EFFECTS OF CLIMATE-SMART AGRICULTURAL AWARENESS ON FOOD SECURITY AMONG SMALLHOLDER FARMERS: THE CASE OF KAPTUMO-KABOI WARD, NANDI COUNTY

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DECLARATION

This research project is my original work and has not been presented for an award of a degree, diploma or certificate in the University of Nairobi or any other University.

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This research project has been submitted with our approval as the University of Nairobi supervisors.

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DEDICATION

I dedicate this work to my parents Benjamin Sitienei and Hellen Sitienei.

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LIST OF ABBREVIATIONS AND ACRONYMS

CA: Conservation Agriculture

CDF: Community Development Fund

CSA: Climate-Smart Agriculture

FAO: Food and Agriculture Organization

GoK: Government of Kenya

GHG: Greenhouse Gases

HDDS: Household Diversity Dietary Scores

HFSC: Household Food Consumption Score

IFPRI: International Food Policy Research Institute

IIIEE: International Institute for Industrial Environmental Economics

KARI: Kenya Agricultural Research Institute

KMD: Kenya Meteorological Department

RUM: Random Utility Maximization

UNFCCC: United Nations Framework Convention on Climate Change

ABSTRACT

Climate variability including temperature and rainfall variations is a core challenge impacting food production and security today. Kaptumo-Kaboi Ward, Nandi County is not immune to the effects despite being a moist region, ensuing in reduction in crop yields. Climate smart agriculture (CSA) is a feasible measure towards minimizing the impacts of climatic variation on food security and an option for mitigating changing climate. Despite the foreseen hope, the uptake of CSA is impacted by many setbacks including, lack of adequate knowledge and awareness. The study was steered by three objectives: to establish the link between farmers' socio-economic characteristics and CSA adoption; to assess the link between CSA awareness and its adoption; and to establish the effects of CSA on food security. The study was qualitative in nature and used simple random sampling technique, selecting 90 respondents. Questionnaires, schedule interviews, FGDs, and field observations were used. Results showed that social-economic issues greatly influenced adoption of CSA practices as age was negatively associated with CSA adoption as shown by *p*-value (Sig.015), education level was positive and significant at .001 household size was negative and significant at .412, farm size was significant at .310 while household income was positive and significant at .520. CSA awareness significantly influenced CSA adoption. Also, CSA adoption was found to positively impact food security as shown by t-value of 5.292 along with p value of 0.00 significant at 5%. The study concluded that that CSA awareness was one of the determinants of CSA adoption. The study proposes a shift to CSA that is entrenched over an agro-ecological approach for food security.

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

UNFCCC outlines climate change as variance of climate resulting from human action that interferes with the conformation of the universal atmosphere, leading to climatic variations experienced over an extended period of time (UNFCCC, 2018). Over the past centuries temperatures have increased by an overage of 0.6 º C due to a rise in greenhouse gases caused by human activities. The IPCC 2007 report (UNFCC 2001), explains that global temperatures are foreseen to increase in the 21st century from 1.5^0 C to 6^0 C. The harmful effects due to climate change are clearly seen and the absence of clear future scientific certainty places a huge threat to human life globally. (WFP 2011, UNFCCC 2001, IPCC, 2013). Change in temperature rise from 1^0 C to 2.5^0 C will lead to notable impacts to agriculture production and people will become more vulnerable to malnutrition and famine (Adger et al., 2013).

It is evident that in the 21st century variability in climate change has caused immense pressure to agricultural production which in return has affected the food security. Many of underdeveloped countries in the sub-Saharan Africa relies on farming as a primary economic activity experiences lower food productivity and little access to water services brought due to changing climate (IPCC, 2007). The link between agriculture and climate change is devastating as agricultural activities result in 30% GHG emissions while climate change affect agricultural productivity (Brown et al., 2008).

Africa is more susceptible to the consequences of climatic variations equated to other regions in worldwide irrespective its little contribution to environmental degradation. This is as an end result over dependency on raw materials and constrained irrigation technologies. The region also have finite financial assets, low and inadequate technical and technological capacities, lack of strengthened institutional arrangements as well as low capacity to adopt to changing environments (IPCC, 2013, Kabubo-Mariara and Kabara, 2015).

In Kenya, the growth of national economy is highly attributed to the agriculture sector which has a contribution of more than 26% of GDP (the Republic of Kenya, 2009). The country exposure to climate change variability presents great danger to the agriculture sector. Events caused such as famine and floods results to loss of crops, destruction of infrastructure which in turn affect availability and access of food (Oseni & Masarirambi, 2013).

The FAO, Conference on Agriculture, Food Security and Climate Change defined Climate Smart Agriculture (CSA) as an approach that integrates the three spheres (environmental economic and social) of sustainable development in a holistic manner that puts into account addressing climate change and food security. This concept is further sub divided into three pillars; climate change mitigation, adaptation and sustainable agricultural productivity. CSA is recognized as a way to bring about a solution to achieving food security, reducing GHG emissions and increasing capacity of vulnerable groups to cope with climatic variations. This can be achieved through adoption of suitable actions and strategies, creating an enabling environment and fostering financial sustainability (FAO, 2010; Beddington et al., 2012).

CSA involves a variety of actions including; growing of multiple crops, deliberately growing woody perennials with other agricultural crops, mulching, integrated long term pest and disease control, practicing no-till farming, mixed cropping, adopting mixed production through crop-livestock farming, diversification of the crops and using water sustainably. It also comprises application of innovative techniques such a weather forecasting system which are informed by better technologies and policies. Post-harvest treatment to lessen losses is considered another critical aspect of CSA (FAO, 2010; World Bank, 2011; 2012). Despite the importance placed in the CSA practices as a solution to food security there is still a limitation in policies, knowledge and capacities and accessibility of financial resources required to promote its adoption (FAO, 2013).

Farmers are required to be alert of the changing climate in order to determine the most suitable adaptation actions and put them into practice for effective adaptation and mitigation. For example, farmers are required to have access to local climate knowledge such as early warning information and possible ways to reducing the climate extremes and events. (Berkes, 2009).

The Agenda 2030 emphasizes on the need to provide solutions to the issue of food insecurity and identifies one way as addressing land degradation resulted from agricultural production; this will help in the attainment of the sustainable development goal. CSA is highly correlated towards attainment of Target 2.4 of SDG 2 that focuses on producing food sustainably and building farmers' resilience to respond to climatic variations such as drought and floods by 2030. According to a report by FAO Africa still remains behind in implementation of the SDG 2 on eliminating starvation and the incidences of starvation continue to rise (FAO & ECA, 2018). It is evident that environmental degradation combined with increase in population growth and high poverty levels poses major dangers to food productivity, land fragmentation and poor agricultural practices (IIIEE, 2017).

1.2 Statement of the Problem

Based on projected effects of climatic variations on agriculture, there calls for a need to move from the business as usual to adoption of CSA. Moving to CSA provides a potential for solving the challenges facing food security and also provides an opportunity for addressing climate variability. (FAO 2013). However the ability for farmers to adopt CSA is not easy due to limitation in knowledge and competencies, farm inputs, inability to take risk and technological accessibility.

Wambugu et al. 2014, conducted a study that showed that regardless of Kaptumo being categorized as an area of high humidity, it is already facing challenges associated with climate change. The study indicated that the area productivity level and sustainability in food security in the future will be threatened with predicted possibility of inconsistence and shortage in rainfall, degraded soils, incidences of disease and pests' outbreak as well as poor farming practices in the midst of others. The study also displayed that farmers in Kaptumo-Kaboi ward relied entirely on rainfall for cultivation, this requires an instant move to CSA for food security.

Notwithstanding the numerous efforts via each the authorities and the development companions in promoting adoption of CSA through policy formulation, the implementation of policies like the Kenya Climate Smart Agriculture Strategy 2017-2026, CSA has not been adopted fully. The

available information has not been disseminated to the grassroots level especially to the small holders.

Some of the farmers have already incorporated the concept of CSA however the adoption still remains low due to limited extension and technical services and knowledge on CSA. Most studies concentrated on the influence climate change to food security but none looked at the agricultural practices that can help in addressing climate change with specific interest on small scale farmers. (Jalloh, 2013; Zougmoré et al., 2016)

There is little information on the aspects that influences climate-smart practices to ensure food security in Kenya. Thus, this study will look at addressing the gaps in knowledge in order to understand how different socio-economic characteristics (age, education level, household size, and land size) of farmers affect CSA adoption, how CSA awareness influence its adoption, and on food security.

1.3 Objectives of the Study

The overall objective of this research was to understand effects of CSA awareness on food security among smallholder farmers. The specific objectives of this research study included:

i. To establish the relationship between farmers' socio-economic characteristics and CSA adoption among smallholder farmers
ii. To establish the influence of CSA awareness on adoption of CSA practices among smallholder farmers
iii. To establish the effects of CSA on food security

1.4 Hypotheses

H_0: There is no relationship between farmers' socio-economic characteristics and CSA adoption

H_1: There is a relationship between farmers' socio-economic characteristics and CSA adoption among smallholder farmers

H_0: There is no relationship between CSA awareness and the adoption of CSA among smallholder farmers

H_1: There is a relationship between CSA awareness on the adoption of CSA among smallholder farmers

H_0: There is no relationship between CSA adoption and food security

H_1: There is a relationship between CSA adoption and food security

1.5 Justification of the study

This findings and recommendations will be of great relevance to a wide group of stakeholders in the agriculture sector including policymakers at the government level, the local farmers, extension officers and research institutions. The findings and recommendations is a starting point for other researchers interested in this field and builds on the global knowledge on matters of climate smart agricultural with focus to farmers practices, knowledge and strategies

The study provides an in-depth understanding to the policy makers on the best way to promote CSA in order to increase levels of adoption in the country. It will also be beneficial to the County Government during preparation of the county development plan in order to mainstream CSA into the county planning. The study also provides insights and encouragement to the farmers interested in adopting CSA which is anticipated to increase adoption hence achieving sustainable crop production which in return will improve food security. (FAO, 2011; Kienzle & Sims, 2014).

1.6 Scope and Limitations of the Study

The scope of this study was to determine the contribution of CSA awareness to the smallholder farmers and its influence on food security. The study is limited to Kaptumo-Kaboi ward, Nandi County. The area is described as a non-ASAL with a big number of small-scale farmers whose primary source of income is agriculture.

