KNOWLEDGE, ATTITUDES AND PRACTICES ON CLIMATE CHANGE ADAPTATION BY SMALL HOLDER FARMERS IN MWALA CONSTITUENCY, MACHAKOS COUNTY, KENYA

LINDA AWUOR OCHIENG

(Z50/64675/2010)

Research Thesis Submitted in Partial Fulfillment of the Requirement for the Degree of Master of Arts in Environmental Policy of the University of Nairobi

September, 2015

DECLARATION

This thesis is my original work and has not been presented for examination towards a Master's degree in any University.

Name:

Signature ______________________________Date____

Name: Linda Awuor Ochieng

Registration Number: Z50/64675/2011

University of Nairobi

Centre for Advanced Studies in Environmental Law and Policy

DECLARATION BY THE SUPERVISORS

This thesis has been submitted for examination with our approval as University supervisors.

Signature____________________________________ Date: ____________________________

Prof Nicholas O. Oguge, PhD

Centre for Advanced Studies in Environmental Law and Policy (CASELAP),

University of Nairobi

Dr. Jones F. Agwata

Signature____________________________________ Date: ____________________________

Centre for Advanced Studies in Environmental Law and Policy (CASELAP),

University of Nairobi

DISCLAIMER

This document describes work undertaken as part of a programme of study at the Centre for Advanced Studies in Environmental Law and Policy (CASELAP), University of Nairobi. All views and opinions expressed therein remain the sole responsibility of the author, and do not necessarily represent those of CASELAP, or University of Nairobi.

ABSTRACT

Climate variability and change is affecting weather patterns and this has serious repercussions on food production among smallholder farmers in Kenya. In particular, semi-arid environments such as Machakos County are extremely vulnerable to climate variability and change because their crop production systems are sensitive to and reliant on rainfall. This study was undertaken in Machakos County, and sought to determine the knowledge, attitudes and practices on climate change adaptation by smallholder farmers within Mwala Constituency. Primary data was collected through interviews with key informants and household heads. Using semi-structured questionnaires, farmers were assessed on their knowledge and attitudes on climate change and practices they were using to adapt to impacts. Farmers' adaptation practices were analysed in relation to rainfall and temperature data to determine their strategies when faced with climatic changes. The study also analysed maize crop yield in relation to rainfall and temperature data between 1984 and 2014. The results show that the long term mean annual rainfall for Mwala was 630 ± 42.22 mm and a temperature range of 15-32 °C. Between 1988 and 2014, the mean annual rainfall for the area decreased at the rate of 5.8 mm per year ($y= 705.44+5.7815x$, $n= 106$ $p<0.001$). The average maize yield for the period was 1620 kg/ha/year. Farmers in Mwala Constituency had a high awareness of changes in rainfall and temperature. Eighty one percent (81%) believed that climate was changing as they had observed changes in their local environment and had taken specific measures to cope with the effects on their crops. Further, it was established that farmers had a positive attitude toward the changes and had joined farmers' groups and cooperative societies for information sharing. Some of the practices adopted by the farmers towards climate variability included agro-forestry, farm forestry, planting different varieties of crops, and staggering planting time. The major factors that drove farmers' investment in adaptation practices were age, level of formal education and level of awareness of climate change issues. Factors constraining them from adaptation measures included poverty and lack of information. The study findings underscore the need for policies towards farmer capacity building that entails education, awareness, poverty alleviation and increased access to more efficient inputs.

ACKNOWLEDGEMENTS

This thesis would not have been possible without the generous support and contributions of many individuals. My special thanks go to my supervisors, Prof. Nicholas Oguge, and Dr. Jones Agwata for their guidance and relentless support. I would like to acknowledge the inspirational instruction and guidance of my main supervisor, Prof. Oguge, his persuasiveness, keen interest and critique sharpened my thinking and enabled me to complete this work.

I would like to express my heartfelt appreciation to my husband Daniel for his support, understanding, love and care, and patience. Special thanks to my parents go to my parents who supported me in every way possible and who always encouraged me to work hard and excel in life.

Finally, I thank God, who nurtured me all the time, and provided me with strength, patience and wisdom required for completing this study.

DEDICATION

To my sons Naeto and Keita, who inspire me to scale greater heights, May I be an inspiration to you to achieve success in every facets of your lives.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

Climate change has direct, often adverse, influence on the quantity and quality of agricultural production. The climate of an area affects the vegetation and by extension the type of crop that can be cultivated. Temperature, rainfall, humidity, and day length are important climatic elements that influence cropping production (Sowunmi & Akintola, 2010). Various studies by the Intergovernmental Panel on Climate Change (IPCC 2007) have pointed Africa to be one of the most exposed continents to suffer the devastating effects of climate variability and change, with colossal economic impacts because of low adaptive capacity. Researchers view the African rain-fed agriculture to be the most vulnerable sector to climate variability and the potential impacts of climate change on agriculture are highly uncertain. The overall global warming is expected to add in one way or another to the difficulties of food production and scarcity (World Meteorological Organization, 1996). The report also stated that reduced availability of water resources would pose one of the greatest problems to agriculture and food production, especially in the developing countries. According to reports of IPCC, factors such as endemic poverty, bureaucracy, lack of physical and financial capital, frequent social unrest and ecosystem degradation contribute to Africa’s vulnerability to climate variability (Oseni & Masarirambi, 2011).

