FACTORS AFFECTING THE ADOPTION OF CLIMATE SMART AGRICULTURAL PRACTICES AMONG SMALLHOLDER FARMERS IN BUNGOMA COUNTY, KENYA

BY

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DECLARATION

Declaration by Candidate

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DEDICATION

This work is dedicated to my family members, fellow course mates, for their sincere support, and to all smallholder farmers in Bungoma County who were very instrumental in providing information.

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ABSTRACT

Globally, agricultural undertakings are responsible for 14% of global greenhouse gas (GHG) emissions; it is the main driver of deforestation and land degradation, which is responsible for an extra 17% of GHG emissions. Although a better understanding of factors influencing adoption of climate smart agricultural practices is important to inform policies aimed at promoting successful climate change adaptation strategies there is little information on the various practices adopted by smallholders. This study sought to analyse the factors influencing adoption of climate smart agricultural practices in Bungoma, County. It describes how social factors such as age, sex, education, economic factors such farm size and income and institutional factors such as access to extension services and noting of unpredictable temperature influence the adoption of climate smart agricultural practices. The study adopted a descriptive and an explanatory research design. Four practices were considered, soil fertility management, improved crop varieties and livestock breed, agro forestry and water harvesting and management. Theory of planned behaviour and technology acceptance theory guided this study. Based on the 30% rule 3 Sub Counties out of 11 were selected using simple random selection. Secondly, systematic random sampling procedure was employed. A sample size of 228 respondents was interviewed using structured questionnaire. Data collected was analysed using combination of descriptive and inferential statistics. Findings indicated that farm size (0.0293**, $p < 0.05$) and noticing of unpredictable temperatures (-0.1643*** $p < 0.001$) had a statistically significant negative influence on the adoption of soil fertility management practices in Bungoma County while income (0.0002**, $p < 0.05$) had a statistically significant positive influence. Access to extension services (0.0792*** $p < 0.001$) had a positive statistically significant effect on the adoption of improved crop and livestock breed as an adaption response to climate change and variability. Age (-0.0020* $p < 0.05$) and unpredictability of temperatures (0.1497***, $p < 0.001$) had a statistically significant positive influence on the adoption of agro forestry. Sex had a statistically significant positive influence on the adoption of water harvesting and management practices as an adaptation to climate change (0.0922**, $p < 0.05$). The log likelihood chi square ratio of 64% (63.83) was highly significant implying that the overall model with predictor was preferred. The study recommends that more integration between extension partners should be considered. There is need for better land security since it increases the likelihood of farmers adopting Climate Smart Agriculture. Policies and strategies should place more emphasis on strengthening the existing agricultural extension service, supporting proven technologies such as soil fertility management, improved crop and livestock breed, agro forestry and water harvesting and management. Capacity enhancement is needed for climate smart agricultural practices including access to weather information adapted to farmers' needs.

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DEFINITION OF TERMS

Adaptation strategies: This is adjustment to ecological, social or economic system in response to observed or expected changes in climatic stimuli and their effects and impact.

Adaptive Strategies: These are strategies that go beyond a single season (Long term) which people need to respond to the set of new evolving climate conditions that they have not previously experienced.

Climate change: The permanent shift or long-term, of the average climatic conditions. The change is due to alteration of the composition of the global atmosphere attributed directly or indirectly to human activity.

Coping Strategies: It is a shorter-term vision of adapting to climate change majorly one season, way of responding to an experienced impact.

Indigenous Strategies: Strategies that have evolved over time (before 1990) through peoples‟ long experience in dealing with the known and understood natural variation that they expect in seasons combined with their specific responses to the season as it unfolds.

Smallholder farmer: This is a farmer who owns less than 4 hectares of land.

ABBREVIATION

CA:	Conservation agriculture
CCFS:	Climate Change Agriculture and Food Security
CSA:	Climate Smart Agriculture
CO_2:	Carbon dioxide
FAO:	Food and Agriculture Organization
GDP:	Growth Domestic Product
GHG:	Greenhouse gases
GOK:	Government of Kenya
IIA:	Independence of Irrelevant Alternatives
ISFM:	Integrated soil fertility management
IPCC:	Intergovernmental Panel on Climate Change
IWMI :	International Water Management Institute
KMD:	Kenya Meteorological Department
KNBS:	Kenya National Bureau of Statistics
MLND:	Maize Lethal Necrosis Disease
MNL:	Multinomial Logit
NGO:	Non-Governmental Organization
N_2O:	Nitrous Oxide
PDA:	Provincial Director of Agriculture
SHF:	Small holder farmers
SPSS:	Statistical Package for the Social Sciences
USAID:	United States Agency for International Development
TPB:	Theory of Planned Behaviour
TZNPS:	Tanzania National Panel Survey

CHAPTER ONE

INTRODUCTION

1.0 Overview of the Chapter

This chapter presents background of the study, objectives, hypothesis of the study, justification, significance and scope of the study.

1.1 Background of the Study

One of the greatest challenges facing the world in the 21^{st} century is climate change. As FAO - Food and Agricultural Organization, (2013) posits climate change has posed food security problems in most countries. Varied stakeholders are in agreement that managing temperature rise within 2°C threshold is now limited and the global population will have to deal with its consequences (IPCC, 2014). Rising temperatures and changes in rainfall patterns affect agricultural production with significant decline in crop and livestock production (Sharma & Ravindranath, 2019). In the wake of this agricultural production systems are expected to produce food for the global population that is expected to reach 9.1 billion people in 2050 and over 10 billion by end of the century (World Bank, 2011). According to Branca *et al.* (2011), agricultural systems need to be transformed to increase the productive capacity and stability of smallholder agricultural production in the wake of climate change.

Over the last century climate change has seen Africa increasing its temperatures by 0.5^{o} and as IPCC (2014) projects this is bound to increase by 1.5 – 4^{o} C by 2099. This according to World Bank (2011) exposes the continent as the most vulnerable. In Kenya the Kenya National Climate Change Strategic plan (GOK, 2010) the evidence of climate change in Kenya is unmistakable. Temperatures have risen throughout the country. Rainfall has become irregular and unpredictable, and when it rains, downpour is more intense. Extreme and harsh weather is now a norm in Kenya.

This has impacted on the agriculture sector that has experienced the impacts of climate change which are manifested in extreme weather events that causes drought, flooding, strong winds, landslides; seasonal weather variations; gradual change in precipitation patterns and increased temperatures.

In light of this there is need for climate smart agriculture that will combat the effects of climate change in Kenya and other sub-Saharan countries (Kabubo-Mariara & Kabara, 2015). Climate smart agriculture is a revolutionary term that aims at integrating climate change in agriculture and make agriculture adapt to climate change and to reduce emissions (or mitigation) that causes climate change. According to FAO (2010) climate smart agriculture is the agriculture that i) sustainably increase productivity, ii) reduce climate change vulnerability (enhance adaptation), iii) reduce emissions that cause climate change (mitigation), while iv) protecting the environment against degradation and v) enhancing food security and improved livelihood of a given society.

According to FAO (2010), CSA strategies to cope with climate change include: agroforestry and carbon trading, awareness creation on rain water harvesting and water management practices. Additionally, methods like crop diversification, adoption of drought/pest resistant crop varieties and seeds, shifting to bio-fuels for domestic and industrial use, sustainable land use, encouraging mitigation through non-forestry activities such as fuel-switching and energy efficiency at the community level and the use of bio-fuels have been largely promoted. Finally, formal, and informal environmental and climate change education, and promotion of agri-business and value addition (Lukano, 2013). El- Fattal (2012) adds to the list by mentioning use of improved agricultural technologies such as improved water management techniques where water is efficiently used, improved livestock breeds and crop varieties that are more adapted to a changing climate, agro-forestry and integrated livestock-crop management.

Integration of climate-smart agricultural practices into a single farming system will provide multiple benefits that can improve incomes and livelihoods. However, there are some practices that cannot be integrated because they simultaneously impact upon other elements of the farming system. For instance: maintenance costs or high investment may exceed the asset capacities of the poor farmers; the timing and intensity of a practice may lead to labour constraints; and competition for crop residues may limit biogas production and the feed for livestock. Developing economically attractive and environmentally sustainable management practise requires identifying these constraints in advance before adoption. (Neufeldt *et al*, 2011).

While farmers strive to adapt through innovation, studies by Rao *et al*., (2011) and Pettengell, (2010) indicated their limited capability to effectively respond to these rapid and overwhelming changes beyond their normal experience. So far the effort of farmers towards combating climate change in Kenya remains low (Mutinda *et al*., 2010). The low adoption has been shown to depend on varying factors in different places and across agro ecological zones in Kenya (Ogada *et al*., 2014). Survey done in Embu and Taita by Mutsotso *et al*. (2011) in Kenya showed that farmer's adoption of biodiversity conservation was constrained by the absence of the technologies in local agro shops. Another study by Mugwe *et al*. (2009), which examined uptake of soil fertility management practices among small holders in central highlands of Kenya, indicated resource endowment as one of the significant factors influencing the decision either to adopt or reject the new innovations. Other work done by Ogada *et al*. (2014) mainly focusing on adoption of fertilizers and improved maize varieties in Kiambu, Embu and Coastal lowlands noted low adoption as a result of climatic conditions, high cost of inputs and labour, limited access to extension services, unavailability of inputs in agro shops, gender and low financial endowments. Surveys (Jones *et al*., 2010), shows that better educated and informed farmers are always at the forefront in terms adoption of new technologies. In spite of the critical role that knowledge plays in the decision and adoption of innovations, studies (Dzanku *et al*., 2011), have shown that small scale farmers are often isolated from information. Even though knowledge is considered a necessary condition for adoption it's not sufficient in itself (Jones *et al*., 2010). For instance, farmers may have knowledge about climate smart practices, but may be constrained to adopt if they consider them not profitable and not consistent to their needs, priorities, beliefs and attitudes.

Climate change in Bungoma County is quite evident with its effects on crops and livestock production significantly experienced (GOK, 2010). It has contributed to high poverty level in Bungoma County. The County Government of Bungoma identifies major effects of climate change as loss of quality and quantity of natural biodiversity and soil erosion. Varying rainfall patterns have affected both land preparation and food production leading to lower yields (Lukano, 2013). Similarly, occasional rise in temperature affects moisture retention by soil which leads to wilting of crops hence lower yields contributing to food insecurity. The County Government noted that the long rains‟ early cessation has led to below average production of both maize and other cereals in the County. Climate change adaptation is therefore highly necessary to cope with the inherent challenges which are hampering food productivity. To this end agricultural production have attracted several institutions and/or organizations, all with the main objective of improving agricultural efficiency and conditions through various intervention such as capacity building of the farmers, provision of improved inputs, on-farm demonstrations plots of new agricultural technologies, remedial or mitigation measures of degrade soils advocacy among other functions. Such Institutions include: One Acre Fund, Conservation Agriculture for sustainable agriculture for rural development (CA SARD), Syngenta, Kick Start, among others.

1.2 Statement of the Problem

The variation in climatic changes has led to uncertainty in the Kenya agricultural sector. Kenya Meteorological Department (KMD) indicates that rise in temperature and rainfall may lead to large areas that were suitable for crops to become unsuitable. This is attributed to the frequent floods and increased incidences of new crop diseases such as Maize Lethal Necrosis Disease (MLND). Small scale farmers often lack knowledge on existing and new potential options for adapting their agricultural systems to the climatic changes. They also have limited assets and risk-taking capacity to access and use technologies and financial services (FAO, IFAD, & UNICEF, 2020). This has arisen from the fact that most of the proposed CSA practices have assisted farmers to cope up with the effects of climate change impacts and not necessarily to adapt to the impacts. Other farmers have not adopted these practices due to social, economic and institutional factors that are site specific.

Several studies conducted in the area of climate smart agriculture by various scholars such as Amin, Mubeen, Hammad, & Jatoi (2015) focused on Climate Smart Agriculture for sustainable food security. Elsewhere, McCarthy, Lipper and Branca (2011) research on climate smart agriculture focused on the role of institutions for CSA improvement. Further study conducted by Crouch, Lapidus, Beach, Birur, Moussavi and Turner (2017) on developing Climate-Smart Agriculture Policies focused on the role of economic modelling as a policy to strengthen CSA. From the on-going little in-depth study has been conducted on the adoption of climate smart agriculture among small holders' farmers. It is against this background that this study sought to factors affecting the adoption of CSA practices among smallholders' farmers in Bungoma County

1.3 Objectives of the Study

1.3.1 General Objective

The general objective of the study was to analyse factors that affect adoption of CSA practices used by smallholder farmers in Bungoma County, Kenya so as to inform policy makers and stakeholders on how to improve the uptake of CSA in Bungoma county, Kenya.

1.3.2 Specific Objectives

The specific objectives of the study are:

i. To assess the social economic characteristics of smallholder farmers in Bungoma County, Kenya.

ii. To evaluate the adoption of climate smart agricultural practices among smallholder farmers in Bungoma County, Kenya.

iii. To analyse the factors influencing the adoption of climate smart agricultural practices among smallholder farmers in Bungoma County, Kenya.

1.4 Hypothesis

H_{01}: Social factors such as age, education and sex have no significant effect on adoption of climate smart agricultural practices among the small holder farmers

H_{O2}: Economic factors such land size, income have no significant effect on adoption of climate smart agricultural practices among the small holder farmers

H_{O3}: Institutional factors have no significant effect on adoption of climate smart agricultural practices among the small holder farmers

1.5 Justification of the Study

The findings of this study will facilitate the designing of necessary interventions that enhances knowledge and practice of climate smart practices among small scale farmers in areas with similar ecological conditions. CSA has been in existence for over a period of time in developed and developing countries and if managed efficiently in Kenya, it has potential to raise not only the incomes of farmers but also reduce farm household poverty and increase food security.

Several studies have been done regarding CSA but most focus on the implication CSA has on the farmers in terms of their yield/output, few have focused in operation related issues and very little has been done in trying to analyse social-economic factors related to adoption of CSA among in Kenya particularly in Bungoma County.

1.6 Significance of the Study

The performance of agricultural sector is determined by efficiency of agricultural activities such as livestock and crop production which depends on several factors. With an increasing population (which is at approximately 40 million) to feed, the decline in agricultural productivity in Kenya is worrying and a real challenge for the government. To make it worse, there are expected adverse impacts of global warming on agriculture in future. In same case, Bungoma County has been rich in crop and livestock production over the past years, but the yields have been declining from 1990s as explained in (Silva, & Ramisch, 2019). Against this background of foreseen adverse climate conditions, limited arable land and declining agricultural productivity, the biggest challenge facing Bungoma County is how to intensify food production so that production can keep pace with the increasing population growth without a large increase in land devoted to food production.

A better understanding of factors influencing adoption of CSA practices is important to inform policies aimed at promoting successful climate change adaptation strategies. While there is a growing body of knowledge on the effects of climate change on agricultural productivity, there is a lack of literature on the adoption of CSA in Bungoma County. In addition, adaptive mechanisms that smallholder farmers use to avoid the impact of climate change have not been adequately studied in Bungoma. One of the ways of dealing with declining productivity of agriculture in the county is to analyse the factors affecting adoption of CSA practices to scale up practices that are favourable for smallholder farmers in Bungoma County. The study addressed these research gaps.

1.7 Scope and Limitations of the Study

The study covered Bungoma County in Western Kenya and targeted smallholder farmers. The study examined social, economic and institutional factors influencing the adoption of CSA Practices among the smallholder farmer. The study did not dwell on mitigation strategies as they required heavy investments thus beyond control of smallholder farmer. Bungoma was chosen because of it experiences climatic changes.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This section discusses the theoretical framework, empirical literature in which CSA practices and its relevance to agricultural sector and the conceptual framework are discussed. Lastly, it gives summary of the literature reviews and gaps identified.

2.1 Theoretical Framework

2.1.1 Theory of Planned Behaviour

The study adopted the Theory of Planned Behavior (TPB), which states that attribute alone is not enough to predict behavior, but also social pressures and the perceived difficulty in carrying out the action are also important. It was developed from the expectancy value model (Fishbein, 1963) and the theory of reasoned action (Fishbein & Ajzen, 2010). TPB regards beliefs as the fundamental blocks of behavior intention. They represent the information an individual has about a specific behavior and attribute of his/ her behavior. The key component to this model is behavioral intent; behavioral intentions are influenced by the attitude about the likelihood that the behavior will have the expected outcome and the subjective evaluation of the risks and benefits of that outcome.

