EVALUATION OF CLIMATE CHANGE ADAPTATION STRATEGIES AND THEIR EFFECT ON FOOD PRODUCTION AMONG SMALLHOLDER FARMERS IN BUNGOMA COUNTY, KENYA

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A Thesis Submitted to the Graduate School in Partial Fulfilment for the Requirements of the Award of Master of Science Degree in Agricultural Economics of Egerton University

EGERTON UNIVERSITY

MAY, 2013

DECLARATION AND APPROVAL

DECLARATION

I hereby declare that this is my original work and has not been presented in this or any other university for the award of any degree.

Signature……. Date……

Oloo George Idi

KM15/2469/09

APPROVAL

This work has been prepared and presented to the graduate school for examination with our approval as University supervisors.

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DEDICATION

I dedicate this work to my spouse Damaris, son Alpha and brother Joe for their sincere support, and to all smallholder farmers in Bungoma County for their cooperation in providing information.

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ABSTRACT

Climate change exacerbates the already daunting challenge facing the agricultural sector, and this is particularly the case in developing countries. There are roughly 800 million food insecure people in the world today, each having this status because food is unavailable, unaffordable or they are too unhealthy to make use of it or some combination of the three. Innovations in agriculture will even be more vital in the context of climate change as they allow farmers to adapt efficiently to the changing climate. Assessing the potential effect of climate change on food production requires understanding the underlying determinants of climate change adaptation strategies and how they have affected smallholder farming. This study done in Bungoma County, undertook to evaluate climate change adaptation strategies and their effect on food production. The theories of utility, stated and revealed preference were used in the study. Random sampling method was used to select a sample of 150 smallholder farmers. Structured questionnaires and Participatory Rural Appraisal approach were the techniques used to collect data. The method of data analysis was both qualitative and quantitative where descriptive statistics was used to analyse the first two objectives which were to identify indigenous and emerging climate change strategies in the study area. Multinomial Logit Model was used to analyse the last two objectives of evaluating socio – economic and institutional factors influencing choice of climate change adaptation strategies.The study identified various indigenous and emerging adaptation strategies and evaluated socio-economic and institutional factors influencing the choice of these strategies. Mulching and soil fertility management were the most common indigenous and emerging strategies respectively. Quality extension services, credit facilities and access to information were vital in facilitating adaptation of better and affordable climate change coping strategies which enhances small holder's food production. Unpredictable rainfall pattern and high temperatures were found to have adversely affected food production and rural livelihoods. Adaptations outside of agriculture are also important for livelihood diversification and increasing resilience to climate variability in study area. Government, research institutions and stakeholder need to provide climate change information to farmers through training and extension services. Research, trainings and extension on climate change issues should be provided by both the public and private sectors as they are crucial in ensuring farmers adapt to climate change. Investments in infrastructure such as roads and irrigation systems, affordable credit schemes, and climate information systems would help create the enabling conditions for adaptation to climate change.

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ACRONYMS AND ABBREVIATIONS

AMREF	-	The African Medical and Research Foundation
CAPro	-	Climate Change Adaptation Project
CCAS	-	Climate Change Adaptation Strategy
CCCS	-	Climate Change Coping Strategies
CEEPA	-	Centre for Environmental Economics and Policy in Africa
CIMMYT	-	International Maize and Wheat Improvement Centre
CO_2	-	Carbon Dioxide
DDP	-	District Development Plan
DFID	-	Department for International Development
FAO	-	Food and Agriculture Organization of United Nations
GDP	-	Gross Domestic Product
GHG	-	Green House Gases
HIV/Aids	-	Human Immunodeficiency Virus
IP	-	Intellectual Property
IPCC	-	Intergovernmental Panel on Climate Change
IWMI	-	International Water Management Institute
MNL	-	Multinomial Logit Model
NGO	-	Non - Governmental Organization
PDA	-	Provincial Director of Agriculture
PRA	-	Participatory Rural Approach
SPSS	-	Statistical Package for Social Science

CHAPTER ONE
INTRODUCTION

1.1 Background Information

Climate change has emerged as one of the defining scientific, political and socioeconomic issues of the twenty-first century. Due to the enormity of likely repercussions of a changing climate on human and natural systems, it has become a matter that man need to understand and respond to. Due to of its complexity climate change, has attracted diverse efforts covering the full spectrum of scientific, economic, social, and political disciplines. Anita *et al.* (2010) argues that the major aim in this climate change debate is to identify options for reducing the extent and effects of future climate change. Of great importance is the need to reduce the effects of climate change on agriculture as Kurukulasuriya *et al.* (2003) have explained, climate change can affect agriculture in three different ways. First, changes in temperature and precipitation can directly affect crop production and can even alter the distribution of agro-ecological zones. Second, runoff or water availability is critical in determining the impact of climate change on crop production. Lastly, agricultural losses can result from climate variability and the increased frequency of changes in temperatures and precipitation (including droughts and floods). Through these effects, climate change can lead to erosion of the developments that people have in the past made in response effects of climate change on agriculture. Agarwal *et al.* (1997) note that climate change has resulted in some loses in biodiversity of domesticated crops as well as of dry land management and water harvesting techniques. Yet, in times of disaster and climate change people's defence lie in diversity of cultivated crops and their varieties of wild plant. Other defence mechanisms are migration, irrigation, water conservation techniques and reclamation.

Combined, all these factors imply that climate change has the potential of enhancing the problems of food insecurity, with important implications on availability, accessibility and utilization of food items. The negative potential effects of climate change suggest the importance of integrating climate change adaptation strategies to agricultural policies. It is important to promote strategies which maintain or increase the resilience of farming systems. Effective integration of adaptation and mitigation may result in lower overall cost of food production. Because some climate impacts are immediate and may affect the financial viability of an agricultural producer in the short run, in contrast with the long term impact that mitigation addresses, adaptation decisions are likely to take precedence over mitigation decisions (Rowenzweig *et al.*, 2007).

1.1.1 Adaptation to Climate Change

Inter-Governmental Panel of Climate Change, IPCC (2001) describes adaptation to climate change as the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Common adaptation strategies in agriculture include use of new crop varieties and livestock breeds that are better suited to current climatic conditions. Kurukulasuriya *et al.* (2008) outlines other strategies as irrigation, crop diversification, adoption of mixed crop and livestock farming systems and changing planting dates.

Climate change adaptation strategies are characterized by adjustment in ecological, social or economic systems in response to observed or expected changes in climatic stimuli and their effects and impacts in order to alleviate adverse impacts of change or take advantage of new opportunities. Adaptation can therefore involve building adaptive capacity, thereby increasing the ability of individuals, groups, or organizations to adapt to changes and implementing adaptations decisions, that is, transforming that capacity into actions. Hence adaptations strategies are continuous stream of activities, actions, decisions and attitudes that informs decisions about all aspects of life, and that reflect existing social norms and processes. Anita *et al.* (2010) points out that some adaptations occurs without explicit recognition of changing risk, while other adaptations incorporate specific climate information and decisions. Since unintentional adaptation has the capacity to reduce the effectiveness of purposeful adaptation, the integration of adaptation actions and policies across sectors remain a key challenge to achieve effective adaptation in practice.

Studies indicate that Africa's agriculture is negatively affected by climate change as argued by Pearce *et al*. (1996). The World Bank (2008) also notes that Sub-Saharan Africa is currently the most food-insecure region in the world. Climate change could aggravate the situation further unless adequate measures are put in place. For smallholder farmers in Kenya, environmental and social consequences of climate change especially put their livelihoods at risk. In the recent past in Bungoma County, as described in Provincial Director of Agriculture, PDA (2010) farmers have tried to use indigenous knowledge to adapt to the climatic changes and the adaptation strategies that are in place have not shown meaningful improvement and smallholder farmers continue to get less and less yields each year.

1.2 Statement of the Problem

Kenyan economy largely depends on agriculture and like other parts of the world has been experiencing pronounced climatic changes since 1990. Since Bungoma County's agriculture is mostly rain fed, the pattern of food production has been declining and rapidly tending towards food insecurity as explained in PDA, (2010) report. Climate change and food insecurity have negatively affected livelihood of smallholder farmers in the area. However, farmers in the County have adapted to strategies to counter the effects of changing climatic patterns. However, there has been little research done on evaluation of the climate change adaptation strategies and their effect on food production in Kenya in general and Bungoma County in particular. The issues of climate change and food security need to be addressed and documented.

1.3 Objectives

1.3.1 General Objective

To contribute towards increased food production among smallholder farmers in Bungoma County by evaluating indigenous and emerging climate change adaptation strategies with a view of selecting the best mix.

1.3.2 Specific Objectives

1) To identify indigenous (traditional) climate change coping strategies currently in use among smallholder farmers in the Bungoma County.
2) To identify and evaluate climate change adaptation strategies which have emerged among smallholder farmers in Bungoma County since 1990.
3) To evaluate socio-economic factors influencing the choice of climate change adaptation strategies by smallholder farmers.
4) To evaluate institutional factors influencing the choice of climate change adaptation strategies by smallholder farmers.

1.4. Research Questions.

1) What are the indigenous climate change adaptation strategies currently in use by smallholder farmers in Bungoma County?
2) What are the various emerging climate change adaptation strategies (after 1990) in use by smallholder farmers in Bungoma County?

3) What socioeconomic factors influence the choice of climate change adaptation strategies by smallholder farmers?
4) What institutional factors influence the choice of climate change adaptation strategies by smallholder farmers?

1.5 Justification of the Study

The performance of agricultural sector is determined by efficiency of crop and livestock production which depends on a large number of factors. Most important is the country's endowment of soils and climate resource. The declining agricultural productivity in Kenya is worrisome and a real challenge for a government with a population of approximately 40 million to feed. Worse still is the expected adverse impact of global warming on agriculture in future. Bungoma County has been rich in crop and livestock production but the yields have been declining from 1990s as explained in PDA (2010). Against this background of limited arable land, predicted adverse climate conditions and declining agricultural productivity, the biggest challenge facing Bungoma County is how to intensify food production so that output can keep pace with rapid population growth without a large increase in land devoted to food production.

A better understanding of indigenous and emerging adaptation strategies 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 soils in agricultural productivity, there is a dearth of literature on the evaluation of climate change adaptation strategies in Bungoma County. In addition, adaptive mechanisms smallholder farmers use to circumvent the welfare impact of climate change have not been adequately studied in study area. One of the ways of dealing with declining productivity of agriculture in the county is to identify and evaluate indigenous and emerging climate change adaptation strategies. After evaluation, the best combination of strategies can be selected and the information passed to the farmer and extension officers through trainings. The study will address these research gaps.

1.6 Scope and Limitation of the Study

The study covered Bungoma County area in Western Kenya and targeted all smallholder farmers. The study evaluated indigenous and emerging climate change adaptation strategies and their effect on food production. Climate change adaptation strategies were evaluated so as to gauge their impact on food production in the study area. It also examined socio-economic and institutional factors influencing adaptation of indigenous and

emerging climate change strategies. The study did not dwell on mitigation strategies as they require heavy investments thus beyond control of smallholder farmer. The study mainly used recall method from farmers which may have been subjective.

1.7 Operational 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: Longer-term (beyond a single season) strategies that are needed for people to respond to a new set of evolving climate conditions that they have not previously experienced.

Climate change: Any change in parameters used to describe climate (means and/or variability) over time, whether due to natural variability or as a result of human activities.

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 4 Hectares of land or less.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

Provision of food to sustain the growing world population is one of the key challenges for mankind. According to a FAO (2002) study, about 800 million people in the developing world do not have enough to eat. Another 41 million people in the industrialized countries and countries in transition also suffer from chronic food insecurity. An enormous amount of water is required to produce food. The question of whether the world will be able to produce sufficient food is associated with many uncertainties as noted by Bryant *et al*. (2000). On top of this is the impact of climate change on food production. The gradual changes in climate and the resultant increases in extreme weather factors, require continual adaptation of agricultural production strategies. However, as Droogers (2003) has noted, coping with extremes of climate variability remain very difficult within the context of food production.

2.2 Climate Change Adaptation and Agricultural Production.

Climate has obvious and direct effects on agricultural production and Greenhouse gas (GHG) implications of agriculture is enormous as explained by Bryant *et al*. (2000). Concerns about mitigating and adapting to climate change are renewing the impetus for investments in agricultural research and are emerging as additional innovation priorities on adaptation strategies. This explains why in the coming years, the development and effective diffusion of new agricultural practices and technologies will largely shape how and how well farmers mitigate and adapt to climate change. The adaptation and mitigation potential is nowhere more pronounced than in developing countries like Kenya, where agricultural productivity remains low.

Often, the most binding constraints in small holder farming occur at the adaptation stage, with several factors potentially impeding smallholder farmers' access to and use of emerging adaptation strategies. These include static, poorly functioning or poorly integrated input and output markets; poor infrastructure; inadequate and ineffective public extension systems; lack of credit and insurance markets. Burton (1997), explains that in recent years, the climate implications of agricultural production and practices have broadened the agricultural agenda to include responses to climate change issues. Agricultural adaptation to climate change is a complex, multidimensional and multi scale process that takes a number of forms which identifies four main components of adaptation: characteristic of the climatic stress, characteristic of the system, multiple scale and adaptive response.

2.2.1 Characteristic of Climatic Change Stress

Climatic stress includes climate signals (climate change and variability) as well as other drivers such as economic conditions, population growth, and government policies. Smit *et al*. (1996) point out that the important question that arises in the literature of climate change is whether farmers adapt their behaviour in response to short-term climate variability or long-term climate change. Some researchers argue that adaptation to short term climate variability may facilitate adaptation to long-term climate change as explained by Burton, (1997). However, Smit *et al*. (1997) notes that some adaptations taken in response to short-term climate variation may not be well suited to long term climate change. Thus, there is need to anticipate long term changes and make appropriate adjustments in addition to coping with current climate conditions.

2.2.2 Characteristic of Agricultural Production System

Bryant *et al*. (2000) explains that agricultural production system characteristics include its sensitivity, resilience, vulnerability, adaptive capacity, and other factors influencing its response to stressors. Other factors include the socioeconomic, cultural, political and institutional characteristics, which can either facilitate or hinder the adaptation process. This is important as we need to come up with a system which is sustainable in the long run for the farmer to reap maximum benefits from farming.