Agriculture is the most susceptible sector to climate change (IPCC, 2001). This is attributed to the fact that climate change affects the two most important direct agricultural production inputs, precipitation and temperature (Deschenes & Greenstone, 2006). Climate change also indirectly affects agriculture by influencing emergence and distribution of crop pests and livestock diseases, exacerbating the frequency and distribution of adverse weather conditions, reducing water supplies and irrigation and enhancing severity of soil erosion (Watson et al. 1998; IPCC, 2001).

Maize and grain legumes are important food crops in Kenya and are common practice with resource poor farmers in semi-arid areas such as Machakos County (Rao & Mathuva, 2000). To cope with vagaries of drought, farmers have adopted drought tolerant maize varieties and maize-legume intercropping as a risk diversification strategy (Muthamia *et al*., 2001).

Currently, there are many actions at different levels designed to respond to the challenge of climate change in the agricultural sector. Kenya, having signed the United Nations Framework on Climate Change, developed a National Climate Change Action Plan that cuts across sectors to implement Kenya's National Climate Change Response Strategy (GOK, 2010), which was put in place in 2010.There is also an Action Plan which states that Kenya is susceptible to climate-related effects and extreme weather events pose serious threats to the socio-economic development of the country. This comprehensive Action Plan includes subcomponents such as a national adaptation plan, low carbon sector analysis, a technology action plan, finance, a policy and regulatory framework, and a knowledge management and capacity building component. Notwithstanding these efforts, climate change adaptation and mitigation techniques remains in practice, a marginal issue for most decision makers. The links between climate change and the other components of food security including access, availability, stability, and utilization have not yet been well-researched (Ziervogel *et al*., 2010).

Kenya's over-dependence on rain-fed agriculture leaves the country vulnerable to climate variability and change. Climate variability affects those in regions that largely depend on rain fed farming and those highly dependent on agriculture. These events can result in massive crop losses, loss of stored food, and damage to infrastructure and consequent increases in food prices. Climate change is increasing the frequency and size of such events (Oseni & Masarirambi, 2011).

The current national plans on agriculture do not include a consideration of the knowledge, attitudes, and practices on climate change adaptation by smallholder farmers to climate change and extreme climatic events on their crops. Kenya's National Food and Nutrition Policy emphasize broad self-sufficiency to meet basic domestic needs of key food items. The adaptations measures it provides are mostly reactive, in the sense that it is triggered by past or current events. Although the policy recognizes the need to promote drought-tolerant food crops such as millet, sorghum and pulses in low production areas such as Machakos, it emphasizes on reliance on food relief to alleviate hunger and malnutrition in food-deficit areas. Whereas international food aid helps fight hunger, it compromises the ability to mobilize internal resources towards food security, which entrenches and worsens poverty (Palma *et al*., 2010).

Various recommendations have been proposed to enhance the adaptive capacities of farmers. Mainstreaming adaptations into national development processes is one such recommendation (Boko *et al*, 2007), however, it is hardly put into practice. Lack of mainstreaming often leaves the smallholders' adaptive role in agriculture overlooked. The disregard of local knowledge of farmers in critical policy documents on climate change could be interpreted as a failure of appreciation and engagement with local knowledge and its capacities to reduce vulnerability of farmers in the wake of climate change. Such reluctance urgently calls for concerted efforts that vouch for local adaptation measures. The adaptive capacity of farmers can be enhanced if national policies support climate change responses that are already being implemented by farmers.

1.2 Statement of the Problem

Climate variability and change is affecting weather patterns and seasonal shifts with serious repercussions on poor rural households and communities in Kenya (GOK, 2010). Since agriculture is intimately linked to climate, policy makers have expressed concerns regarding the potential effects of climate change on agricultural production systems. Despite the great efforts made to increase maize production in Kenya, the demand has occasionally outstripped the supply due to rapid population growth and low production due to increasing rainfall variability hence requiring importation to supplement the deficit. Overall, there is consensus that local knowledge is part of the solution to effective adaptation. However, there are limited studies that have elaborated on attitudes, perceptions and knowledge of losses of crops that result from climate variability, yet these perceptions can shape the adaptation strategies of smallholders.