The TPB has been used successfully in predicting and explaining a wide range of health behaviors and intentions. The TPB states that behavioral achievement depends on both motivation (intention) and ability (behavioral control) (Carsrud & Brännback, 2011). It distinguishes between three types of beliefs - behavioral, normative, and control. Greaves, Zibarras and Stride (2013) points that the TPB comprises of six constructs that collectively represent a person's actual control over the behavior.

i. **Attitudes** - refers to the degree to which a person has a favorable or unfavorable evaluation of the behavior of interest. It entails a consideration of the outcomes of performing the behavior.

ii. **Behavioral intention** - motivational factors that influence a given behavior where the stronger the intention to perform the behavior, the more likely the behavior will be performed.

iii. **Subjective norms** - belief about whether most people approve or disapprove of the behavior. It relates to a person's beliefs about whether peers and people of importance to the person think he or she should engage in the behavior.

iv. **Social norms** - customary codes of behavior in a group or people or larger cultural context.

v. **Perceived power** - perceived presence of factors that may facilitate or impede performance of a behavior. Perceived power contributes to a person's perceived behavioral control over each of those factors.

vi. **Perceived behavioral control** - person's perception of the ease or difficulty of performing the behavior of interest. Perceived behavioral control varies across situations and actions, which results in a person having varying perceptions of behavioral control depending on the situation. This construct of the theory was added later, and created the shift from the Theory of Reasoned Action to the Theory of Planned Behavior.

This theoretical framework is appropriate to study climate smart agriculture for two reasons. First, TPB provides a methodology for the elicitation of the farmers' cultural beliefs (Buckle, 2020) and allows for understanding factors affecting the actual farmers' behavior regarding probable climate information. Secondly, agricultural climate information use behavior is not fully under volitional control. It is mainly influenced by environmental factors, e.g., water stress and drought shocks that force farmers to search for climatic information. Thus, perceived behavioral control becomes a valuable theoretical construct.

It is relevant to keep in mind that the TPB application is not limited only to basic habits of daily life (Kaufmann, *et al*., 2009). Behaviors such as technology adoption, farmer conservation action (Beedell & Rehman, 2000), farmer innovative and new commercial enterprise behavior (Kolvereid & Isaksen, 2006) and environmental related protection behavior (Karami and Mansoorabadi, 2007) or "ecological behavior" are progressively more or less complex behaviors, which are considerably more complex. In a similar way, the principle of planned actions may be extended to the study of the use of climate knowledge in agricultural decisions.

Thus, this study applies Ajzen’s theory of planned behaviour to predict behavioural intention and actual behaviour of voluntary use of climate smart agriculture information forecasts in farming decisions. It provides an understanding of the determinant of climate information use in farming decisions from farmers’ point of view. This is appropriate for this study because it provides a basis for understanding the social and the economic factors affecting the Smallholder Farmers in the adoption of the CSA practices.

2.1.2 Technology Acceptance Model

This theory was introduced in 1989 by Fred Davis to show acceptance of information or technologies. The basic model of the theory is to test two specific beliefs: a) perceived usefulness which means the potential user’s subjective likelihood that the use of a certain system will improve his/her action and b) perceived ease of use where it is the person’s belief towards a system that is influenced by other factors referred to as external variables. (Davis 1989). Therefore, how farmers perceive the usefulness and ease of use of the CSA practices on adaption to climate change influences their adoption.

2.2 Empirical Review of Literature

2.2.1 Social Economic Characteristics of Small holders' Farmers

The performance of African agriculture has been disappointing over many decades (FAO 2008 cited in Wayo *et al*., 2011), whereas Sub-Saharan Africa is reported as the only region in which per capita agricultural value added has not seen a substantial increase, rather a declining trend on average over the last three decades since 1961 with considerable variation over time and across countries (FAO 2008 cited in Wayo *et al*., 2011). This decline in per capita food production has led to rising poverty in rural areas, increased food prices, widespread drought and increased imports of food. The Green Revolution, which saved many lives in Asia and South America, is disappointing to note that, despite past investments in research and development, Africa is being overcome and poverty still prevails on the continent. In addition, inadequate investments in agriculture, limited access to smallholder credits for farmers, high cost of inputs and unavailability of inputs like fertilizers and improved seeds, the absence of a conducive political climate, and insufficient use of modern technologies include some of the factors that hindern agrarian growth in Africa; Modern African input consumption is relatively poor, especially fertilizers.

FAO reported in Wayo *et al*. (2011), projected that the situation was not going to change much in the short run as Africa was expected to account for less than 3% of world fertilizer consumption by the end of 2012. The use of improved agricultural inputs in Africa is very low and has remained largely static over the last 25 years; lower input usage are in smallholder food crop and livestock production systems.

However, it has been reported that more than half of the population in most East African countries lives five hours or more from a market center as a result market access and input use is generally low (Salami *et al*., 2010). Furthermore, Mccormick, Lawyer, Berlin, Swan, Paterson, Bielefeldt & Wiggins (2010) indicated that the average application rates of fertilizer for arable crops in East African countries are estimated to be below 30 kg/ha/year which is far less than the world average of 100kg/ha/year.

In reaction to this low use of farm inputs, the Member States of the African Union (AU) adopted a resolution on Abuja to increase farmers' timely access to fertilizer by an average of 50kg/hectare by 2015. It aims to enhance the access and use of fertilizers by removal of barriers to access to fertilizers such as fertilizer tariffs and the raw material of fertilizers. Increased utilization of fertilizers can improve production, lower food insecurity, and lower poverty among farmers (Aloyce *et al*., 2014).

The low use of fertilizer in Africa can be explained by demand side as well as supply-side factors. Demand for fertilizer is often weak in Africa because incentives to use fertilizer are undermined by the low level and high variability of crop yields on the one hand and the high level of fertilizer prices relative to crop prices on the other (Aloyce *et al*., 2013). Therefore, increased use of inputs (seeds, fertilizers and chemicals) alongside organic soil fertility enhancing practices is crucial in addressing the technical change needed for sustainable smallholder agricultural growth in Africa.

2.2.2 Overview of Climate Smart Agricultural Practices

According to United States Agency for International Development (USAID) (2003) climate-smart agriculture includes proven practical techniques and approaches that can help achieve a triple win for food security, adaptation and mitigation. For example, by increasing the organic content of the soil through conservation tillage, its water holding capacity increases, making yields more resilient and reducing erosion.

Climate-smart agriculture seeks to increase productivity in an environmentally and socially sustainable way, strengthen farmers' resilience to climate change, and reduce agriculture's contribution to climate change by reducing greenhouse gas emissions and increasing carbon storage on farmland.

Wollenberg, Campbell, Holmgren, Seymour, Sibanda and Braun (2011) argues that there are many technologies and practices "on the shelf" that have not been implemented and promoted but with the current scale and speed of climate change, these requires considerable investment on more knowledge gaps and in research. This should include the development of decision-support tools to prioritize promotion, adaptation and mitigation actions and investments. More so, further work should be intensified on incentives and institutions that work for farmers such as payments for environmental services such as soil carbon sequestration. In support of this, continued research attention is needed to produce more with less, for example increasing productivity while reducing the ecological footprint of agriculture (Meridian Institute, 2011).

2.2.2.1 Soil Fertility Management

A large proportion of agricultural land has been degraded due excessive disturbance, erosion, organic matter loss, salinization, acidification, or other processes that curtail productivity. Managing these soils involves increasing its physical quality while maintaining or improving its fertility. Practices that reclaim productivity and restore carbon storage include: nutrient amendments, applying organic substrates such as manures and composts and reducing tillage and retaining crop residues; conserving water.

2.2.2.2 Water Harvesting & Management Technologies

As a strategy to secure water resources in rural areas, various types of rainwater management and harvesting system have been implemented, Kenya Rainwater Association (2010). This will involve harnessing of rain or groundwater for agricultural or domestic use. Therefore, provision of supplementary water to croplands through irrigation and use of efficient irrigation measures can enhance carbon storage in soils through enhanced yields and residue returns. Use of clean energy is important to avoid off-setting these gains through CO_2 emissions from the energy used to deliver the water or from N_2O emissions from higher moisture and fertilizer nitrogen inputs.

There are several water-harvesting technologies: Zai pits, retention ditches, road runoff harvesting, rock catchment harvesting, roof catchment harvesting, and construction of ponds, dams, and water pans, among others. To consider the adoption of the various water management and harvesting technologies, several social, cultural and economic factors should be considered such as peoples' priority and ability to use (Ibrahim, 2012).

2.2.2.3 Agro Forestry

Agro-forestry is the set of land-use practices involving the deliberate combination of trees with agricultural crops and/or animals on the same land management unit in some form of spatial arrangement or temporal sequence. There are lots of possible combinations of food products including crops and fruits, fodder, mulch/green manure and timber Trees may, for example, be planted around homesteads (home garden), along fences, on the farm boundaries or on crop- or pasture land. The introduction of trees or shrubs will create a more diverse, productive and ecologically sound land use and environment. Social, economic and environmental benefits can for example be better food security, increased income and enhanced soil fertility (FAO, 2012).

Von Braun and Díaz-Bonilla (2008) argued that a country where the economy is heavily based on agriculture, development of the agricultural sector is the most efficient poverty reduction measure. Yet agricultural expansion for food production and economic development which comes at the expense of soil, water, biodiversity or forests, conflicts with other global and national goals, and often compromises production and development in the longer term.

2.2.2.4 Adoption of Climate Smart Agricultural Practices among Farmers

Smallholder farmers require knowledge and information on the appropriate CSA practices, technologies to effectively adapt to changing climatic conditions and cope with climate variability. As reported by Po-Yi Liu (2013) trainings on the innovative climate-smart agricultural has equipped smallholder farmers the skills and techniques to make their agricultural activities part of the solution to the negative impacts of climate change. As a result, the smallholder farmers and family members in the villages of Dongoroba in China are directly benefiting from the improved garden thus experiencing a reduction in the level of poverty.

Further, in Mali, women's groups have been trained in good practices for producing and selling quality seed. The women's association has been linked to local private seed distribution and training for certification in seed selling. In Niger, similar capacity building activities have been conducted in where, smallholder farmers seed and grain producers have been assisted with animals and ploughs and smallholder farmers processors have been assisted with small scale oil extraction machines to reduce the drudgery associated with groundnut production and processing (Popescu, 2020). As well in Kenya, CCAFS (2013) East Africa together with partners has facilitated the training of 130 women farmers in the Nyando region on climate smart innovations. The focus areas included; appropriate on farm tools and technologies, new climate smart practices and agro-advisories and accessing micro- insurance and microfinance. Such capacity building activities makes the smallholder farmers more adaptive to climate change and more resilience.

2.2.2.5 Emerging Issues on Climate Smart Agricultural Practices

Although agriculture is facing lots of climate hazards, smallholder farmers still depend on it to earn their livelihoods. Agriculture pays 95% of family life sustenance to the majority. Smallholder farmers however, produce half of the food needed for the family's life (Oberhauser, 2004). In more detail he points out that, the role of smallholder farmers to produce and successfully harvest includes: Early preparation of farms, planting early, practice tilling cultivation, utilization of compost manure, plant multiple crops (drought and non-drought resistant crops), making water edges around the farms, avoid cultivating in high lands, plant trees around the farms.

According to a study conducted by Mugwe *et al*, 2009, in Meru County Kenya, they provided an empirical account of the factors associated with farmers' decisions to adopt or not to adopt the newly introduced integrated soil fertility management (ISFM) technologies. The findings showed that that the adoption of ISFM practices could be enhanced through targeting of younger families where both spouses work on the farm full-time and food insecure households.

Additional, Marenya *et al*. (2007), in their study using panel data collected in western Kenya in 1989 and 2002, found out that adoption of soil fertility management techniques was low among many farmers because of resource constraints. More so, in the same study they ascertain that value of its livestock, off-farm income, family labor supply, size of the farm owned by a household, educational attainment and gender of the household head all had a significant positive effect on the likelihood of adoption of the soil fertility management techniques.

In the Virginia in the US, successful reduced tillage where acreage under conservation tillage increased among crops from 48.2% in 1989 to 67.6% in 2007 (Ballard, Chamberlin, Elliott, Hickey, Jahncke, Reiter & Warzybok, 2018) was reported. The positive trend was attributed to increased awareness among Virginia farmers on the benefits of low and no-tillage regimes and is consistently improving their production systems to move towards sustainability. Similarly, Kaumbutho and Kienzle (2007) points out that adoption of CA by medium and large-scale farmers in Kenya has been possible because of understanding the benefits despite the challenges of CA as presented in the case study above.

A study conducted in Tanzania using the TNS-Research International Farmer Focus (FF) and The Tanzania National Panel Survey (TZNPS) showed that inorganic fertilizers use among small scale farmers is significantly and strongly determined by availability of extension services (Rahman & Zhang, 2018), thus indicating the importance of imparting knowledge and advice in adoption agricultural technologies including use of inorganic fertilizer use.

In Kilimanjaro, a combination of field practical and classroom training on CA was used to impart knowledge to farmers, extension staff and village leaders to enhance adoption of CA. As a result, 67% (760 farmers) of trained farmers were the first to adopt CA (SUSTAINET, undated). After appreciating the benefits of CA from fellow farmers, other 6500 farmers adopted (SUSTAINET, undated). Therefore, a combination of classroom and practical training is important to up scaling technologies.

Access to agricultural inputs and services should be widely available especially for women.

According to FAO (2012), women's access to services, improved seeds, pesticides and fertilizers, are limited. Asenso-Okyere and Davis (2009) emphasize in their study that there is a high need for agricultural extension services in rural areas, as they are predominantly viewed as supply-driven and excluding the rural poor.

Introduction of more secure tenures can have a significant effect on farmers' willingness to invest in their land and improve productivity. Norton-Griffiths (2008) showed that net returns on adjudicated land was approximately three times higher than on un-adjudicated land where tenure is less secure among smallholder farmers in Kenya. Thus, investments in agro forestry, improved livestock and fodder crops, crop diversity and soil conservation were all substantially higher on more securely tenured land.

In his study, Nelson *et al*. (2010) found that increased market accessibility increases income generation opportunities offered by farming. This can be accomplished by better infrastructure, or more locally, by forming cooperatives that pool resources for market access. As shown above, an increased income is one of the most productive ways of reducing the vulnerability of farmer to climate change. Thorlakson, (2011) found that market access was an important factor in improving household incoms when comparing advantages derived from agroforestry in Kenya. Wilkes (2011) states that farmers are active in the project planning process. Input from farmers should be used to ensure that development programs are aimed at the local communities most relevant and are planned to achieve the negotiated targets most efficiently in a local context.

Improving the ability of farmers to plant more trees for several different purposes was seen as an essential boost to access to information and training. Kiptot (2006) has shown farmers to disseminate agricultural technologies as a possible alternative mechanism for the spread of agricultural and Thorlakson (2011) has shown educational exposures to agricultural practices can enhance adoption rates.

Beddington, (2011) urged that overcoming the barriers of high opportunity costs to land helps smallholder farmers to improve their management systems. This is a key requirement for successful implementation of climate-smart agriculture in developing countries and to-date it has been given little attention (AU-NEPAD, 2010). Many improved management practices provide benefits to farmers only after considerable periods of time. This can be inhibitive to poor households because investing in new practices requires labour and incurs costs that must be borne before the benefits can be reaped. Pairing short-term with longer term practices may overcome some of the timing constraints.

2.2.3 Factors for Effective Introduction of Climate-Smart Agricultural Practices

Climate smart agriculture is at this very moment high on the global climate change development agenda, African policymakers have been adequately advised on agricultural development strategies since the 1960s (Delgado, 1995), and that over the course of years many agricultural development initiatives have failed to succeed due to, among others, a lack of land ownership, technology, infrastructure, finance and gender inequality (Lahiff, 2001; Macleod *et al*., 2008). Advances in the fight against poverty and hunger have even begun to slow or reverse progress made (UNDPI, 2015).

FAO & CARE (2010) points out that, secure access to land, livestock and water resources are essential for investments in climate smart agriculture as they represent the foundation for rain fed subsistence agriculture. Access to land and water is not a given fact, especially not in Africa as the land is communally owned. Secure access is to land and livestock for Smallholder Farmers is problematic as they often do not have secure rights even though they are responsible for subsistence farming or livestock keeping when their men leave to migrate. A lack of secure access to land and water could constrain efforts to invest in agriculture. Second; access to finance is necessary as it provides access to agricultural tools and resources. It also serves as a “buffer” in times of need, which makes it less risky to invest in alternative livelihoods (FAO, 2010; CARE, 2010).

Thirdly; investing in climate smart agriculture will only succeed if people understand the reasons why these investments are made, and what type of threats they are facing. Education, information and knowledge sharing should contribute to communication and thereby community involvement. Especially traditional and local knowledge, also known as Indigenous Technical Knowledge (Chambers & Gillespie, 2015) of poor farmers and resource users will prove vital in building more understanding of agriculture and the environment (IIED, 2011). Awareness that climate change is an issue is well established and investment strategies need to be put in place. Practical guidance should go beyond creating awareness (Brown *et al*. 2007), according to FAO (2010), awareness raising on smart climate need to be enhanced through farmer facilitators and radio and TV and by visiting agricultural experts and through video.