It was restricted to household analysis. Seasonal differences which would have had effect on food productivity were not figured out during determination of agricultural production. The Household Food Consumption Score (HFCS) was used to measure the food security which greatly depends on the capability of the farmers to provide information on the food used within a week period.

1.7 Operational Definitions

Climate Smart Agricultural practices: According to FAO CSA is described as agricultural practices that are efficient and have a positive long term effect to productivity and revenue generation, mitigates GHG emissions and enhances attainment of national food security as well as sustainable development goals (FAO, 2010).

Food security: refers to reliable access to socially suitable means to nutritionally satisfactory and secure food for an active and a healthy lifestyles by all people (Bickel *et al*., 2000).

Small-scale farmers: These are farmers that own less than 2 hectares of land, produce cops and rare livestock for subsistence purposes

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

It is divvied into three sections, empirical review, theoretical and conceptual frameworks. The conceptual framework contains a visual explanation on how research variables are interrelated.

2.2 Socio-economic characteristics of smallholder farmers and adoption of CSA Practices

It is evident that agricultural is highly influenced by social and political situations. According to Juan et al (2016), Bajo Andarax district in Almeria grow above 1000 hectares of citrus crops. EU then withdrew subsidies for conventional production, which stemmed in loss of profits. This ensued a study to establish economic sustainability of the change looked at sustainability at municipality and farm levels. The results indicated that switch to organic farming could result in economic and social sustainability. Also (David, et al, 2013) conducted a study that aimed at understanding how political factors influence sustainability. It concluded that globalization and low margins are some of the issues affecting ecological agriculture adoption.

Lan et al. (2018) examined the extent which social-aspects influencing CSA uptake in Vietnam, Nicaragua and Uganda. Area specific CSA-RA methodology was applied. The study findings revealed that high income inequality, size of the farm and credit access greatly swayed the CSA adoption across the three regions. In Malawi, Chimwemwe (2015) conducted a research to establish the socio-economic aspects affecting Conservation Agriculture (CA) in Balaka District. Nassari (2013) did a similar study but on implementing CAWT in Tanzania. Random selection with an aid of village registers was used to determine and select the sample. Logistic regression model was used to ascertain the impact of socio-economic issues affecting Conservation Agriculture with Trees (CAWT) adoption. Both studies established that socio-economic issues significantly affect CAWT adoption rate.

According to Mwungu (2018), in a study in Tanzania, observed that socio-economic factors were important in adoption of CSA. Elements of CSA adoption were assessed using a multivariate probit model (MVP) thus allowing interdependence and trade-offs of technologies being adopted among 357 households. Agroforestry, improved crop varieties, irrigation, manure and minimum

were considered in this study. The results showed that literacy index, agricultural information access, credit, assets endowment and livestock ownership influenced the decision to adopt CSA technologies.

In addition, Wambua et al. (2014) added to the knowledge on how socio-economic variables influence food security in Tseikuru division, Kenya. From the study, market availability, household income and cultural values were discovered to be the key elements affecting food security, and that people in this region were mostly food insecure. The area of study is classified as an ASAL and therefore differing from this study being conducted in Kaptumo-Kaboi which is a humid area.

A study by Awinda (2018) revealed that farmers' socio-economic aspects influenced smallholder irrigation adoption for food security in Gem Rae irrigation scheme. Pass-sectional survey was used with and 120 farmers were questioned. The results indicated that land tenure and size, education level and credit access were the main influences of adoption of irrigation. He recommended that there is need for commutation in order to upscale the implementation.

From the review above, the existence of wide range of knowledge is clear (David, et al, 2013; Nassari, 2013; Wambua et al., 2014; Chimwemwe; Awinda*;* 2018) that shows how Socio-economic characteristics influence CSA adoption. As per the studies, this research will add to the existing knowledge from a humid environment perspective.

2.3 CSA awareness influence on its adoption

Awareness is seen as an important factor influencing farmer's adaptation and resilience. Rohila, Shehrawat and Malik (2018), sort to explore effects of CSA awareness on its adoption in Haryana state in India. He interviewed 180 farmers drawn from 6 villages using random sampling. Regression analysis was also adopted whose results indicated that farmers' awareness and knowledge on CSA significantly affected its implementation.

Olorunfemi et al. (2019) examined the bases of participation of extension agents in creating CSA awareness using regression analysis. It was established that prominent initiatives disseminated by the extension agents were minimum tillage practices and cover crops planting. However, dissemination of CSA practices such as agro-forestry, agro-weather related initiatives, use of soil amendments among other important practices. The study concluded that significant causes affecting dissemination of certain CSA knowledge by extension agents' include education qualification, years of experience, participation in CSA training and numbers of community covered should be considered.

Anuga et al. (2019) examined CSA among small scale farmers in Brong Ahafo Region, Ghana. A total of 320 small scale farmers were nominated applying suitability sampling technique from purposively selected 10 communities within the municipality. The study results revealed that the farmers had implemented CSA practices that included zero tillage, use of manure and agroforestry. The main source of knowledge about CSAs was derived from using traditional and advanced methods of weather prediction. The study concluded that development actors ought to dynamically step up to support the inculcation of indigenous knowledge about CSA initiatives in to ensure increased uptake of CSA in Ghana.

Kadzamira and Ajayi (2019) carried out a research on promoting CSA adoption in Zimbabwe, Zambia and Malawi. The study argued that CSA awareness particularly on crop-insurance to enhance awareness alone is not sufficient for improved adoption. Majority of the farmetrs interview in Zimbabwe (60%) confirmed that they were aware of crop insurance while on 16% had adopted it. In Zambia, those who confirmed to be aware of the innovation were 43% but only 4% had adopted. Trade-offs shows that farmers being aware does not guarantee adoption but is influenced by a combination of factors. Kadzamira and Ajayi (2019) supported this finding by stating that in addition to awareness other factors like market access must be enhanced.

In a study by Wamalwa (2017), using a sample of 420 small-scale farmers, observed that farmers in this area were highly privy to CSA and had a positive attitude towards it, which in-turn affected its adoption. He further reiterated the findings of Kadzamira and Ajayi (2019) by stating that for improved CSA adoption there is need to ensure that other factors not only awareness is improved.

Based on the literature described above, this study sort to fill the gaps in knowledge that were not covered by Bernier et al. (2015) and Wamalwa (2017) regarding CSA awareness effects on adoption by examining farmers' CSA awareness and adoption of CSA.

2.4 Climate-Smart Agriculture and Food Security

CSA is a technological facet whose implementation could result in food security. Hassan et al. (2018) attempted to investigate the impact associated with CSA adoption on food security in Kalapara southern Bangladesh. The study also looked into the many dynamics of food security in the region. He identified 17 CSA practices and on average, 7 of them were adopted by each farmer. According to the sampled households study results, 32% of the households food secure, 51% of modestly food secure while the rest of them (17 percent) were extremely food insecure. Findings revealed that CSA practices adoption expressively influenced food security.

Amadu (2018) conducted an assessment of the impact of CSA practices on food security on 808 households in southern Malawi. The study employed logistic regression probit model to approximate CSA strategies adopted. The results showed that CSA adoption resulted in 90% increase in yields. The study informed policy makers to promote CSA practices not only in Malawi but also across Africa. In addition, IIIEE did a research on enhancing sustainable horticulture in Nakuru County, Kenya. They mainly centered on best practices currently being implemented and how those practices could be downscaled to smallholder farmers. As per their results, green horticultural farming was being implemented by most horticulture farmers in the area. They also noted that the available knowledge was not available to small-scale farmers and therefore they continued practicing unsustainable farming.

Wekesa et al. (2018) performed a pragmatic research seeking to identify the bases of CSA determinants and the interlinkage with food security in Teso-North Sub-County Kenya. 3284 farmers were involved in the study. The objective was to establish the interlinkage amid CSA and food security. The study results revealed farmers who adopted all the four sets; crop, field, soil management and farm risk reduction were more food secure. It also established that CSA systems are likely to result in food security if used in combinations.

2.5 Gaps in Literature Review

In this empirical analysis, quite several scholarly works have given consistent results of inverse relationship on results of study autonomous variables in regard to climate smart agriculture on reliant variable which is food security; others have also shown positive relationship on same phenomenon. The impact of socio-economic factors on food security situation has been established by quite several studies. However, many studies exist on how socio-economic aspects influence farmers' adoption of CSA. The study will build on the existing knowledge by further assessing how CSA impact food security in Kaptumo-Kaboi ward, Nandi County.

In terms of CSA awareness and its adoption, consistent results show positive influence on results of CSA awareness on its adoption by small scale farmers; others also argued that extension officers, trainers and different institutions mainly avail such information to the farmers. However more work needs to be done to raise awareness and capacity the farmers. The research provides further information on the influence of CSA awareness on CSA adoption.

The reviewed literature on CSA strategies shows there is a strong relationship involving CSA practices adoption on food security. The development can be enhanced by employing various CSA practices thus increasing the food production.

2.6 Theoretical Framework

2.6.1 The Random Utility Theory

The random utility theory is a model of recreation site choice also referred to the random utility maximization (RUM) model. This theory has verified to be useful for gauging access value and the impact of change (for example, increased bag rate for hunting, improved water quality and wider beaches). It has the possibility to easily handle many sites and substitution at simultaneously (McFadden, 1973). The theory suggests that farmer's choices are influenced by random factors and that utility of choice is encompasses deterministic and mistakes part. This means it's not possible to envisage farmers' choices with confidence but can express probability that the adoption of an option is greater than alternatives.