In Machakos County, maize is the main rain-fed crop cultivated widely. This reflects cultural dependence on maize as a staple food. There is, however, a scarcity of information on agricultural adaptation strategies embraced by the farmers in Machakos County. There is therefore an urgent need to examine and document the how, when, why and what conditions adaptation actually occurs in economic and social systems (Smit & Olga, 2001), and implications of future climatic conditions. This is crucial in designing and implementing integrated policies that will enable the farmers to operate sustainable agricultural production systems. To address this gap, this study was designed to assess farmer knowledge and attitudes of climate change and to establish adaptation strategies to cope with the effects of climate change experienced by farmers in the County. The study sought to address the problems facing maize farmers in Machakos County, specifically factors leading to low crop yield in Mwala Constituency. The broad objective of this study is thus to assess the knowledge, attitudes and practices on climate change adaptation by smallholder farmers in Mwala constituency in Machakos County.

1.3 Research Questions

The main research question was:

What is the knowledge, attitudes and practices on climate change adaptation by smallholder farmers in Mwala constituency, Machakos County?

The sub-questions were -

1. What are the trends in maize production in Mwala Constituency, Machakos County under changing climate regime?
2. What are the farmer's attitudes towards climate change and its impacts on crop production in the area?
3. What is the level of awareness of the local people on climate change and its impacts in the County?
4. What strategies have local farmers in the County adopted to cope with climate change impacts and how appropriate are they?

1.4 Objectives of the Study

The main objective of the study was to evaluate the knowledge, attitudes, and practices on climate change adaptation by smallholder farmers in Mwala constituency in Machakos County, Kenya. The specific objectives of the study were to:

1. Determine the trends in maize production in Mwala, Machakos County under changing climate regime
2. Assess the farmers attitudes towards climate change and its impacts on crop production in the area
3. Evaluate the level of awareness of the local farmers on climate change and its impact on maize production in the County

4. Determine strategies local farmers in the area have adopted to cope with climate change impacts

1. 5 Scope and Limitations of the Study

The study was conducted in Machakos County, specifically Mwala constituency. It focused on the local knowledge and relationships that exist between attitudes and adaptations strategies employed in the crop sector alone. It did not touch on other forms of agriculture for instance livestock farming. The study narrowed down the crops under study to maize since it is the staple crop grown in the area.

The research did not take into account the revenue from livestock production, yet most farmers in Kenya combine livestock and crop production for subsistence. The localization of the study to only Machakos County in Kenya might limit the generalizations of the findings to the rest of the regions in Kenya under different geographical settings. It was also expected that the respondents might not cooperate fully in the study and some being reserved in giving the necessary information for the study. This limited the scope of the study.

As this research sought to interrogate the effectiveness of various policy documents in achieving food security in Kenya, some of the constraints that were faced included:

i. Bureaucracy in Government Departments. This manifested itself through difficulty in accessing public documents that are in the custody of the Government and this in effect hindered the smooth running of the research.
ii. Lack of adequate and up to date information: The research will only be effective if there is up to date statistics about food security situation in Kenya.
iii. The area of study was too wide for a comprehensive research to be undertaken within the specified time period.
iv. Lack of adequate finances to effectively carry out extensive research.
v. Limited existing quantitative evidence on the ability of adaptation to improve food security outcomes in the face of climate change.

1.6 Justification and Significance of the Study

Agricultural policies in Kenya aim to improve farmers' livelihoods. With projected climate change, these policies are short of mechanisms that promote farmers' adaptation. As a result, smallholders are confronted with a variety of challenges including climate change, which hinders their agricultural production. Local knowledge can be instrumental in assisting smallholders to cope with climate change and variability. The Government of Kenya and other organizations have been undertaking various interventions to mitigate the impacts of climate change and variability but little has been done to build adaptive capacity of smallholder farmers in the area. However, it is believed that knowingly or unknowingly farmers have been trying to adapt to climate change impacts through different farming practices and technologies but these have not been documented. There is need therefore to assess and affirm the incidence of indigenous and innovative climate change adaptation practices or technologies being applied by smallholder farmers, and understand the links among applied climate change adaptation strategies, farming systems and livelihood security in the study area. It is very important to document the indigenous and emerging technologies and innovations for climate change adaptation and factors that influence adoption of various adaptation strategies in order to come up with interventions that can build up smallholder farmer's adaptive capacity and resilience to climate change impacts. Identifying both the generic and climate-specific elements of farmers' adaptation behavior is vital in order to facilitate a societal response to the changes in climate that scientists have predicted. Tailoring adaptation practices to specific societies may make it possible to offset the adverse impacts of climate change (Fussel, 2007).