2.2.3 Multiple Scales of Adaptation

Climate impacts, adaptive capacity and adaptation responses differ across multiple scales from plot and farm levels to the country and international levels. Therefore, Vincent (2007) argues that analysing the adaptive capacity of a system and appropriate adaptation responses should take into account the scale of analysis.

2.2.4 Adaptive Response to Climatic Changes

Responses to climate changes can be either reactive or proactive as described by Smit *et al.* (1997). Reactive strategies are adapted after the farmers have experienced climate change while proactive are those adapted to prevent or reduce the impacts of adverse climate change. Adaptive response can also be classified according to duration covered by the adaptation strategy, that is, short or long-term. Short term strategies are those that are done in one season while long terms are across seasons

2.3 Vulnerability to Climate Variability

Blaikie (1994) describes vulnerability as the characteristics of a person or a group to anticipate, copes, resists and recovers from the impact of a natural hazard. Vulnerability also represents the ability of, or not to modify the impacts of disaster and the means to cushion risks. On a national level, vulnerability manifests itself in poorer countries due to a lack of resources and capacity to respond. Blaike (1994) also explains that at the farm level house hold income, gender, number of children, age, level of education and access to information all determine vulnerability. Climate change researchers define vulnerability as a function of exposure, sensitivity and adaptive capacity IPCC (2001). The term "exposure" addresses the incidence of climate impacts, that is, the degree to which actors are in the "firing line" of climate change impacts. The term sensitivity in turn addresses the capacity of actors to be wounded by climate change. Finally, IPCC (2001) describes term "adaptive capacity" or "resilience" addresses the ability of actors to shield them and to recover from adverse climate change impacts

The ability to adapt and cope with weather hazards firstly, depends on economic resources, infrastructure, technology, and social safety nets as noted by IPCC (1995). Smallholder farmers often do not have the resources for coping or adapting to weather hazards and thus are ill-prepared in dealing with them. Secondly, for many farmers, climate change is only one of the many environment problems they confront. IPCC (2001), shows that many of smallholder farmers already being under pressure from high population growth, rural to urban migration, marketing challenges and poverty, making them vulnerable to the further challenges thrown up by climate change.

2.4 Recovery from Adverse Impacts of Climate Change

Poorer communities also have limited means to cope with the losses and damage inflicted by natural disasters. IPCC (2007) explains that lack of insurance, savings or credit make it almost impossible to replace or compensate for the numerous assets lost or destroyed, including houses, livestock, food reserves, household items and tools. Poor farmers also risk losing crops when there is rain as crops ripen for harvest. In the longer term, poor households also risk losing wage opportunities as the disaster destroys the need for labour. Recovery strategies, like selling assets, can leave the poor without future income and thus more vulnerable. These effects contribute to long-term vulnerability leaving people more at risk to the next disaster.

2.5 Climate Change Impacts on Food Security

Climate change may affect agriculture through changes in temperature and precipitation, soil moisture and soil fertility, length of growing season and an increased probability of extreme climatic conditions. There is general agreement as noted by IPCC (2001) that climate change may lead to significant reductions in agricultural productivity in developing countries. Rosenzweig *et al.* (1994) have examined world food supply, food prices and the number of people at risk from hunger in developing countries. These studies have found that whilst developed countries are likely to experience some increase in agricultural output, developing countries suffer a decrease in the scenarios which were constructed. There have of course been criticisms of the Rosenzweig studies, from those who feel the predicted yield losses are too large, as noted by Reilly *et al.* (1994) and to others who have suggested that not enough attention was paid to the likelihood of adaptation by farmers. The IPCC (2001) however, has accepted the likelihood that agricultural productivity will decrease, even as a result of small temperature increases and has suggested that a mean global temperature increase of 2.5ºC would lead to an increase in food prices.

2.6 Agricultural Adaptation Strategies for Climate Change

Travis *et al*. (2010) indicate that the core challenge of climate change adaptation in agriculture is to produce more food and more profitably even under more volatile production conditions. Over the years farmers have adapted differently to climate change as discussed below.

2.6.1 Exploring the Use of Sseasonal Fforecasts

Timely seasonal forecasts have the potential to help both governments and the local people cope with climate variability. Smallholder farmers could greatly benefit from seasonal forecasts in a number of ways. For example, knowing in advance whether the rainfall will be normal, below or above average could help them chose the right crops varieties, adjust their cropping practices or take other necessary measures like soil and water conservation strategies to maximize benefits or minimize losses as explained by Rao *et al.* (2005). As farmers and other stakeholder deals with changes in climate and more variability in weather, history becomes a less reliable guide. There is need for improvement to weather forecasts and interpretations. McCarthy *et al*. (2001) argues that long-term climate change is likely to exacerbate both the frequency and magnitude of extreme climatic events in Africa. This means that seasonal climate forecasts should have a more important role to play in the future.

Serigne *et al.* (2006) argues that one of the reasons why African farmers are reluctant to adapt to improved strategies such as high-yielding crop varieties and use of inorganic fertilizers is that they do not want to invest their scarce resources without knowing whether the rains will be adequate or not. Seasonal forecasting can significantly reduce these uncertainties. Seasonal climate forecasting could play a major role in climate change adaptation in the future, but before that happens, more research is needed to produce forecasts that are tailored to the needs of local farmers by and effectively interpret and communicate forecasts outputs to various stakeholders.

2.6.2 Improved CropVarieties and NewBreeds of Livestock

Serigne *et al.* (2006) explains that drought is likely to be the biggest obstacle to the achievement of food security in Sub –Saharan Africa. There is a clear need to develop; test and release new crop varieties and livestock breeds that would be adapted to the changing climatic and ecological conditions of Sub- Saharan Africa. New crop varieties and breeds as noted by Travis *et al.* (2010) could lead to less intensive use of other inputs such as fertilizer and pesticides. Crop varieties and livestock breeds that are resistant to drought, pests and diseases will improve smallholder farmer's ability to adapt to climate change. It is in this context that research partnerships have been built around organizations such the International Maize and Wheat Improvement Centre (CIMMYT) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), both supported by the Consultative Group on International Agricultural Research (CGIAR). The emergence of these improved crop varieties and livestock has been a gigantic step forward in the development of appropriate technologies for the smallholder farming sector. While hybrid seeds and mineral fertilizer technologies have significantly boosted large scale commercial maize production, they have largely by-passed the majority of subsistence farmers in the region, who are normally cut, off from the market and credit systems.

2.6.3 Soil and WaterManagement

In the midst of increasing urban and environmental demands on soils and water, agriculture must improve soil and water use efficiency. Adding climate change to this mix only intensifies the demands on soil and water use in agriculture. Although stress tolerant varieties can contribute to stabilizing food production, the 'cultivar-alone approach' may not be sufficiently effective to reduce the small farmers' vulnerability to climatic variability. CIMMYT (2004) explains that since water resources in Africa are likely to become

increasingly scarce as a result of climate change, strategies that combine the improvement of soil fertility and the harvesting, storage and efficient use of water will be necessary to build resilient agricultural systems. Soil and water conservation techniques such as terracing and mulching, can significantly improve the water holding capacity of soils and mitigate the negative effects of dry spells. Conservation tillage has the potential to improve soil fertility, reduce erosion and enhance the water use efficiency of crops as explained by Kaumbutho *et al*. (1999). In the semiarid regions of South Africa, for instance, sorghum producers have found a way of maintaining high yield levels by combining weed control in the off –season and cultivation to store water in the sandy soils with the use of high yielding varieties and moderate to high levels of fertilization.

Developing simple techniques for harvesting runoff water and use it for supplemental irrigation also has great potential when rainfall decreases or becomes more erratic as a result of climate change. One major problem with soil and water conservation, however, is that many of the promising techniques are labour or energy intensive and require an appropriate training of extensions officers and farmers. Serigne, *et al*. (2006) explains that conservation tillage, for instance, is a useful option for improving the storage of rainwater in the soil and can help mitigate agricultural drought. However, it requires adequate draught power, appropriate machines and good training of farmers to be effective. Seldom are these conditions met in smallholder farming conditions. External support from governmental institutions and development agencies is often needed to implement soil and water conservation projects. One incentive for farmers to participate in such projects would be to pay them for the environmental services they provide to society. Erosion control has benefits well beyond the farmers' field as it can reduce the siltation of rivers and lakes, which can have deep ramifications in the mainstream economy and the environment. Well implemented 'food for work' schemes can also be an effective way of involving farmers in soil and water conservation.

2.6.4. Agro Forestry and Improved Fallows

Agro forestry as noted by Sanchez (2000) is emerging as a promising climate change adaptation strategy to improve and sustain agricultural productivity and also to enhance rural income. Growing multipurpose tree and shrub species with crops and/or animals can provide additional benefits, like fodder for animals and wind breaks. Kwesiga *et al*. (2003) explains that products and services provided by agro forestry include the improvement of soil fertility,

the provision of animal fodder; the creation of a favourable micro-climate for crops, reducing temperature stress; and fruits and wood for fuel and construction.

Kwesiga, *et al*. (2003) explains that improved fallow is without question one of the most promising strategies to improve soil fertility, control erosion and enhance the water holding capacity of soils. In this agro forestry system, fast leguminous trees or shrubs (these species fix nitrogen from the atmosphere and recycle it in the system) are rotated with maize to improve yields of the cereal crops in Sub- Saharan Africa. Another technology that has been tested along with improved fallows to enhance land productivity in smallholders' farms in Southern Africa is biomass transfer. This technology entails the cutting and carrying of leaves from trees grown outside the cropping area such as the field boundaries to be applied in relatively small areas for crop production. However, given the huge amount of biomass needed per unit area and the important labour required to cut, carry and apply this biomass to the fields, biomass transfer can only be justified when high value marketable crops such as vegetables are grown.

2.7 Theoretical and Conceptual Framework

2.7.1 Theoretical Framework

One of the theories that are behind consumer behaviour in economics is the theory of utility. Utility as a concept in economics is seen as an abstract measurement of the degree of goal-attainment or want-satisfaction provided by a product or service. This is what informs the theory behind this study. One cannot measure directly how much utility a person may gain from a product or a service. However, inferences can be made about utility based on the person's behaviour, if it is presumed that people act rationally. In economics as explained by there is an assumption that a rational person acts to increase her utility (Train, 2003).

Revealed preference theory is a way by which it is possible to discern the best possible option on the basis of consumer behaviour. Essentially, this means that the preferences of consumers can be revealed by their purchasing habits. Revealed preference theory came about because the theories of consumer demand were based on a diminishing Marginal Rate of Substitution (MRS). This diminishing MRS is based on the assumption that consumers make consumption decisions based on their intent to maximize their utility. While utility maximization was not a controversial assumption, the underlying utility functions could not be measured with great certainty. Revealed preference theory was a means to

reconcile demand theory by creating a means to define utility functions by observing behaviour. Revealed preference methods use actual choices made by consumers.

Stated preferences are elicited directly based on hypothetical, rather than actual scenarios. Stated preference methods are criticized because the behaviour they depict is not observed and thus they generally fail to take into account certain type of real constraints (Louvier *et al*., 2000). Swait *et al.* (1994) explains that stated preferences can be used to cover a wide range of proposed quality or quantity changes in the attributes of public good. Hence they can be used to consider an array of choices that are fundamentally different than existing ones, as well as exploit information about attributes trade off. Revealed preference data have high "face validity" because the data reflect real choices and take into account various constraints on individual decisions such as market imperfections, budgets and time. Recent research indicates that combining the stated and revealed preferences methods through data fusion, which also known as data enrichment method, builds on the strengths and diminishes the drawbacks of each method. Haab *et al.* (2002) notes that the amount of information increases, and findings can be cross-validated. Use of revealed preference data ensures that estimation is anchored in observed behaviour. At the same time inclusion of stated preference responses to hypothetical changes enables identification of parameters that otherwise would be identified.

2.7.2 Conceptual Framework

Farmers will choose a climate change adaptation strategy which will increase their ability to satisfy their need of maximum food production. The indigenous and emerging strategies which were mostly observed in their farms were seen as revealed preferences. The stated preferences may be the emerging ways of adapting to climate change which may not be currently observed on their farms. The vulnerability context frames the external environment in which people exists. Peoples' livelihood and the wider availability of wealth are fundamentally affected by critical trends as well as by shocks and seasonality over which they have limited or no control. Shocks can destroy wealth directly in case of floods, drought and storm. They can also force people to abandon their home area and dispose assets such as land, livestock and produce prematurely as part of the adaptation strategy. Trends may be dangerous, though they are more predictable. They have a particular important influence on rates of return and economics to chosen livelihood strategies. Seasonal shifts in prices, employment opportunities and food availability are one

of the greatest and most enduring sources of hardship for poor people in developing countries.

The dependent variable in the empirical estimation was the choice of an adaptation option from a set of adaptation strategies. The explanatory variables for this study includes household characteristics such as education, sex, age of the household head, household size, farm and non-farm income and livestock ownership; institutional factors such as access to information, access to credit and group membership. The interaction between dependent variables and explanatory variables can be illustrated in figure1. Human interference through activities can emit greenhouse gases into the atmosphere leading to climate change. Adaptation strategies through policy responses can result into positive outcomes of increased food production as the smallholder famers need to adapt to these climate changes. Effective adaptation coupled with policy responses lead to outcome of increased food production, livelihood diversification, increased farm income, soil and water conservation and reduced pest and disease infections. This is illustrated in Figure 1.