If U stand for utility that a person represented as i earn from good consumption, j evident deterministic component, V utility function and E random component (Cascetta (2009);

Utility theory is specified as follows:

$$U_{ij} = V_{tJ} + E_{ij}$$

Utility is described as U a dependent of choices taken relies upon on alternatives made from j CSA options is presumed to have a utility function as follows;

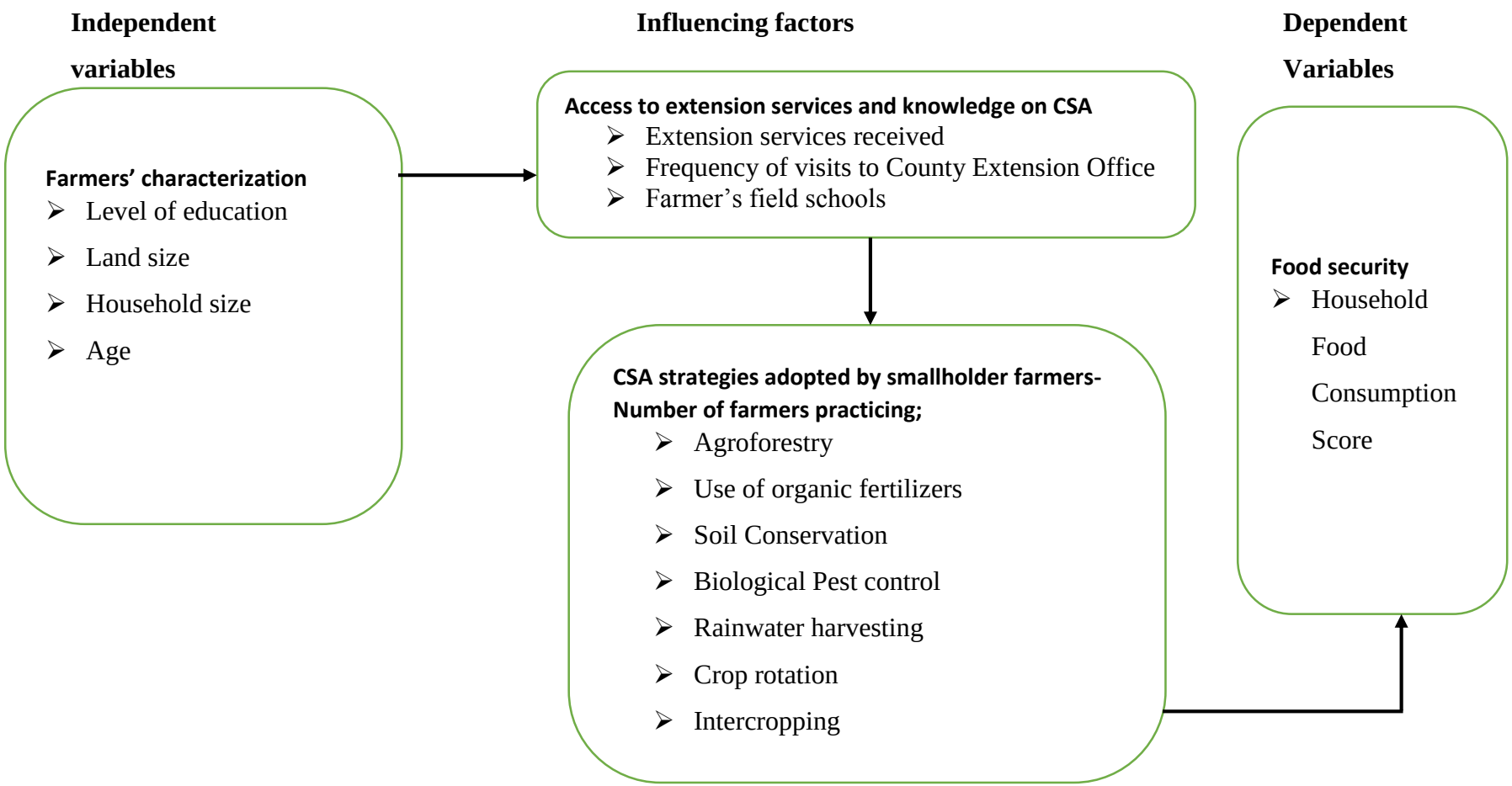
$$U_{ll} = V(Xj,Zi)$$

McFadden, 1973 further explains that a farmer's judgment to implement certain CSA practices is mainly based on the handiness and advantage of using that specific practice. If a choice is not convenient for a farmer, then they are unlikely to adopt it. In the case of this study, socio-economic characteristics and awareness are some of the factors that determine the handiness of a specific strategy to a farmer (Deressa et al., 2005).

2.7 Conceptual Framework

This section describes the interconnectedness among CSA awareness, uptake and food security. Both socio-economic aspects and CSA awareness play an important role on whether a farmer adopts CSA or not. Also, as farmers practice CSA, there is also a likelihood of influencing food security depending on the extent of adoption. Food security can be indicated by Household Food Consumption Score (Figure 2.1).

Figure 2.1: Conceptual Framework



Source: Modified from Behrman et al (2014)

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter sets out a summary of methodology utilized. Sampling and population blueprints and the instrument used for collecting data and the research strategies are spelt out. It also provided the relevant justifications for the selection of the techniques and methods that were chosen. It also expounded on how the data was examined and illustrated for the aim of drawing inference and commendations.

3.2 Study Area

It was done in Nandi County in a ward called Kaptumo-Kaboi ward (figure 2), which is based in Rift Valley Province. Kaptumo-Kaboi ward location mapping are 0.07°N 35.07°E of an altitude of 1882m above sea level. It covers an area of $98km^2$, $38m^2$ with a total number of seven sub-locations as follows Mugundoi, Ibanja, Kaboi, Kamarich, Masombor, Kapsoo and Chepkong'ony.

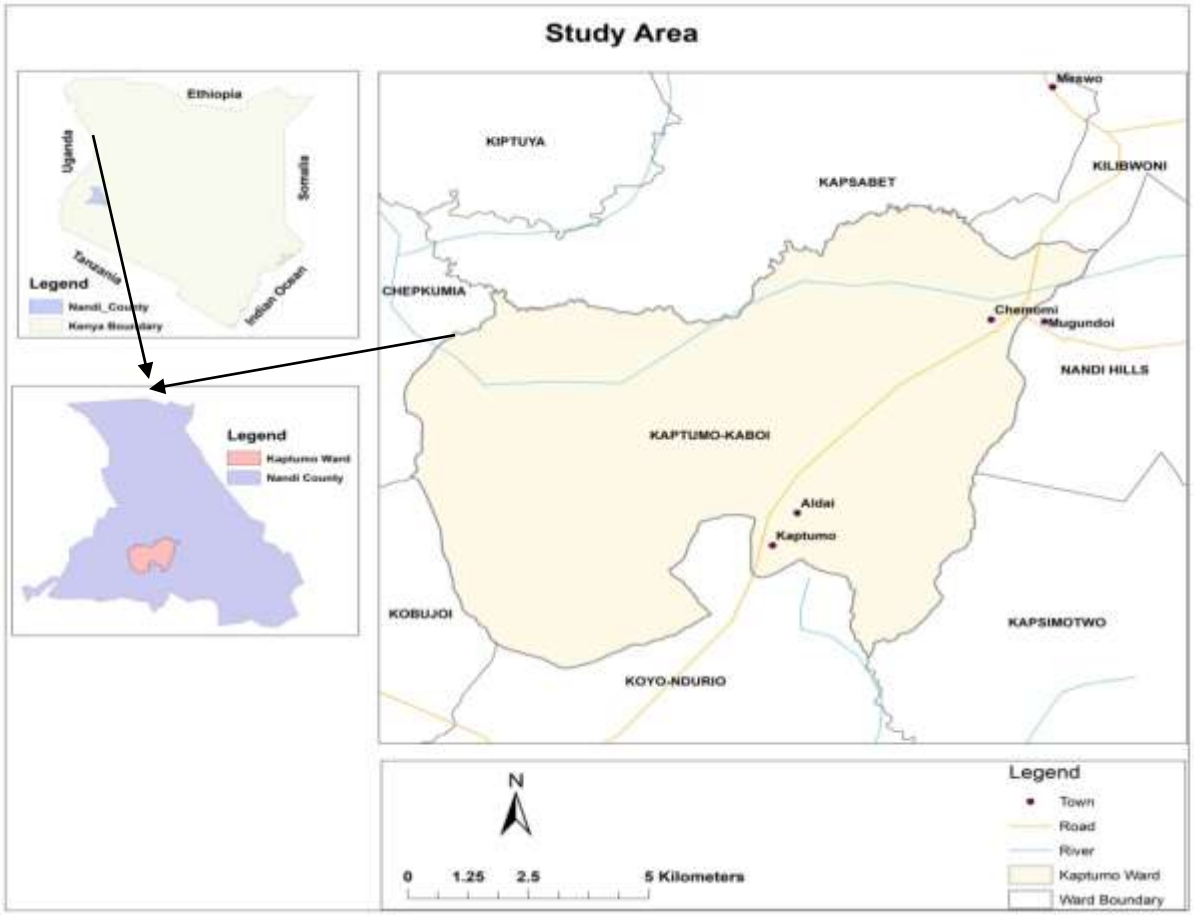


Figure 3.1: Kaptumo-Kaboi Ward Map Source: Researcher, 2019

The area climate is moderately wet and cool, with yearly rainfall fluctuating from approximately 1200mm to 2000mm and with temperature ranging from 15℃and 25℃. The area experience a dry season December to March, but all through the year the area has not recorded periods with no rain completely. Long showers are usually experienced between March to June and light showers are faced in October and November.

The Sub-county has undergone environmental deterioration characterized by loss of biodiversity, lessening water levels, poor soil fertility and soil erosion, affecting food availability. County's consolidated Development Plan, states that oscillating rain designs results in low yields.

The area lies on the Nyando escarpment unit and is marked by hills and topographical traits integrated rich wealthy soil that is the backbone of the cultivation and socioeconomic activities of the region. Agro-ecological zone of an area is defined by its agro-climatic factors and soil patterns. Agro-ecological zone were introduced by FAO in 1978 with an aim of informing agricultural policies. The study area falls under lowland highlands agro-ecological zone. The zone mainly occurs on elevations between 900-1800m. The zone is mostly important for both crop and livestock farming.

The inhabitants mostly took part in rain dependent cultivation as the focal source of earning, with the main crops grown being maize, sugarcane tea, and corn as the principal crops cultivated. Dairy crossbreeding is another main economic venture.

3.3. Target Population

Kaptumo-Kaboi ward population included small farmers and county farming extension officers hailing from Nandi County that provided crucial information during the research. As per the population of Kenya census 2009, Kaptumo-Kaboi Ward in Nandi comprises of 24,464 people and 4,893 households which was arrived at by apportioning the population by 5 the average number of people per household (GOK, 2009).