This study will build on other authors who have crosschecked local knowledge with quantitative climate data to ascertain its relevance for climate variability. The study therefore will assist in designing capacity-building programs for farming communities to adapt to climate change impacts. This will contribute to designing programs that would enhance behavioral change towards climate change adaptation measures at household, community, and institutional level. Building on the local knowledge would foster adaptive capacity that is acceptable to farmers by promoting and supporting locally developed adaptations. The results of the study will also inform policy makers with recommendations for building climate change adaptive capacity

1.7 Key Concepts and Definitions

1.7.1 Climate Change

The United Nations Framework Convention on Climate change (UNFCCC) defines climate change as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.” It generally refers to longer term changes in means or in climate variability itself, and often specifically to change resulting from human activities, for example global warming due to the burning of fossil fuels (IPCC, 1997).

Climate is usually defined as the average weather, or more rigorously, as the statistical description of the weather in terms of the mean and variability of relevant quantities over periods of several decades (typically three decades as defined by World Meteorological Organization). These quantities are most often-surface variables such as temperature, precipitation, and wind, but in a wider sense, the "climate" is the description of the state of the climate system (IPCC, 1997).

1.7.2 Climate Variability

The weather represents variability in the atmospheric conditions on a daily and weekly basis. The term climate variability generally refers to variations of the climate system, which includes oceans and the land surface as well as the atmosphere, over months, years and decades. This encompasses predictability, i.e. the march of the seasons, but also includes an inherent uncertainty. The rainy season is a predictable occurrence, but the amount, timing and distribution of the rains is uncertain (Hellmuth et al., 2007). Adaptation - is the ability to respond and adjust to actual or potential impacts of changing climate conditions in ways that moderate harm or take advantage of any positive opportunities that the climate may afford. It includes policies and measures to reduce exposure to climate variability and extremes, and the strengthening of adaptive capacity. Adaptation can be anticipatory, where systems adjust before the initial impacts take place, or it can be reactive, where change is introduced in response to the onset of impacts (IISD, 2003).

1.7.3 Adaptation to Climate Change

Adaptation to climate change is the process through which people reduce the adverse effects of climate variability on their health and well-being, and take advantage of the opportunities that their climatic environment provides (Burton, 1992). The term adaptation means any adjustment, whether passive, reactive or anticipatory, that is proposed as a means for ameliorating the anticipated adverse consequences associated with climate change (Stakhi, 1993 quoted in Smit et al., 2000). Adaptability refers to the degree to which adjustments are possible in practices, processes, or structures of systems to projected or actual change in climate. Adaptation can be spontaneous or planned, and can be carried out in response to or in anticipation of changes in conditions (IPCC, 1996).

1.7.4 Adaptive Capacity

This is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damage, to take advantage of opportunities, or to cope with the consequences (IPCC, 2001). Thus, the adaptive capacity of a system or a community describes its ability to modify its characteristics or behaviors to cope better with changes in external conditions. Adaptation to climate change is very crucial in order to reduce the impacts of climate change that are happening at present time and increase resilience to future impacts. Climate change mitigation - An anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks (IPCC, 2007).

1.7.5 Climate change perception

Perception is the process of attaining awareness or understanding of sensory information. The word "perception" comes from the Latin words perceptio, percipio, and means "receiving, collecting, and action of taking possession, apprehension with the mind or senses". Farmers learn and adopt innovations in many ways. Based on their perception and observations from neighbors, success stories and practices, farmers tend to update and try to adapt to the adverse effects of weather changes. However, this depends on the resources available in their hands and opportunities in accessing extension serves, credits as well as inputs.

Two steps are involved in climate change adaptation: first perceiving change and then deciding whether or not to adopt a particular measure (Madison, 2007). Whenever they have the opportunity, farmers tend to adopt new variety of measures or technologies in response to the perceived changes of weather conditions. The supports from extension workers, information gained and technologies available to them will highly influence their adaptation and response capacity. For instance, farmers use water conservation techniques whenever the rainfall patterns are changed and amounts of rain are reduced. They tend to plant different crop varieties and use short-term crops with adjustment of planting dates. These adjustments are done when they perceive reduction in rainfall and changes in the onset and offset of rainy seasons.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

In this chapter, relevant past studies on the subject were reviewed with a view to identifying the various gaps which the study will endeavor to fill. The review will also be useful in terms of the theoretical framework of the study from which the conceptual frameworks of the study were derived.

2.2 Review of Past Studies

Although climate change is expected to have adverse impacts on socio economic development globally, the degree of the impact will vary across nations. The IPCC findings indicate that developing countries, such as Kenya, will be more vulnerable to climate change. This may have far reaching implications to Kenya for various reasons, mainly as its economy largely depends on agriculture. A large part of the country is arid and semiarid, and is highly prone to desertification and drought. Climate change and its impacts are, therefore, a case for concern to Kenya.