Action Aid (2010) and the four partners believes that there are alternative approaches to land use and food production that would bring ‘wins’ in terms of CSA adaptation and mitigation, but lack of awareness to small-scale farmers and policy makers on the adaptation and mitigation to CSA has been the problem. Awareness among farmers increases successfulness of CSA. Thus availability of extension services is essential in scaling up CSA. External support especially by imparting more awareness and supplementing the communities with coping technologies has been clearly emphasised. Climate smart agriculture initiatives are therefore of paramount importance. Non-governmental organisations are likely to play an increasingly important role in building awareness and delivering appropriate technologies to farmers. The awareness of the farming community on the impacts of climate change and their ability to adapt needs to be supported (Dodman & Mitlin, 2013; Mapfumo, Adjei-Nsiah, Mtambanengwe, Chikowo & Giller, 2013).

2.3 Conceptual Framework

The Probability of a farmer to adopt CSA is affected by social economic and institutional factors such as age, education level, sex, land size, income, extension service, knowledge on CSA activities and noticing of temperature change.

Independent Variables

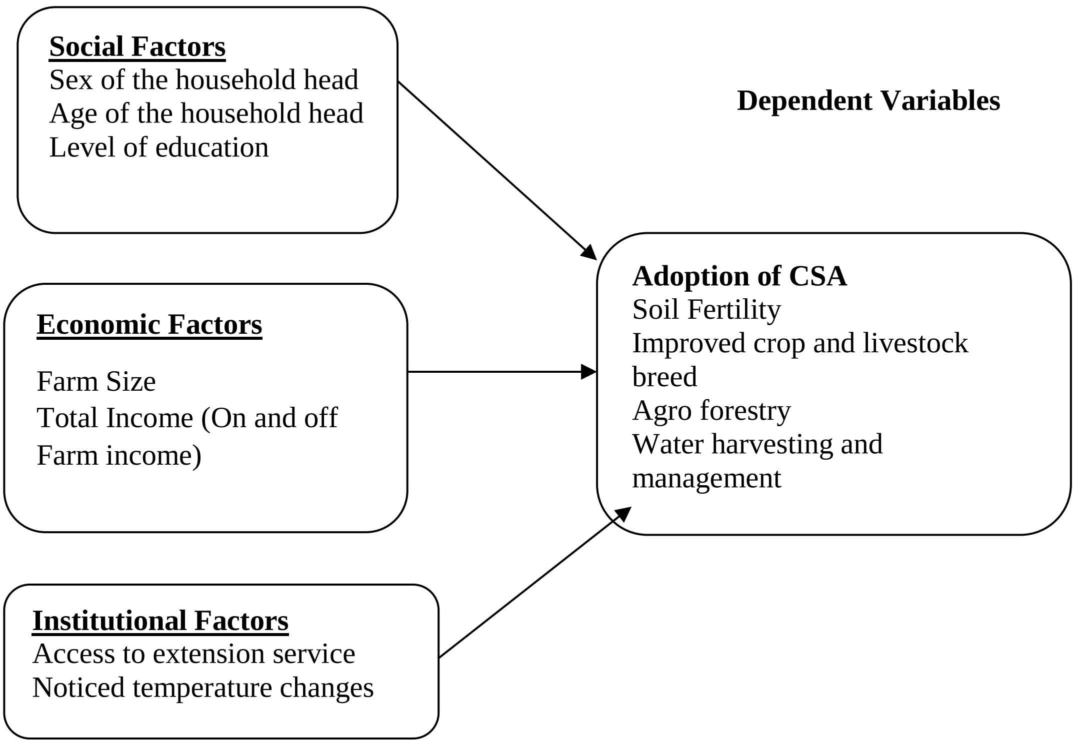

Figure 1: Conceptual Framework

Source: Author 2015

As indicated in the conceptual framework the world in which agriculture take place has changed fundamentally. Today's philosophy of crop and livestock production encourages a broader and a multifaceted approach of resource utilization. New management practices and models are therefore required to handle such situation. The framework underlying the adoption of CSA makes use of concepts and relationships in broad category including social, economic and institutional factors.

The research focused on how social, economic and institutional factors can enhance the adoption of CSA among farmers so as to increase production and improve fertility as shown conceptually in Figure 1. In this conceptual framework, the independent variables social factors, economic factors and institutional factors are a means to an end, and not an end in itself. These are factors proposed as practices providing infrastructure to support CSA.

2.4 Summary of Literature Review

From the review of literature studies on climate smart, there have been various practices such as conservation agriculture; water management, agroforestry that exists. However, adoption of many CSA practices has been very slow, particularly in food insecure and vulnerable regions in sub-Saharan Africa and Southeast Asia especially among smallholders' farmers. There are several potential explanations for failure to adopt such activities which in the above literature they have not been addressed (Giller *et al*., 2009). Due to dynamic and the uncertain nature of climate change impacts, capacity development approach that is comprehensive and which stimulates socio-institutional learning processes and at the same time utilizes the innovation potential of agricultural systems is required to transition towards climate-smart agriculture. Bridging the current information and knowledge gap for more inclusive and effective decision-making within CSA is a key challenge. Successful adaptation to climate change by small producers is not merely a question of developing new adaptation technologies but depends on ensuring access and use of them.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.0 Introduction

This chapter describes the study area, research philosophy, research design population, sample and sampling techniques, research instruments, instruments validation, ethical consideration data collection procedures, data analysis, and analytical framework.

3.1 Study Area

The study covered Bungoma County (Figure 2) which occupies approximately 2,068.5 km^2 with a population of roughly 1,630,934 people and a population density of 482 persons/km^2 (KNBS, 2009). The County is located between longitude 34° 21.4′ and 35° 04′ East and latitude 0°25.3 and 0° 53.2′ North.

There is a bimodal rainfall pattern; the long rains (March–July) and the short rains (August-October). The annual rainfall ranges between 1250 and 1800 mm. The altitude ranges between 1200 and 2000 m Above Sea Level (A.S.L) and temperature ranges between 21-25°C during the year (GoK, 2005).The County is endowed with well-drained, rich and fertile arable soils but poor husbandry methods and a bulging population have resulted in declining yields, deforestation and soil erosion. Small scale crop and livestock production is an important component of agricultural activity in this area.

Bungoma County was selected because firstly, of it being one of the Counties in Kenya having high agricultural potential with different agro-ecological zones and livelihoods. Smallholder farmers' livelihoods have been affected by declining productivity and this is made worse by climate change. Secondly, there are various projects on climate-smart farming backed by the UN's Food and Agriculture Organization. The programme has so far been introduced to the Community Research in Environment and Development Initiatives in Bungoma County among others counties.

3.2 Research Design

The study adopted a descriptive and an explanatory research designs since it seeks to describe and explain the factors that influence Adoption of CSA activities.

3.3 Sample Size and Sampling Procedure

The study population consisted of 326,150 smallholder farmers in Bungoma County who were registered with the Ministry of Agriculture, Fisheries and livestock development. The sample size for the study was arrived at by use of formulae by Krejcie & Morgan (1970). The formula entails determining the sample size(s), from a given fixed population (P) with the sample size within plus or minus 0.05 of the population proportion at 95 percent level of confidence. The 95% confidence level is preferred because it’s narrower, with lower variability and when coupled with a higher sample size it enhances precision (Bryman, 2008).

This formula is shown as follows:

$$S = \frac{X^2\ NP\ (1-P)}{d^2\ (N-1)} + X^2P(1-P)$$

Where: X^2 = Chi-Square table value for 1 degree of freedom at the preferred confidence level (in this case 3.84), N = the population size (326 150), P = the population proportion (assumed to be 0.5), d – the degree of precision stated as a proportion (0.05). Use of the formula gave 333 as the minimum sample size for the study.

3.4 Sampling Procedure

The researcher selected 30% of the 11 Sub counties in Bungoma County (Webuye West, Bungoma Central, Bungoma East, Bungoma North, Bungoma South, Bungoma

West, Cheptais, Kimilili, Mt. Elgon, Tongaren and Bumula). This resulted in the picking of 3 Sub Counties which were selected using simple random sampling. Secondly, systematic random sampling procedure was employed to select farmers. This approach was chosen because it ensures an equal probability of inclusion of each unit in the population than simple random sampling (Nassiuma & Mwangi, 2004). The procedure involves drawing a sample of size n from a population consisting of N units in such a way that starting with a unit corresponding to a number r chosen at random from the numbers 1,2….,k every kth unit is selected.

Sampling of households was carried out considering two sampling frames of farmers: adopter of respective CSA and non-adopters. A farmer engaged in at least any of the CSA for two or more years was considered as adopter. This is because of the intention not to consider opportunistic farmers that just try for a year and abandon the next year.

3.5 Data and Data Collection

Primary data and secondary data were used in the analysis. Primary data was obtained from the farmers and included age, education level, farm sizes, sources of income, CSA practices being adopted among others. Data was collected through observation and interviews using semi-structured questionnaires.

3.6 Piloting

The instruments were piloted and this was conducted in the neighbouring Kakamega County. Kakamega County was chosen because just like Bungoma County it has similar ecological and climatic condition like Bungoma. The aim of the pilot study was to determine how effective the data collection instruments will be during the actual field research, whether the items in the instruments would be clear and unambiguous to the respondents and the problems they were likely to encounter in response to the item. As suggested by Mugenda and Mugenda 10% of the sample size (33 smallholder farmers) was utilized during piloting.

3.7 Data Analysis

Descriptive statistics was used to describe the characteristics of farmers. Quantitative and qualitative data analysis methods are used. This involves the use of tables, charts, graphs, percentages and means. To evaluate the social, economic and institutional factors that influence the adoption of CSA practice by smallholder farmers, Multinomial Logit (MNL) model was used.

3.8 Analytical Framework

3.8.1 Empirical Model Specification; Multinomial Logistic Model

Multinomial Logit (MNL) model was used to analyse the factors influencing adoption of climate smart agricultural practices among smallholder farmers in Bungoma County. The model was preferred because it permits the analysis of decisions across more than two categories in the dependent variable; hence it becomes possible to determine choice probabilities for the different climate smart practices. On the contrary, the binary probit or logit models are limited to a maximum of two choice categories (Maddala, 1983). The MNL is preferred for this study because it is simple to compute than its counterpart, the multinomial probit model (Hassan & Nhemachena, 2008).

The MNL model is expressed as follows:

$P [y = j/x]$

$= \exp(x\beta_j)/(1+\sum^{j}_{n=1}\exp(x\beta_n))$……………………………………………..Eqn.1

Where, *y* denotes a random variable taking on the values {1, 2, …, J} for a positive integer *J* and *x* denote a set of conditioning variables.

X is a 1xK vector with first element unit and βj is a K×1 vector with j = 1,2, …, J.

For this case, y denotes climate smart agricultural practices or categories while *x* denotes specific social economic and institutional characteristics of the Smallholder Farmers. The inherent question is how changes in the social, economic and institutional characteristics affect the response probabilities $P(y = j/x)$, $j = 1, 2, \ldots, J$. Since the probabilities must sum to unity, $P(y = j/x)$ is determined once the probabilities for $j = 1, 2, \ldots, J$ are known.

Independence of Irrelevant Alternatives (IIA) is assumed to hold for the parameter estimates of the MNL model in Eq. (1) to be unbiased and consistent the (Deressa *et al*., 2008). The IIA assumption requires that the probability of using one CSA by a given farmer must be independent of the probability of choosing another CSA (that is, *Pj/Pk* is independent of the remaining probabilities). The basis of this assumption is the independent and homoscedastic disturbance terms of the basic model in Eq. (1). More so, the parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent variable; therefore, the estimates represent neither the actual magnitude of change nor the probabilities. Therefore, to measure the expected change in probability of a technique being adopted with respect to a unit change in an independent variable from the mean, marginal effects are used (Greene, 2000).

The empirical model will be specified as:

$Y_{(i\ =\ 1,\ 2,\ldots n)} = \beta 0 + \beta_1 Sex + \beta_2 Age + \beta_3\ EducYrs + \beta_4 landsize + \beta_5 Inc + \beta_6 Extn + \beta_7 Tempchng + \mu$

$Y_{(1,2\ldots4)}$ = Climate Smart Agriculture practices

β_1.......... B_7= the slope which represents the degree in which adoption of CSA as the independent variable change by one unit variables

Table 3.1: Description of the Variables for the Model and their Expected signs

Variable	Description of Measurement/ units	Expected Sign
Dependent variable		
Adoption of CSA (Y_1)	A farmer has adopted at least 1 CSA=1, has not adopted=2	None
Independent Variable		
Age	Age in years(yrs.)	+
Sex	Male=1, Female=0	-
Education (level attained by the farmer)	Number of years of formal education	+
Income (Inco)	Amount (KES) income received in a year(continuous)	+
Land size (Land size)	Total household farm land size in Acres	±
Extension (Extn)	Households obtain farming information from extension service Yes=1, No=0	+
Temperature Change (Temp chng)	Noticed unpredictable temperature change Yes=1, No=0	+

3.8.2 The Apriori Assumptions

Socioeconomic factors are those experiences that help shape ones' attitude, personality and lifestyle. These factors can also define region and neighbourhood. According to Elizabeth *et al*. (2009) socio economic factors include the following:

i. **Age of the Household Head:** Age of the head of household could be used to determine ability to adopt agricultural practices as well as capture farming experience. Studies have shown that there is a positive relationship between number of years of experience of the household head in agriculture and the adaptation of improved agricultural technologies Kebede *et al*. (1990).

ii. **Sex of Household Head:** Male headed households were more likely to make decisions to adopt the emerging strategies and undertake risky businesses than female headed households (Asfaw, 2004). Tenge (2004) in his study showed that having female as the head of household could have a negative effect on adaptation of some practices such as water and soil conservation strategies, because women may have limited access to land and decision making ability and other resources due to traditional barriers. However, a study by Nhemachena *et al*. (2007) found contrary results, arguing that since women are responsible for much of the agricultural work in the farm, female- headed households were therefore more likely to adapt because they have more access to information and experience on various management and farming practices.

iii. **Education:** Norris (1987) points out that a farmer with a higher level of education such as tertiary level, is believed to be associated with access to information on CSA practices and thus has higher productivity. More so, various sources indicate that there is a positive relationship between the education level of the household head and adaptation strategies as noted by Igoden *et al*. (1990) and adaptation to climate change (Madison, (2006). Therefore, with a higher level of education, a farmer is more likely to adopt the CSA practices.

iv. **Farm Size:** On farm size, studies have shown that the effect of farm size on adaptation strategies is inconclusive on adaptation of climate change strategies. Most indicate that farm size has both positive and negative effect on adaptation, (Bradshaw *et al*., 2004).

v. **Income**: Farm and off-farm income and livestock ownership represents continuous income flow among farmers. Studies that explored the impact of income on adaptation on agricultural technologies found a positive correlation (Franzel, 1999). Farmers with high and continuous incomes have greater chance of access to information on climate change and could easily adopt various CSA practices.

vi. **Extension, Training and Access to Information:** Extension and training on improved agricultural practices and access to information on climate change is required to make the decision to adopt CSA practices. Several studies in developing countries, including Kenya, report a strong positive relationship between access to information and adaptation behaviour of farmers (Yirga, 2007). Equally, this study also hypothesizes that access to information will increase the probability to adapting CSA practices.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND INTERPRETATION

4.1 Introduction

This chapter presents data collected using the questionnaire described in Chapter 3. The corresponding interpretations also follow each presentation. The results of the study are presented according to the objective. The findings in this chapter were also arrived at by analysing and interpreting the available data using SPSS and STATA. All the responses are presented in terms of frequencies, percentages and means.

A total of three hundred and thirty three (333) questionnaires were distributed to the farmers of which two hundred and twenty-eight (228) were returned. The researcher adopted the drop and pick later approach. The researcher used research assistants who were conversant with the study areas to distribute and collect the questionnaire later. The response rate for the distributed questionnaires was therefore sixty eight percent (68%).

4.2 Descriptive Analysis

4.2.1 Social and Demographic Characteristics

The first objective of the study sought to find out the social and demographic characteristics of the sampled small holders farmers in Bungoma County. A number of variables were investigated. These included the demographic characteristics of respondents that included sex, age, and length of residence in community in years, number of persons in household, number of dependents and the education of the respondents. Table 4.1 presents the findings.