3.4 Sampling Procedure and Sample Size

Sampling is a mixture of various parts of a cluster, where a conclusion or decision about the sum is determined; narrations constructed in regard to the sample reflect the entire inhabitants (Kothari, 2006). Simple random sampling is the technique utilized. Yamane's formula (Yamane, 1967), was the sample size determining technique used as shown;

$$n=\frac{N(CV)^2}{CV^2+(N-1)e^2}$$

where, n= sample size; N= population; CV Coefficient of variation (O.5) & e= tolerance of desired level of confidence (0.05 at 95% confidence level)

The study's sample size was further expounded as shown below;

$$n=\frac{4,893(0.5)^2}{0.5^2+(4893-1)0.05^2}$$

$$n=98$$

3.5 Sources of data

Data was obtained by carrying out home interviews, Focus group dialogues and indispensable informers. Secondary data amassed was the base of the study publication review that fostered establishing the study gaps. These info was gathered from websites, journals, books, newspaper articles etc. Secondary data was also picked from county officers on how the field visits as well as records from veterinary, cereals and dealers stores.

3.5.1 Primary data

3.5.1.1 Questionnaires

Qualitative data was accumulated by employing semi structured questionnaires as the main data gathering instruments (Appendix 2). Open-ended and closed questionnaires were issued for interview with chosen agronomists from whole population through simple random sampling technique to represent of the whole population.

3.5.1.2 Focus Group Discussions (FGDs)

The Focus groups were classified into 2 sects, this included agronomists who go through CSA and agronomist who do not bank on CSA segregations each with 15 people bringing the sum to 30 smallholders who were connected in the FGD utilizing a FGD Guide (appendix 3). The FGD of smallholders who utilized CSA included 10 male and 5 female participants, while the class of those who don't utilize CSA was made of 9 men correspondents and 6 female research participants.

3.5.1.3 Key Informants Interviews

The pundits were out growers, county officials, agro-vet dealers, managerial level employees from EPK and KTDA factories in the ward were interviewed using interview guides. The out growers' manager train farmers on how to farm tea and on sustainable farming options .The aim of this category was to further inform on the gather knowledge on CSA awareness from an expert perspective.

3.5.2 Secondary data

Secondary evidence derivation included internet assessments from different prior research aligned to this study. These pedigrees comprised of manuals, publications of regime and the non-administrative firms, journals by divergent scholars, articles, data documents on crop produce and procure of farm inputs.

3.6 Data Collection Methods

Questionnaires, schedule interviews, FGDs, desktop research and field observations were employed. Approximately 98 separate questionnaires were rolled out to aid in data gathering from small agronomists who were unsystematically chosen; major informant interviews were assigned to officials in the agriculture sector. The questionnaires had both structured and open ended questionnaires. It showed data on demographic traits and socioeconomic side view of research participants, CSA awareness, CSA implementation by the research participants, and the upshot of the correspondents' food security. For rationality and logic, questionnaire try outs was carried out, and standardization of the tools done to streamline the loopholes present.

3.6.1 Validity Test

For this analysis, the questionnaires were issued to various correspondents and different feedback from the research participants were regarded as dissimilar correspondents comprehend the inquiry in different ways. Thus, greater magnitude of variation in how the correspondents look at the queries would mean contrive needed adjustment.

3.7 Data Analysis

Both quantitative and qualitative data audit methods were used this was aided by use of SPSS version 23.0. This was later analyzed through frequencies and percentages together with regression statistical test.

Ganguly *et al*. (2010) points out that multiple regression frameworks are the models that are least likely to give biased outcomes. Linear regression tools were utilized to establish the correlation between farmer's socio-economic features CSA implementation. Herein, the null hypothesis tested displayed no significant link joining farmers' socio-economic traits and CSA implementation.

It was also used to establish if CSA awareness had a major upshot on implementation of CSA amid agronomist in Kaptumo-Kaboi region as it permits measure of the correlation in CSA awareness affecting adoption (Park & Lohr, 2005).

The null hypothesis assessed showed 'No significant interrelation between farmers' awareness on CSA adoption.

This was calculated as follows;

$yi=\beta0+\beta1xi1+\beta2xi2+...+\beta pxip+\epsilon$

Where,

i=n observations:

yi=dependent variable

xi= explanatory variables

β0=y-intercept

βp=slope coefficients for each explanatory variable

ϵ=the model's error term

While evaluating the upshot of CSA on food reliability, the farmers were classified into 2 parts, depending on who are utilizing CSA or not. This provided a platform to compare the farmers in regard of those who had implemented and those that had not. The study employed the WFP's Household Food Consumption Score (HFCS); HFCS mostly uses substitutions to establish accessibility to food (WFP, 2009). The foods categorized into 8 groups as follows; Cereals, tubers and root Cereals, roots and tuber crops, meat and fish, milk, oils /fats, fruits, vegetables, pulses and sugar. Each food group was weighted from 0.5-4.The usage pattern was decided by the frequency of consumption within 7 day and multiplied by the exact score, and its sum ensued in FSC.

FCS= ∑ [Consumption frequency X Food Group Weight]

According to WFP (2009), food security is categorized based on the following threshold;

≤ 21.0= Poor

21.5-35= Average

> 35 = acceptable

Ordinal Regression was also carried out. This was to give better understanding of the outcome and discovery via interpretation of the outputs of the Ordinal Regression procedures. Therefore, twenty-five predictors were thrown into a Logistic Regression model. Sequel with a p value of < = 0.05 were regarded statistically significant.

3.8 Ethical Issues

Before administering the questionnaires, FGDs, and Key Informants interviews, respondents were briefed on the nature of the study and informed that their participation is voluntary. The respondents were then issued with letters seeking their consent to take part in the study. The principle of confidentiality was upheld, and that collected information was only utilized in the study and no other business. In addition, consent from research governing body the NACOSTI was sort for.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This chapter highlights study findings and discussions with reference to statistical data derived from questionnaires and interviews on CSA influence on food security among smallholder farmers. Scrutinizing, formatting and arranging were carried out for convenience in data analysis. SPSS 23.0 was also employed used as an analysis aid tool.

4.2 General Characteristics of Respondents

Target population of the study was small scale farmers within the ward. Hence, the key informants were county agricultural extension service agents. Face to face interviews were conducted to 90 respondents which was 91.84% response rate was attained since the rest of the respondents (8 questionnaires) were not satisfactorily filled in to.

The respondents comprised of 81.11% male and 18.89% female. Greater part of the farmers who were involved in the empirical research was between age brackets; 36-45 years then 46-55 years. Most of the households had between 4-6 people at 60.0%, followed by 7-9 at 23.33% and 1-3 at 16.67% (table 4.1).

Table 4.1: Respondents Characteristics

Characteristic	Categories	Total per category	Percentage	Total sample
Age	0- 25	12	13.33	90
	26-35	15	16.67	
	36-45	43	47.78	
	46-55	20	22.22	
Gender	Male	73	81.11	90
	Female	17	18.89	

Level of Education (no of years in school)	5-8	35	38.89	90
	9-12	32	35.56	
	13-16	23	25.55	
Household size	1-3	15	16.67	90
	4-6	54	60	
	7-9	21	23.33	
Income from off-farm employment	0-6000	8	8.89	90
	7000-13000	52	57.77	
	14000-20000	14	15.56	
	21000-27000	16	17.78	
Land size (acres)	0-1	5	5.56	90
	1-3	63	70	
	4-6	18	20	
	7-9	4	4.44	
Last time attended FFS	o-2	61	67.78	90
	2-6	9	10	
	7-12	10	11.11	
	12-18	10	11.11	
Last contact with extension officers	o-1	38	42.22	90
	2-4	18	20	
	5-8	26	28.89	
	9-12	8	8.89	

Source: Fieldwork, 2019

4.3 Socio-Economic Characteristics of Smallholder Farmers and Adoption of CSA Practices

Age bracket of participants was typified using age-brackets; this included, below 25, between 26-35, 36-45, 46-55 and above 56 years. It is evident from the results that the larger portion of farmers who participated in this study happened to be between 36-45 years, then 46-55 years followed after. Respondents between age bracket below 25 years where at 13.3% while those from 26- 35 years were at 16.7%. There were no respondents over 55 years. From the findings, it was noted that the CSA practices usage was negatively influenced by the age of farmer, since older farmers have limited information access compared to younger farmers (Obuobisa-Darko, 2015).

The farmers' educational level was also sought after by indicating number years of education categorize using scale of: 0-4; 5-8; 9-12-13-16-17-21 years. There is a likelihood that respondents with considerable level of education can easily adopt CSA as they can easily access information, can understand and apply lessons learned in terms of CSA compared to those with no formal education. The findings indicate that farmers who went to school for 5-8 years were at 38.9%, those with 9-12 years of education at 35.6% and those with the highest level of education between 13-16 years of education at 25.6 (Figure 4.1).

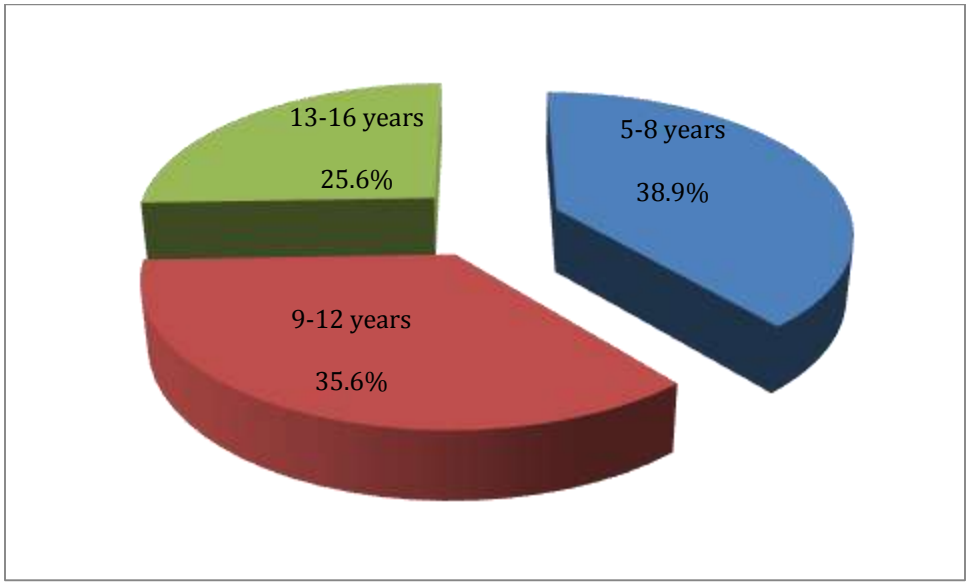


Figure 4.1: Level of education; Source: Fieldwork, 2019

The results shows that a larger portion of households (60%) comprise between 4-6 people, between 1-3 at16.7% and 7-9 people per household at 23.3%.In Sub-Saharan Africa, farming is highly dependent on household labour as explained by Teklewold *et al*. (2013). Households in this vicinity relied totally on own family exertions and therefore, larger households ensured labour options especially for labour intensive CSA as further reported by Nkonya *et al*. (2008). Hence, larger household size as observed by Teklewold *et al*. (2013) is linked to important CSA initiatives.