As Kenya's population continues to grow, producing enough food for all remains a challenge. Unpredictable weather patterns, poor planning, and slow adoption of modern farming methods negatively influence food security. The Kenya Economic Report (KIPPRA, 2009) indicates that about half of Kenya's population is poor, and about 7.5 million people live in extreme poverty. Over 10 million suffer from chronic food insecurity and poor nutrition. The Millennium Development Goals (MDGs), to which Kenya is a signatory, place elimination of hunger at the top of the list of international goals. It is estimated that about 34.8 percent of the rural population and 7.6 percent of the urban live in extreme poverty, so much that they cannot meet their food needs even when they use all their resources in the access to food. This is evident of a serious food problem in the country (Oluoko-Odingo, 2011). Agriculture remains the backbone of the Kenyan economy. It is the single most important sector in the economy, contributing approximately 25% of the GDP, and employing 75% of the national labor force (Republic of Kenya, 2005).

There are four ways that climate would have a physical effect on crops (Kurukulasuriya & Rosenthal, 2003). Changes in temperature and precipitation directly affect crop production and can even alter the distribution of agro-ecological zones. Secondly, increased carbon dioxide is expected to have a positive effect on agricultural production due to greater water use efficiency and higher rates of plant photosynthesis. Thirdly, runoff or water availability is critical in determining the impact of climate change on crop production, especially in Africa. Finally, agricultural losses can result from climate variability and the increased frequency of changes in temperatures and precipitation (including droughts and floods). Kurukulasuriya and Rosenthal (2003) state that in middle and higher latitudes, higher temperature will lengthen growing seasons and expand crop producing areas pole-ward, thus benefiting countries in these regions. In contrast, in lower latitudes, it is expected that higher temperature will adversely affect growing conditions, especially in areas where temperature close to or at optimal level for crop growth to begin with. A study of the economic impact of climate change on Kenyan crop agriculture by (Kabubo-Mariara & Karanja 2006) showed that climate change affects agricultural productivity. The result further showed that increased winter temperature associated with higher crop revenue, but increased summer temperature has a negative impact (Kabubo- Mariara & Karanja, 2006).

African smallholders use complex adaptation processes. In agriculture adaptation is evolutionary and occurs in the context of climatic, economic, technological, social, and political forces that are difficult to isolate, and most adaptation practices serve multiple purposes and are strongly interrelated (Smit and Skinner 2002; Adger *et al.,* 2007). Furthermore, adaptation is an iterative, dynamic, multiscale, and multi-actor process, not a mechanical adjustment to a current state (Osbahr *et al.,* 2008). The dynamic nature of adaptation makes it difficult to determine when, for example, the decision of a farmer to grow one crop variety instead of another is an adaptive response to short-term drought (climate variability) and when it is a planned adaptation to climate change (increased climate variability or gradual long-term changes in climate parameters). The multi-actor character of adaptation means that it involves a variety of stakeholders, such as rural households, private businesses, NGOs, and governments at local, regional, national, and international levels. Any realistic assessment of adaptation practices needs to take into account the linkages between actors and levels (Smit and Skinner 2002). In summary, adaptation is highly context sensitive, and determining when the climate is the driving force behind adaptation behavior is difficult.

According to Nelson *et al*., (2010) since food production is critically dependent on local temperature and precipitation conditions, any changes require farmers to adapt their practices and this adaptation requires resources that could be used for other purposes. Farmers everywhere will need to adapt to climate change. They advanced that for a few of the farmers, the adaptations might be beneficial, but for many farmers there might be major challenges to productivity and more difficulties in managing risk. The agricultural system as a whole will have difficulty supplying adequate quantities of food to maintain constant real prices. The challenges extend further: to national governments to provide the supporting policy and infrastructure environment.

Farmers have a long history of responding to climate variability. Traditional and newly introduced adaptation practices can help farmers to cope with both current climate variability and future climate change. However, the debate about the adaptation of small-scale farmers in Africa to climate change has occurred in the absence of knowledge about existing and potential adaptation practices. Because prevailing ideas about adaptation are vague, conducting focused research on potential adaptation practices and formulating appropriate advice for implementing new practices is difficult. Adaptation generally takes place at the micro- and macro-levels: Farmers introduce practices at the local level, and the main factors influencing their diffusion are seasonal climatic variations, the agricultural production system, and other socioeconomic factors; the government, NGOs, or private companies introduce practices nationally, and long-term changes in climatic, market, and other conditions influence their establishment (Nhemachena and Hassan, 2007).

Often, the most binding constraints in smallholder farming occur at the adaptation stage, with several factors potentially impeding smallholder farmer’s 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.

Over the years, farmers have adapted differently to climate change. 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.

2.3 Legal and Policy Framework Governing Climate Change and Crop Production in Kenya

2.3.1 Crops Act, 2013

The objective of the Crops Act, 2013 is to accelerate the growth and development of agriculture in general, enhance productivity and incomes of farmers and the rural population. In addition, it is to improve investment climate and efficiency of agribusiness and develop agricultural crops as export crops that will augment the foreign exchange earnings of the country, through promotion of the production, processing, marketing, and distribution of crops in suitable areas of the country. The Act seeks to, *inter alia*, conduct farmers' training programs aimed at increasing their knowledge on production technologies and on market potentials and prospects for various types of crops, through farmer training institutions.