Table 4.1: Social and Demographic Characteristics of the Sampled Smallholder Farmers in Bungoma County

Social/Demographic Characteristics		Frequency	Percent (%)
Sex	Male	105	46.1
	Female	123	53.9
	Total	**228**	**100**
Age range of respondent:	18-25	22	9.6
	26-33	44	19.3
	34-41	77	33.8
	42-49	10	4.4
	Above 50	75	32.9
	Total	**228**	**100**
Length of residence in Community in years	Less than 1 year	3	1.3
	1-5yrs	6	2.6
	6-10yrs	21	9.2
	11-15yrs	11	4.8
	16-20yrs	187	82
	Total	**228**	**100**
No. of persons in household:	1-3 persons	128	56.1
	4-6 persons	20	8.8
	7-10 persons	80	35.1
	Total	**228**	**100**
No. of dependants:	1-3 persons	129	56.6
	4-6 persons	51	22.4
	Above 6	48	21.1
	Total	**228**	**100**
Education of respondent	Primary	100	43.9
	Secondary	45	19.7
	Technical/vocational	10	4.4
	Tertiary	73	32
	Total	**228**	**100**

Findings in Table 4.1 indicate that 53.9% (123) of the respondents are female while 46.1% (105) are male. This is an indication that there was almost equal representation of male and female smallholder farmers. Age is said to be a primary latent characteristic in adoption decisions. In regard to the age of the respondents, 33.8% (77) of the respondents are between 34 to 41 years of age, 19.3% (44) of them are between 26 to

33 years, 9.6% (22) are between 18 to 25 years, 4.4% (10) of the respondents are between 42 to 49 years and 32.9% (75) are above 50 years of age. Most of the respondents are between 34 to 41 years of age implying that they are in their productive age bracket. However, there is a contention on the direction of the effect of age on adoption.

In terms of length of residence in the community, 82% (187) of the respondents have lived in the community for 16 to 20 years, 9.2% (21) for 6 to 10 years, 4.8% (11) for 11 to 15 years, and 2.6% (6) of them for 1 to 5 years and 1.3% (3) of the respondents have lived in the community for less than a year. Overall, most of the respondents (82%) had lived in the community for more than 16 years and this provided responses based on a wider knowledge base.

The number of persons in household was also established. From the findings, 56.1% (128) of the respondents noted that there are between 1 to 3 persons,35.1% (80) 7 to 10 persons while 8.8% (20) of the respondents affirmed that there are between 4 to 6 persons in the household. The large number of persons in the household may provide for family labour required in agricultural production.

In terms of the number of dependents, 56.6% (129) of the respondents established that there are between 1 to 3 dependents, 22.4% (51) of the respondents stated that there are between 4 to 6 dependents while on the other hand 21.1% of the respondents stated that there are over 6 dependents. The high numbers of dependents in most cases is translated into increased family pressure on the limited resources.

In regard to the education of the respondents,43.9% (100) of the respondents have primary as their highest education level,32% (73) tertiary level of education,19.7% (45) secondary level of education and 4.4% (10) technical/vocational. This shows that on average, farmers attained the minimum required education level that is adequate for understanding agricultural instructions provided by the extension workers. They also have higher allocative abilities and can adjust faster to farm and technologies adoption conditions.

4.2.2 Economic Characteristics

The study sought to find out the economic factors that influence adoption of climate smart agricultural practices among the sampled small holder farmers in Bungoma County. The economic factors include land ownership, land size and use and total income earned by the farmers.

4.2.2.1 Land Ownership

Land as a factor of production and storage of wealth is the most important asset influencing adoption (Shively, 1999). Land ownership and size are associated to the ability to uptake climate change adaption strategy. Small scale farmers and those who lease land to farm for a short period of time are unlikely to adopt major climate change and adaptation strategies. This prompted the researcher to establish land ownership. Figure 3 highlights the results on land ownership.

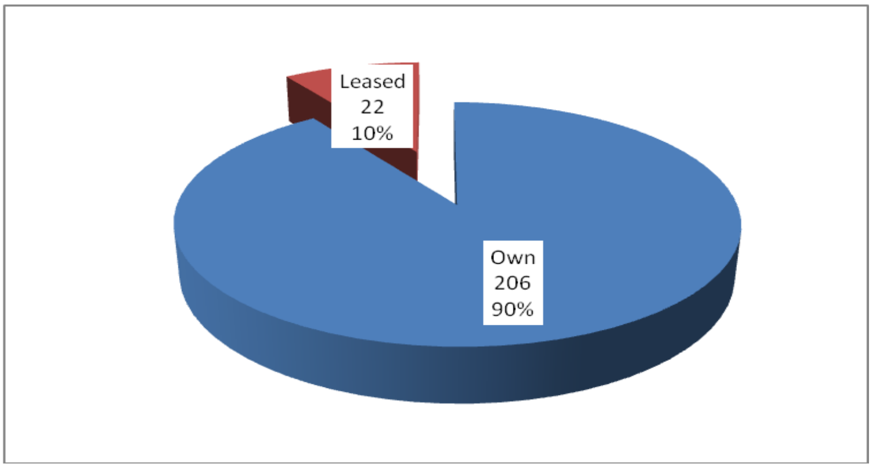

Figure 3: Type of Land Ownership among the Smallholder Farmers

Finding in Figure 3 indicated that 90% (206) of the respondents own the land while 10% (22) of them have leased the land. This implies that adoption of the CSA may not be a problem to the majority small holder farmers.

4.2.2.2 Land Size (acres) and Use

The researcher deemed it important to establish the number of acres owned by the respondents. This information is presented in Table 4.2.

Table 4.2: Category of Land Size in Acres owned by SHFs

Land Size (acres)	Frequency	Percent %
Below 1 acre	33	14.5
1-2	92	40.4
3-4	61	26.8
5 and above	42	18.4
Total	**228**	**100**

As presented in Table 4.2, 4.2, 40.4% (92) of the respondents 1-2 acres of land, 26.8% (61) 3-4 acres of land, 18.4% (42) of them own four acres of land while 14.5% (33) of the respondents do not own land. Therefore, majority of the farmers in Bungoma County are small scale farmers with less 2 acres. This result is in concurrence with a study done by Waithaka (2010) in Western Kenya which points out that land size is getting smaller and exacting pressure on the agricultural activities.

The researcher deemed it important to establish land use. Table 4.3 highlights the results.

Table 4.3: Land use among Small Holders Farmers in Bungoma County

Land use type	N	Minimum	Maximum	Mean	Std. Deviation
Livestock-size in acres	228	0	1	0.1	0.296
Livestock - year in same use	228	0	25	8.18	12.247
Livestock – rank	154	0	2	0.51	0.873
Crops-size in acres	217	0	0	0	0
Crops- year in same use	217	0	30	13.14	8.013
Crops- rank	154	0	5	0.89	1.595
Homestead -size in acres	228	0	3	1.53	1
Homestead - year in same use	228	0	40	13.43	12.093
Homestead – rank	154	0	1	0.4	0.491
Forest-size in acres	217	0	2	0.29	0.625
Forest - year in same use	194	0	15	7.18	8.649
Forest – rank	126	0	3	0.24	0.814

Finding in Table 4.3 indicated that most part of the land was used for crops (mean = 0.89, 1.595) followed by livestock (mean = 0.51, SD = 0.873) then homestead (mean = 0.4, SD = 0.491) and finally agro forest (mean = 0.24, SD = 0.814). The homestead and crops were used for an average of 13 years, forest for 7 years and livestock 8. These findings gives credence to the study by Waithaka (2010) in Western Kenya, in which findings showed that western farmers were practicing conservation agriculture and crop intensification as a buffer to climate change as compared to other activities.

4.2.2.3 Sources of Income

The researcher sought to establish the source of income of the respondents. Figure 4 shows that the major sources of income were livestock and livestock products (87%).The respondents equally agreed that agro forestry products, home industries and crop production are their other sources of income; this was at a proportion of 73.2%. Besides, 63.6% of the respondents noted that off-farm employment is their source of income. From this result it shows that the main source of income of most of the farmers in Bungoma County is from agricultural activities as compared to off- farm activities.

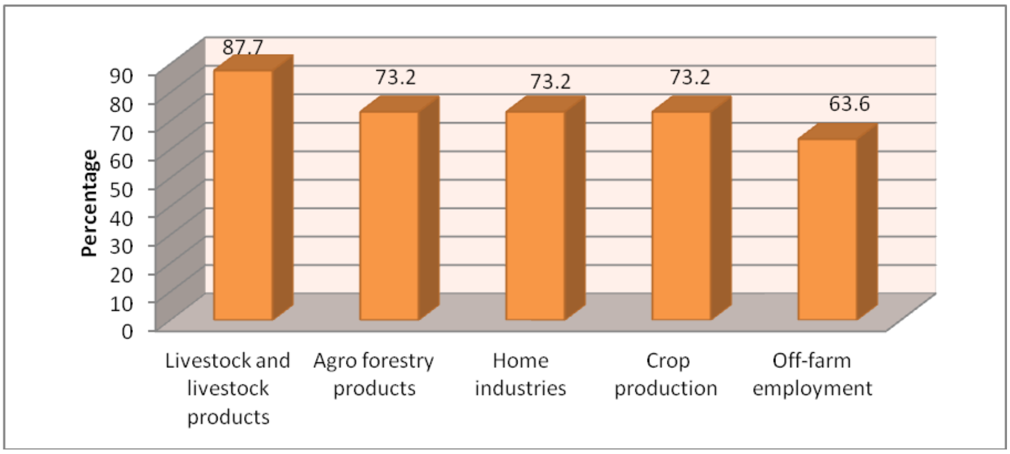

Figure 4: Type of Sources of Income among the SHFs

The researcher sought to establish the range of income per month for the respondents from farming activities. The findings are presented in Table 4.4;

Table 4.4: Range of Income per Month per Household from Farming Activities

Income Range per month	Frequency	Percent (%)
Less than 5,000	75	32.9
5000-10,000	51	22.4
Above 10,000	32	14
Total	**158**	**69.3**

Table 4.4 shows that 32.9% (75) of the respondents earn less than 5000 per month, 22.4% (51) of them earn between 10,000 and 20,000 and 14% (32) of them earn between 5,000 and 10,000 monthly. From the findings, most of the farmers earn less than 5,000 followed by those earning Ksh5, 000 to 10,000 per month. Since farmers earn low income, it might be a challenge to adopt new practices compared with those

with high income. This is mainly since level of income dictates the level of expenditure, since most agricultural practices are money demanding such as costs for veterinary drugs and pest control.

Further information was sought on the average income per month. The information is presented in Table 4.5.

Table 4.5: Average Income per Month

	N	Min	Max	Mean	Std. Deviation
Average amount per month	228	0	5,000	1947.81	1615.848
Income do you expect to get from you farm end month	2280	0	9,000	1797.81	2519.692

As shown in Table 4.5, the respondents earn an average of Ksh1947.81 per month and they expect an average of Ksh1797.81 from their farm at the end of the month.

4.2.3 Institutional Factors

The study sought to find out the institutional factors that influence adoption of climate smart agricultural practices among the sampled small holder farmers in Bungoma County. This included knowledge of Climate smart Agricultural practices, access to extension service and noticed of climate change among the sampled farmers in Bungoma County.

4.2.3.1 Knowledge and Awareness on Climate Smart Agricultural Practices

Efficient and effective capacity development and knowledge management in adapting to climate change is an important role that National Climate Change Action Plan (NCCAP) acknowledges. The researcher assessed the respondents' knowledge and awareness on CSA practices. The respondents were asked if they are aware of any CSA practices to help them adapt to climate change. Information gathered is presented in Figure 5.

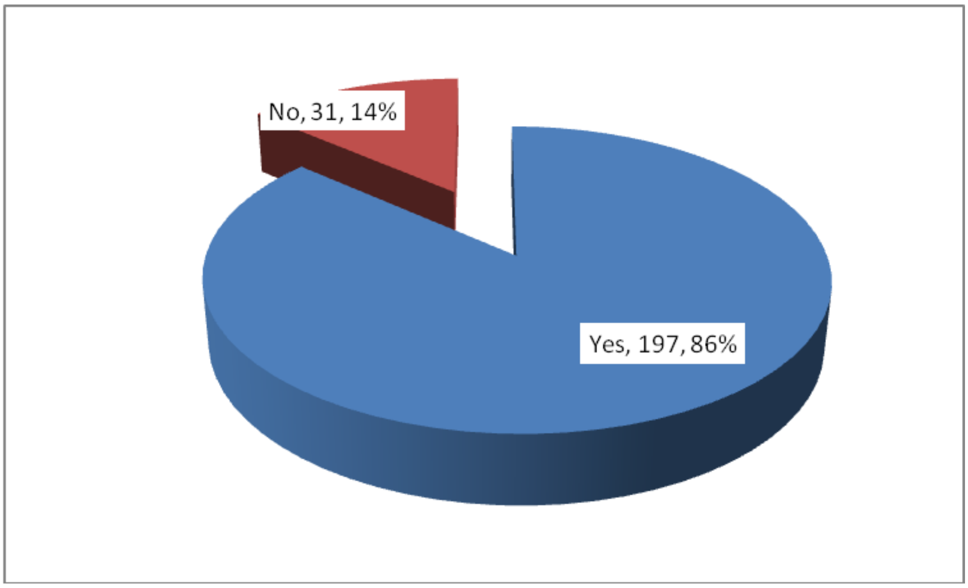

Figure 5: Proportion of the Sampled awareness on Climate Smart Agricultural

Finding in Figure 5 shows that 86% (197) of the respondents are aware and have some basic knowledge on CSA practices. However, 14% (31) of the respondents noted that they lack awareness and no knowledge on climate smart agricultural practices. This implies that adoption of Climate Smart Agriculture may be a challenge thus the need to institutionalise structures that will be enable information reaching as many farmers as possible.

Further information was sought from the respondents on the climate smart practices they were aware of. The CSA practices investigated in the study were grouped into 4. Findings are indicated in Table 4.6;

Table 4.6: Type of CSA Practices Sampled Farmers are aware of

CSA Practices	Frequency	Percent (%)
Soil Fertility Management	127	55.7
Improved Crop and livestock breeds	174	76.3
Agro forestry	32	14
Water harvesting and management	133	58.3

Findings in Table 4.6 shows that 55.7% (127) of the respondents are aware of soil fertility management, 76.3% (174) respondents were aware of improved crop and livestock breed, 14% (32) agro forestry and 58.3% (133) water harvesting and management practices. Findings indicate that majority of the farmers talked of change to high-yielding and maturing varieties especially for maize and most included indigenous crop types and varieties. More so, some of the farmers pointed out to have changed to early planting.

On the contrary few farmers were aware of agro forestry as represented by 14%. The farmers that had trees on their farm were not deliberate in the combination of trees with agricultural crops and/or animals on the same land management unit in some form of spatial arrangement or temporal sequence.

Water harvesting practices that they are aware off was roof catchment. Therefore, majority did not mention any other practice of water harvesting such as zai pits, retention ditches and water pans.

The researcher sought to establish source of respondent’s awareness of CSA practices. Findings are represented in Table 4.7.

Table 4.7: Source of CSA Awareness

Source of CSA Awareness	Frequency	Percent (%)
School and other social gatherings	73	32
Seminars and group trainings	124	54.4
Extension officers	61	26.8
Friends	51	22.4
Internet and other social media platforms	61	26.8
Radio	158	69.3

Table 4.7 shows that 69.3% (158) of the respondents gained their knowledge from the radio, 54.4% (124) from seminars and group trainings, 32% (73) from school and social gatherings, 26.8% (61) from the internet and extension officers and 22.4% (51) friends. This therefore shows that, radio programs (69.3%) are an important medium to disseminate agricultural technology. Similarly, group trainings (54.4%) are important since majority of the farmers (95%) belong to a farmer/ social group as shown in Figure 6 below

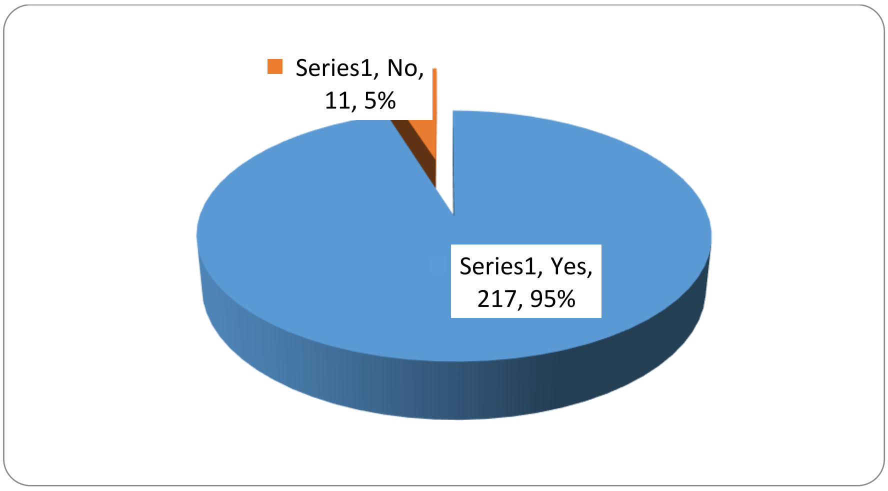

Figure 6: Proportion of Farmers Belonging to a Farmer/Social Group

4.2.3.2 Access to Extension Service

Extension services play a critical role in agricultural development through dissemination of technologies, innovations and knowledge. When well-coordinated and collaborative, it produces synergies and delivers sustainable results. Therefore, the study determined the various forms of extension service that farmers in Bungoma received and the providers of the service.