Farmers owning larger portions of land have a greater likelihood to implement CSA practices this is attributed by the fact that large farms sizes results in availability of space to practice crop diversity and crop rotation. Also, farmers with large farm sizes tend to have better access to finances as land could act as loan collateral which in-turn could influence access to new and improved technologies. Therefore, farmers owning larger portion of land in Kaptumo-Kaboi ward had the ability to make use of CSA technologies as compared to those with smaller farm sizes. Menale et al. (2010) reported that farm size usually determines the adoption of various CSA strategies due to the fact that it represents financial capital, relaxing liquidity constraints to implement CSA. The findings show that the size of land for majority of farmers (70%) was between 1-3 acres followed by 20% between 4-6 acres, 5.6% below 1 acre and 4.4% between 7-9 acres.

The study considered linear regression in determining the relationship between Socio-economic aspects and CSA initiatives implementation by smallholder farmers. Linear regression model summary is provided below. The study opted to test for social economic-characteristics on Adoption of CSA; that is age, number of household, size of the land and income. Hence, 0.05 (α-significance level) was executed in this regression.

Model summary results showed that socio-economic traits of farmers explained 16 percent variation of CSA implementation in the study area. According to these findings, there was a likelihood of predicting climate smart agriculture technologies adoption by 16% (R2=0.16) (table 4.2). This figure discerns that the 84% remaining is concerned to other viable factors that impact CSA adoption not tested in this study.

Table 4.2: Model summary for Socio-economic Characteristics

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.400[a]	.160	.110	1.15944
a. Predictors: (Constant), Income, size of land, Education level, Age, Household size				

Source: Fieldwork, 2019

According to ANOVA findings shown below (table 4.3) clearly show that F-value for socio-economic factors at 3.204 plus the p value of .011[b]significant at 5% simply make obvious that the entire regression model involving the four predictors was found to be significant, for that reason, Income, size of land, Level of education, Age and Household size shared impact was significant in predicting the CSA practices adoption. Thus, the overall regression is significant.

Table 4.3: Anova for Socio-economic Characteristics

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	21.535	5	4.307	3.204	.011[b]
	Residual	112.921	84	1.344		
	Total	134.456	89			
a. Dependent Variable: CSA strategies adoption						
b. Predictors: (Constant), Income, Size of land, education level, Age, Household size						

Source: Fieldwork, 2019

The regression coefficient was also tested. The results for linear regressions in Table 4.4 suggest that these four factors (age, education level, household size, land size and income) influence the CSA practices adoption.

Age affects adoption of CSA practices as evident by *p*-value (labeled Asymp. Sig.015), which is higher than .05 to -imply that two aspects are impartial of each different. Consequently, statistical affiliation among the specific variables exists. These results suggest that the likelihood of using CSA practices is significantly reduced by increase of age. The study's null hypothesis is rejected and alternative hypothesis retained. Shongwe et al. (2015) highlighted a poor relationship between old age and CSA adoption, which means that agriculture, is a labour intensive task which usually necessitates healthful, hazard bearing and enthusiastic people. Education level was observed to be extensively related to the adoption of CSA by .001 at 5% significant level. The findings suggest that there is likelihood of educated farmers adopt various strategies since education could guarantee them. However, as argued by Gido *et al*. (2015) and Chimwemwe (2015), higher education levels tend to build farmers' innovativeness at the same time enhance their information processing, which is crucial in implementation of various enhanced agriculture technologies.

The CSA technologies demand was further impacted by farmers' land size. This was significant at 3.1%. Smallholders who had larger portions of land ought to have had higher likelihood to make use of CSA practices. The ownership of larger piece of land creates a decisive opportunity for farmers to experiment different CSAs due to the fact that land will always remain a primary fixed input in agricultural production. Deininger et al. (2008) had earlier established that size of the land is significantly associated with augmented probability to implement on water and soil preservation. However, Menale et al. (2010) reported that farm size was positively linked with various CSA practices adoption due to the fact that it acts as a symbol of wealth or financial capital. As a result, constraints involving liquidity in implementing the practices are prevented.

Farmers' monthly household income positively impacted the likelihood of maximum implementation of CSA practices and significant at 5.2%. High monthly income received from other sources significantly contributed to usage of many CSAs. Therefore, farmers' cash constraints are reduced during the time when their sources of resources are stable, thus allowing them to acquire important farm inputs. Most probably, when adequate finances are available, farmers will always prefer capital-intensive CSAs and labour intensive technologies. Financial soundness will increase the farmers' financial ability to purchase advanced seed, organic fertilizer and different CSA inputs (Adekemi et al., 2016). But the profitability of the technology remains a crucial determinant of this investment. When households have adequate funds, they can afford CSA upgraded seeds and fertilizers without delay as established by Beshir et al. (2012).

Table 4.4: Regression coefficient for Socio-economic Characteristics

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	.431	.705		.612	.542
	Age	.355	.142	.272	2.491	.015
	Level of education	.527	.159	.341	3.323	.001
	Household size	-.182	.220	-.093	-.824	.412
	Size of land	-.218	.214	-.110	-1.022	.310
	Income	.000	.000	.067	.645	.520
a. Dependent Variable: 39.What types of strategies i.Crop rotation						

Source: Fieldwork, 2019

4.4 CSA Awareness CSA Adoption

Half of the respondents mentioned to have knowledge about county extension services while the rest 50% mentioned that they were not aware. The study further wanted to find out from the respondents the last time they received extension services. From the findings, a substantial portion of smallholder farmers (40.1%) revealed that the last time they received extension services was 1 month ago while 44.1% mentioned that they had received the service within the past 6 months while the remaining 15.3% over the past 1 year. From the FGD session it was noted that most of the services received from extension officers were mostly as a result requests from farmers where they had to pay for the fuel cost for the officers. This was further confirmed during the interviews with two county extension officers, who both mentioned that they have limited resources hindering them from conducting frequent field visits and trainings.

Farmers were asked whether they had visited the extension offices. 50.7% responded to have visited while 49.3% had not visited. In terms of the objective for visiting their offices, findings suggest that a larger portion of smallholder farmers (92.3%) who visited extension office were seeking information on planting methods, 92.3 percent also went to gain insight on production strategy, 80.7% to learn about pesticide application, 69.9 percent to learn about fertilizer application and 50% of them to be more knowledgeable about shade tree planting (Figure 4.2).

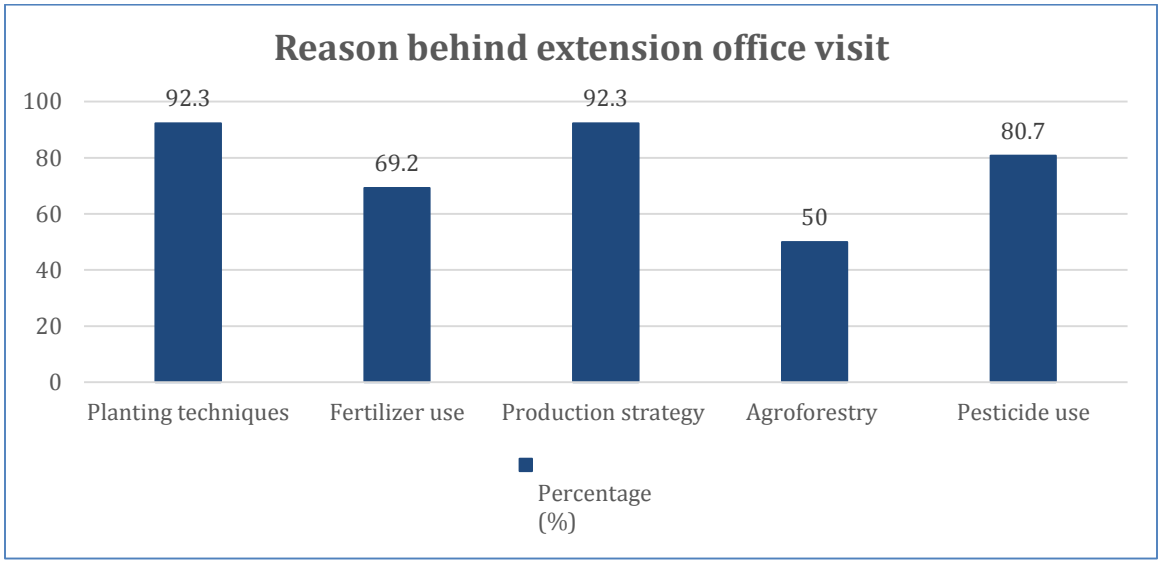
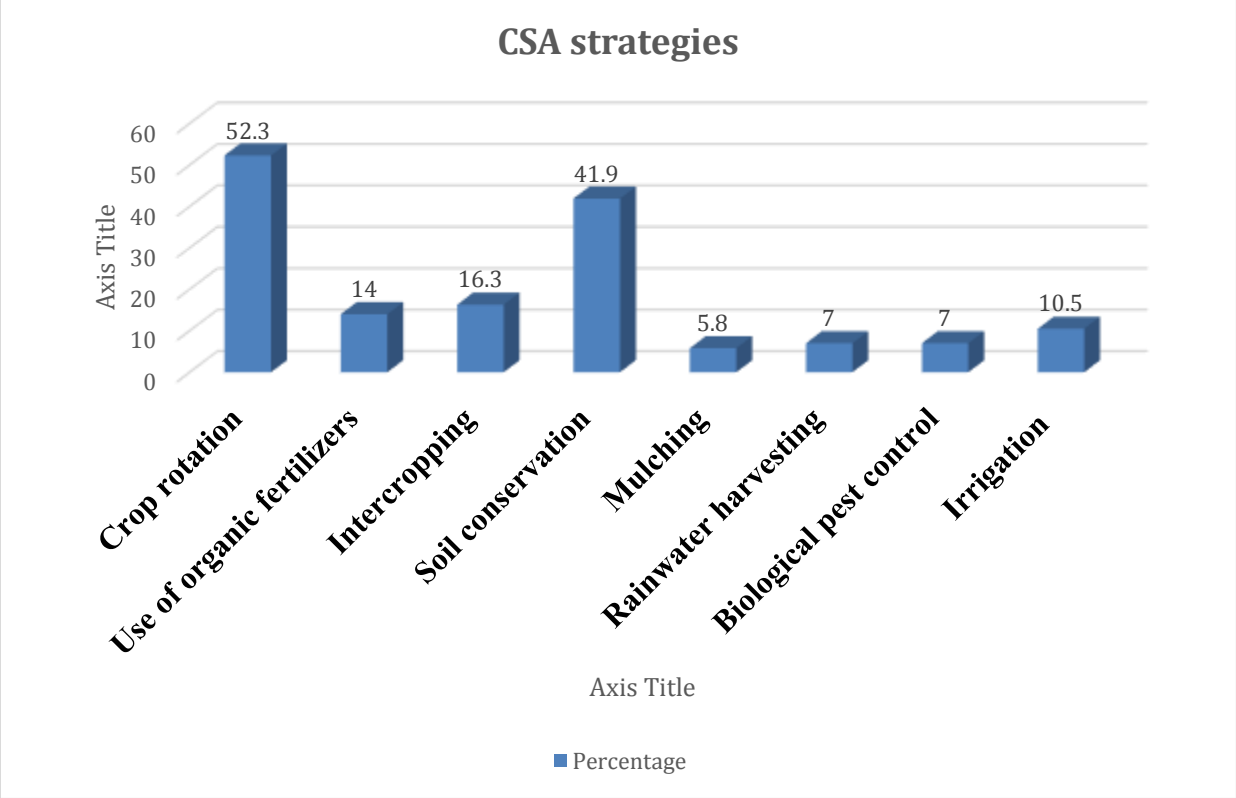