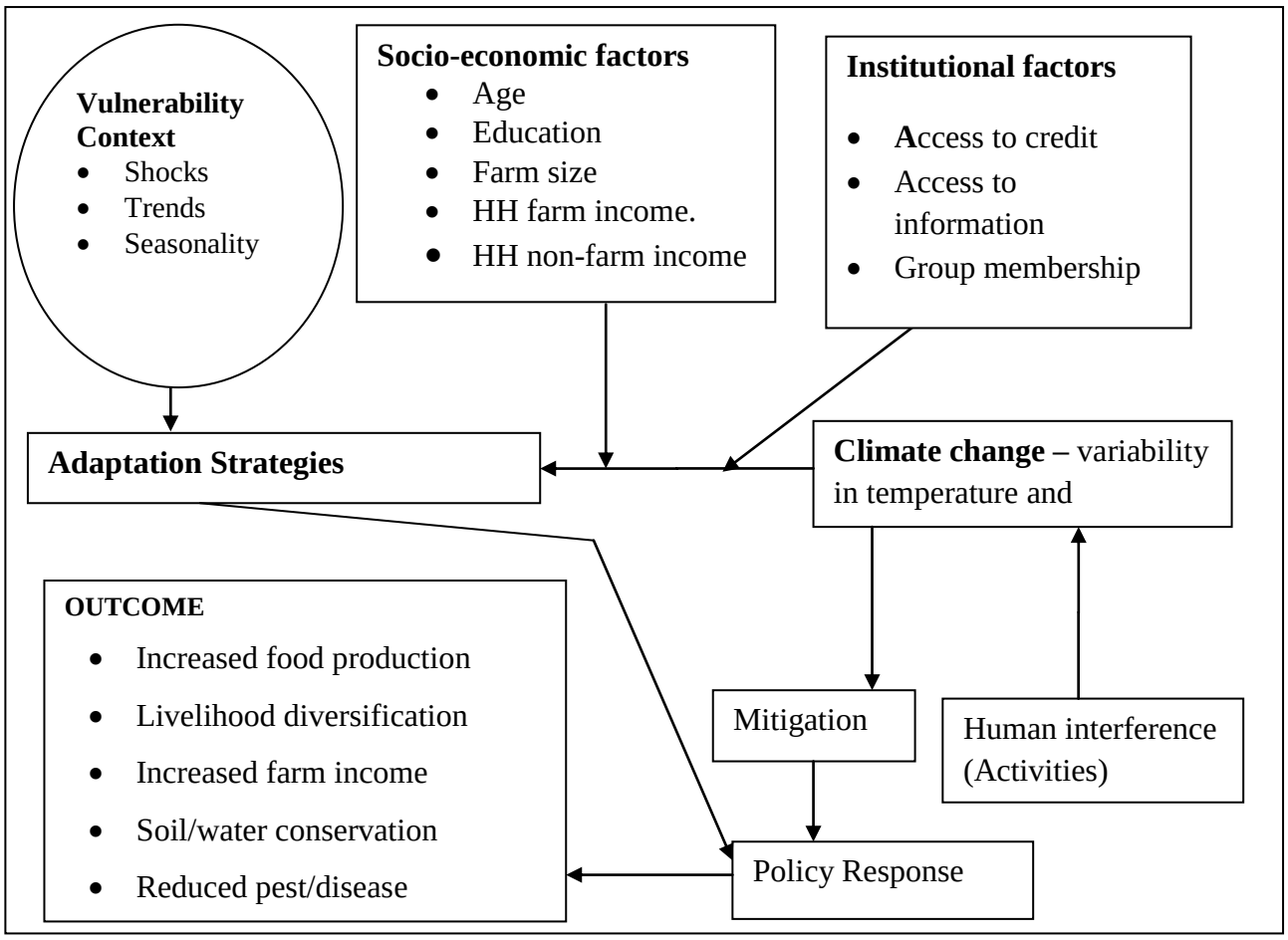

Figure 1: Conceptual framework: Source - Modified from DFID Livelihood, (2002).

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Study Area

The study covered Bungoma County which occupies a total of about 2,068.5 square kilometres with a population of roughly 1,630,934 people and a population density of 482 persons per square kilometre (KNBS, 2009). The County is located between longitude 34 º 21.4` and 35 º 04` East and latitude 0 º 25.3 and 0º 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 meters above Sea Level (A.S.L) and temperature ranges from 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 has been an important component of agricultural activity in this area. Crops commonly grown include; maize, sunflower, sugarcane, coffee, tobacco, potatoes, beans, kales, groundnuts and bananas. Livestock production includes; dairy cattle, goats, sheep and chicken. Out of the total labour force of about 565,000 people, 52% are engaged in agricultural production which provides 60% of all household incomes, 19% have wage-employment and 13% are self-employed (GoK, 2005).The number of unemployed is estimated at 200,000 people and 60% of the population lives below the poverty line. The poverty incidence in Bungoma is higher than the national average of 53% (GoK, 2005).

Bungoma County was selected because firstly, of it being one of the County's 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, the population growth in the County was high compared to the land resource available and thus there was need to evaluate climate change adaptation strategy so as to come up with sustainable food production system. Thirdly, Bungoma County was one of the sites selected by Climate Change Adaptation (CAPro) project which funded this study. The other sites were Nakuru, Mbeere, Kajiado and Kilifi Counties.

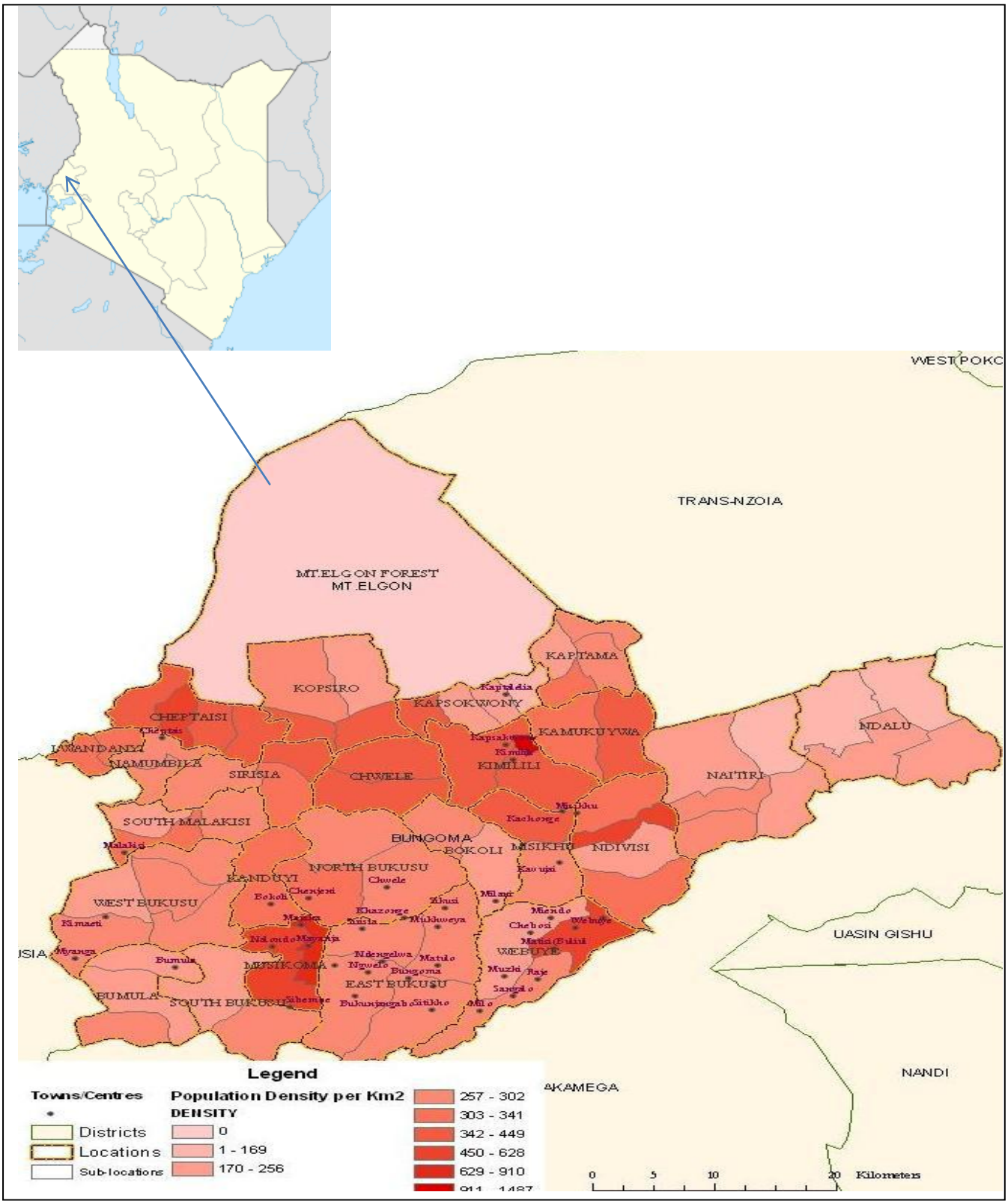

Figure 2: Map of Kenya showing Bungoma County and also map of Bungoma County (Source: GOK, 2005)

3.2 Sampling Design

The population of the study consisted of all smallholder farmers in the Bungoma County. Purposive sampling was used to select 3 districts in the county with different livelihoods and agro ecological zones. The second stage was to employ systematic random sampling to select proportional number of farmers from each of the three districts. Systematic random sampling was used to select respondents from a list from Ministry of Agriculture.

3.3Sample Size

Determination of the sample size was based on the formula given by Kothari, (2004) as shown below:

$n = \frac{pqZ^2}{E^2}$ ..... equation 1

Where; n is the sample size, Z is confidence level ($\alpha = 0.05$), p is the proportion of the population of interest, smallholder farmers in the study area. Variable q is the weighting variable and this is computed as (1 – p) and E is an acceptable error (precision). P was set to 0.5 since statistically, a proportion of 0.5 results in a sufficient and reliable size particularly when the population proportion is not known with certainty. This led to Q of 0.5 (1- 0.5). An error of less than 10% is usually acceptable according to Kothari, 2004. Thus, the study took an error of 0.08 to approximate a sample size of 150 respondents

3.4 Data Collection

The study used both primary and secondary data. Primary data was collected by use of questionnaires and a checklist. Structured questionnaire schedules were used in the individual interviews and administered by trained enumerators. Data was also collected by use of a checklist. This was done in two steps. Firstly, smallholder farmers in focal groups were asked to identify and categorize indigenous and emerging climate change adaptation strategies which were currently in place in the study area. Secondly, they were required to evaluate these strategies using a checklist.

3.5 Data Analysis

Primary data was analysed by use of SPSS and STATA computer programs.

3.6 Analytical Framework

Objective one and two: The objectives one and two were analysed using descriptive statistics. This involved the use of percentages, tables, graphs and means to describe the indigenous and emerging climate change adaptation strategies.

Objective three and four: The third and fourth objectives were analysed using Multinomial Logit (MNL) model which evaluated the socioeconomic and institutional factors that influenced the choice of indigenous and modern coping strategies by smallholder farmers. The MNL was used to analyse the determinants of farmers' choice of adaptation strategy in the study areas of Bungoma County. Kurukulasuriya *et al*. (2008) and Nhemachena *et al.* (2007) noted that this method could also be used to analyse crop and livestock choices to adapt to the negative impacts of climate change. The advantage of MNL is that it permits the analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories as explained by Woodridge (2002) and it is also computationally simple Tse, (1987).

To describe MNL model, let y denote a random variable taking the values (1, 2 ……..j) for j, a positive integer, and let x denote a set of conditioning variables. In this case, y denotes adaptation category and x contains different socioeconomic and institutional attributes. The question is how other factors remaining constant, changes in the element x affect the response probabilities (P (y = j/x), = 1, 2…..j. Since the probabilities must sum up to unity, P(y=j/x) is determined once we know the probabilities for j = 2,…..j. Let x be a 1 x k vector with first element unity. The MNL model has response probabilities:

$$P\left(y=\frac{j}{x}\right)=\frac{\exp(x\beta j)}{[\,1+\sum_{h=1}^{j}\exp(x\beta_{h,j=1,\ldots..j}}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{equation 2}$$

Unbiased and consistent parameter estimates of the MNL model in equation 2 required the assumption of independence of irrelevant alternative (IIA) to hold. More specifically, the IIA assumption requires that the probability of using a certain adaptation method by a given household needs to be independent from the probability of choosing another method (that is P_jP_k is independent of the remaining probabilities). The premise of the IIA assumption is the independent and homoscedastic disturbance terms of the basic model in equation 1. The parameter estimates of the MNL model provide only the direction of the effect of the independence variables on the dependent (response) variable.

Differentiating equation 1 with respect to the explanatory variable provides marginal effects of the explanatory variables given.

$$\frac{\partial P_j}{\partial X_k} = P_j\left(\beta_{jk} - \sum_{j=1}^{j-1} Pj\beta_{jk}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{equation 3}$$

The structural form can be reduced to the form:

$Y_i = \alpha + \beta_1$age $+\beta_2$educ.$+\beta_3$far sze$+\beta_4$hhinc.$+\beta_5$hhnn far inc$+\beta_6$acc to credt$+\beta_7$exte ser. β_8 train $+ \beta_9$gpmesp $+ \beta_{10}$Acc inf. ……..…equation 4

Where:

Y_i are the climate change adaptation strategies and others are institutional and socio economics factors.

The marginal effects or marginal probabilities are functions of the probability itself and measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable from the mean (Green, 2000). The variables, measurements and hypothesis that are going to enter the model are shown in Table 1.

Table 1: Description of variables used in the MNL model and their expected signs

Variable	Description	Unit of measurement	Expected sign
Age	Farm family head's age	Years	+/-
Experience	Farm family head's years' experience in farming	Years	+
Sex	Gender of the farm family head	1= male, 0= female	+/-
Children	Number of children in the farm family	Number in age categories	+/-
Education	Number of years of education attained by the farmer (from primary to college/ University)	Years	+
Land size	Number of acres owned by household	Number in acres category	+
Income	Total amount of farm and non-farm income	Shillings	+
Group membership	Farmer belonging to a group	Number of groups in which he or she is active	+
Extension services	Extension services being offered to the farmer	Number of visits by extension officers	+
Training	Trainings being offered to the farmer and lengths of training	Number of trainings attended by farmer	+
Information	Farmer access to information	Number of times farmer receives Information	+
Credit	Farmer access to credit facilities	Shillings	+
Farmer to farmer extension.	Other farmers influence on farmers perception and presence of farmers who are role models	Number of Framers consulted in a year	+
Climate Change	Farmer's perception of the expected climate situation.	1=increased, 2=no change, 3=decreased	+, 0 -

3.5 The *Apriori* Assumptions and Hypothesis

3.5.1 Socio-economic Factors Affecting Adaptation of Climate Change Strategies

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

Level of Education: Norris (1987) argues that higher level of education was believed to be associated with access to information on climate change strategies and higher productivity. Evidence from various sources indicates that there was a positive relationship between the education level of the household head and improved adaptation strategies as noted by Igoden *et al.* (1990) and adaptation to climate change (Madison, (2006). Therefore, a farmer with higher levels of education was more likely to adapt better to climate change.