2.3.2 Climate Change Bill, 2014

The Climate Change Bill was gazetted in January 2014. It seeks to provide for the legal and institutional framework for the mitigation and adaption to the effects of climate change; to facilitate and enhance response to climate change; to provide for the guidance and measures to achieve low carbon climate resilient development and for connected purposes. The Bill defines adaptation as adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects which moderates harm or exploit beneficial opportunities. The main objective of the Bill is to provide a framework for mitigating and adapting to the effects of climate change on all sectors of the economy and levels of governance; and further, to provide a mechanism for coordination and governance of matters relating to climate change.

It also seeks to advance coordination mechanisms for formulation of programmes and plans to enhance the resilience of human and ecological systems against the impacts of climate change
The bill proposes the establishment of the National Climate Change Council whose functions will be to advise the national and county governments on legislative and other measures necessary for mitigating and adapting to the effects of climate change; and to provide coordination between and amongst various governmental and non-governmental stakeholders dealing with matters related to climate change.

2.3.3 National Climate Change Framework Policy

This Policy was developed to facilitate a coordinated, coherent and effective response to the local, national and global challenges and opportunities that climate change presents. This will be achieved through the adoption of a mainstreaming approach that ensures integration of climate change considerations into the development planning process, budgeting, and implementation in all sectors and at all levels of government. This Policy therefore aims to enhance adaptive capacity and build resilience to climate variability and change, while promoting low carbon development pathways. The Policy underscores the need for sustainable development of Kenya and therefore significantly advocates for the design and implementation of mechanisms that trigger and enhance climate change resilience and adaptive capacity. The plan proposes the mainstreaming of climate change into the planning process. This is necessary to equip various coordinating and sectoral agencies of the Kenyan national and county governments with the tools to effectively respond to the complex challenges of climate change. In this context, mainstreaming implies the integration of climate change policy responses into national, county, and sectoral planning and management processes. This requires explicitly linking climate change actions to core planning processes through cross-sectoral policy integration that operates both horizontally by providing an overarching guide for all sectors; and vertically, requiring all sectors and levels of government to implement climate change responses in their core functions. This is done, for instance, through the Medium Term Expenditure Framework for budget making and converting policies and plans into expenditure and action. The Policy acknowledges that mainstreaming is a process that encourages cooperation across government departments in planning for a longer-term period; rather than fragmented, short-term and reactive budgeting. County governments are required by law to prepare and implement County Integrated Development Plans, through which climate change actions can be main

2.3.4 Agricultural Policy

The Agricultural Policy undertakes to address the identified challenges in the Agricultural Sector by providing guidelines to the national and County Governments towards ensuring household and national food and nutrition security. It also aims at increasing agricultural production and productivity through the use of appropriate good quality and affordable inputs; facilitating access to premium domestic, regional and international markets and reducing post-harvest losses while promoting agribusiness, value addition and product development. The policy recognizes that agricultural production declined in 2013 because of depressed performance of the long and short rains. Apart from rice and wheat, most cereal crops recorded significant declines in production during the period. Maize production declined to 39.7 million bags in 2012 from 38.9 million bags in 2013. The Agricultural policy seeks to improve and intensify agricultural production and productivity to meet market requirements while promoting conservation, development, and sustainable utilization of resources in agriculture, livestock and fisheries. It provides that the two levels of governments will develop strategies for joint early warning systems for unforeseen disasters and control of weeds, diseases, and pests.

2.3.5 Agricultural Sector Development Strategy 2010-2020

The Agricultural Sector Development Strategy 2010 - 2020 is the overall national policy document for the agricultural sector ministries and all stakeholders in Kenya. The vision of the strategy is to establish a food-secure and prosperous nation. Since the agricultural sector is the backbone of Kenya's economy and the means of livelihood for most of the rural population, it is inevitably the key to food security and poverty reduction. The plan therefore aims at ensuring food security through sustainable agricultural practices.

2.3.6 National Food Policies

Arising from the shortages of essential staple food grains in 1980; in June 1981 Kenya launched the sessional paper No. 4 of 1981 on National Food Policy. The overall objects of the policy are three fold. Achieve a calculated degree of food supply for each area of the country. Maintain a position of broad self-sufficiency in the main food stuffs in order to enable the nation to be fed without using scarce foreign exchange on food imports. Ensure that these foodstuffs are distributed in such a manner that every member of the population has a nutritionally adequate diet. The National Food Policy addresses specific issues of price policy, agricultural trade policy, agricultural inputs policy, research and extension policy, food security policy, processing and marketing policy, nutrition policy, resource development policy and, employment policy. The Policy emphasizes preventing land degradation and encouraging use of drought-resistant crops in marginal areas. Further, it recommends the utilization, marketing and conservation of indigenous food crops and the use of indigenous food plants to fight poverty and improve household food security. The Kenyan food policy document was reviewed in sessional papers No. 1 of 1986 and No. 2 of 1994 to improve focus and response to changing demand. However, key elements of the policy remained the same and continue to revolve around food availability, accessibility and nutritional adequacy.