Figure 4.2: Reason for visiting extension office, Source: Fieldwork 2019

Further, all the respondents indicated that they frequently exchange farming experiences with other farmers. (81.8%) respondents had not joined any group but according to 18.2% of the respondents, they belong to one or more farmers' groups; in these farmers' group they occasionally share ideas and experiences about agricultural activities. These groups tend to be of assistance farmers to perk up farmers' CSA awareness and stakeholder interaction (Uddin et al., 2014; Tiwari et al., 2014).

Analysis on crop rotation showed that 52.3% of the respondents had the knowledge. CSA strategies such as soil conservation, intercropping and use of natural fertilizers accounted for 40.9%, 16.3% and 14% respectively (Table 4.6). This means that there are four fundamental CSA strategies adopted. In line with these findings, FARA (2015) mentioned that farmers adopt CSA as a way to build their resilience.

Figure 4.3 CSA strategies



Source: Fieldwork, 2019

The study also considered Linear Regression Test in order to define relationship between CSA awareness and the implementation of four CSA strategies. These initiatives included crop rotation, soil conservation, intercropping and use of organic fertilizers. The three predictors: last time extension services was received, number of years in farmers' group and frequency of meetings in farmers' group.

The results showed that the three predictors which included last time received extension services, number of years in farmers' group and frequency of meetings in farmers' group explained 4.1% variation of CSA technologies adoption. According to these findings, there was a likelihood of predicting climate smart agriculture technologies adoption by 4.1% (R2=0.695). This figure discerns that the rest (95.9%) is associated with other aspects of knowledge and extension services not considered in this empirical test (Table 4.5).

Table 4.5: Model summary for access to knowledge and extension services

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.203[a]	.041	.008	1.22422
a. Predictors: (Constant), 45. , Last received extension services, Last visit to extension office and Last time they attended FFS				

Source: Fieldwork, 2019

The statistical results indicated in Table 4.9 clearly shows that F-value for awareness of extension services, source of information and how often extension services at 1.238 along with p value of 301[b] simply make obvious that the entire regression model involving the three predictors was found to be significant, for that reason, Last received extension services, Number of years in

farmers' group, frequency of meetings in farmers group shared impact was significant in predicting the CSA practices adoption. Thus, the overall regression is significant.

Table 4.6: ANOVA results for access to knowledge and extension services

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	5.567	3	1.856	1.238	.301[b]
	Residual	128.889	86	1.499		
	Total	134.456	89			
a. Dependent Variable: Adoption of CSA strategies						
b. Predictors: (Constant), Last received extension services, Last visit to extension office and Last time they attended FFS						

Source: Fieldwork, 2019

The study sort to understand how CSA awareness influenced its adoption where respondents were asked the last time they received extension services, last visit to extension office and last time they attended FFS. As shown by the findings the study null hypothesis was rejected and alternative hypothesis accepted that is there is an association between CSA awareness and its adoption. Maguza-Tembo (2017) reported that relevant stakeholders should frequent advocate and provide farmers with CSA knowledge for increased adoption.

The statistical findings revealed that number of years in farmers' group was negatively linked with the CSA technologies being implemented in Kaptumo-Kaboi ward. As such, the study null hypothesis is rejected and alternative hypothesis accepted, that is there is an association between number of years in farmers' group and adoption of CSA strategies. In line with these findings, Rohila, Shehrawat and Malik (2018) established that farmers who have been members of various farmers groups for a very long time are likely to make use of CSA practices.

Frequency of meetings by farmers group was found to be negatively related to the adoption of CSA strategies. As such, the study null hypothesis is rejected and alternative hypothesis accepted, that is there is an association between frequency of meetings by farmers group and adoption of CSA strategies. The findings suggest that there is high likelihood of farmers interacting with extension officers/fellow farmers during frequent farmers group meetings and adoption of various strategies since these meetings are aimed at developing farmers. In agreement with these findings, Anim-Kwapong and Frimpong (2010) reported increased partnerships between farmers and relevant stakeholders significantly increases CSA practices adoption (Table 4.7)

Table 4.7: Regression coefficient for access to knowledge and extension services

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.685	.398		6.738	.000
	Last received extension services	-.058	.089	-.071	-.654	.515
	Last visit to extension office	-.170	.136	-.143	-1.245	.217
	Last time they attended FFS	-.069	.133	-.060	-.516	.607
a. Dependent Variable: Adoption of CSA strategies						

Source: Fieldwork, 2019

4.5 Effect of CSA on Food Security

This section addresses the relationship between climate smart agriculture and food security through the use of Food Consumption Score model. Farmers were first asked to indicate if they practice CSA. A total of 51.1 percent of the respondents stated that they practice CSA while the rest 48.9% stated they do not practice CSA. Then, farmers were asked to recall the foods consumed

for the past seven days. The findings indicated that cereals were the most consumed, specifically, consumption score of a maize meal within 24 hours was found to be high as indicated by 88 percent of the households, beans followed next as the most preferred as indicated by 38.3 percent. On the other hand, rice and Irish potatoes consumption was found to be highly consumed and was well distributed across the week. The mostly preferred veggies were Sukuma wiki and indigenous vegetables. Milk products were also highly consumed: both fresh milk and sour milk were consumed within 24hrs at 70.1%, and 57.9% respectively (4.8).

Nevertheless, as revealed from the research results, meat products were found to be a rare commodity: was much less consumed meals merchandise within various 7 days. White meat was rarely consumed even though a substantial number of household members (65.3%) consumed meat between 4-7 days. Overall food consumption results show that there are is sufficient food in the area.

Table 4.8: Regression coefficient for access to knowledge and extension services

Food item	Yesterday (F)	(%)	Last 2 days (F)	(%)	Last 3 days (F)	(%)	Last 4 days (F)	(%)	Last 5 days (F)	(%)	Last 6 days (F)	(%)	Last 7 days (F)	(%)
Maize meal	88	82.2	76	13.1	82	2.8	90	1.9	83	0.9	78	-	84	-
Rice	9	8.4	18	16.8	43	40.2	22	20.6	10	1.9	12	3.7	22	8.4
Wheat meal	2	1.9	-	-	-	-	5	4.6	5	4.6	14	13.1	41	38.3
Millet meal	24	22.4	13	12.1	16	14.9	9	8.4	6	5.6	30	28.0	9	8.4
Sorghum	-	-	-	-	2	1.9	-	-	5	4.6	4	3.7	12	11.2
Sweet potatoes	7	6.5	6	5.6	4	3.7	2	1.9	3	2.8	2	1.9	14	13.1

Irish potatoes	15	14.0	36	33.6	44	41.1	2	1.9	3	2.8	2	1.9	4	3.7
Yams	-	-	-	-	3	2.8	1	0.9	-	.-	4	3.7	5	4.6
Cassava	1	0.9	1	0.9	3	2.8	-	-	-	-	6	5.6	8	7.4
Beans	41	38.3	32	29.9	12	11.2	6	5.6	5	4.6	2	1.9	3	2.8
Groundnuts	2	1.9	6	5.6	-	-	-		14	13.1	6	5.6	16	14.9
Green grams	2	1.9	3	2.8	-	-	-	-	5	4.6	5	4.6	8	7.4
Green peas	5	4.6	6	5.6	5	4.6	2	1.9	9	8.4	21	19.6	14	13.1
Fresh Milk	88	70.1	88	20.5	88	2.8	88	0.9	88	0.9	88		88	-
Sour milk	62	57.9	23	21.4	40	-	66	-	34	-	24	3.7	16	-
White tea	90	41.1	90	30.8	90	1.9	90	1.9	90	4.6	90	-	90	1.9
Beef	12	1.9	32	2.8	7	6.5	14	13.1	26	17.7	22	20.5	29	27.1
Mutton	-	-	2	1.9	2	1.9	1	0.9	-	-	-	.-	4	3.7
Rabbit	-	-	-	-	-	-	-	-	-	-	-	-	2	1.9
Fish	-	-	-	-	-	-	-	-	-	-	1	0.9	1	0.9
Poultry meat	2	1.9	-	-	-	-	-	-	-	-	3	2.8	11	10.2
Eggs	14	13.1	16	14.9	8	7.4	18	16.8	21	19.6	14	13.1	7	6.5
Omena	-	-	-	-	-	-	-	-	-		2	-	-	-
Goat meat	2	1.9	1	0.9	-	-	-	-	-	-	3	2.8	14	13.1
Cabbage	19	17.7	24	22.4	6	5.6	6	5.6	11	10.2	8	7.4	10	9.3