Gender of Household Head: Male headed households were more likely to get information about emerging strategies and undertake risky businesses than female headed households (Asfaw, (2004). Moreover, Tenge (2004) showed that having female head of household could have a negative effect on adaptation of soil and water conservation strategies, because women may have limited access to information, land, and other resources due to traditional barriers. A study by Nhemachena *et al.* (2007) found contrary results, arguing that female- headed households were more likely to adapt because they are responsible for much of the agricultural work in the region and therefore have greater experience and access to information on various management and farming practices. Thus, the adaptation of emerging strategies appears to be rather context specific.

Age of the Household Head: Age of the head of household could be used to capture farming experience. On the one hand, studies have shown a positive relationship between number of years of experience in agriculture and the adaptation of improved agricultural strategies Kebede *et al.* (1990) while a study by Shiferaw (1998) indicated a negative relationship between age and adaptation of improved soil conservation practices. On the other hand, studies by Madison (2006) and Nhemachena *et al*. (2007) reported that experience in farming increased the probability of uptake of adaptation measures to climate change. This study hypothesizes that experience increases the probability of adapting to climate change.

Household Size: The influence of household size on use of adaptation methods could be seen from two angles. Yirga (2007) said that the first assumption was that households with large families may be forced to divert part of the labour force to off-farm activities in an attempt to earn income in order to ease the consumption pressure imposed by a large family. The other assumption was that large family size was normally associated with higher labour endowment, which would enable a household to accomplish various agricultural tasks. For instance, Croppernsted *et al*. (2003) argued that households with a larger pool of labour were more likely to adapt to climate change strategies and use it more intensively because they have fewer labour shortages at peak times. Here it was expected that household with larger families were more likely to adapt to climate change.

Farm Size: Studies on adaptation of climate change strategies indicate that farm size had both negative and positive effect on adaptation, showing that the effect of farm size on adaptation strategies was inconclusive (Bradshaw *et al*., 2004). However, because farm size is associated with wealth, it is hypothesized to increase adaptation to climate change.

Farm and Non-farm Income: Farm and non-farm income and livestock ownership represents wealth. The study hypothesized that adaptation of climate change strategies requires sufficient financial wellbeing as noted by Knowler, (2007). Other studies that investigated the impact of income on adaptation found a positive correlation (Franzel, 1999). Farmers with high incomes have more access to information on climate change and could easily afford various climate change strategies (CIMMYT, 1993). Livestock played a very important role by serving as a store of value and by providing traction (especially oxen) and manure required for soil fertility maintenance (Yirga, 2007). Thus in this study, farm and nonfarm income and livestock ownership was be hypothesized to increase adaptation to climate change.

3.5.2 Institutional Factors Affecting Adaptation of Climate Change Strategies.

These are institutional structures that have attained high degree of resilience. Scots (2001) notes that social structures are composed of cultural, cognitive, normative and regulative elements that together with associated activities and resources provide stability and meaning to social life. They include the following:

Extension, Training and Access to Information: Extension and training on crop and livestock production and information on climate represent access to information required to make the decision to adapt to climate change. Various studies in developing countries, including Kenya, report a strong positive relationship between access to information and adaptation behaviour of farmers (Yirga (2007). Access to information through extension services increases the likelihood of adapting to climate change (Nhemachena *et al.*, 2007). Thus, this study also hypothesizes that access to information increases probability of adapting to climate change.

Access to Credit: Availability of credit eases the cash constraints and allows farmers to buy purchased inputs such as fertilizer, improved crop varieties and irrigation facilities. Research on adaptation of agricultural strategies indicates that there is a positive relationship between the level of adaptation and availability of credit (Yirga, 2007). Likewise, this study hypothesizes that there is a positive relationship between availability of credit and adaptation.

Group Membership: Informal institutions and private social networks like group membership play two distinct roles in adaptation to climate change strategies. First, they act as conduit for information about new strategies. Second, they can facilitate cooperation to overcome collective action dilemmas, where the adoption of technology involves externalities. Thus, this study, just like Nhemachena *et al.* (2007) hypothesizes that group membership positively influences adaptation to climate change strategies.

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CHAPTER FOUR
RESULTS AND DISCUSSION

This chapter presents findings from the study and this is divided into five sections. The first section presents perceptions and climate data in the study site. The second section shows descriptive results on household characteristics. The third section presents results on farmers' choice of Indigenous Climate Change Strategies (ICCS), which were strategies the farmers have been using before 1990. They were categorized into two groups; Crops and livestock strategies. The fourth section presents farmer's choice of emerging Crop and Livestock Climate Change Adaptation Strategies (CCAS) which were strategies that farmers have been using from 1990. Finally, the fifth section presents the Multinomial Logit results on socio-economic and institutional factors hypothesised to influence adaptation of climate change strategies.

4.1 Perception of climate change

Smallholder farmers in the study area had various perceptions on climate. While they found it hard to explain climate change phenomenon they were able to understand changing regular weather parameters like rainfall and temperature.

4.1.1Climate Change

Majority of farmers in Bungoma County agreed that climate was changing due to variability of rainfall and temperature. Those who strongly agreed were 35% while 58% agreed that climate was indeed changing. Only 7% were undecided. No farmer strongly disagreed that climate was changing. This is illustrated in figure 3 below.

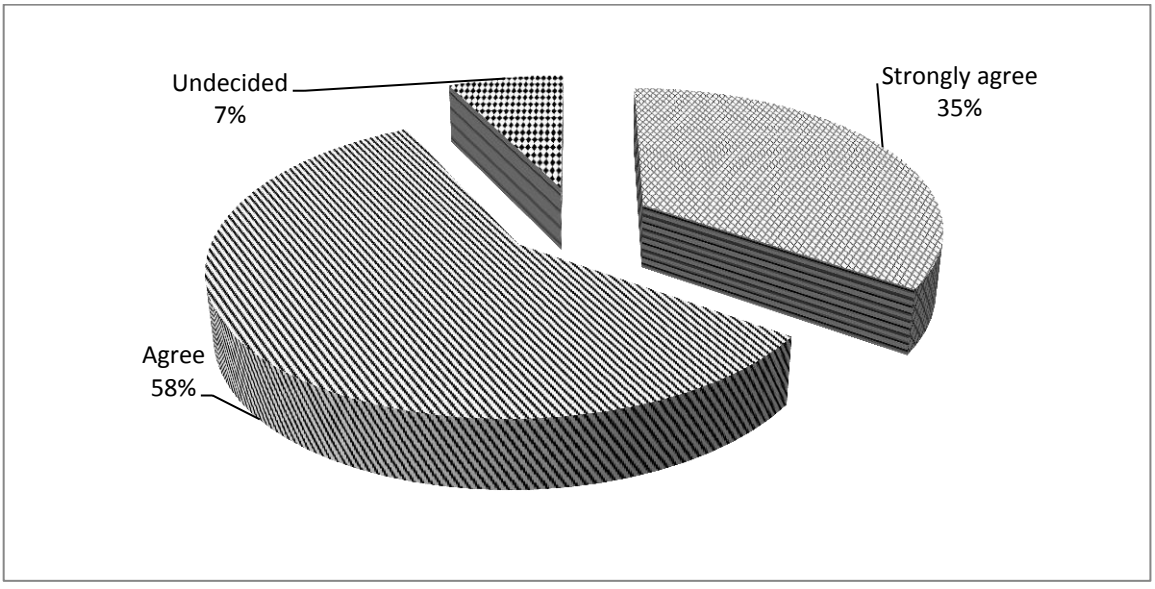

Figure 3: Climate was changing

4.1.2 Climate change due to human activities

An overwhelming majority of farmers in the study site perceived that climate change was due to human activities, that is 58% strongly agreed while 35% agreed. Only 3% and 4% were undecided and disagreed respectively. This showed that farmers had started relating human activities to climate change and not just being a natural phenomenon. This means that people can have control over climate change if they change their actions. This is illustrated in figure 4.

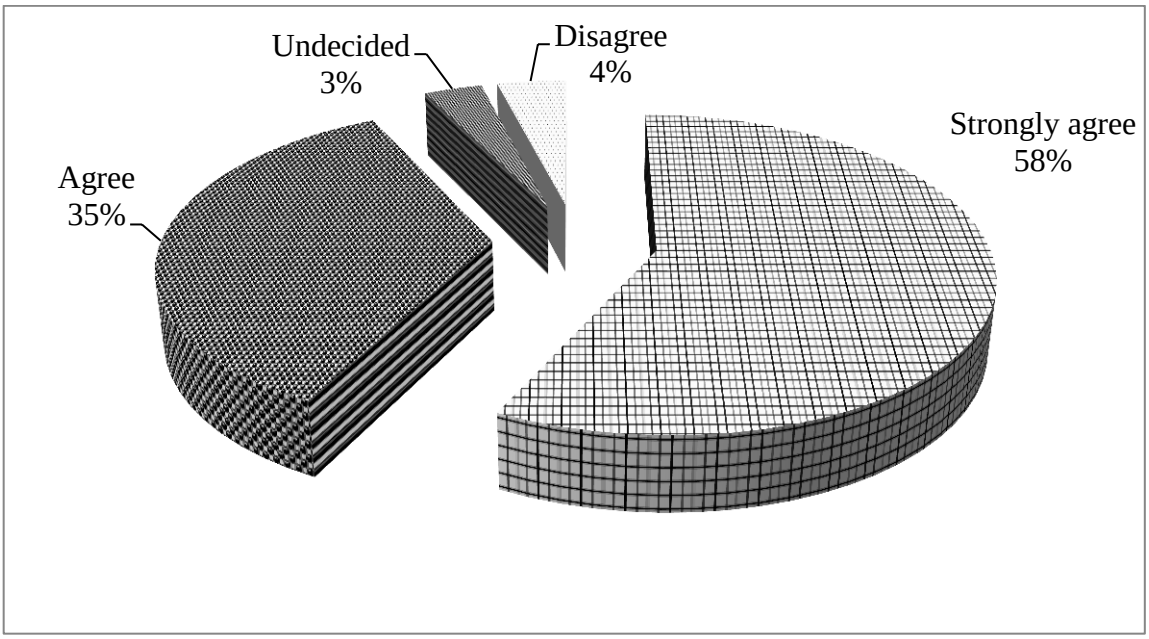

Figure 4: Climate changing due to human activities

4.1.3 Rising Temperature

Most of the farmers, 19% and 67% strongly agreed and agreed respectively that temperature was rising. Those who were undecided were 12% while 2% disagreed that temperature was rising. Farmers' perception was subjective as they related wilting of crops, drying of streams and rivers, sweating and outbreak of diseases like malaria as signs of rising temperature. This is illustrated in figure 5.

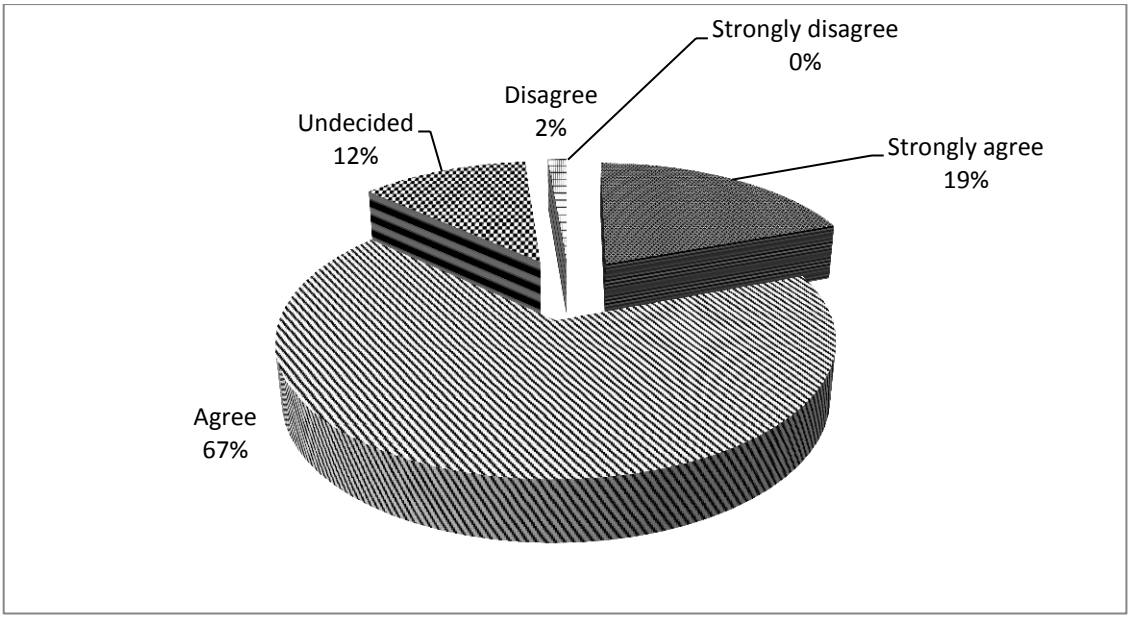

Figure 5 : Temprature was rising

4.1.4 Decreasing Rainfall

An overwhelming percentage of smallholder farmers in the study area, 47% and 40% of strongly agree and agreed respectively that rainfall amount was decreasing. Their perception was due to drying up of streams and rivers and unpredictability and unreliability of rainfall pattern in the study site. Only 7% and 5% of farmers were undecided and disagreed respectively that rainfall was decreasing.

Understanding the trends in complex and variable phenomena such as rainfall is not straightforward and doubts have been expressed on the ability of farmers to accurately discern climate trends from their casual observations (Kempton *et al.*, 1997), the completeness of their assessment since they represent simplified versions of complex reality and the subjective nature of these perceptions (Sattler and Nagel, 2010). Further, farmers' perceptions are also likely to be shaped by the agro-economic performance of crops and other farm enterprises that affect their livelihood where climate is only one of the many bio-physical and socio-economic factors that affect productivity. Farmers' perceptions are also expected to be influenced by a range of other factors such as gender, level of education and farm size.