The researcher sought to establish whether the farmers' sought extension services from the Ministry of Agriculture extension workers. The findings are indicated in Figure 7.

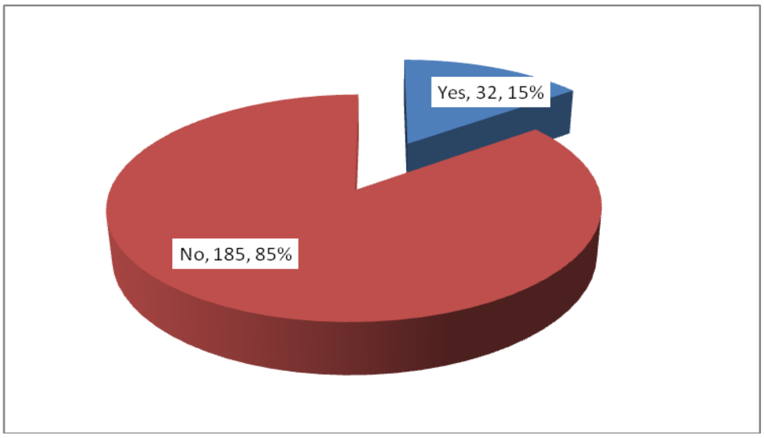

Figure 7: Proportion of Farmers who Accessed Extension Service On Climate Change

Figure 7 shows that majority (85%) of the respondents did not seek advice on climate change from the extension workers. It is only 15% of the respondents that sought advice on climate change. Majority of farmers who did not seek extension service could be attributed to the adopted mechanism by the Ministry of Agriculture of demand driven approach, where farmers go and visit the Ministry of Agriculture staff in their offices.

However, when asked whether they had received extension from other service providers, 64% of the respondents noted that they had been offered information on climate smart agricultural practices. The main service providers of extension services were also established. As evidenced in Table 4.8, the main provider of is NGOs (51%), followed by radio/television (29.6%) and (19.3%) and through Government extension staff.

Table 4.8: Main Service Provider of CSA Extension

Type of Service Provider of CSA extension service	Frequency	Percent (%)
NGOs	74	51%
Government extension staff	28	19.3
Radio/television	43	29.6
Total	**145**	**64%**

The respondents were also asked who visited them in the past one year to offer extension service. Table 4.9 presents the findings:

Table 4.9: Main People who Provide Information through Farm Visit

Type of People	Frequency	Percent (%)
Public extension agent	18	8.8%
NGO	54	26.4%
Neighbor/Farmer	132	54.7%

Findings in Table 4.9 indicated that, 54.7% (132) of the respondents have been visited by neighbours/farmers, 26.4% (54) of the respondents equally agreed that they have been visited by NGO.As well, 8.8% (18) of the respondents have been visited by public extension agent.

The study further enquired the type of training attended on climate change. Findings are presented in Table 4.10.

Table 4.10: Type of Training Attended By Farmers on Climate Change

Type of training attended on Climate change	Frequency	Percent
Workshop/seminars	44	19.3
Field day	76	33.3
Group training	82	36

Findings in Table 4.10 indicate that, 36% (82) of the respondents have attended group training, 33.3% (76) field day and 19.3% (44) workshop/seminars.

The researcher sought to establish the household member that attends the training. Findings are presented in Figure 8.

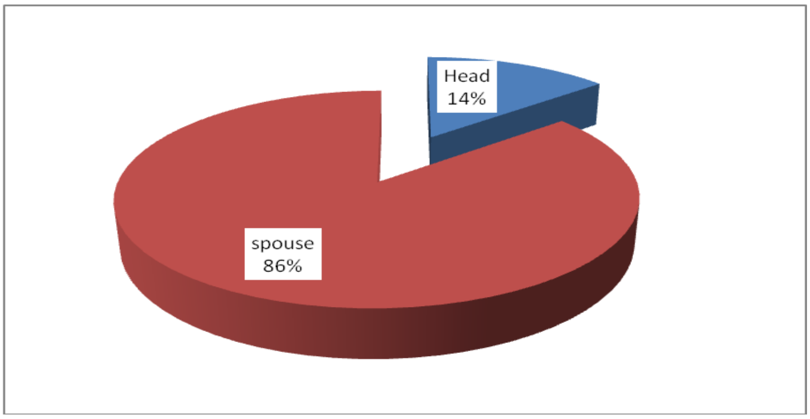

Figure 8: Attendee of Trainings on Climate Change and CSA

Figure 8 shows that the spouse (86%) majorly attends the training compared to the household head (14%).

4.2.3.3: Notice of Unpredictable Climate Change

The researcher put into account whether there is climate change. Table 4.11 highlights the results.

Table 4.11: Type of Climate Change Noticed

Type of climate change noticed	**Mean**	**Std. Deviation**
Human activities in the area are causing the environment to change	1	0
Climate is changing over time	1.09	0.284
Temperature is increasingly rising	1	0
Rainfall amount is decreasing every year	1.36	0.887
Rainfall received is variable	1.09	0.284
The weather is becoming drier every year.	1.09	0.284
The yearly rains are not supporting crop production as before	2.04	0.717
Crop diseases and pest infestation because of Climate change	1.44	0.829
Climate change has affected food production	1	0
Climate change has led to increased cost of food	1	0
Decreased vegetation due climate change.	1	0
Fuel wood scarcity is being experience	1	0
Rural-urban migration because of Climate change	2.17	0.784
Decline of forest cover and resources	1	0
Change of livelihood system because of climate change	1.09	0.284
During the raining season, there have been increased incidences of floods	1	0
During the dry season, there have been increased incidences of droughts	1.46	0.986
There is serious campaigns and awareness on climate Change	4.68	0.466

Eighteen in Table 4.11 items were measured on a 5-point Likert scale and respondents agreed to the following statements; that human activities in the area are causing the environment to change (mean = 1),the climate is changing over time (mean = 1.09,SD = 0.284), temperature is increasingly rising (mean = 1), rainfall amount is decreasing every year (mean = 1.36, SD = 0.887), rainfall received is variable (mean = 1.09, SD = 0.284),the weather is becoming drier every year (mean = 1.09, SD = 0.284), crop diseases and pest infestation because of Climate change (mean = 1.44, SD = 0.829), climate change has affected food production (mean = 1), climate change has led to increased cost of food (mean = 1), decreased vegetation due climate change. (mean =1),there is now fuel wood scarcity (mean = 1), decline of forest cover and resources (mean = 1), change of livelihood system because of climate change (mean = 1.09, SD = 0.284), during the raining season, there have been increased incidences of floods (mean = 1) and during the dry season, there have been increased incidences of droughts (mean = 1.46,SD = 0.986).Additionally, the respondents somewhat agreed that the yearly rains are not supporting crop production as before (mean = 2.04, SD = 0.717) and climate change has led to rural-urban migration (mean = 2.17, SD= 0.784).However, the respondents agreed that there is serious campaigns and awareness on climate change (mean = 4.68, SD = 0.466).

The researcher sought to establish the people that were seriously affected by climate change. Findings are indicated in Figure 9

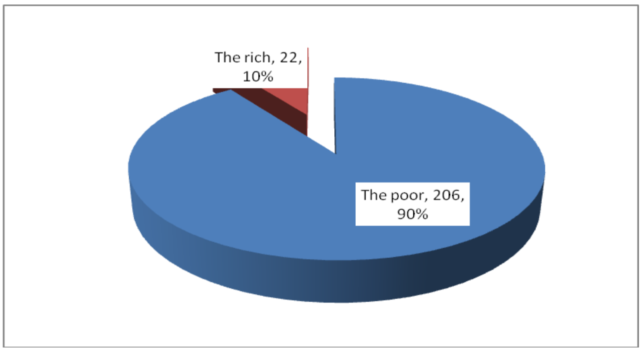

Figure 9: Proportion of People Seriously Affected by Climate Change

Figure 9 shows that the poor (90%) have been seriously affected by climate change compared to the rich (10%).

In addition, the threats of climate change were also established by the researcher. Table 4.12 below presents the results.

Table 4.12: Threat of Climate Change

Category	Frequency	Percent
Health	20	8.8
Food production	186	81.6
Businesses	22	9.6
Total	228	100

Information indicated in Table 4.12 shows that among the threats of climate change are food production (81.6%), businesses (9.6%) and health (8.8%).

4.2.3.4 Challenges faced by the Farmers when Adapting to Climate Change

The researcher sought to establish the challenges that the respondents have been facing when adaption to climate change. Table 4.13 illustrates the results.

Table 4.13: Challenges Faced by Farmers while Adapting to Climate Change

Challenges	Frequency	Percent (%)
Drought	32	14
Fake seeds in the market	60	26.3
Lack of skill	73	32
Gender biasness	42	18.4
Land ownership problems	50	21.9
High cost of farm inputs	22	9.6

Findings in Table 4.13 indicate that, 26.3% (60) of the respondents have faced the challenge of fake seeds in the market,32% (73) lack of skills,21.9% (50) land ownership problems,18.4% (42) gender biasness and 14% (32) have faced drought making it difficult for them to adapt smart agricultural practices. From this it shows that that despite the farmers being aware of the CSA practices, the lack enough skills to implement them. Therefore, appropriate and effective techniques should be used by extension service providers to ensure farmers are equipped with skills that they can adopt and use to mitigate and adapt to climate change while enhancing their resilience.

The researcher deemed it important to establish the strategies employed by the respondents to deal with the challenge of adapting climate smart agricultural practices. Findings are indicated in Table 4.14.

Table 4.14: Strategies of Dealing with Challenges of Adopting CSA Practices

Strategies	Freq	Percent (%)
Planting drought resistant crops and/or early yielding varieties	83	36.4
Fencing	39	17.1
Use of locally available materials	44	19.3
Knowledge and skills enhancement	228	100
Help farmers financially	22	9.6

As shown in Table 4.14, 36.4% (83) of the respondents have planted drought resistant crops and/or early yielding varieties, 17.1% (39) of them have engaged in fencing and 19.3% (44) of them have enhanced the use of locally available materials.

4.3 Econometric Analysis: Factors Affecting Adoption of Smart Agricultural Practices

4.3.1 Preliminary diagnostics of the variables to be used in the econometric analysis

This section presents the econometric results of the study. Preliminary diagnostics for statistical problems of multicollinearity, heteroskedasticity, homoscedasticity of residuals and independence of residuals test results were conducted for explanatory variables. These included socio-economic (age, length of residence, number of persons in the household, land ownership, land size and use and income) and institutional factors included knowledge and awareness, access to extension services and notice of unpredictable climate changed.

4.3.1.1 Test for Multicollinearity

The researcher first diagnosed multicollinearity, which refers to a state of very high inter-correlations or inter-associations among the proposed independent variables was tested using variance inflation factor (VIF) for all continuous variables and results presented in Table 4.15. The results confirmed that there was no serious linear relationship among the explanatory continuous variables tested since VIF values were less than 10.

Table 4.15: Variance Inflation Factor Test Results for Continuous Explanatory variables

	VIF	TOLERANCE
Age range	2.01	0.497034
Length of residence	1.67	0.600461
Number of persons in the house hold	1.56	0.641958
Land ownership	1.50	0.667115
Land size and use	1.42	0.706593
Income	1.29	0.776057
Number of dependents	1.10	0.905509
Years of education of the household head	1.23	0.654787
Mean VIF	**1.4725**	

For categorical variables, contingent coefficients were calculated and results presented in Table 4.16. Similarly, results confirmed that there was no serious linear relationship among the categorical explanatory variables because contingent coefficients were less than 0.75 in all cases. By rule of thumb, there was no strong association among all hypothesized explanatory variables. Therefore, all of the proposed potential explanatory variables were used in regression analysis.

Table 4.16: Contingency Coefficient Test Results for Categorical Explanatory Variables

	Sex of the household	Knowledge and awareness	Extension services	Notice of unpredictable climate change
Sex of the household	1.000			
Knowledge and awareness	0.2335	1.000		
Extension services	0.0622	0.0036	1.0000	
Notice of unpredictable climate change	0.0185	0.1142	0.1075	1.000

4.3.1.2 Test for Heteroskedasticity

To detect heteroskedasticity for all hypothesized explanatory variables, white test was used and results presented in Table 17. Unlike the Breusch-Pagan test which would only detect linear forms of heteroskedasticity, white test was preferably applied as it incorporates both the magnitude as well as the direction of the change for non-linear forms of heteroskedasticity (Williams, 2015).

Table 4.17: Test for Heteroskedasticity

	chi^2	**df**	**P**
Heteroskedasticity	63.83	210	0.0008
Skewness	15.78	17	0.0049
Kurtosis	3.92	1	0.0266
Total	83.53	228	0.0000
$chi^2(228) = 63.83$			
Prob > chi^2 =0.0001			

White's general test is a special case of the Breusch-Pagan test, where the assumption of normally distributed errors has been relaxed. The results indicated absence of heteroskedasticity as a chi^2 of 63.83 was moderate.

4.3.1.3 Homoscedasticity of Residuals

The research sought to determine the homoscedasticity of residuals.

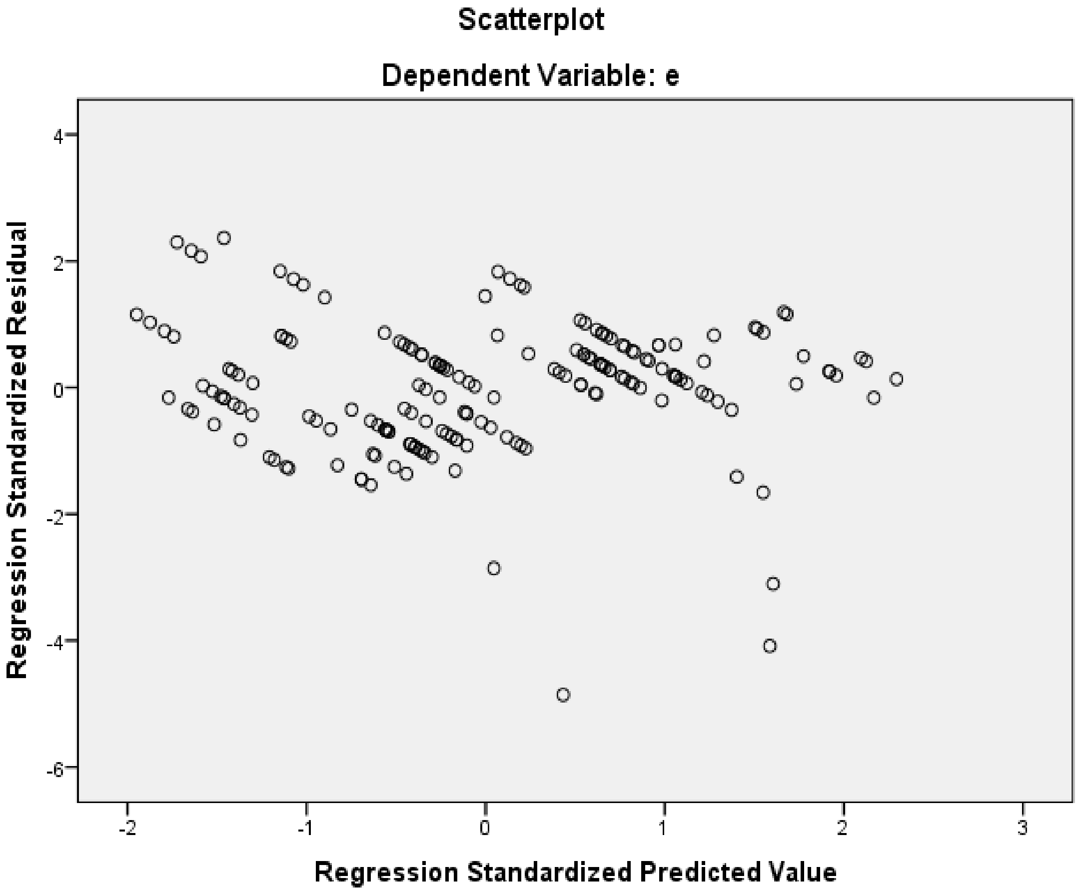

Figure 10: Homoscedasticity of Residuals

Figure 10 indicated that the scatterplot of standardized residuals showed that the data met the assumption of homogeneity of variance and linearity

4.3.1.4 Independence of Residuals Test Results

The researcher sought to examine if the residual values are independent.