Sukuma wiki	56	52.3	24	22.4	14	13.1	5	4.6	2	1.9	2	1.9	7	6.5
Spinach	22	20.5	16	14.9	3	2.8	3	2.8	7	6.5	8	7.4	11	10.2
Indigenous vegetables	68	19.6	44	41.1	23	21.4	34	5.6	14	1.9	54	1.9	28	2.8

Source: Fieldwork 2019

4.5.1 HDDS Regression and HFCS Pairwise Correlation

The most practiced CSA strategies in Kaptumo-Kaboi ward established earlier were crop rotation, soil conservation, intercropping and use of organic fertilizers. The ordinary least squares regression of HFCS and HDDS of the households (Table 4.9) was therefore used to estimate each CSA technology. CSIO abbreviation was used to the four CSA strategies package adopted by farmers.

The findings indicate that treatment effect is as a result of divergence in food security status which is attained through utilization of a particular package involving climate smart agriculture technologies. The difference linking treated characteristics and the untreated characteristics enable this impact to be achieved. Apart from small scale farmers making use of $C_1S_1I_1O_1$, $C_1S_1I_1O_0$ and $C_1S_0I_1O_0$, Every single set of climate smart agriculture initiatives that integrated soil conservation.

All technologies showed a positively impacted on food security apart from $C_1S_0I_1O_1$. As per the study findings, small-holders farmers in need to further improve the uptake of soil conservation methods as it will help them achieve improved food security status whenever there is occurrence of tough climate changes.

Farmers who utilized $C_1S_1I_0O_1$, $C_1S_1I_1O_0$ and $C_1S_1I_1O_1$ were more meals cozy than the alternative group who chose not to adopt climate smart agriculture initiatives in actual scenarios. As estimated and presented by both HFCS and HDDS, the statistical results suggest that the maximum effect with 31.38 and 1.95 rankings on the small scale farmers' wellbeing can be motivated by using a whole set of strategies that consist of crop rotation, soil conservation, intercropping and use of natural fertilizer (C1S1I1O1).These research results entail that smallholders farmers who made

use of this set of CSA technologies were likely more food secure when measure up to other group of farmers who by no means did not implement any climate smart agriculture technology. In other words, farmers who implement this kind of customized set of climate smart agriculture technologies will always be more food secure. It is therefore evident that an entire set of technologies that incorporate $C_1S_1I_1O_1$ impact food security status and also attend to challenges associated with climate changes.

Table 4.9: HDDS Regression and HFCS Pairwise Correlation

		HFCS			HDS		
		Treated characteristics	Untreated characteristicsβ	Impact/Returns	Treated characteristics	Untreated characteristics	Impact/Returns
$C_1S_0I_0O_0$	Treated (X_1)	53.16 (1.26)	53.46	-0.18	5.29 (0.18)	6.11 (0.09)	-0.31
	Untreated (X_2)	55.45(3.23)	65.07 (0.80)	-12.72	5.68 (0.019)	6.89 (0.07)	-1.21
	Level effects	-2.19	-16.46***	-16.21	-0.54	-0.79***	-1.61
$C_1S_0I_1O_0$	Treated	66.28 (7.33)	57.49 (2.48)	10.09	8.12 (1.02)	7.54 (0.32)	0.88
	Untreated	64.43 (4.23)	64.46 (1.33)	-0.52	7.53 (0.54)	7.63 (0.12)	-0.21
	Level effects	2.52	-8.05***	3.34	0.72	-0.44**	0.52
$C_1S_0I_1O_1$	Treated	62.71 (4.68)	81.49 (3.11)	-20.22	7.65 (0.65)	7.75 (0.45)	0.13
	Untreated	58.24 (3.16)	64.44 (1.06)	-7.63	7.52 (0.46)	7.88 (0.16)	-0.72
	Level effects	4.06	18.17***	-3.48	0.56	-0.22	-0.30
$C_1S_0I_0O_0$	Treated	57.19 (1.84)	67.41 (2.56)	-12.09	8.19 (1.28)	9.32 (0.28)	-0.42
	Untreated	60.55 (1.25)	70.23 (1.08)	-10.32	7.42 (0.53)	8.47 (0.91)	-1.02
	Level effects	-4.22***	-4.19***	-14.46	-0.36	-0.29	-1.81
$C_1S_0I_0O_1$	Treated	64.71 (2.89)	70.32 (1.06)	-7.19	7.42 (0.73)	8.81 (0.16)	-1.02
	Untreated	64.22 (2.12)	64.03 (1.03)	-0.52	7.64 (0.74)	7.38 (0.48)	0.39
	Level effects	0.70	7.02***	0.40	-0.11	1.02***	-1.05

$C_1S_1I_1O_0$	Treated	75.45 (1.95)	63.36 (1.03)	12.14	8.26 (0.47)	7.51 (0.18)	1.68
	Untreated	76.09 (1.75)	61.56 (1.23)	16.44	8.43 (0.37)	7.62 (0.16)	1.76
	Level effects	-1.11	2.78*	28.16	-0.42**	-0.22*	1.46
$C_1S_1I_1O_1$	Treated	84.14(1.74)	69.16 (1.02)	16.19	9.45 (0.59)	8.22(0.19)	1.94
	Untreated	80.55 (2.24)	54.59 (1.03)	16.09	9.23 (0.19)	7.63(0.57)	1.67
	Level effects	5.63***	5.69***	31.38	0.56**	0.64***	1.95
Pairwise Correlation							
	HDS	HFC					
HDS	1						
HFC	0.9887***	1					

Source: Fieldwork, 2019

4.5.2 Treatment Effects: Average Treatment Effects of CSA

Endogenous switching regression estimates was also conducted in this study. It was conducted using a real and hypothetical scenario in order to test treatment effects of CSA adoption on both adopters and non-adopters. It represents an increase by 85% in food production. Based on counterfactual assumption, if farmers have not adopted CSA practices, they may have had 85% less of their food production (table 4.10).

Table 4.10: Average treatment effects

Outcome	Category of Households	CSA adopting mean	Non-adopting mean	Average treatment effect	Percentage (%)
Food yields	Adaptors	15.86 (0.156)	14.054 (0.112)	12.208 0.632	85.1***
	Non-adaptors	13.5214 (0.105)	16.521 (0.149)	-9.361 [6.566]	-47.08

Source: Fieldwork, 2019

CHAPTER FIVE
SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter delves into the summary of the study based on its findings, conclusions and recommendation.

5.2 Summary of Key Findings

The influence of social economic characteristics significantly influences adoption of CSA practices. For example, Age was associated negatively with adoption of CSA practices. It is evident that the *p*-value (labeled Asymp. Sig.015), which is more than.05 to -imply that two aspects are independent of each other. Education level correlated positively with the adoption of CSA strategies by .001 at 5% significant level. Domestic household was negative and represented at .412. Bigger households explained high possibility of adopting CSA practices. This was significant at .31. Smallholders monthly household income from other sources impacted positively the likelihood CSA practices at .52 representing higher demand. As a result, the hypothesis of no significant correlations between farmers' social and economic elements and their CSA adoption was therefore rejected.

It was established that knowledge about CSA significantly influence CSA practices adoption. Number of years in farmers' group negatively linked with the adoption of CSA strategies. The last time extension services were received was negatively associated with adoption of CSA. Frequency of meetings by farmers group was found to be negatively related to the agreement of CSA strategies. In light of this, the study null hypothesis is rejected and alternative hypothesis accepted, as per the study, there is an association between CSA awareness and adoption of CSA strategies.

From the study, t-value of 5.292 along with p value of 0.00 significant at 5%, CSA technologies influenced food security positively. In regards to HFC correlation analysis results, a correlation coefficient of 0.9887 shows that a strong positive relationship between CSA practices and food security existed. Thus, it is evident that a comprehensive set of technologies incorporating

$C_1S_1I_1O_1$ (crop rotation, soil conservation, intercropping and use of organic fertilizer) impact food security status which also attend to challenges associated with climate changes.

5.3 Conclusions

It was concluded that extension facilities and knowledge were key to influencing climate smart agriculture technologies adoption. It was also concluded, as per regression tests that number of years in farmers' group last time extension services were received, frequency of meetings by farmers group were found to be negatively related to CSA uptake In that case, the study findings are in support of the hypothesis of momentous relations involving facilities/knowledge and climate smart agriculture technologies adoption.

Regarding the impact of socio-economic characteristics, the study concludes that socio-economic aspects hugely impact CSA technologies uptake. Findings exposed that age, household size and size of the land are negatively associated with adoption of CSA. The hypothesis of no correlations of farmers' socio-economic aspects and demand for climate smart agriculture technologies adoption is therefore rejected.

In expense of the influence CSA strategies on food security, the study concludes as per HFC regressions findings that key elements such as use of organic fertilizers, intercropping, crop rotation as well as soil conservation contributed to food security status. The study further concludes, as per the findings of correlation analysis that CSA technologies and food security demonstrate a positive link. It is evident from the study findings that CSAs have could help promote food security especially if all the four categories are adopted.

5.4 Recommendations

5.4.1 Recommendations for Policy Makers

The following are the recommendations of the study for policy makers:

Farmers should be encouraged to join and take part in various farmers groups or organizations in order to be well-versed with shared information about farming, thus improving usage of CSA practices. In addition, the chances of being conveniently linked with extension service providers and farm supporting representatives are high. It is a fact that off-farm income plays a crucial role

towards farm liquidity, therefore acting as an alternative resource to finance farm activities. Therefore, partnership involving the County and national government as well as other development partners should emphasize on development of various important infrastructures such as roads and electricity which can positively transform the experience of farmers in various rural based economic activities.