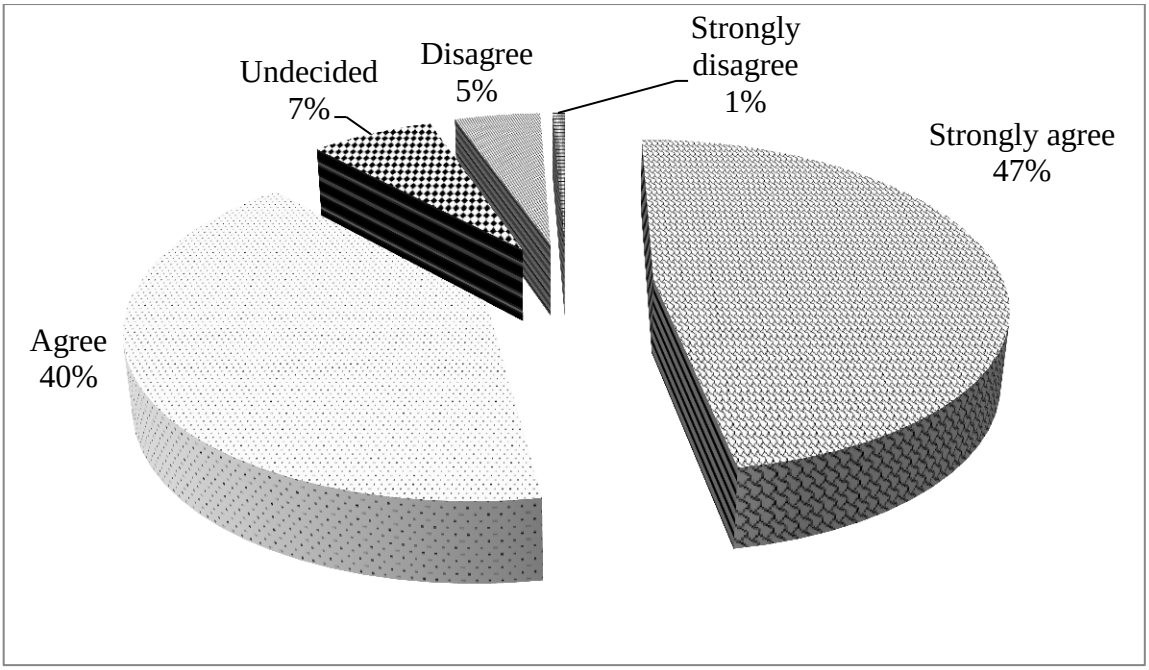

Figure 6: Rainfall was decreasing

4.2 Climate Data in Bungoma County

The impacts of climate change on agriculture and food production come about through changes in variability, seasonality, changes in mean precipitation and water availability, and the emergence of new pathogens and diseases (Fischlin *et al.,* 2007). Each of these mechanisms is likely to become more significant with higher rising temperatures and rainfall variability. Agronomic research indicates that higher temperatures associated with climatic change will be harmful to the production of many crop and livestock groups. Where there is water stress, heat stress or a combination of the two, the world's cereal crops can be vulnerable to even minor changes in temperature. Rainfall and temperature data was collected in the study area and analysed as below.

4.2.1Rainfall data

There has been a perception that rainfall is declining in the study area but from the climate data shown graphically below in figure rainfall amount per annum has been fluctuating in the years between 1983 and 2010 as shown in figure below. The trend is contrary to perceptions in that it is getting wetter in the study site. The highest amount of rainfall was obtained in 1995 (2489 mm) while the least was 1307 in 1989. This fluctuating amount of rainfall has a negative effect on farming as it negatively affects the yields.

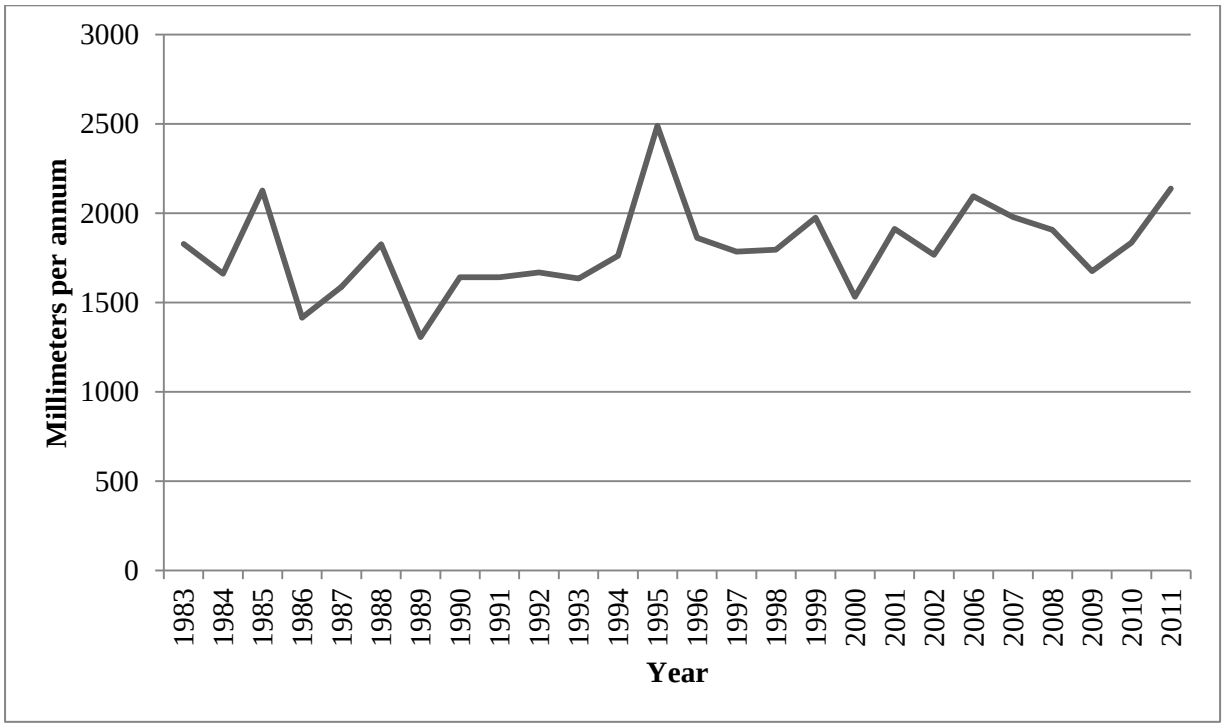

Figure 7 : Rainfall data

4.2.2 Temperature data

The perception of smallholder farmers that it was getting warmer in Bungoma County was true even from the climatic data obtained from the study site proved the same. This is shown in the figure below.

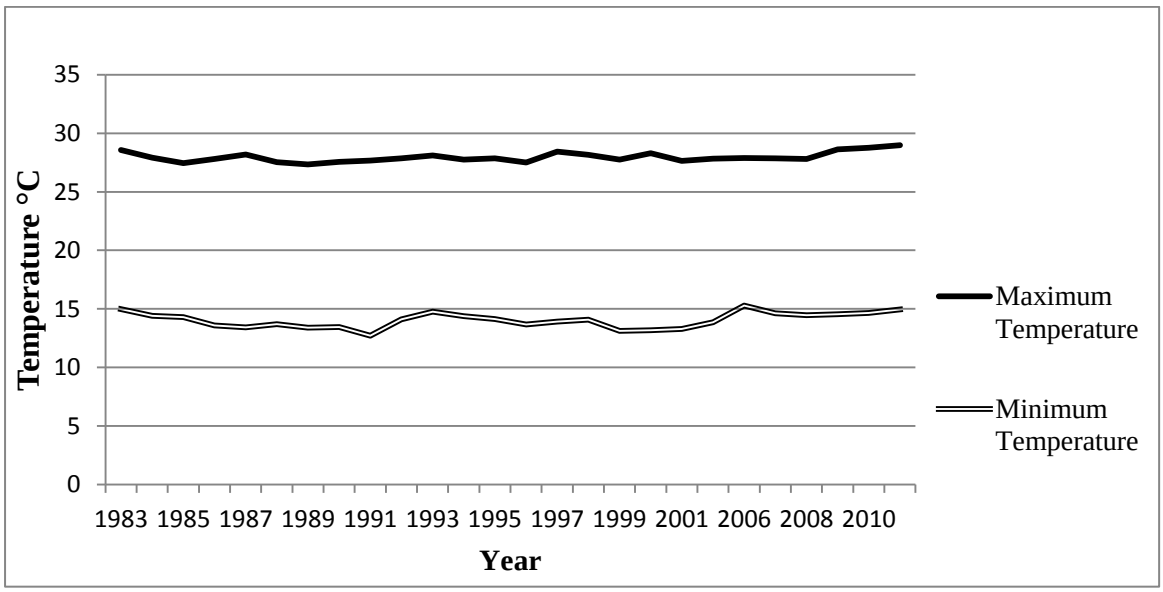

Figure 8 : Annual Maximum and Minimum Temperatures

4.3 Descriptive Results of Small Holder Farmers in the Study Area.

Characteristics that can be measured quantitatively are presented using t – test of difference while those that are ordinal were subjected to chi – square.

4.3.1 Selected Household Characteristics of Farmers in Bungoma County

Table 2 presents household characteristics of farmers in the study area. Results show that adapters of CCAS were significantly ($t = -3.49$, $p \leq 0.001$) younger than non-adapters. The mean number of children per household was also statistically significant, ($t = -3.906$, $p \leq 0.000$), with adapters having fewer children compared to non- adapter. Farming experience was statistically significant ($t = -3.031$, $p \leq 0.003$), indicating that the longer the experience of farming the less the adaptation of CCAS. Extension services were statistically significant ($t = 1.946$, $p \leq 0.054$), indicating that adapters of CCAS had more extension service contacts than the non-adapters.

Table 2: Descriptive statistics of selected farmer socio – economic characteristics.

Characteristic	Mean		Overall	t-ratio	Probability
	Adapters	Non-adapters			
Age(Years)	40.28	51.60	41.70	-3.549***	0.001
Number of children	3.72	6.60	4.1	-3.906***	0.000
Education (years)	13.83	12.85	13.70	1.471	0.143
Land size(Ha)	4.06	5.29	4.22	-1.66	0.245
Experience(Years)	13.40	20.00	14.28	-3.031***	0.003
Income (KES)	22423.32	284717.05	228995.82	-1.053	0.294
Extension(Contacts)	1.21	0.100	1.06	1.946*	0.054
Training(Contacts)	2.44	2.75	2.48	-0.366	0.715
Credit (KES)	32976.92	16500.00	30780.00	1.245	0.215

***** Significant at 1%; and * significant at 10 %**

Table 3 presents categorical household characteristics of farmers in the study area. For the farmers who adapted to CCAS, 74.62% were males while 25.38% were females while for non- adapters , 80% were males while 20% were females. In terms of group membership, 62.3% of the adapters of CCAS belong to a farmer group while 37.7% were not in farmer groups. Among the non-adapters of CCAS, 45% were in farmer groups while 55.00% do not belong to a farmer group.

Table 3: Categorical characteristics of the household head in Bungoma County

Characteristic	Category	Percentage			*Chi-square*	Probability
		Adapters	Non-adapters	overall		
Sex	Male	74.62	80.00	75.33		
	Female	25.38	20.00	24.67		
	Total	86.67	13.33	100	0.270	0.603
Group Membership	Yes	62.3	45.00	64.7		
	No	37.7	55.00	40.0		
	Total	86.67	13.33	100	2.163	0.141

4.3.2 Identification of Indigenous Climate Change Strategies used by Smallholder Farmers in Bungoma County

Characterization of CCAS was done in order to determine how the practices varied across farmers in the study area. The results are given in Figure 2 which shows the proportion of farmers (in percentage) practicing each coping strategy. The indigenous strategies were divided into crop and livestock strategies.

4.3.3 Indigenous Crop Strategies

From the result, 24.4 % of small holder farmers used mulching as a strategy to combat climate change. This was because it was easy to get mulching materials as they were locally available and most of them had local knowledge on how to use the strategy. Tree planting was the second common strategy and was used by 19.2 % of farmers. This was because of accessibility of varieties of tree seedlings to be planted. Farmers also planted trees due to its beneficial uses like source of income and timber, wood fuel, local medicine and control of soil erosion.

Planting of cover crops mostly sweet potatoes was used as a strategy by 14.6% of the smallholder farmers. Farmers preferred sweet potatoes as apart from being utilized as food its vines was also used as livestock feed. Intercropping of crops like maize and beans, sugarcane and beans, millet and maize was practiced by 9.1%. This was encouraged by extension officers to allow smallholder farmers spread their risks should one crop fail. Agroforestry, planting drought resistant crops, early planting, crop rotation and growing short seasoned crops strategies were at 8.7%, 7.7%, 6.6%, 5.6% and 4.2% respectively. This is shown in Figure 2.