Table 4.18: Independence of Residuals Test Results

Model Summary[b]

Model	Durbin-Watson
1	1.745

a. Predictors: (Constant), socio – economic and institutional factors
b. Dependent Variable: Adoption of CSA practices

From the findings the residual values were independent since Durbin Watson was 1.745 which was close to 2.

4.3.2 Results for the MNL Showing Marginal Effects of the F actors that affect the Adoption of CSA Practices

The maximum probability method was used to test the multinomial logit model's parameters using a set of 228 observations by small farmers in Bungoma County to assess the factors affecting the introduction of smart agricultural practices.

The autonomy from the presumption of irrelevant alternatives was tested and annexed to Appendix 1. The findings of the Hausman test did not refute the null hypothesis that the multinomial lodge is being used independently of insignificant alternatives. No climate-smart activity is used as the foundation result for this study. Given that multinomial logit parameter estimates provide only direction and not likelihood or magnitude of change, the marginal effects of this study are discussed. Table 4.19 shows the marginal consequences of the CSA practice factors in the Bungoma Count Table 4.19.

Table 4.19: Results for the MNL Showing Marginal Effects of the F actors that affect the Adoption of CSA Practices

Variable	**Soil Fertility management**	**Improved Crop and livestock breed**	**Agro Forestry**	**Water harvesting and management**
Sex of the household head	-0.0350	0.0201	-0.0161	0.0922**
Age	0.0010	-0.0006	-0.0020*	-0.0002
Education	0.0017	-0.0281	0.0727	0.0575
Farm Size	-0.0293**	-0.0047	0.0056	0.0079
Income	0.0002**	-0.0001	-0.0000	-0.0000
Extension Service	0.0168	0.0792***	-0.0664	-0.0040
Notice unpredictable temperature	-0.1643***	-0.0061	0.1497***	0.0323
Base Outcome: No CSA Practice				
Number of Observations: 228				

***, **, *** implies statistical significance at 10%, 5% and 1% respectively**

Source: Computation from field survey, 2015

Findings in Table 4.19 indicate that Farm size had a statistically significant negative influence on the adoption of soil fertility management practices in Bungoma County (-0.0293**, $p < 0.05$); income from crop sales had a statistically significant positive influence on the adoption of soil fertility management practices in Bungoma County (0.0002**, $p < 0.05$) while noticing of unpredictable temperatures had a statistically significant negative influence on the adoption of soil fertility management practices in Bungoma County (-0.1643*** $p < 0.001$.)

Findings in Table 4.19 further It showed that there has been a positive statistically important effect on the adoption as an adaptation to climate change and variability of improved crop and livestock breed (0.0792*** $p < 0.001$).

Lastly, Table 4.19 indicate that Age had a statistically significant negative influence on the adoption agro forestry (-0.0020* $p < 0.05$) while unpredictability of temperatures had a statistically significant positive influence on the adoption of agro forestry (0.1497***, $p < 0.001$). The findings further showed that Sex had a statistically significant positive impact on the adoption of water harvesting and management practices as an adaptation to climate change (0.0922**, $p < 0.05$).

If a farmer has broad land sizes, the likelihood of soil fertility and maintenance is reduced by approximately 3%. Adoption of soil fertility and management practices such as use of inorganic fertilizers, herbicides and compost, comes at an extra cost. Therefore, having an additional piece or larger piece of land under cultivation requires additional use and purchase of these agrochemicals which smallholder farmers cannot afford. Therefore, smallholder farmers are less expected to adopt soil fertility and management practices.

The results show that with an increase in income, the probability of adoption of Soil fertility and management practices. The results indicate that smallholder farmers with additional income can afford the cost of soil fertility technologies. However, it should be noted that putting the additional income from on these CSA technologies guarantees better yields and higher incomes which can be reinvested to enable the cycle to continue.

More so, a small farmer who has observed the unpredictability of temperatures is around 16 per cent less likely to accept soil fertility and management practice. This is because of the cost involved in acquiring and implementing some of the soil fertility practices, fear of landslides, erosion among others. Therefore, most smallholder farmers in Bungoma are unwilling to adopt Soil fertility related strategies when temperatures are perceived to be unpredictable.

When farmers have access to extension services, the probability of adopting improved crops and livestock breeds increases by around 8%. It is emphasized that the key ties between farmers and agricultural researchers are agricultural expansion agents. Thus, the key distributors by way of which farmers enter and hire CSA practices are agricultural extension officials. The Ministry of Agriculture and other workers are more likely to implement better crops and breeds of animals for the small-time farmers with access to agricultural expansion officials from different partners such as NGOs. The result of this study supports the finding of Nhemachena and Hassan (2007), who points out those farmers who have access to extension services have better chances to be aware of the changing climatic conditions and of the various agricultural practices that they can use to climate change.

The probability of adoption of agro-forestry reduces marginally as a farmer age. Most elderly farmers considered laggards when it comes to adoption and trying of new technologies such as combining growing of trees and crops until they have been proven to be effective. Moreover, the majority of older farmers don't typically have the strength and resources to invest in recommended farming practices. The fact that temperatures are volatile raises the likelihood that agro-forestry is adopted by about 15% against not implementing a policy that has been implemented. Small farmers willingly follow recommended farming practices which could cost little or nothing. Grow trees like closed doors.

Through the various social networks that women are involved in and participation in the agricultural activities, the female headed household tend to be more aware of climate smart practices among other agricultural technologies. More so, female was found to cultivate vegetables such as Sukuma wiki and maize, keep chicken and all integrated in a small piece of land. More so, the NGOs on the ground tend to use them to test other introduced strategies on a small scale before scaling the practices out for adoption. This result confirms the findings of Nhemachena and Hassan (2007) who states since most of the agricultural work is done by women therefore the female headed households tend to adopt agricultural technologies.

However, this finding contradicts of other various studies (for instance, Mandleni & Anim, 2011, Nhemachena & Hassan, 2008; Deressa *et al*., 2010;) who all argue that male headed households are more likely to adopt adaptation strategies because of the decision making power by males and more so access and control over agricultural resources.

4.3.3 Results for the MNL showing Coefficients

The results of the study suggest that the chi square log probability ratio of 64 per cent is important; suggesting that a predictor model as opposed to a model without predictors should be favored in general as shown in Table 4.20.

Table 4.20: Results for the MNL showing Coefficients

Variable	Coefficients	Standard Error	P> z
Soil Fertility Management			
Sex of household head	0.3039	0.6631	0.647
Age	-0.0112*	0.0105	0.283
Education	0.7654	0.3652	0.036
Farm size	-0.1905***	0.0749	0.11
Income	0.2276	0.3837	0.553
Extension	-0.1759	0.4322	0.684
Noticed unpredictable temperature	0.0010**	0.0005	0.029
Constant	1.6492	0.6468	0.011
Improved Crop and Livestock Breed			
Sex of household head	0.5289	0.8933	0.554
Age	-0.0214	0.0176	0.225
Education	0.2997	0.5779	0.604
Farm size	-0.2225	0.1828	0.224
Income	1.4727*	0.5786	0.011
Extension	-0.0207	0.6936	0.976
Noticed unpredictable temperature	-0.0002	0.0009	0.822
Constant	0.0896	1.0822	0.934
Agro Forestry			
Sex of household head	0.2489	0.8811	0.778
Age	-0.0320***	0.0148	0.030
Education	1.4675***	0.6081	0.016
Farm size	-0.0751	0.1000	0.453
Income	-0.4290	0.5449	0.431
Extension	1.5207***	0.5144	0.003
Noticed unpredictable temperature	0.0006	0.0006	0.317
Constant	-0.0617	0.8998	0.945
Water harvesting and management			
Sex of household head	1.5776***	0.7823	0.044
Age	-0.0158	0.0163	0.334
Education	1.5423	0.7079	0.029
Farm size	-0.0173	0.1005	0.863
Income	0.1196	0.5676	0.833
Extension	0.6187	0.5922	0.296
Noticed unpredictable temperature	0.0004	0.0007	0.564
Constant	-1.4377	1.0415	0.167
Base outcome: No CSA Practice			
Test statistics			
Number of Observations	228		
LR Chi^2 (228)	63.83		
Prob > Chi^2	0.0001		
Pseudo R^2	0.0818		
Log Likelihood	-358.2592		

Notes: *, **,* indicates significant at 1%, 5% and 10% levels respectively.**

Age of the household head was negatively associated with adoption of soil fertility management practices at 10% level of significance. This implies that older farmers were less likely to implement many strategies compared to younger ones. Factors associated with old age such as a shorter term planning horizon, and loss of energy, as well as being more risk averse could be leading to the negative effect of age on soil fertility management. This observation is similar to that of Bernier *et al*. (2015) who noted that age was negatively correlated with adoption of climate change adaptation strategies. The explanation was that older farmers were more risk averse and mostly less educated. Contrary, Challa & Tilahun (2014) noted that age of farmers positively influenced the probability of adoption of climate change related technologies because it is related to farming experience which improves skills for better farming.

The adoption of CSA practices was further influenced by size of farm owned by farmers. This was significant at 1 percent. Farmers who owned larger pieces of land had higher likelihood of adoption of soil fertility management. Land is a primary fixed input in agricultural production and having a larger piece provides an opportunity for farmers to experiment many different CSAs. A previous study by Deininger *et al*. (2008) reported that land size was strongly correlated with increased likelihood to invest in soil and water conservation activities, and that it more than doubles the predicted number of hours spent on each activity. Similarly, Menale (2010) reported that farm size had a positive association with adoption of many CSA strategies because it represents wealth or financial capital, which relaxes liquidity constraints in implementing the practices.

Notice of unpredictable temperature was positively associated with soil fertility management practices at 5% level of significance. This implies that rainfall received was variable and that during the raining season, there have been increased incidences of floods and during the dry season, there have been increased incidences of droughts.

Income was positively associated with improved crop and livestock breed and significant at 10 percent. This implies that small holders' farmers with sufficient income were engaged in improved crop and livestock breed of the CSAs. Income improves farm liquidity as it provides an alternative source of financing agricultural activities. The income could be used to purchase farm inputs and meet labor costs involved. Previous study by Muzari *et al*. (2012), postulated that income facilitates adoption of high yielding and resilient adaptation practices. They argued that income could finance production to meet labor bottlenecks, resulting from higher labor requirements that CSA demand.

Age of the household head was negatively associated with adoption of agroforestry management practices at 1% level of significance. This implies that older farmers were more likely to implement many strategies compared to younger ones. Education level had a positive and significant influence on adoption of CSA practices at 1% significance level. The results suggested that farmers with higher level of education had a higher likelihood of participating in agroforestry which requires a lot of knowledge and skills. Research carried out by Mlenga and Maseko (2015) working in Swaziland found that education level of the household head influenced adoption of conservation agriculture. The results showed that a household head with some form of education was three times more likely to adopt conservation agriculture compared to a household head without any education.

Access to extension service was significant at 1% and positively associated with adoption of agroforestry as a CSA practice. Extension agents play an important role in creating awareness and demonstration of agroforestry. Essentially, the more the contacts the more the knowledge acquired because sustainable farming requires a whole set of new skills, including observation, monitoring and risk assessment. Extension in the County is offered by One Acre Fund and other NGOs. These agencies have climate change mitigation measures attached to their services delivered. They inform farmers about the changing climatic conditions which enhances the chances of the farmers to adapt to climate change. Thus, exposure to such information increased the farmer's awareness and adaptation thereafter (PALWECO, 2012). Gido *et al*. (2015) found that extension services play a central role of providing support for institutional mechanisms designed to support the dissemination and diffusion of knowledge among farmers and demonstration of gains from new technologies. Akudugu *et al*. (2012) also argues that extension helps farmers understand the importance of modern technology and enhance the accuracy of implementation of the technology packages.

Gender of the household head was positive and significant at 1 percent showing that it is associated with CSA practices that involved water harvesting and management. The results revealed that male headed households had higher likelihood of water harvesting and management than female headed. This may be explained by the dominant culture that males still have exclusive rights to make farm decisions regarding both short term and long term adjustments in terms of water harvesting. Gbegeh & Akubuilo (2012) found similar results and reported that in many parts of Africa, women are often deprived of property rights due to social barriers. Consequently, they have fewer capabilities and resources than men in so far as land management is concerned. Ndamani & Watanabe (2016) also reported that women are less able to diversify income sources and adapt to climate change because of other domestic responsibilities and less control of financial resources.

4.3 Hypothesis Testing

The researcher performed a logistic regression analysis so as to test the relationship among independent variables (social factors, economic factors and institutional factors) on dependent variable (adoption of climate smart agricultural practices).

The first hypothesis (Ho_1) stated that Social factors such as age, education and sex have no statistically significant effect on adoption of climate smart agricultural practices among the small holder farmers. However findings showed that age ($\beta = -0.0112$, $P < 0.05$), had a negative and significant influence on soil fertility management. Age ($\beta = -0.0320$, $P < 0.05$) had a negative and significant influence on agroforestry, education ($\beta = 1.4675$, $P < 0.05$) has a positive influence on agroforestry. Sex of the household head ($\beta = 1.5776$, $P < 0.05$) had a positive and significant effect on water harvesting and management. Thus the hypothesis (Ho1) was rejected

The second hypothesis (Ho_2) stated that economic factors such land size, income have no statistically significant effect on adoption of climate smart agricultural practices among the small holder farmers. However findings showed that farm size ($\beta = -0.1905$, $P < 0.05$), had a negative and significant influence on soil fertility management. Income ($\beta = 1.4727$, $P < 0.05$) had a positive and significant influence on improved crop and livestock breed. Thus the hypothesis (Ho2) was rejected

The third hypothesis (Ho_3) stated that institutional factors have no statistically significant effect on adoption of climate smart agricultural practices among the small holder farmers. However findings showed that noticed unpredictable temperature ($\beta = 0.0010$, $P < 0.05$), had a positive and significant influence on soil fertility management. Extension services ($\beta = 1.5207$, $P < 0.05$) had a positive and significant influence on agroforestry. Thus the hypothesis (Ho3) was rejected

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of findings, conclusion, recommendations and areas for further studies. The findings are outlined in direct response to the specific objectives of the research. Also presented in this chapter are recommendations and areas for further research which arose during the conduct of the research and conclusion.

5.2 Summary of the Findings

The study unravelled that the climate smart agriculture practices used by the smallholder farmers were; combination of soil fertility management, improved crop and livestock breed, agro forestry and water harvesting and management practices. Study findings have also indicated that social factors have an influence on the adoption of climate smart agriculture.

Study findings have revealed that majority of the farmers own land with a few that have leased, and this is of utmost importance since overcoming the barriers of high opportunity costs to land helps smallholder farmers to improve their management systems (Beddington, 2011). Farmers with larger farms are less likely to adopt CSA especially soil fertility management because of the high cost involved in some practices. For small scale farmers it is possible for them to take risks of experiment with new technology. They can make use of intercropping techniques and rainwater harvesting technologies at small scale.

However, most of the farmers earn less than 5,000 monthly. For the household heads, most of them earn between Ksh2000 and Ksh5000 per month. It can be inferred that smallholder farmers have secure access to land though the output from the farm are at low levels. The underlying conditions favour the adoption of CSA since it offers a low-external-input agricultural strategy for the poorest and most vulnerable farming communities. Consistently, FAO & CARE, (2010) point out that, secure access to land, livestock and water resources are essential for investments in climate smart agriculture.

Finally, smallholder farmers have made use of climate smart agriculture practices such as using improved varieties, early planting, crop rotation, mulching, intercropping, crop rotation and the water harvesting. There is also combination of trees, crops and livestock to cope with the climate change. Consistently, a study by Po-Yi Liu (2013) revealed that the innovative climate-smart agricultural training has made it possible for the farmers to have the skills and techniques to make their agricultural activities part of the solution to the negative impacts of climate change.

Besides, (Reiter, 2009) noted that awareness among Virginia farmers on the benefits of low and no-tillage regimes resulted in an increase in acreage under conservation tillage increased among crops from 48.2% in 1989 to 67.6% in 2007. This assertion closely aligns with the study findings. Considering the foregoing prior literature, the socio-economic factors have a positive influence on adoption of CSA practices among the farmers. Generally, the study results are in tally with the extant literature.

The regression model results indicated that age of the household head was negatively associated with adoption of soil fertility management practices. The adoption of CSA practices was further influenced by size of farm owned by farmers. Notice of unpredictable temperature was positively associated with soil fertility management practices at 5% level of significance. This implies that rainfall received was variable and that during the raining season, there have been increased incidences of floods and during the dry season, there have been increased incidences of droughts. Income was positively associated with improved crop and livestock breed and significant at 10 percent. Age of the household head was negatively associated with adoption of agroforestry management. Education level had a positive and significant influence on adoption of CSA practices. Access to extension service was significant at 1% and positively associated with adoption of agroforestry as a CSA practice. Gender of the household head was positive and significant at 1 percent showing that it is associated with CSA practices that involved water harvesting and management.

