dried fruit			
10	Dried meat			
11	Dried fish			
12	Canned food			
13	Bottled water			

Section E: Access to Credit

Who in the household has an outstanding loan? *See (A)*	What is the amount of the loan? (KShs)	Who provided the loan? *See (B)*	Acquired date of loan.	Source name of loan	What is the repayment period (at start of loan) (months)?	What is the annual interest rate charged?	What collateral was required? *See (C)*	Did you receive the amount asked for (0=no, 1=yes)	What is the loan used for? *See (D)*

A.Who received loan	**B.Source of loan**	**C. Collateral**	**D.Use of loan**
1=husband, 2=wife, 3=joint husband/wife, -66=other, specify	1=bank, 2=relative, 3=friend, 4=input supplier, 5=trader, 6=processor, 7=community group, specify name, -66=other, specify	0=no, 1=livestock, 2=land, 3=hh items, 4=crop harvest, -66=other, specify	1=food, 2=health, 3=funeral, 4=wedding, 5=seed, 6=fertilizer, 7=livestock, 8=water management, 9=livestock management, 10=repay other loan, -66=other, specify

Section F: Household Characteristics

Group membership (social network)

Is the household head or spouse(s) a member(s) of an agricultural / developmental group? // *Yes=1, No =2.*

If yes, Please fill the table below.

Number	Name of the group	Who is a member? (codes A)	What type is your group?: (Codes B).	What are the key activities of the group? *See (C), three options at most*	What is the main benefit of being a member? See (D)	How do you participate in the group? (E)
	.					

A. Group member	**B. Group type**	**C. Group activity**	**D. benefits**	**E. benefits**
1=husband, 2=wife, 3=joint husband/wife, -66=other, specify	0= no, 1=CBO, 2=farmer cooperative, 3=union, 4= political party, 5= NGO, 6= government agency, 7= church, 9=mosque, -66=other, specify	1=savings and credit, 2 = Tree nursery, 3=soil improvement, 4= crop introduction, 5= fish farming, 6= small business, 7= marketing agricultural products, 8= women empowerment, 9 = agricultural training, 10 = other training, specify, -66=other, specify	1=access to credit, 2=trainings, 3=advice, 4=social contact, -66=other, specify	1=leader, 2=active member, 3=passive member, -66 = other (specify)

Section G: Training

In the last 12 months have you been able to have access any form of extension services? 1= yes 0= no

If so, please fill table below:

Who in the household has received the training? (Code A)	Who provided the training?	Topics of training received (list B)	If YES, which was the last year?	

Code A: 1=Householdhead, 2=Spouse, 3=Son/daughter, 4= Parentlivingwithson/daughter, 5=Son/daughterin-law, 6=Grandchild, 7=other relative, 8=Hired worker,9=Other, specify_	**code B:** 0=None, 1 =Agricultural Sector Productivity & Food Security (ASP&FS), 2=Maternal/Child Health & Nutrition (H&N), 3 =Managing finances, 4=Farmer Field Days (NOT counted as beneficiaries), 5=Good agriculture practices, 6=Post Harvest Practices, 7=Disease Surveillance, 8=Fodder production, 9 = Poultry Management, 10=Pasture Management, 11 = Breeding Management, 12=Steer Fattening, 13 =seed potato multiplication, 14 = Vine multiplication, -66 =Other (specify)

Section H: Market access

	Motorable road	Local food market	Cattle/goat/sheep market
What is the distance in km to the nearest……			
What is the time taken to the nearest…..(on foot-walking)			
What is the time taken to the nearest … (on motor bike)			
What is the type of the road to the nearest….(1=Path,2=Earth,3=Gravel, 4=Murram, 99=Not applicable)			

Section I:Land tenure system

List all plots of land within the farm (code A)	What is the ownership status of the plot (code B)	What crop is cultivated on the plot? (codes C)	What size is the plot (ha)	Who does most of the work (code D)

Code A: 1= homestead, 2=fodder crop, 3=cash crop,4 =food crop, 5=grazing land	**Code B:** 1=owned and worked, 2=owned and rented out, 3=rented, 4=communal land, 66=other, specify	**Code C:** 1 = Beans, 2=Cassava, 3 = Lentils, 4 = Maize, 5 = Millet, 6 = Peas, 7 = Potatoes, 8 = Sorghum, 9 = Sweet potato, 10 = Tomatoes, 11 = Yam, 66 Other, specify	**Code D:** 1=adult males in household, 2=adult females in household, 3=male children in household, 4=female children in household, 5= male/female children in household, 6=hired labor, -66=other, specify	

Thank you

Annex 2: VIF; Tobit model

Variable	VIF	1/VIF
Age of household head	1.71	0.586390
sex of household head	1.22	0.818886
Formal education	1.60	0.626545
Credit access	1.30	0.771170
Group membership	1.30	0.769863
Total dependants	1.25	0.800999
Wealth Index	1.21	0.829468
Off-farm occupation	1.17	0.858010
Training	1.15	0.866850
Total land size	1.05	0.951838
Distance to cattle market	1.21	0.823349
Mean VIF	1.28	

Annex 3: VIF; MVP and Poisson models

Variable	VIF	1/VIF
Household savings	2.23	0.447459
Log of land size	1.75	0.570107
Age	1.69	0.591015
Sex	1.62	0.616315
Formal education	1.59	0.628607
TLU	1.55	0.647049
Group membership	1.44	0.693795
Credit access	1.39	0.720802
Training	1.36	0.733251
Distance to the cattle market	1.33	0.752630
Flood shock	1.22	0.820819
Mean VIF	1.55	

Annex 4: Breusch-Pagan / Cook-Weisberg test for heteroscedasticity

Tobit Model

Ho: Constant variance

Variables: fitted values of household savings

chi2 (1) = 924.37

Prob > chi2 = 0.0000

Poisson &MVP model

Ho: Constant variance

Variables: fitted values of number of CSA adopted.

chi2 (1) = 14.19

Prob > chi2 = 0.0002

Annex 5: goodness of fit

Deviance goodness-of-fit = 22.18564

Prob > chi2 (104) = 1.0000

Pearson goodness-of-fit = 21.88475

Prob > chi2 (104) = 1.0000

Annex 6: Z-score for the maximum ten data points

Monthly savings (Ksh)	Z-score
400000	9.166925
200000	4.42567
100000	2.055043
60000	1.106792
55000	0.9882603
53000	0.9408477
50000	0.8697289
50000	0.8697289
40000	0.6326661
38000	0.5852535