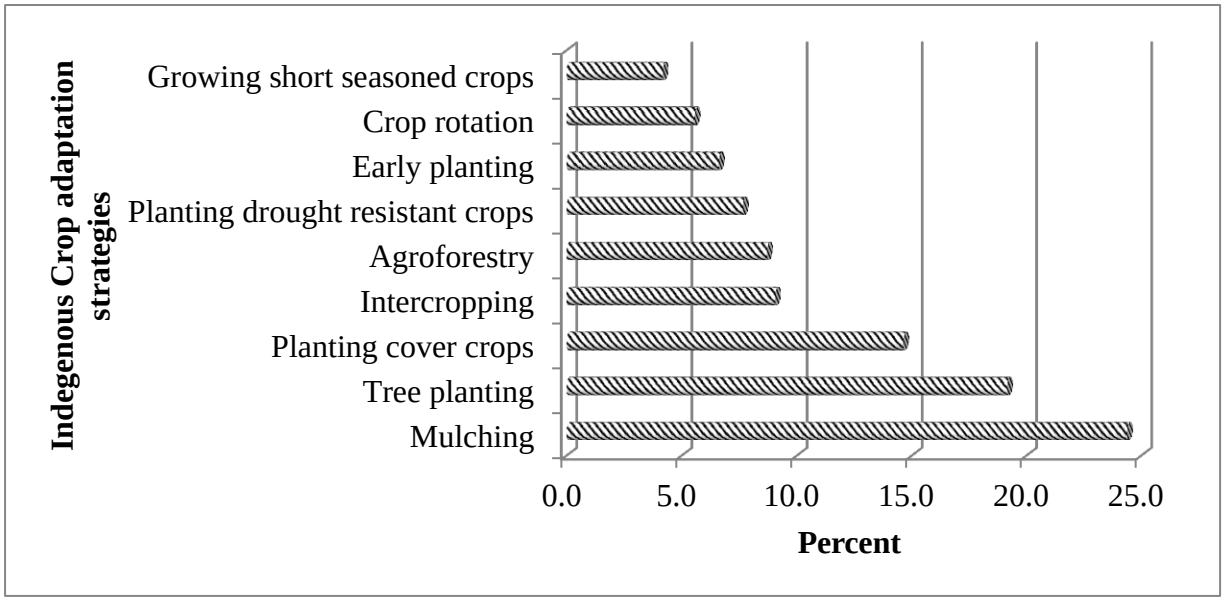

Figure 9 :Identified indigenous crop strategies carried out by smallholder farmers in Bungoma County

4.3.4 Indigenous Livestock Strategies

Bungoma County is a predominantly crop growing region as noted by PDA, 2010. This is one of the reasons why 32.59% of farmers did not employ any indigenous livestock strategy. Cross breeding was done by 24.11% of farmers as a strategy of improving the local breeds so as to enhance productivity and was also cheaper than rearing pure breeds. This was done by qualified inseminators with supervision from public officers from department of veterinary services in the district. Livestock feeds were formulated and preserved as a CCAS by 20.54 % of livestock farmers which they did during favourable climatic conditions to be utilised during harsh climatic conditions. Farmers were trained by district extension officers on how to use locally available materials during feed formulation and preservation. Rearing local breeds, planting napier grass, Rearing mixed livestock, zero grazing and paddocking

strategies were 12.05%, 3.57%, 2.68%, 2.68 and 1.57 % respectively. This is illustrated in Figure 4.

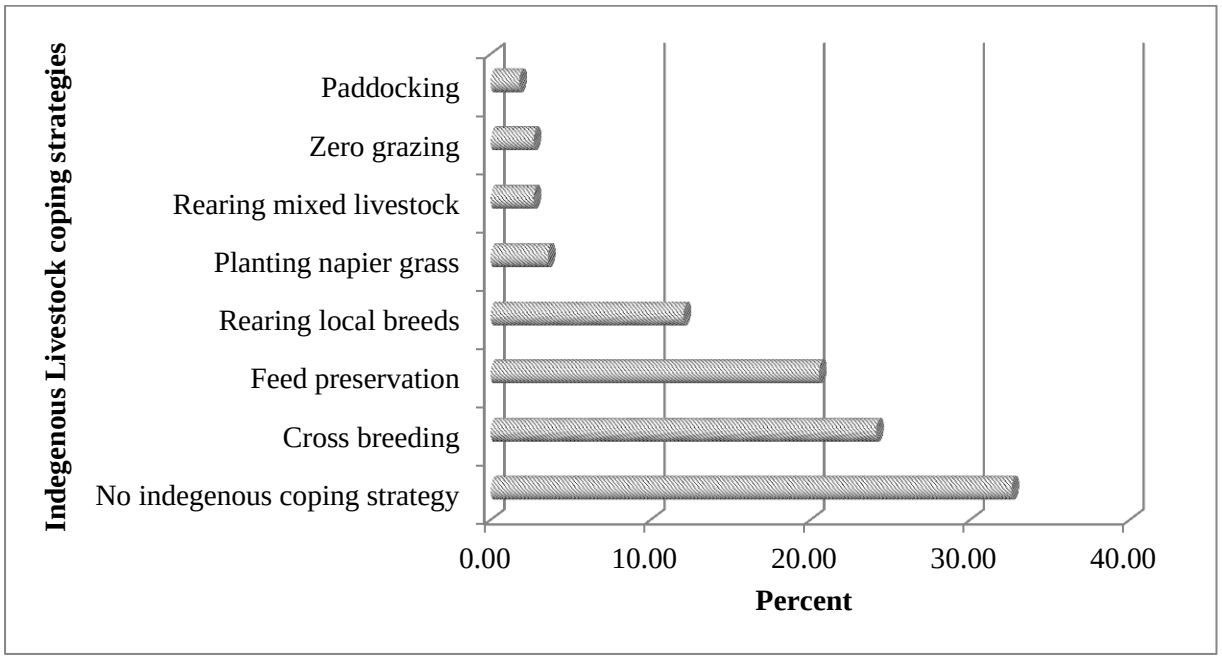

Figure 10 : Identified indigenous livestock strategies carried out by smallholder

4.3.5 Emerging Crop Adaptation Strategies

Tree planting was the most common emerging crop adaptation strategy with 24.9 % of farmers choosing it. This has been due to government policy of planting trees on at least 10% of farmer's land acreage with trees. Fast growing tree varieties especially *Eucalyptus species* from South Africa and *Gravilliea spp.* have been extensively promoted by the Ministry of Agriculture and Ministry of Environments and Natural Resources for wood fuel and also timber production. The hope of carbon credit, carbon markets and clean development mechanisms has made farmers engage more in tree planting. Due to declining soil fertility which had negatively affected agricultural productivity in Bungoma County, 18.3 % of small holder farmers used organic farming as a strategy in dealing with declining soil fertility. Farmers were trained on how to make organic manure using locally available materials by both public extension officers and other private organizations like One Acre fund. Organic farming was being encouraged in Bungoma County by MOA because the soils were acidic. Farmers who used mulching as an emerging strategy were 16.6 %. This was because mulching materials were cheap, locally available and could also be used as both manure and soil conservation measure. As a result of soil cover by vegetation and residues,

soil erosion through runoff are eliminated or greatly reduced thus crop production is more reliable. Planting short seasoned crops was selected by 8.9% of farmers a means of mitigating against climate change. Cover crops and green house technology strategies were picked by 8.3%. Cover crops like sweet potato were both used as food and livestock feed in form of vines thus having a dual purpose. Agroforestry was chosen by 7.4% of the farmers. This strategy was being promoted by Kenya Forestry Services and Kenya Forestry Research Institute where farmers were encouraged to grow improved fallow crops. Green house technology was used by 7.1% of farmers. Planting improved crop varieties and early planting strategies were chosen by 5.3 % and 3.3% respectively by farmers in the study area. This is illustrated below in figure 5.

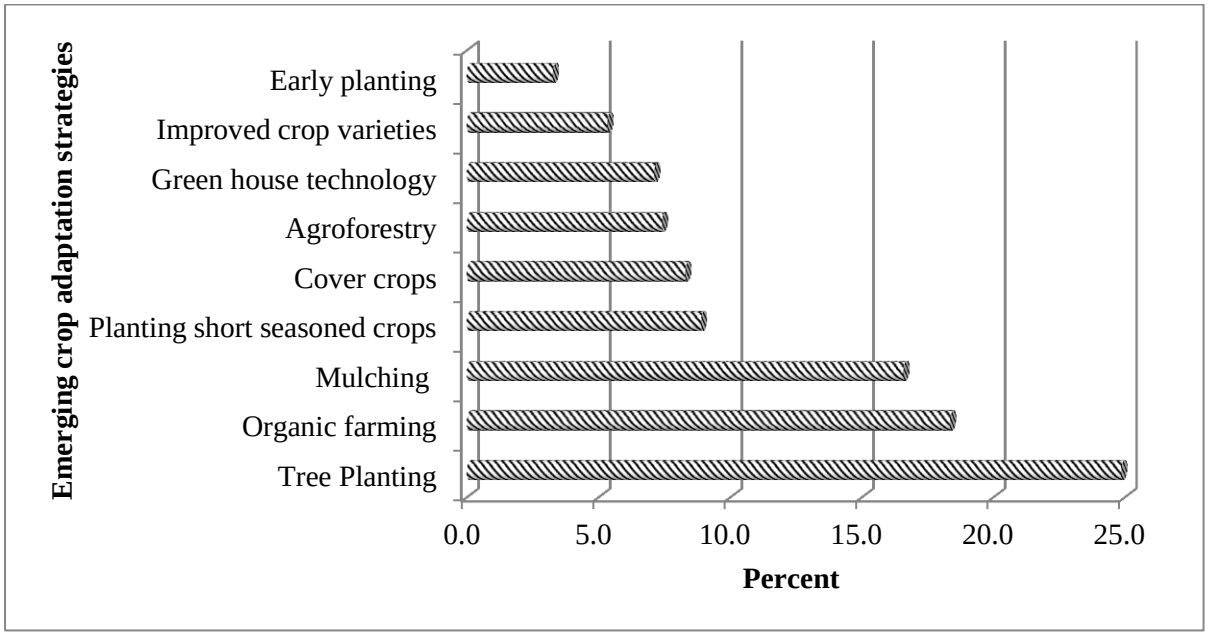

Figure 11: Identified emerging CCAS carried out by smallholder farmers in Bungoma County

4.3.6 Emerging Livestock Adaptation Strategies

Few smallholder farmers in Bungoma County rear livestock as the area is more suitable for growing crops. This was the reason that 30.7 % of farmers did not adapt to any emerging livestock adaptation strategy. Zero grazing was practiced by 18.1 % of smallholder farmers in the study area. This was because of low acreage of farms owned by these farmers. Feed preservation strategy was done by 14.7% of farmers. This was mostly through preservation of maize stovers, maize cobs and sugarcane tops. Cross breeds were kept by 13.7 % of farmers and because of increased productivity compared with indigenous cattle. Paddocks were used

by 9.7 % of farmers thus ensuring efficient grazing systems on the land. Pure breeds were kept by 6.7% of farmers due to their high productivity. Planting new varieties of napier grass and rearing different breeds were emerging livestock adaptation strategies in 4.6% and 2.1 % of farmers. This is illustrated in the Figure 6 below.

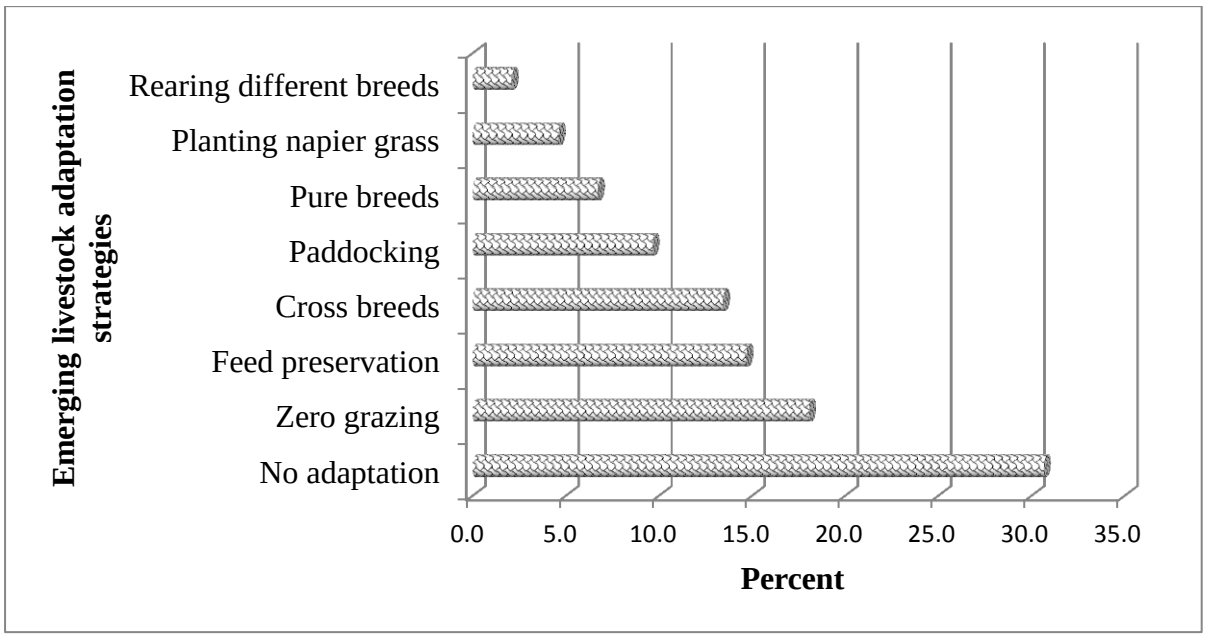

Figure 12 : Identified emerging livestock adaptation strategy carried out by smallholder

4.4 Climate Change Adaptation Strategies as Dependent Variables

The climate change research community has identified different adaptation methods. The adaptation methods mostly commonly cited in literature as explained by Bradshaw, Dolan *et al.* (2004) and Kurukulasuriya *et al.* (2008), includes the use of crop varieties and livestock species that are more suited to drier conditions, irrigation, migration, crop use of water and soil conservation techniques, change use of capital and labour, time of planting, feed preservation and no adaptation. The adaptation methods for this study are based on asking farmers about their perception of climate change and the actions they take to counteract the negative impacts of climate change.. The adaptation measures that farmers report may be profit driven, rather than climate change driven. Despite this missing link, it is assumed that their actions were driven by climatic factors as reported by farmers themselves in the studies by Madisson (2006) and Nehemencha *et al*. (2007).This is illustrated in Figure 6 on the next page

Despite having identified several indigenous and emerging climate change strategies in the area, these strategies were categorized into the following climate change adaptation strategies: Crop variety, feed preservation, breeds of cattle, soil fertility management, time of planting and no adaptation. Therefore, these variables were used as choice variables in the Multi Nomial Logit model.

4.4.1 Farmers Adapting to Climate Change.

As indicated in Figure 7 below, use of crop variety is the most commonly method whereas soil fertility management is the least practiced among major adaptation methods identified in Bungoma County. Greater use of different crop varieties as an adaptation method could be associated with lower expenses, more trainings and extension on the same, and ease of access by farmers. Soil fertility and water management strategies were very low due to lack of information on soils in terms of soil PH and mineral requirements. It was hard for farmers to manage fertility of what they do not know. Training on conservation agriculture has increased adaptation of soil fertility management strategies.