5.3 Conclusion

From the results, social factors (age and sex) were found to significantly relate to adoption of climate smart agriculture. Specifically, most of the farmers are in the productive age bracket (34 to 41 years) with the minimum required educational level to adopt CSA. Besides, the ratio of male to female farmers is 5:4 meaning that both male and female farmers have decision-making power pertaining the adoption of CSA at the household level.

Economic factors are of essence in the adoption of CSA. Farm land size has been found to be significant and affects adoption of CSA. It has been revealed that increase in land size decreases the ability of the farmer to adopt soil fertility management whereas increase in income facilitates the adoption of CSA. Land ownership increases the likelihood that farmers adopt strategies that will capture the returns from their investment in the long run. More so, the small land sizes make the farmers to enhance farm intensification by using improved varieties. For small scale farmers, income is a limiting factor to adopt some of the CSA practices. However, with an increase in income the farmer increases the probability of adopting CSA practice of soil fertility Management. From the foregoing, economic factors play a role in the adoption of CSA.

On institutional factors, both access to extension service and noticing of unpredictable temperature change is significant in influencing adoption of CSA practices. It is evident that majority of the farmers have received and are aware of at least one of the CSA practices. This is through various extension service providers but majorly from NGOs. Most of the training that they have received has been mainly through workshops, field day and group trainings. For sustainability and synergies well-coordinated and collaborative approach is required by extension providers.

To sum up, smallholder farmers have adopted climate smart practices such as soil fertility management, improved crop and livestock breed, agro forestry and water harvesting and management practices. Despite this, there is still room for improvement regarding the intensity of use of CSA since smallholder farmers are yet to enjoy the fruits of drought and flood tolerant varieties that will meet the demands of the changing climate.

5.4 Recommendations

To improve the adoption CSA practices, farmers should be motivated to join and participate in farmer organizations so that they could share farming information. Further, farmers could also stand a chance to be linked conveniently with extension service providers and farm financing agents. This is based on the fact that income and access to extension services were critical in the adoption of CSA practices. Crucially, income improves farm liquidity which provides an alternative means of financing farm operations. Thus, the County and national government together with development partners should invest in important infrastructure like electricity and roads which could spur rural based economic activities making it easier for farmers to engage in income generating activities that will enable them to adopt CSA practices that require financial input such as improved livestock breeds and water harvesting practices. Economic factors have shown to contribute to the adoption of CSA.

Smallholder farmers should be encouraged to incorporate all CSAs as much as possible to have a higher effect on food security status. Also, farmers should be sensitized on the need to invest in productive farm assets to enable them absorb risks associated with climate change at the same time enhancing their ability to uptake important CSAs. The sensitization could be done in groups by extension service providers. Land fragmentation should also be discouraged through civic education and engagement in alternative income generating activities for farmers to benefit more from CSAs when practiced on relatively bigger portions of land.

On Institutional policies, the study has shown to contribute to influence adoption of CSA practices. As well, there is need for appropriate policies to be designed to provide adequate and effective basic knowledge and awareness to the smallholder farmers. Policies and strategies should place more emphasis on strengthening the existing agricultural extension service provision through providing incentives, training and building of synergy among partners. Also, considerable policy support and capacity enhancement is needed for climate smart agricultural practices including access to weather information adapted to farmers' needs.

The Ministry of Agriculture, Livestock and Fisheries at National and County level and Kenya Meteorological Services to upscale dissemination of climate information by packaging it into user friendly formats and using channels that are effective and accessible to small scale farmers.

5.5 Further Research Recommendations

A study might include factors influencing the acceptance of different CSA activities. The purpose of a study may also be a detailed profile, consideration of strength of use of the CSA activities and related programs adopted or planned for the Bungoma County. Future studies could also take into account measuring the vulnerability of smallholders to climate change and variability through various economic approaches to vulnerability assessment.

REFERENCES

Action Aid (2010) Climate Resilient Sustainable Agriculture (CRSA): Experiences from Action Aid and Its Partners. http://ag-transition.org/?initiative=climate-resilient-agriculture-experiences-from-action-aid-and-its-partners

Ajayi, S., Olajide, O., Uzowulu, G. I., Ebu, V.T. (2006). Predicting Individual Tree Heights in Gmelina arborea Plantation of Ukpon River Forest reserve, Cross River State, Nigeria. *Journal of Agriculture, Forestry and the Social Sciences.* 4(2): 107 – 118.

Akudugu, M. A., Guo, E., & Dadzie, S.K. (2012). Adoption of Modern Agricultural Production Technologies by Farm Households in Ghana: What Factors Influence their Decisions*? Journal of Biology, Agriculture and Healthcare*, 2(3): 2224-3208.

Aloyce, G. M., Gabagambi D. M. & Hella J. P. (2014). Assessment of operational aspects of the input supply chain under national agriculture input voucher scheme (NAIVS) in Tanzania, *Journal of Development and Agricultural Economics*, Vol. 6(3), pp. 94-104, March, 2014

Amin, A., Mubeen, M., Hammad, H., & Jatoi, W. (2015). Climate Smart Agriculture: an approach for sustainable food security. *Agricultural Research Communication*. 2015. 13-21.

Asenso-Okyere, K. and Davis, K. (2009). Knowledge and innovation for agricultural development, IFPRI Policy Brief 11. Retrieved in July 2011: http://www.ifpri.org/sites/default/files/publications/bp011.pdf

AU-NEPAD, (2010). *The AU-NEPAD Agriculture Climate Change Adaptation-Mitigation Framework*. CAADP, Pretoria, South Africa.

Ballard, G., Chamberlin, L., Elliott, M., Hickey, C., Jahncke, J., Reiter, M. & Warzybok, P. (2018). *Setting Four Conservation Priorities in a Changing World: Site Guide.*

Beddington, J., Asaduzzanman, M., Fernandez, A., Clark, M., Guillou, M., Jahn, M., Erda, L,, Mamo, T., Van Bo N, Nobre, C. A., Scholes, R., Sharma, R., Wakhungu, J. (2011). *Achieving Food Security in the Face of Climate Change: Summary for Policy Makers from the Commission on Sustainable Agriculture and Climate Change.* CGIAR Research Program on Climate Change, Agriculture and Food Security, Copenhagen.

Beddington, J. (2011). *Sir John Beddington on food production and climate change*. Video. Copenhagen, Denmark: CCAFS.

Beedell, J., & Rehman, T. (2000). Using Social-psychology Models to Understand Farmers' Conservation Behaviour. *J. Rural Stud.,* 16(1): 117–127.

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

Branca, G., McCarthy, N. Lipper, L. & Jolejole, M. C. (2011). "Climate Smart Agriculture: A Synthesis of Empirical Evidence of Food Security and Mitigation Benefits from Improved Cropland Management." FAO Working paper No. LAC3/10. Rome.

Bryman, A. (2008). *Social research methods* (3rd ed.). New York: Oxford University Press Inc.

Buckle, C. (2020). Touching, scrolling and swooping: Performing and representing migrant stories through geospatial technologies. *Geoforum*, 111, 83-93.

Carsrud, A., & Brännback, M. (2011). Entrepreneurial motivations: what do we still need to know? *Journal of Small Business Management*, 49(1), 9-26.

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.

Chambers, D. W., & Gillespie, R. (2015). Locality in the history of science: Colonial science, technoscience, and indigenous knowledge. *Osiris*, 15, 221-240.

Chandra, A., & McNamara, K. E. (2018). Climate-Smart Agriculture in Southeast Asia: Lessons from Community-Based Adaptation Programs in the Philippines and Timor-Leste. In *Resilience* (pp. 165-179). Elsevier.

Crouch, L., Lapidus, D., Beach, R., Birur, D., Moussavi, M., and Turner, E. (2017). Developing Climate-Smart Agriculture Policies: The Role of Economic Modeling. RTI Press Publication No. OP-0034-1701. Research Triangle Park, NC: RTI Press. http://doi.org/10.3768/rtipress.2017.op.0034.1701.

Delgado, C. L. (1995). Africa's Changing Agricultural Development Strategies: Past and Present Paradigms as a Guide to the Future, Food, Agriculture and the Environment Discussion Paper 3. IFPRI.

Deressa, T., R. M. Hassan, T. Alemu, M. Yesuf & Ringler, C. 2010. An Analysis of Determinants of Farmer's Choice of Adaptation Methods and Perceptions. International Food Policy Research Institute (IFPRI), Washington, D.C., pp: 2.

Deininger, K., Ali, D.A. & Alemu, T. (2009). Impacts of Land Certification on Tenure Security, Investment, and Land Markets: Evidence from Ethiopia. Environment for Development Discussion Paper Series EfD DP 09-11.

Dodman, D., & Mitlin, D. (2013). Challenges for community-based adaptation: discovering the potential for transformation. *Journal of International Development*, 25(5), 640-659.

Dzanku, F., & Sarpong, D. (2011). Agricultural Diversification, Food Self Sufficiency and Food Security in Ghana-Role of Infrastructure and Institutions. (G. E. Djurfeldt, Ed.) *African small holders; Food crops, Markets and Policy*. CABI, Wallingford, UK, 189-213.

El-Fattal, L. (2012). Climate-Smart Agriculture Is 'Smarter' When Informed by a Gender Perspective. WOCAN Policy Brief. Smallholder Farmers Organizing for Change in Agriculture & Natural Resource Management, Bangkok, Thailand. http://wocan.org/sites/drupal.wocan.org/files/FINAL%20120919_WOC_Policy_Brief_3_vol1.pdf

FAO & CARE. (2010). *Climate-smart agriculture: Policies, practices and financing for food security, adaptation and mitigation.* Rome: Author

FAO, IFAD., & UNICEF. (2020). WFP and WHO. The state of food security and nutrition in the world 2020. Transforming food systems for affordable health diets. Rome, FAO. 2020.

Food and Agriculture Organization. (2010). Climate Smart Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation. Rome, Italy.

Food and Agriculture Organization. (2013). Multiple dimensions of food security. The state of food insecurity in the world. Rome, Italy.

Fishbein, M. (1963). An investigation of the relationships between beliefs about an object and the attitude toward that object. *Human Relations*, 16, 233– 240.

Fishbein, M., & Ajzen, I. (2010). *Predicting and changing behavior: The reasoned action approach*. New York, NY: Psychology Press.

Gbegeh, B. D. & Akubuilo, C. J. (2012). Socioeconomic determinants of adoption of yam minisett by farmers in Rivers state, Nigeria. *Wudpecker Journal of Agricultural Research.* 2(1): 033-038.

Gido, E. O., Sibiko, K. W., Ayuya, O. I. & Mwangi, J. K. (2015). Demand for Agricultural Extension Services Among Small-Scale Maize Farmers: Micro-Level. *The Journal of Agricultural Education and Extension*, 21 (2): 177–192.

Giller, K. E., Witter, E., Corbeels, M., & Tittonell, P. (2009). Conservation agriculture and smallholder farming in Africa: The heretics 'view. *Field Crops Research,* 114: 23-34.

GoK, (2005). *Bungoma District Strategic Plan 2005-2010*. Government of Kenya Printing Press, Kenya.

GOK. (2010). *National Climate Change Response Strategy.* Ministry of Environment and Mineral Resources. Nairobi.

Greaves, M., Zibarras, L. D., & Stride, C. (2013). Using the theory of planned behavior to explore environmental behavioral intentions in the workplace. *Journal of Environmental Psychology,* 34, 109-120.

Hassan, R., & Nhemachena, C. (2008). Determinants of African farmer's strategies for adapting to climate change: Multinomial choice analysis. *Afr. J. Agric. Res.*, 2(1): 83-104.

Ibrahim, I. A. (2012). *Investigation of rainwater harvesting techniques in Yatta District, Kenya* (Doctoral dissertation, Master thesis, Nairobi: Jomo Kenyatta University of Agriculture And Technology).

IIED. (2011). "Mainstreaming Environment and Climate Change", Agriculture. Retrieved on July 2011: http://pubs.iied.org/pdfs/G03098.pdf

IPCC. (2007). Climate Change 2007: Impacts, Adaptation and Vulnerability. In Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Intergovernmental Panel on Climate Change

IPCC. (2014). Climate change 2014: Impacts Adaptation and Vulnerability, Part B Regional Aspects, Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, New York

Jones, L., Lundi, E., & Levine, S. (2010). Towards a Characterization of Adaptive Capacity: A Framework for Analyzing Adaptive Capacity at the Local Level. Overseas Development Institute, UK.

Kabubo-Mariara, J. & Kabara, M. (2015). Climate Change and Food Security in Kenya. Environment for Development. Discussion Paper Series No. 15-05.

Karami, E. & Mansoorabadi, A. (2008). Sustainable Agricultural Attitudes and Behaviors: A Gender Analysis of Iranian Farmers. Environ. *Dev. Sustain.*, 10(6): 883-898.

Kaumbutho, P., & Kienzle, J. (2007). Conservation agriculture as practised in Kenya: two case studies. Nairobi, Kenya: African Conservation Tillage Network (ACT); Centre de Coopération Internationale de Recherche Agronomique pour le Développement (CIRAD); Food and Agriculture Organization of the United Nations (FAO).

Kiptot E, Franzel S, Hebinck, P. G. M., Richards, P. (2006). Sharing seed and knowledge: farmer to farmer dissemination of agroforestry technologies in Western Kenya. *Agroforestry Systems* 68, 167 – 179

KNBS (2009). *Kenya Population and Housing Highlights*. Government of Kenya Printing Press, Kenya

Kolvereid, L. & Isaksen, E. (2006). New Business Start-Up and Subsequent Entry into Self Employment. *J. Bus. Venturing,* 21(6): 866–885

Kotir, J. H. (2011). Climate change and variability in Sub-Saharan Africa: a review of current and future trends and impacts on agriculture and food security. Environment, *Development and Sustainability,* 13(3), 587-605.

Lahiff, E. (2001).Land Reform in South Africa: is it Meeting the Challenge Policy Brief No. 1, Programme for Land and Agrarian Studies, University of the Western Cape, Bellville.

Lipper, L., Thornton, P., Campbell, B. M., Baedeker, T., Braimoh, A., Bwalya, M., ... & Hottle, R. (2014). Climate-smart agriculture for food security. *Nature climate change*, 4(12), 1068.

Lukano, L. S. (2013). Bungoma County Integrated Development Plan, 2013–2017, Ministry of Planning and County Development, County Government of Bungoma.

MacLeod, N. D.; McDonald, C. K. & Van Oudtshoorn, F. P. (2008). “Challenges for Emerging Livestock Farmers in Limpopo Province, South Africa”, *African Journal of Range and Forage Science* Vol. 25 (2): 71-77.

Maddala, G. S., (1983). *Limited Dependent and Qualitative Variables in Econometrics. Econometric Society Monographs*. Cambridge University Press, Cambridge.

Mapfumo, P., Adjei-Nsiah, S., Mtambanengwe, F., Chikowo, R., & Giller, K. E. (2013). Participatory action research (PAR) as an entry point for supporting climate change adaptation by smallholder farmers in Africa. *Environmental Development*, 5, 6-22.

Marenya, P. P., & Barrett, C. B. (2007). Household-level determinants of adoption of improved natural resources management practices among smallholder farmers in western Kenya. *Food policy*, 32(4), 515-536.

Menale. K., Zikhali, P., Pender, J. & Kohlin, G. 2010. The Economics of Sustainable Land Management Practices in the Ethiopian Highlands. *Journal of Agricultural Economics*, 61: 605-627.

McCarthy, N., & Lipper, L., Branca G. (2011). Climate-smart agriculture: smallholder adoption and implications for climate change adaptation and mitigation. FAO, MICCA Series No. 4. Rome, FAO.

Mccormick, M., Lawyer, K., Berlin, M., Swan, C., Paterson, K., Bielefeldt, A., & Wiggins, J. (2010). Evaluation of sustainable engineering education via service learning and community service efforts. In American Society for Engineering Education. American Society for Engineering Education.

Meridian Institute. (2011). “Guidelines for REDD+ Reference Levels: Principles and Recommendations.” Prepared for the Government of Norway, by Arild Angelsen, Doug Boucher, Sandra Brown, Valérie Merckx, Charlotte Streck, and Daniel Zarin. Available at: www.REDD-OAR.org.

Meridian Institute. (2011). “Modalities for REDD+ Reference Levels: Technical and Procedural Issues.” Prepared for the Government of Norway, by Arild Angelsen, Doug Boucher, Sandra Brown, Valérie Merckx, Charlotte Streck, and Daniel Zarin. Available at: http://www.REDD-OAR.org.

Mlenga, D. H., & Maseko, S. (2015). Factors influencing adoption of conservation agriculture: A case for increasing resilience to climate change and variability in Swaziland. *Journal of Environment and Earth Science,* 5(22), 16-25.