The Government policy as stipulated in a number of policy papers emphasizes self-sufficiency in domestic production of the food crops as well as the generation of foreign exchange as a means of achieving food security. It has been established that given adequate support and non-interference in the production and marketing of the various crops, Kenya is capable of increasing both production and productivity in agriculture as has been demonstrated in the remarkable success in tea, horticulture and dairy sub-sectors. The success in these sub-sectors is attributable to a combination of a number of factors including favorable weather conditions, emerging market opportunities, government sponsored credit schemes, research, extension services, training and monitoring among others. Kenya is the third major tea producer in the world after India and Sri-Lanka while her horticultural and dairy sub-sectors expansions have created both employment and income in the rural areas.

2.3.7 Economic Review of Agriculture (2010)

According to the most recent economic review of Agriculture, the sector registered mixed results in 2009. The long rains of March to April were thinly spread and the short rains expected between October and December were generally erratic and uneven; some areas received above normal rains and others lower than average rains. Prices of most agricultural commodities rose on average during the year because of supply constraints. This is evidence of climate change impacts on agriculture in the country.

2.3.8 National Climate Change Response Strategy

In line with global talks on climate change, Kenya developed a National Climate Change Response Strategy (NCCRS) in order to put in place robust and thorough adaptation and mitigation measures to minimize risks and maximize opportunities. The strategy states that climate change in Kenya has been evidenced by rising temperatures throughout the country, irregular and unpredictable, rainfalls making extreme and harsh weather a norm in Kenya. Major rivers show severe reduced volumes during droughts, and many seasonal ones completely dry up. The consequent crop failures in 2009 for instance, placed an estimated 10 million Kenyans or one fourth of the entire population at risk of malnutrition, hunger and starvation. Droughts reduce the production of not only staple food crops such as maize but also other major crops such as tea, sugarcane, and wheat. This increases imports (maize, wheat and sugar) and reduces exports (tea), weakening the country’s balance of payments. As a response to the challenges posed by climate change to Kenya, the Strategy has proposed a number of measures meant to curb the adverse impacts of climate change on the country (adaptation measures) and to tame global warming (mitigation measures). These include Agriculture: provision of downscaled weather information and farm inputs; water harvesting e.g. building of sand dams for irrigation;

protection of natural resource base (soil and water conservation techniques); and research and dissemination of superior (drought tolerant, salt-tolerant, pest and disease resistant) crops.

2.3.9 National Climate Change Action Plan

Kenya launched its National Climate Change Action Plan in March 2013. The Plan addresses the options for a low-carbon climate resilient development pathway as Kenya adapts to climate impacts and mitigates growing emissions. The plan also addresses the enabling aspects of finance, policy and legislation, knowledge management, capacity development, technology requirements, monitoring, and reporting. The Plan recognizes that drought is a widespread phenomenon across large areas of sub Saharan Africa, with an estimated 22% of mid-altitude/subtropical and 25% of lowland tropical maize growing regions affected annually inadequate water supply during the growing season (Heisey and Edmeades, 1999).

The Plan not only considers a series of individual adaptation and mitigation measures, it considers the enabling conditions that will ensure lasting, sustainable and integrated adaptation and low-carbon benefits for the Country. The Plan proposes that Kenya moves towards a low carbon climate resilient economy. It advocates for promoting economic growth while limiting pollution and greenhouse gas emissions, minimizing waste and inefficient use of natural resources, and maintaining biodiversity are opportunities presented by actions to implement green growth – related strategies.

This analysis has shown that existing policies and legislation are relatively weak and inadequate to deal with climate change issues. Very few sections address climate change and mitigation, and they are not exclusively devoted to climate change adaptation. Knowledge of climatic perceptions and adaptations are vital for decision makers and policy makers to learn how and where to enhance the adaptive capacity of smallholder farmers in semi-arid areas. The existing legislation and policies have produced limited benefits to smallholders because proposed responses in agriculture at national levels are predominantly solutions often unfavorable to the locals and government focus does not necessarily integrate climate change and variability into their strategies. Agricultural improvement can be achieved if smallholders are targeted. As part of targeting smallholders and solutions for climate change and variability, local knowledge of farmers becomes very important to enhancing their adaptive capacity. Local knowledge is based on practice and assists farmers to make informed decisions about how to respond to environmental changes and how to improve the amount of their yield. The adaptive capacity of farmers can be enhanced if national legislation and policies support climate change responses that are already being implemented by farmers. However, there is limited information on adoption of strategies and other adaptive mechanisms that farmers use to deal with the impact of climate change in Kenya. Hence, this study was designed to make a contribution towards bridging the gap.