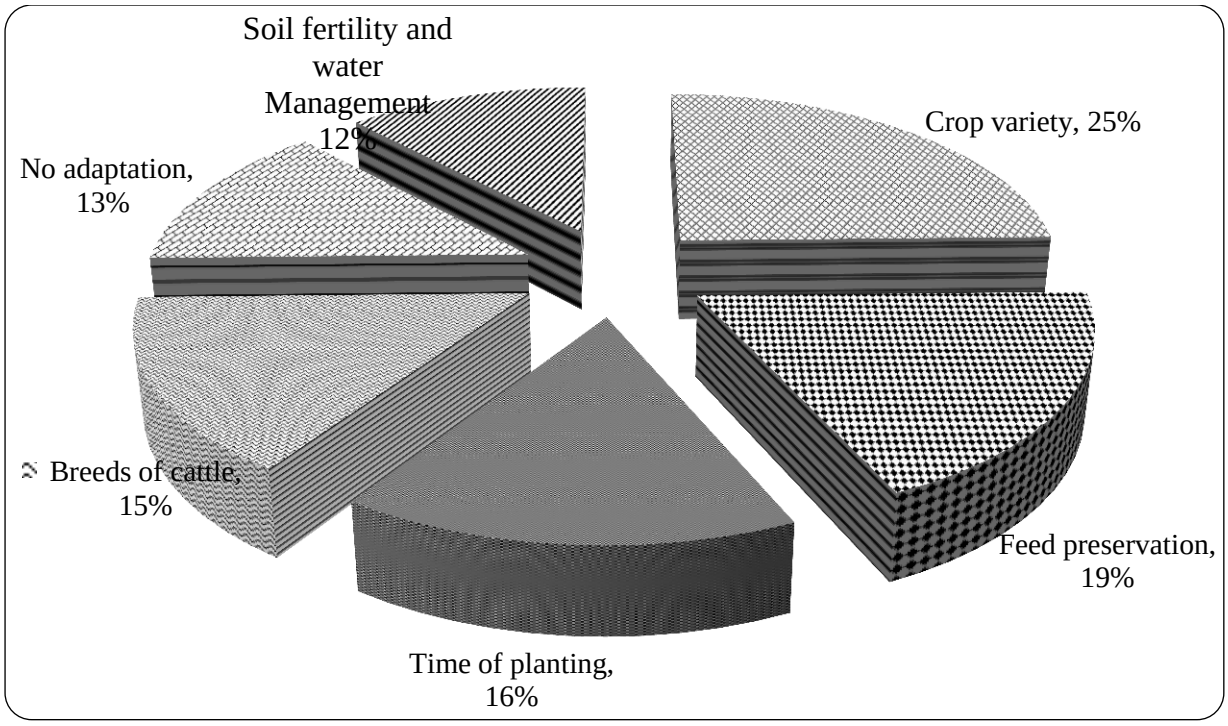

Figure13: Identified adaptation strategy carried out by smallholder farmers in Bungoma

4.5 Socio-Economic and Institutional Factors Affecting Adaptation of Climate Change Strategies.

The factors affecting adaptation of climate change strategies were divided into socio – economic and institutional factors. These factors are discussed below.

4.5.1 Socio Economic Factors

Sex: The results in Table 4 indicate that male headed households adapt more readily to climate change strategies. Male headed households were 7.88 % more likely to adapt to soil fertility strategies than female headed households. This was consistent with Tenga *et al*. (2004) who argued that having female headed household may have negative effects on adaptation of soil and water conservation strategies, because women may have limited access to information, land, and other resources due to traditional barriers.

Age: For most of the adaptation strategies, age did not significantly increase or decrease the probability of adaptation of climate change strategies. There were both positive and negative relationships between increase in age and adaptation of CCAS.

Number of children: Increasing household size did not significantly increase or decrease the likelihood of adaptation to climate change strategies.

Education: Education of the head of household increases the probability of adapting to climate change strategies. A unit increase in one level of education would result to a decrease of 7.05 % in adaptation of soil fertility strategy. This was contrary to expectation where higher level of education was believed to be positively related to adaptation to climate change. Soil fertility management is labour intensive and tedious and this may be the reason why highly educated head of households will avoid using them.

Farming experience: Farming experience had both positive and negative relationship on adaptation to climate change strategies. This was consistent with both Kebede *et al.* (1990) and Shiferaw (1998) .A unit increase in one year of farming experience results in an increase by 0.59% and 0.64% in breeds of cattle and no adaptation strategies respectively while a unit increase in one year of farming experience results in an decrease by 1.10%, 0.76% and 0.47% in time of planting, soil fertility and feed preservation strategies respectively.

Land size: As can be observed in table 4, a unit increase in land acreage had a positive and significant impact to adaptation of crop varieties strategies by 2.08 %. Growing of different crop varieties require more land.

Income: For most of the adaptation strategies, income did not significantly increase or decrease the likelihood of adaptation of climate change strategies. Though it was expected that higher income would significantly increase the adaptation of CCAS as indicated by Franzel, (1999) this was not the case in the study area.

4.5.2 Institutional Factors

Extension: As expected, access to extension services had significant and positive impact on crop varieties, breeds of cattle and feed preservation adaptation strategies and significant and negative impact on no adaptation strategy. A unit increase in 1 extension contact to farmers increased the likelihood of adaptation of crop varieties, breeds of cattle and feed preservation strategies by 6.61%, 3.04 % and 1.00% respectively. For instance a unit increase in extension contact resulted in a 4.53 % decrease to no adaptation strategy. This result implies the important role extension services in promoting the use of adaptation strategies. This was consistent with Yirga (2007) which reported a positive relationship between access to information through extension and adaptation of CCAS.

Training: Training had a significant and positive impact on adaptation of time of planting, soil fertility and no adaptation strategies. This was consistent with Nhemachena *et al*. (2007). A unit increase in 1 of training contacts increased the probability of adaptation to time of planting, soil fertility and no adaptation by 5.00%, 3.54% and 2.41% respectively. Training had a significantly and negative impact on adaptation of crop varieties and breeds of cattle strategies by 6.94% and 5.93 %. Training of farmers may have been geared towards growing specific varieties of crops and rearing specific breed of cattle.

Group membership: Group membership had a significant and positive impact on the likelihood of using time of planting strategy by 14.49%. This meant that farmers in groups planted their crops in specific times as they did this in groups.

Credit: Access to credit has a negative and significant impact on the likelihood of using no adaptation strategy of climate change. A unit increase in access to credit decreases the probability of no adaptation strategy by 0.80%. Availability of credit eases the cash constraints and allows farmers to purchased improved crop varieties, breeds of cattle, and plant timely, purchase facilities for soil fertility management and feed preservation. Research on adaptation of climate change strategies as explained in Yirga (2007) showed that there was a positive relationship between the level of adaptation of climate change strategies and

availability of credit. This result implies the important role of increased institutional support in promoting the use of adaptation of climate change strategies.

Table 4: Marginal effects from the multinomial logit of choice of climate change strategies

Explanatory variables	Crop Varieties		Time of Planting		Breeds of cattle		Soil Fertility		Feed Preservation		No Adaptation	
	Coeff.	P-level	Coeff.	P-value	Coeff.	P-value	Coeff.	P-value	Coeff.	P-value	Coeff.	P-value
Sex	-0.1325	0.203	-0.0187	0.823	0.0356	0.445	0.0788*	0.067	0.0088	0.934	0.0280	0.371
Age	0.0909	0.551	-0.1109	0.406	-0.0092	0.905	0.0685	0.423	-0.0827	0.614	0.0434	0.492
Number of Children	-0.0444	0.106	0.0205	0.346	-0.0134	0.369	-0.0050	0.727	0.0275	0.344	0.0146	0.129
Education	0.0706	0.289	-0.0268	0.630	0.0322	0.350	-0.0705*	0.060	-0.0102	0.883	0.0049	0.853
Experience	0.0110	0.125	-0.0110*	0.096	0.0059*	0.089	-0.0076*	0.089	-0.0047*	0.047	0.0064*	0.063
Land Size	0.0208*	0.064	-0.0081	0.438	0.0057	0.346	-0.0127	0.277	-0.0078	0.547	0.0021	0.621
Income	-0.0386	0.370	0.0401	0.303	-0.0113	0.608	0.0011	0.964	0.0354	0.452	-0.0266	0.128
Extension	0.0661***	0.004	-0.0379	0.129	0.0304**	0.010	-0.0233	0.181	0.0100*	0.089	-0.0453***	0.005
Training	-0.0694*	0.091	0.0500**	0.035	-0.0593***	0.003	0.0354**	0.037	0.0193	0.567	0.0241*	0.068
Group Membership	0.0677	0.501	0.1449*	0.087	-0.1215	0.103	-0.0171	0.768	0.0033	0.977	-0.0707	0.161
Credit	-0.0036	0.723	0.0088	0.321	0.0018	0.700	-0.0029	0.620	0.0039	0.726	-0.0080*	0.079

Notes: *, **, * = significant at 1%, 5%, and 10% probability level, respectively.**

CHAPTER FIVE
CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Conclusion.

Climate change was a new phenomenon in the study area though smallholder farmers' perception of climate change was that temperatures were rising while level of precipitation was declining. Those who did not use any of the methods considered lack of information on adaptation methods and lack of money as major constraints to adaptation. The smallholder farmers in the study area were predominantly crop growers. Climate change had adversely affected production of maize, beans and sugarcane which were their common crops. From the study, various indigenous strategies were identified for both crop and livestock production. Mulching was the most common crop strategy because mulching materials were cheap, locally available and most farmers had local knowledge on how to use the strategy. Tree planting, planting cover crops intercropping and planting drought resistant crop varieties were some of the other indigenous crop strategies. Cross breeding was the most common indigenous livestock strategy. The cross breeds produced more milk compared to local breeds and were also disease resistant and manageable in terms of feeds compared to pure breeds. Feed preservation, rearing mixed livestock and planting napier grass were other indigenous livestock strategies.

Declining soil fertility had negatively affected productivity of farming in the study area. Soil fertility management strategies and mulching, tree planting, planting short term crops and cover crops are some of the emerging crop adaptation strategies. Zero grazing, paddocking, cross breeds, pure breeds and feed preservation are some of the common emerging livestock adaptation strategies. Farmers in most sites stressed soil and water conservation measures and fertility restoration through the use of manure and compost (but also inorganic fertilizer). Men cited planting trees and cover crops that help improve soil fertility and the need to combat soil erosion.

The common farmers' adaptation strategies in the study area were growing a variety of crops, feed preservation, time of planting, rearing different breeds of cattle and soil fertility management. This was done to spread risks involved in farming due to unpredictable weather changes caused by climate change. Participants in all sites emphasized community-based organizations and farmers' groups as key to adaptation. They recognized that such organizations enable farmers to exchange information, establish rotating credit schemes, access training and technologies, and secure better prices and markets. There was need to aggressively create more awareness through trainings on climate change in the study area.

5.2 Policy Recommendations.

Adaptation of new and appropriate farm strategies or technologies requires knowledge and experience. Successful adaptation of these measures will require greater access to information and advice through extension services, trainings, access to inputs, as well as additional financial resources, particularly in the case of more costly investments such as irrigation and construction of green houses. Policymakers can facilitate adaptation of the most promising practices and technologies in several ways like expanding access to credit which can encourage the adaptation of more costly practices and technologies that offer multiple benefits and improved productivity. Promoting agricultural intensification to avoid the expansion of cultivated area, through investments in agriculture such as the provision of inputs, capacity development, and additional research and development would further facilitate the adaptation of climate change adaptation strategies.

Furthermore, through some carbon markets (such as the Clean Development Mechanism) farmers can be provided with financial incentives for soil carbon sequestration. These opportunities should be further explored while international climate negotiators intensify efforts to create additional incentives for agricultural mitigation.

Government investments in infrastructure such as roads and irrigation systems, demand driven extension services, affordable credit schemes, and climate information systems would help create the enabling conditions for adaptation to climate change.

Diversification of income sources is also a key adaptation strategy that should be encouraged further. This may include highly targeted efforts to broaden income-generating opportunities by creating opportunities for off-farm employment. Major changes within the agricultural system may be required in order to protect livelihoods and ensure food security. Responses to climate change need to encompass several levels, including crop and farm-level adaptations; collective action at the community level; and supporting policies and investments at national, regional, and global levels. This will require the involvement of all stakeholders. Potential strategies include infrastructural investment, water-management reform, land-use policy, and food trade. Conducting research on use of new crop varieties and livestock species that are better suited to drier conditions, encouraging informal social networks and investing in irrigation would be better policy interventions.

5.3 Issues for Further Research.

The study proposed that the effect of poverty and household income on the uptake of climate change adaptation strategies should be investigated clinically in order to ensure that

farmers are able to afford the technologies. There is also need to research further on the relationship between farmers' perception on climate change and actual climate change in Bungoma County is important to be conducted in order to effectively create awareness of climate change impact in the study area. Last but not least, research should also be done to determine the impact of climate change on the livelihoods of smallholder farmers in Bungoma County.

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APPENDIX I: Checklist for Focus Group Discussion

1. What are your understanding on the following concepts:
    a) Weather
    b) Weather changes
    c) Climate
    d) Climate change
    e) Indigenous climate change coping strategies
    f) Emerging climate change adaptation strategies
2. What are your perceptions of climate change in the study area?
3. Identify, rank and evaluate indigenous climate change coping strategies in the study area in :
    a) Crop production
    b) Livestock production
4. Identify, rank and evaluate emerging climate change adaptation strategies in the study area.
    a) Crop production
    b) Livestock production
5. Discuss impacts of climate change on your livelihood.
6. List and rank on livelihood areas where there is threat due to climate change.
7. List and rank of perceived hindrances to adaptation of emerging climate change strategies.
8. Name crop and livestock diversifications brought about by climate change.
9. Name livelihood diversification brought about by climate change.
10. Name any emerging crop or livestock introduced due to climate change.
11. Describe how socio-economic factors have affected climate change adaptation strategies.
12. Describe how institutional factors have affected climate change adaptation strategies.
13. List challenges that you have faced while dealing with climate change.
14. List possible solutions of climate change challenges named above.