Small scale farmers should be often encouraged on how to make use of all CSAs to ensure that food security status is always sustainable. Furthermore, farmers should be enlightened on the need to maximize their purchase of productive farm assets capable of withstanding the risks connected to climate change and also enhance their potential to fully apply CSAs.

Enlightenment can be conducted in teams by extension service vendors within the location. Discouraging land subdivision to small parcels should also be dejected by using civic awareness and engagement in other sources of income coming up with activities for farmers to gain from CSAs despite ownership of small portion of land.

Respective authorities within the agriculture sector should improve the current policies and at the same time support all viable institutions to make certain that CSA uptake is successful.

To develop access of small scale farmers, governments and other players in private firms and financial resources required to develop and implement CSA, innovative financing schemes capable of unlocking both agriculture and climate finance should be developed.

5.4.2 Recommendation for Scholars

There is need for more empirical studies on analyzing the possibilities to adopt capital intensive CSA technologies such as testing soil, nutrient micro dosing, and intensive livestock production technologies that may possibly consider livestock insurance which, might be of greater assistance as far as necessary interventions that promote CSA uptake.

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APPENDICES

Appendix I: School Introductory Letter

UNIVERSITY OF NAIROBI

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

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P.O. BOX 30197-00100
NAIROBI
KENYA

26 June 2019

The Director,
National Commission for Science & Technology
Nairobi, Kenya.

Dear Sir/Madam,

RESEARCH PERMIT: JOYCE JELAGAT – C50/81066/2015

This is to confirm that the above named is a Master of Arts student (Registration Number – C50/81066/2015) at the Department of Geography and Environmental Studies, University of Nairobi registered.

Ms. Jelagat is currently undertaking research on a topic titled: **Effects of Climate Smart Agricultural Knowledge and Practices on Food Security Among Small holder Farmers in Kaptumo-Kaboi Ward, Nandi County.**

Any assistance accorded to her will be highly appreciated.

CHAIRMAN
Department Of Geography
and Environmental Studies
UNIVERSITY OF NAIROBI

Dr. Boniface Wambua
Chairman, Department of Geography & Environmental Studies

Appendix II: Researcher Introduction Letter

6th August 2019

Dear respondent,

RE: RESEARCH STUDY

My name is Joyce Jelagat a student at the University of Nairobi, pursuing a Master of Arts in Environmental Planning and Management. I am currently conducting a study aiming at assessing the effects of climate-smart agricultural awareness and practices on food security among smallholder farmers in Kaptumo-Kaboi ward, Nandi county.

Regarding the above, I have identified you as one of my respondents in the study and I am hereby requesting for up to 30 minutes of your time to answer the questions below.

All information provided shall be held with due confidentiality and shall only be used for the purposes of this research, while adhering all regulations governing research.

Yours sincerely,

Joyce Jelagat

C50/81066/2015

0724426678

Appendix III: Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **554445**

Date of Issue: **23/August/2019**

RESEARCH LICENSE

This is to Certify that Miss.. Joyce Jelagat of University of Nairobi, has been licensed to conduct research in Nandi on the topic: EFFECTS OF CLIMATE-SMART AGRICULTURAL KNOWLEDGE AND PRACTICES ON FOOD SECURITY AMONG SMALLHOLDER FARMERS IN KAPTUMO-KABOI WARD, NANDI COUNTY for the period ending : 23/August/2020.

License No: **NACOSTI/P/19/818**

554445

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

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

Appendix IV: Questionnaire

Section A: Demographic information

1. Gender: Male: ( ) Female: ( )
2. Are you… Single: Married: Divorced:
3. What is your age bracket? Below 25 26-35 36-45 45-55 above 56

Section B: Socio-economic characteristics

1) How many years have you been in school? (5-8….) (9-12….) (13-16…...)
2) How many people are in your household? (1-3…...) (4-6….) (7-9….)
3) Is your land owned or rented? (Owned…...) (Rented…...)
4) What is the size of your land?(0-1….) (2-3….) (4-6……) (7-9……)
5) Do you participate in off-farm employment?
6) If yes, what is the range of your income from off-farm employment? (0-6000…...) (7000-13000……) (14000-20000….) (21000-27000……)

Section C: Access to extension services

1. When was your last contact with extension officers? (0-1….) (2-4…...) (5-8……) (9-12….)
2. What type of information did you seek from the officers?
3. When was the last time you visited their offices? (0-1….) (2-4…...) (5-8……) (9-12….)

Section D: Climate-smart agriculture

1. Are you aware of CSA? (0-1….) (2-6…...) (7-12…...)
2. Where do you acquire relevant information on CSA strategies
3. Are you aware of the types of CSA strategies? If yes please specify
4. Do you participate in any CSA strategies? If yes please elaborate

5. Do you participate in any social groups such as farmers groups, saving/credit, group savings farmers association

Section E: Food security (Food Consumption Score)

No	Food item	Yesterday	Last 2 days	Last 3 days	Last 4 days	Last 5 days	Last 6 days	Last 7 days
1)	Cereals, tubers and root crops							
1.	Maize meal							
2.	Rice							
3.	Wheat meal							
4.	Millet meal							
5.	Sorghum							
6.	Sweet potatoes							
7.	Irish potatoes							
8.	Yams							
9.	Cassava							
2)	Pulses							
10.	Beans							
11.	Groundnuts							
12.	Green grams							
13.	Green peas							
14.	Groundnuts							
15.	Other pulses							
3)	Milk products							
16.	Fresh Milk							
17.	Sour milk							
18.	White tea							
4)	Meat and Fish							
19.	Beef							

20.	Mutton							
21.	Rabbit							
22.	Fish							
23.	Poultry meat							
24.	Eggs							
25.	Omena							
26.	Goat meat							
5)	Vegetables							
27.	Cabbage							
28.	Sukuma wiki							
29.	Spinach							
30.	Indigenous vegetables							
6)	Fruits							
31.	Please specify							
7)	Sugar							
32.	Please specify							
8)	Oils/fats							
33.	Please specify							

Appendix V: Focus Group Discussion Guide

1. What CSA strategies have you ever followed and why did you select the precise strategies?
2. Why some farmers have not used CSA?
3. How else do you get hold of facts on CSA?
4. What different institutions have you acquired help on CSA?
5. Has CSA had any impact on food production?

Appendix VI: Key informants interview guide: Extension officers

1. What kind of information disseminated to farmers
2. Regularity of farm visits
3. Challenges faced
4. Farmers' awareness on CSA
5. What CSA do farmers practice and the determinants of choice

Appendix VII: Data Matrix

1. Age in years			
Category		Frequency	Percentage
Valid	below 25	12	13.33
	26-35	15	16.67
	36-45	43	47.78
	45-55	20	22.22
	Total	90	100.0

2. gender			
		Frequency	Percentage
Valid	male	73	81.11
	female	17	18.89
	Total	90	100.0

3. Level of education			
		Frequency	Percentage
Valid	5-8	35	38.89
	9-12	32	35.56
	13-16	23	25.55
	Total	90	100.0

4. Household size			
		Frequency	Percentage
Valid	1-3	15	16.67
	4-6	54	60.0
	7-9	21	23.33
	Total	90	100.0

5. Land tenure			
		Frequency	Percentage
Valid	owned	76	84.44
	rented	14	15.56
	Total	90	100.0

6. Land size			
		Frequency	Percentage
Valid	under 1 acre	5	5.56
	1-3 acres	63	70.0
	4-6 acres	18	20.0
	7-9acre	4	4.44
	Total	90	100.0

7. Income from off-farm employment			
		Frequency	Percentage
Valid	0-6000	8	8.89
	7000-13000	52	57.77
	14000-20000	14	15.56
	21000-27000	16	17.78
	Total	90	100.0

8.Last attendance of farmers field (in months)

		Frequency	Percentage
Valid	Never attended	61	67.78
	2-6	9	10.0
	7- 12	10	11.11
	12 and above	10	11.11
	Total	90	100.0

9. Awareness of county agricultural extension services			
		Frequency	Percentage
Valid	yes	50	55.56
	no	40	44.44
	Total	90	100.0

10. Do you practice CSA			
		Frequency	Percentage
Valid	yes	46	51.11
	no	44	48.89
	Total	90	100.0
11. Last contact with extension officers			
		Frequency	Percentage
Valid	0- 1 month	38	42.0
	2-4	18	20.0
	5-8	26	28.0
	9-12	8	8.0
	Total	90	100.0

Appendix VIII: Food Consumption Score Groups and Weights

	FOOD ITEMS (examples)	Food groups	Weight	Justification for weight
1	Maize, rice, millet, wheat, bread, sorghum, other cereals, cassava, potatoes, sweet potatoes, and other tubers	Main staples	2	Energy dense, protein content lower and poorer quality than legumes, micronutrients (bound by phytates)
2	Legumes, beans, peas, peanuts, nuts	Pulses	3	Energy dense, high amounts of protein but of lower quality than meats, micronutrients (inhibited by phytates), low fat
3	Vegetables, leaves	Vegetables	1	Low energy, low protein, no fat, micronutrients
4	Fruits	Fruit	1	Low energy, low protein, no fat, micronutrients
5	Beef, goat, poultry, pork, eggs, fish, insects	Meat and fish	4	Highest quality protein, easily absorbable micronutrients (no phytates), energy dense, fat. Even when consumed in small quantities, improvements to the quality of diet are large
6	Milk, yogurt, and other dairy	Milk	4	Highest quality protein, micronutrients, vitamin A, energy. However, milk could be consumed only in very small amounts and should then be treated as condiment, and therefore reclassification in such cases is needed.
7	Sugar and sugar products, honey	Sugar	0.5	Empty calories. Usually consumed in small quantities.
8	Vegetable oil, fats and butter	Oil	0.5	Energy dense but usually no other micronutrients. Usually consumed in small quantities.
9	Spices, tea, coffee, salt, fish powder, small amounts of milk for tea	Condiments	0	These foods are by definition eaten in very small quantities and not considered to have an important impact on overall diet.

Source: World Food Programme (2008)