Mugwe, J., Mugendi, D., Mucheru-Muna, M., Merchx, R., Chianu, J., Vanlauwe. B. (2009) Determinants of the Decision to Adopt Integrated Soil Fertility Management Practices By Small Holder Farmers in the Central Highlands of Kenya. *Expl Agricu.* Volume 45, pp 61-75 Cambridge University Press

Mutinda, S., Mayieko, S., Peterson, O., & Wanyama, K. (2010). Climate Change Vulnerability and Adaptation Preparedness in Kenya. Heinrich Böll Stiftung, East and Horn of Africa.

Mutsotso, B., Muya, E., & Roimen, H. (2011). Farmers Knowledge, Attitudes and Practices (KAP) in Embu and Taita:Bencmark sites before and after below-Ground Biodiversity Project Interventions. *Tropical and Subtropical Agro ecosystems*,13 (2011), 51-58.

Muzari, W., Gatsi, W. & Muvhunzi, S. (2012). The Impacts of Technology Adoption on Smallholder Agricultural Productivity in Sub-Saharan Africa. *Journal of Sustainable Development*, 5(8): 1913-9063.

Nassiuma, D.K., & Mwangi, J.W. (2004). *Statistical Methods For information analysis. An Introduction.* Egerton University Press. Kenya

Nelson, G. C., Rosegrant, M. W., Palazzo, A., Gray, I., Ingersoll, C., Robertson, R. Tokgoz S., Zhu T., Sulser, T, Ringler, C., Msangi, S., You, L. (2010). Food Security, Farming, and Climate Change to 2050: Scenarios, Results, Policy Options. IFPRI, Washington, DC.

Neufeldt, H., Kristjanson, P., Thorlakson, T., Gassner A, Norton-Griffiths M, Place F, Langford, K, (2011). ICRAF Policy Brief No 12: Making climate-smart agriculture work for the poor. World Agroforestry Centre, Nairobi, Kenya.

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.

Norton-Griffith, M. (2008). Revitalizing African agriculture. PERC Reports 26 (3), 32-36.

Oberhauser, A. M.; Pratt, A. (2004). "Women's Collective Economic Strategies and Transformation in Rural South Africa", *Gender, Place and Culture*. 11(2): 209-228.

Ogada, M., Mwambu, G., & Muchai, D. (2014). Farm Technology Adoption in Kenya: a Simultaneous Estimation of Inorganic Fertiliser and Improved Variety Adoption Decisions. *Agricultural and Food Economics*, 2 (1), 1-18.

PALWECO (2012). Progress Report March – June 2012, PALWECO Programme Support Unit (PSU), Butete plaza, Busia.

Popescu, A. (2020). Oilseeds Crops: Sunflower, Rape And Soybean Cultivated Surface And Production In Romania In The Period 2010-2019 And Forecast For 2020-2024 Horizon. Scientific Papers: Management, Economic Engineering in Agriculture & Rural Development, 20(3).

Po-Yi L. (2013). Reducing Women's Poverty through Climate-Smart Agricultural Community Development in The Gambia. *Business Fights Poverty*. On June 6.

Rao, K. P., Ndegwa, W. G., Kizito, K., & Oyoo, A. (2011). Climate Variability and Change: Farmer Perceptions and Understanding of Intra-Seasonal Variability in Rainfall and Associated Risk in Semi-Arid Kenya. *Experimental Agriculture*, 47(2), 267–291.

Sahman, K. M., & Zhang, D. (2018). Effects of fertilizer broadcasting on the excessive use of inorganic fertilizers and environmental sustainability. *Sustainability,* 10(3), 759.

Salami, A., Kamara, A. B., & Brixiova, Z. (2010). Smallholder Agriculture in East Africa: Trends, Constraints and Opportunities, Working Papers Series No. 105 African Development Bank, Tunis, Tunisia

Sharma, J., & Ravindranath, N. H. (2019). Applying IPCC 2014 framework for hazard-specific vulnerability assessment under climate change. *Environmental Research Communications*, 1(5), 051004.

Silva, J. V., & Ramisch, J. J. (2019). Whose gap counts? The role of yield gap analysis within a development-oriented agronomy. *Experimental Agriculture*, 55(2), 311-338.

Thorlakson, T, (2011). Reducing subsistence farmers' vulnerability to climate change: the potential contributions of agroforestry in western Kenya. ICRAF Occasional Paper 16. World Agroforestry Centre, Nairobi.

UNDPI (2015). The millennium development goals report 2015.

United States Agency for International Development (USAID). 2003. Congressional Budget

Von Braun, J., & Díaz-Bonilla, E. (2008). Globalization of agriculture and food: causes, consequences and policy implications. *Globalization of food and agriculture and the poor*, 1, 1-46.

Wayo S., Monty, J., Emmanuel, T., & Gbadebo O. (2011). *Input Market Initiatives that Support Innovation Systems in Africa*. Accra, Ghana.

Wilkes A, (2011). Three Rivers Grassland Carbon Sequestration Project. Project Report. Mimeo.

Wollenberg, E. K., Campbell, B. M., Holmgren, P., Seymour, F., Sibanda, L. M., & Braun, J. V. (2011). *Actions needed to halt deforestation and promote climate-smart agriculture.*

World Bank. (2011). Climate-smart agriculture: increased productivity and food security, enhancing resilience and reduced carbon emissions for sustainable development, opportunities and challenges for a converging agenda: country examples. The World Bank. Washington, D.C.

APPENDICES

Appendix 1: Hausman Tests of Independence of IR Relevant Alternatives Assumption

H o: Odds are independent of other alternatives

Omitted	**Chi^2**	**df**	**P Chi ^{2}**	**Evidence**
No CSA practices	-108.808	22	1.000	For Ho
Soil fertility management	4.760	23	1.000	For Ho
Improved crop and livestock breeds	-109.6222	15	1.000	For Ho
Agro forestry	-105.375	16	1.000	For Ho
Water harvesting and management	-104.596	15	1.000	For Ho

Appendix 2: Questionnaire

My name is Joyce Wangoi Njuguna a post-graduate student at Moi University, Eldoret Kenya (ADM No: SBE/PGA/04/2012), pursuing studies in Masters of Science degree in Agricultural Economics and Resource Management. The purpose of this questionnaire is to gather information on: factors that affect adoption of CSA practices used by smallholder farmers in Bungoma County, Kenya. The information collected will be treated with utmost confidentiality.

NOTE:

i. This is not a test and only sincere and honest answers are expected

ii. Do not write your name or admission number

iii. Put a tick on the appropriate response [√], or write your response in the space provided.

Section A: Respondent Social and Demographic Characteristics

A1.	Gender Information:		01 Male	( )
			02 Female	( )
A2.	Age Range of respondent:	01	18-25	( )
		02	26 -33	( )
		03	34 – 41	( )
		04	42 – 49	( )
		05	Above 49	( )
A3.	Length of residence in Community			
	01		< 1 year	( )
	02		1- 5 years	( )
	03		6-10 year	( )
	04		11-15 years	( )
	05		16- 20years	(
	06		> 20 years	( )
A4. No. of persons in		01	1-3 persons	( )
		02	4-6 persons	( )
		03	7-10 persons	( )
		04	above 10 persons	( )
A5. No. of dependants:		01	1-3 persons	( )
		02	4-6 persons	( )
		03	Above 6 persons	( )
A6. Education level of respondent:		01	Primary	( )

	02	Secondary	( )
	03	Technical/Vocational	( )
	04	Tertiary (college, university)	( )
	05	Other…………………………….	

SECTION B. ECONOMIC CHARACTERISTICS

B1. Land Ownership

	Size in Acres	Rental Price (Ksh.) Per acre	Approximate Value (Ksh.) Per acre
1. Own			
2.Rented			
3. Leased			
4.Others (specify)			

B2: Category of Land Size in Acres owned by SHTs

Land Size (acres)	
Below 1 acres	
1 – 2	
3 – 4	
5 and above	

B3: Land Use

Land use, (specify	**Size in Acres**	**Years in Same use**	**Rank : 1 for major**
Livestock size in acres			
Livestock – year in same use			
Livestock – rank			
Crops –size acres			
Crops – year in same use			

Crops –rank			
Homestead –size in acres			
Homestead – year in same use			
Homestead –rank			
Forest –size in acres			
Forest –year in same use			
Forest - rank			

B4: Sources of income (Jan- Dec 2013)

B4a. Rank from the highest to the lowest with the highest being 1 the main source of income.

Livestock and livestock products

Crop production

Home industries

Agro forestry products

Off-farm employment

B4b.Do you have any off-farm employment?

1 = Yes [ ] 2 = No [ ]

B4c. If yes, what is the range of income per month? ....

(1) =Less than 5,000.00 (2) = 5,000 – 10,000.00 (3) = above 10,000.00

B4d. What is the average income of the head of the farm family per month?

Less than Ksh 2,000.00 [ ] Ksh. 2,000.00 – 5,000. 00 [ ] Ksh. 5,000.00 – 10,000.00 [ ] Ksh. 10,000.00 – 20,000.00 [ ] More than Ksh. 20,000.00 [ ]

How much income do you expect to get from you farm end month

SECTION C. INSTITUTIONAL FACTORS

C1. Do you have any knowledge on CSA?

Yes [ ] 2.No [ ]

C1.a If yes, Where did you get the knowledge from? (Tick Appropriately)

Source	Tick Appropriately
School and other social gatherings	
Seminars and group trainings	
Extension Officers	
Friends	
Internet & other social media platforms	
Radio	

C2. Of the following CSA practices, which ones are you aware of?

CSA Practice	Tick Appropriately	List the practices
Soil fertility management		
Improved crop and livestock breeds		
Agro -forestry		
Water harvesting and management		

C3. Name adaptation strategies that are being used to deal with climate change on your farm?

Crop & Livestock Breeds	Soil Fertility	Water harvesting techniques
1.	1.	1.
2.	2.	2.
3.	3.	3.
4.	4.	4.
5.	5.	5.

C4. For the last one year have you attended any training on climate change adaptation?

1. Yes [ ] 2.No [ ]

C5. If yes, which of the following

1. Workshop/seminar [ ] 2. Field day [ ] 3. Group training [ ]

C6. Who normally attend such training? (Tick)

1. Head [ ] 2. Spouse [ ] 3. Daughter/son [ ] 4. Worker [ ]

C7. Did you seek advice on climate change adaptation?

1. Yes [ ] 2. No [ ]

C8. Do extension officers give you information on climate smart agriculture?

1. Yes [ ] 2. No [ ]

C9. Who is the main service Provider of CSA practices?

1=Public extension agent 2= NGO 3=Neighbour/Farmer 4= Private extension 5=CBO 6=radio/Television 7=Mobile phone 8=Farmer organization/Cooperative 9= Private Engineer

C10. For the last one year have you been visited by:

a) Public extension agent [ ] 1. Yes 2. No

b) NGO [ ] 1. Yes 2. No

c) Neighbour/Farmer [ ] 1. Yes 2. No

d) Private extension [ ] 1. Yes 2. No

e) CBO [ ] 1. Yes 2. No

f) Farmer organization/Cooperative [ ] 1. Yes 2. No

C11. Do you belong to any group in your area?

1. Yes [ ] 2. No [ ]

C12 If yes fills the details in the table

Group Type	Year started	Group activities

Group types: 1=Self Help Group 2= Welfare group 3=Cooperative Society 4= Farmers group

5. Others (Specify)________________________________

Group activities: 1=Farming 2=Business 3=Merry go rounds 4=Advocacy 5= other (specify)____

SECTION D: CLIMATE CHANGE.

D1. Have you noticed temperature changes in your region in the last 3 years?

Yes 2. No

D2. Kindly use the options below to answer the following Questions according to your level of agreement or disagreement:

1–Strongly Agree, 2–Somewhat Agree, 3–I Don't Know 4–Somewhat Disagree, 5–Strongly Disagree

	Issue	Select
A	Human activities in the area are causing the environment to change	
B	Climate is changing over time	
C	Temperature is increasingly rising	
D	Rainfall amount is decreasing every year	
E	Rainfall received is variable	
F	The weather is becoming drier every year.	
G	The yearly rains are not supporting crop production as before	
H	Crop diseases and pest infestation because of Climate change	
I	Climate change has affected food production	
J	Climate change has led to increased cost of food	
K	Decreased vegetation due climate change.	
L	Fuel wood scarcity is being experience	
M	Rural-urban migration because of Climate change	
N	Decline of forest cover and resources	
O	Change of livelihood system because of climate change	
P	During the raining season, there have been increased incidences of floods	
Q	During the dry season, there have been increased incidences of droughts	
S	There is serious campaigns and awareness on climate Change	

D3) Who are the people seriously affected by climate change?

1. The poor 2. The rich

D4) The threat of climate change is more on;

1. Health [ ] 2. Food production [ ] 3. Fuel wood availability [ ]

4. Businesses [ ] 5. Prevention of disasters [ ]

D5. What are the strategies to adapting to climate change?

(Ranking 1 to 5 with 1 being the highest)   TICK

	Yes	No	Rank
soil fertility			
Improved crop and livestock			
Agro forestry			
Water harvesting and management			
None f. No adaptation method used			
D6. Hindrances to adaption to climate change			
A. Lack of improved seeds/breeds			
b. Lack of access to water for irrigation farming			
c. Lack of current knowledge on adaptation methods			
d. Lack of information on weather incidence			
e. Lack of money to acquire modern techniques			
f. There is no hindrance to adaptation			

D7: List the challenges that you have been facing when adapting to climate change?

....

D8: How have you been dealing with challenges named above?

…………………………………………………………………………………………

D9: What do you recommend to be done that will enhance the fight towards climate change

…………………………………………………………………………………………

Appendix 3: Map of Study Area

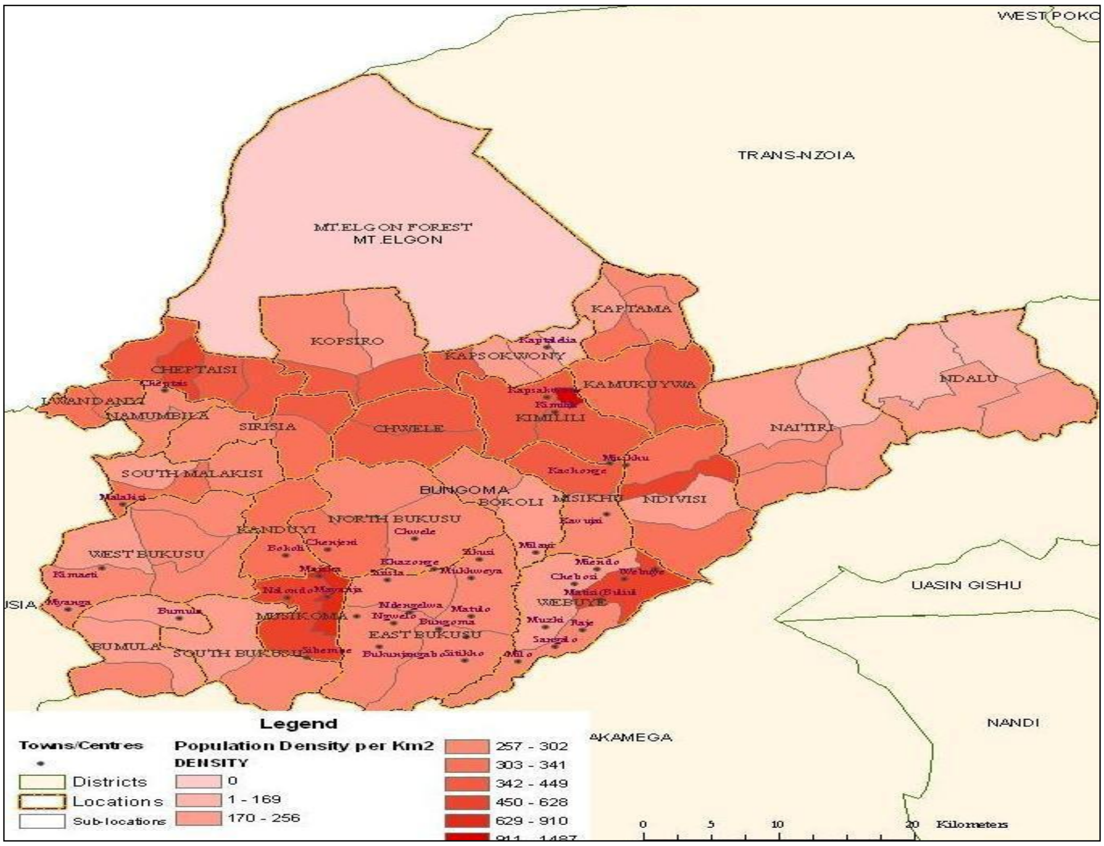

Figure 11: Map of Bungoma County

Source: GOK, 2005