APPENDIX II: Structured Questionnaire

Questionnaire No.

You are one among several smallholder farmers in this area who have been selected for this study. The study seeks to evaluate the effects of climate change adaptation strategies on food production. The information you will give will therefore be strictly confidential.

APPENDIX I: QUESTIONNAIRE

Date…….... (EN) Enumerator' name…….....

A GENERAL INFORMATION

(A1) Geographical Location

(DIST) District…… (DIV) Division……

(LOC) Location…… (SLOC) Sub-Location……..

(VIL)Village…… *(AEZ) Agro-ecological zone* ……..

(A2) Respondent

i) Respondent Name…… 1= Male 2= Female

ii) Are you originally from this Village 1. Yes [] 2. No []

iii). Were you raised in this village? 1. Yes [] 2. No []

(**A3) Profile of the Head**

	Name	**Sex**	**Yr. of Birth**	**Marital Status**	**Education Level**	**Experience in Farming**
HHM	NAME	SEX	YBTH	MRTS	EDUL	EGHTD
1						

CODES for ------

Sex
1=male
2=female

Marital Status,
1= Married,
2= Single
3= Divorced
4= Separated,
5= Widowed;

Education Level, 1=No formal education
2=Primary level
3=Secondary level 4=Tertiary level

Experience in farming
1= < 5
2= 5-10
3=10-15
4= >15

Number of children (if any) ……

(**A4)Land Ownership**

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

(**A5) Land Use**

1. Land use, (specify	**Size in Acres**	**Years in Same use**	**Rank : 1 for major**
2. Homestead			
3. Forest			
4. Crops			
5. Livestock			
6. Others (specify)			

(A6) Sources of income (Jan- Dec 2010)

	Tick	Rank
a) Livestock and livestock Products	[]	[]
b) Crops	[]	[]
c) Home industries	[]	[]
d) Agro forestry products	[]	[]
e) Off-farm employment	[]	[]
f) Others, Specify……..	[]	[]

A7. Ask the following questions for all crops produced in the last season **(Jan- Dec 2010)**.

Crop	Land prep' Costs	Seed costs	Fertilizer costs	Harvesting costs	Total labour Costs	Total variable costs	Total revenue	Gross margin

Crop codes	8= cowpea leaves	15 =Avocado
1= beans	9 = maize(Dry)	16= Local vegetables
2= bananas	10 = Maize (Green)	17= onions
3=Watermelon	11 = sorghum	18= cassava
4= Soya beans	12= finger millet	19= sweet potatoes
5= Green peas	13=Tomatoes	20= kales
6= pigeon peas	14 = mangoes	21= groundnuts
7= sugarcane		22=Oranges
		23=passion fruit
		24=Other(specify)_____

A8. Ask the following questions for all livestock reared in the last season **(Jan- Dec 2010)**.

Livestock	Input costs	Vet drugs costs	Treatment costs	Total labour costs	Other costs	Total variable costs	Total revenue	Gross margin

Livestock codes

1. Dairy cattle 2. Beef cattle 3. Goats 4 Sheep 5. Poultry 6. Pigs 7. Bees 8. Other (Specify) ……..

A9. Do you have any off-farm employment? 1 = Yes [ ] 2 = No [ ]

A10. If yes, what is the range of income per month? .....

(1) =Less than 5,000.00 (2) = 5,000 – 10,000.00 (3) = 10,000 – 20,000.00 (4) = More than 20,000.00

A11. What is the total 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 [ ]

A12. Does the family receive any remittances? 1= Yes [ ] 2 = No [ ]

A13. If yes, what is the average amount per month? _____

SECTION B. INSTITUTIONAL FACTORS

(B1**) Who is the main service Provider of?**

a) Crop production extension []
b) Livestock production extension []
c) Climate change information []
d) Marketing information []

Code: 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

(B2)For the last one year have you been visited by:

	1. Yes	2. No
a) Public extension agent	[]	[]
b) NGO	[]	[]
c) Neighbour/Farmer	[]	[]
d) Private extension	[]	[]
e) CBO	[]	[]
i. Farmer organization/Cooperative	[]	[]

(C1**) Do you belong to any group in your area?**

1. Yes [] 2. No []

C2 If yes, fills the details in the table

Group type	No. of female members	No. of male members	Year started	Group activities	Meetings per month	Savings per month

Group types: 1=Self Help group 2= Welfare group 3=Cooperative Society 4= Farmers group 5= Climate change CIG 6= Others (Specify) _____

Group activities: 1=Farming 2=Business 3=HIV/AIDS 4=Advocacy 5= other (specify)

C3. What benefits do you derive from membership in the groups?

1. Information on credit [ ] 2. Welfare [ ] 3. Advice on farming [ ]

Others (specify) _____

C4. What are your farming objectives?

1= Making Profits [ ] 2 = Support the family [ ] 3 = Reduce risk of hunger [ ]

4 = As a way of life [ ] 5 = Have no other option (could abandon farming) [ ]

6 = Others (*Specify*) ……..

(D1) For the last one year have you attended any training on climate change adaptation?

1. Yes [] 2.No []

(D2) If yes, which of the following

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

(D3) Who normally attend such training? (Tick)

Head [] Spouse [] Daughter/son [] Worker []

(D4) Did you seek advice on climate change adaptation?

1. Yes [] 2. No []

(D5) Did you implement the advice? 1. Yes [] 2. No []

(D6) If no, why didn't you succeed? **1.** Yes [] 2. No []

E.CREDIT

(E1) Did any member of the household apply for credit in the last season?

1. Yes [] 2. No []

(E2) Was the credit availed? **1.** Yes [] 2. No []

(E3) If yes, what was the purpose of the credit? 1. Crops production [] 2. Livestock Production []3. Others, specify…….. []

(E4) If No, what was the reason for not being given credit?

1. Had outstanding loan [] 2. Did not need []

3. No security [] 4. Others, specify…….. []

(E5) Which is the main source of credit?

1. Commercial Bank [] 2. NGO [] 3.Sacco []

4. Relative [] 5. Group [] 6.Others, Specify []

F ROADS INFRASTRUCTURE

(F1). Distance from homestead to:

	Distance	Road type
1. The nearest farm inputs stockist	[]	[]
2. The nearest Extension service provider	[]	[]
3. The nearest crop production service provider	[]	[]
4. The nearest livestock service provider []	[]	
5. The nearest agriculture produces market	[]	[]
6. The nearest climate change service provider	[]	[]

Code Road type: 1= tarmac 2= murram**3**= no road

G EXTENSION SERVICES

G1.Have you ever received any form of extension services on climate change? Yes [ ] No [ ]

G2. How often do you meet with extension agents? 1. Weekly [ ] 2. Fortnightly [ ] 3.Once a month [ ] 4.Once in three months [ ] 5.Once in six months [ ] 6.Once a year [ ] 7. Others (Specify) ……..

G3. What is the mode of meetings? (*Tick appropriately*)

1. Farm visits ☐ 2. Group visi☐ 3.Field day☐ 4. Office vi☐s 5. ☐ Barazas

6. Others (*specify*)☐ _____

G4. Do you air your views to the extension providers? Yes [ ] No [ ]

G5. To what level do the information providers consider your views? [ ]

(Code: 1- Always, 2- Often, 3- when I offer it, 4- very little, 5- Never)

G8. Rank indigenous coping strategies that are currently being used to deal with climate change:

Crop	**Livestock**
1.	1.
2.	2.
3.	3.
4.	4.
5.	5.

G8. Rank emerging adaptation strategies that are being used to deal with climate change:

Crop	**Livestock**
1.	1.
2.	2.
3.	3.
4.	4.
5.	5.

G9. a) Have there been any diversification in crops/livestock as a strategy in dealing with climate

change? Yes [ ] No [ ]

b) If yes, name the diversifications

c) If No, Why?

G10. a) Have there been any diversification in livelihoods as a strategy in dealing with

climate change?

b) If yes, name the diversifications

c) If No, Why?

G11. a) Do you have any crops/livestock introduced due to climate change?

Crop	**Livestock**
1.	1.
2.	2.
3.	3.
4.	4.
5.	5.

b) If yes, who introduced the crop/livestock? [ ]

Code: 1=Public extension agent 2= NGO 3=Neighbour/Farmer 4= Private extension 5=CBO 6=radio/Television 7=Farmer organization/Cooperative

SECTION C: CLIMATE CHANGE.

H1. 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	The environment in this area is changing due to human activities.	
B	The Climate is changing	
C	Temperature is rising.	
D	Rainfall is decreasing every year	
E	There is rainfall variability	
F	The weather is becoming drier every year.	
G	The yearly rains are not supporting crop production as before	
H	Climate change has led to crop pest infestation and diseases	
I	Food production has been affected by climate change	
J	The cost of food is increasing because of climate change.	
K	The Environment suffers from decreased vegetation due climate change.	
L	There is now Fuel wood scarcity.	
M	Climate change has led to rural-urban migration	
N	Climate change has led to the decline of forest resources	
O	Climate change has led to the change of livelihood system	
P	There have been increase incidences of floods during the raining season	
Q	There have been increase incidences of droughts during the dry season	
R	The incidence of climate change will affect the Sustainability of our environment.	
S	There is serious awareness on climate Change	

H2) Who are the people seriously affected by climate change? A. The poor B. The rich

H3) The threat of climate change is more on;

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

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

H4 : What are the strategies to adapting to climate change?

	Tick	**Rank**
a. Planting Different Varieties of crops	[ ]	[ ]
b. Different (staggering) time of planting	[ ]	[ ]
c. Rearing different breeds of livestock	[ ]	[ ]
d. Soil fertility and water management	[ ]	[ ]
e. Feed preservation	[ ]	[ ]
f. No adaptation method used	[ ]	[ ]

H5: What are the perceived hindrances to adaptation of emerging techniques of combating climate change?

	Tick	Rank
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 acquired modern techniques	[]	[]
f. There is no hindrance to adaptation	[]	[]

H6: List the challenges that you have been facing when coping/adapting to climate change?

.....

.....
.....
.....
.....

H7: How have you been dealing with challenges named above?

……
……
……
……
……..

H8: What do you recommend to be done that will enhance the fight towards climate change? Comment freely.

……
……
……
……
……

APPENDIX III: CLIMATIC DATA OF BUNGOMA COUNTY

YEAR	MRAIN	MAXTE	MINTEM	MTEM	YEAR	mm p.a
1983	5.01	28.56	14.97	21.77	1983	1829
1984	4.54	27.93	14.42	21.13	1984	1662
1985	5.83	27.44	14.3	20.87	1985	2128
1986	3.88	27.81	13.6	20.71	1986	1416
1987	4.35	28.18	13.42	20.80	1987	1588
1988	4.99	27.54	13.7	20.62	1988	1826
1989	3.58	27.33	13.4	20.37	1989	1307
1990	4.5	27.57	13.44	20.51	1990	1643
1991	4.5	27.68	12.7	20.19	1991	1643
1992	4.56	27.85	14.11	20.98	1992	1669
1993	4.48	28.11	14.76	21.44	1993	1635
1994	4.83	27.75	14.38	21.06	1994	1763
1995	6.82	27.85	14.14	21	1995	2489
1996	5.09	27.51	13.66	20.59	1996	1863
1997	4.89	28.44	13.92	21.38	1997	1785
1998	4.92	28.16	14.09	21.13	1998	1796
1999	5.41	27.74	13.11	20.39	1999	1975
2000	4.19	28.3	13.19	20.73	2000	1534
2001	5.24	27.63	13.29	20.46	2001	1913
2002	4.84	27.84	13.85	20.84	2002	1767
2006	5.74	27.9	15.28	21.59	2006	2095
2007	5.42	27.87	14.62	21.25	2007	1978
2008	5.21	27.81	14.47	21.14	2008	1907
2009	4.59	28.63	14.54	21.59	2009	1675
2010	5.03	28.76	14.66	21.71	2010	1836
2011	5.86	28.99	15.0	21.07	2011	2139

APPENDIX IV:THE AUTHOR PLANTING A TREE IN THE STUDY AREA

APPENDIX V:A SMALL HOLDER FARM IN STUDY AREA SHOWING A VARIETY OF CROPS GROWN

APPENDIX VI: Parameter estimates of the MNL choices of climate change strategies

Explanatory variables	Crop Varieties		Time of Planting		Breeds of cattle		Soil Fertility		Feed Preservation	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
Gender	-1.0020	0.191	-0.6800	0.416	-0.1350	0.883	0.5837	0.559	-0.5451	0.495
Age	-0.4418	0.725	-1.3976	0.311	-0.8667	0.539	0.0134	0.993	-1.0342	0.422
Number of Children	-0.4160**	0.034	-0.1409	0.455	-0.4045*	0.077	-0.3143	0.156	-0.1685	0.374
Education	0.1655	0.762	-0.2388	0.683	0.2660	0.658	-0.8884	0.165	-0.1191	0.827
Experience	-0.0736	0.203	-0.1757***	0.008	-0.0477	0.436	-0.1987***	0.007	-0.1278**	0.030
Land Size	0.0372	0.665	-0.0833	0.398	0.0259	0.794	-0.1820	0.258	-0.0624	0.488
Income	0.3322	0.315	0.6983*	0.063	0.3459	0.357	0.4823	0.223	0.5847*	0.087
Extension	1.0353***	0.001	0.5838*	0.080	1.1325***	0.000	0.5342	0.134	0.8321***	0.006
Training	-0.6730***	0.008	-0.1411	0.196	-1.0750***	0.003	-0.0230	0.826	-0.3630**	0.034
Group Membership	1.3674*	0.071	2.0228**	0.019	-0.0597	0.944	0.9104	0.290	1.0982	0.153
Credit	0.1280	0.121	0.1907**	0.033	0.1606*	0.063	0.1079	0.253	0.1535*	0.072
Base category	No adaptation									
Number of observations	150									
LR Chi- Square	127.57***									
Log likelihood	-204.98									
Pseudo R-Square	0.24									

Notes: *, **, * = significant at 1%, 5%, and 10% probability level, respectively.**