2.4 Theoretical Framework

This study was underpinned by two theories, namely, the action theory of adaptation and the integral theory of adaptation. These theories, in one way or another offer insight into why people chose one option or another and capture the extent of farmers' awareness and perceptions of climate variability and change, and the types of adjustments they have made in their farming practices in response to these changes. These theories are useful in explaining and understanding the practices that smallholder farmers in Mwala, Machakos County adopt while taking into account their knowledge and attitudes while dealing with the effects of climate change.

2.4.1 Integral Theory of Adaptation

This study sought to apply and advance the integral theory of adaptation as propounded by O'brien et al., (2010). Integral is defined as comprehensive, inclusive, non-marginalizing, embracing. Integral approaches to any field attempt to be exactly that: to include as many perspectives, styles, and methodologies as possible within a coherent view of the topic. In a certain sense, integral approaches are "meta-paradigms," or ways to draw together an already existing number of separate paradigms into an interrelated network of approaches that are mutually enriching (Visser, 2003).

According to O'bien et al, (2010), some of the critical issues facing the field of adaptation include: 1) the need for a rigorous integrative framework that brings together multiple perspectives and approaches to adaptation; 2) the need to integrate individual and collective interiority with biophysical, scientific, and technological approaches involved in climate change adaptation; and 3) the need for capacity building among leaders and practitioners to carry this forward.

O'brien et al, (2010) suggest that integral theory offers a framework that takes into account the bigger picture in which climate change is occurring, and thus it can offer insights on the types of responses and strategies that are necessary to confront the challenges of climate change responses that address all four quadrants, lines, levels, and types i.e. (I, we, it, its). All four quadrants are closely related, and cannot be seen as isolated or independent from each other. The links between the systemic processes associated with climate change are linked to human development: The impacts of climate change can influence human development, just as human development can influence the future climate system.

An integral approach to adaptation recognizes that adaptation cannot be solely conceptualized or engaged as behavioral and systemic changes. It must also include interior changes, both personally and culturally. Adaptation involves a changed sense of self, not as a passive subject to shifts in the climate system that are outside of one's control, but as an active player in the future of the community and world, all of which relate to worldviews, values, beliefs, and self-definitions. This includes individuals' personal capacities to be creative and innovative by thinking outside the box, to be reflective yet action-oriented as leaders, and to be internally resilient in the face of disruptive change. Invoking multiple scales, an integral approach also includes the cultural dimension of adaptation, such as the capacity of groups to peacefully negotiate responses in turbulent times (e.g., through periods of unpredictable weather events and financial instability), to undertake collaborative action in spite of conflicting values and beliefs, and to take into consideration the ethics of greenhouse gas emissions reductions (e.g., cultures with the smallest carbon-emission footprints are often the most vulnerable to the impacts of climate change). This has been applied by the farmers in Mwala in that the strategies adopted by the farmers were based on individual experiences e.g the number of years of experience the farmers had, the sizes of their land and the individual knowledge they had on the occurrence of changes in the climate. The farmers also applied an integral approach by not only relying on their individual knowledge but applying information from their surrounding environments into their strategies. For instance, the farmers not only relied on information from extension officers even though the visits were not frequent but were also members of groups where information on best strategies to adopt to climate change was shared.

Integral theory recognizes a diversity of needs and motivations, hence responses. The proponents of this theory, O'brien et al, (2010) suggest that there is no single solution to climate change, and it is unlikely that one single solution will be found. What is needed is a multitude of measures that transform energy systems, social systems, economic systems, and institutions at an unprecedented rate and scale. The most important solutions to climate change already exist. While there is still a need to focus research and development on, for example, plant-breeding and improved renewable energy technologies, there are a tremendous number of changes that can be enacted immediately, and which may have positive social effects regardless of climate change.
This theory recognizes that the depth of the human dimensions of climate change may be essential to responding to the enormous challenges with regard to climate change.

The integral approach was very effective in Mwala Constituency as it showed the multiple actors required to come together to build the resilience of the farmers when faced with the effects of climate variability and change.

2.4.2 Action Theory of Adaptation to Climate Change

Adaptations are defined as processes of entities and systems, or adjustments of human systems. The action theory refers only to human systems, individuals and collective actors. The theory defines a stimulus as a change of biophysical, in particular meteorological, variables triggered by climate change (IPCC 2010).

Action theory proposes a way to think about adaptation that emphasizes the interconnectedness of complex activities that address societal consequences of climate change along means-end chains, and considers multiple actors in different roles (Eisenhack et al., 2011). Based on the theory one could define adaptations as individual or collective actions that are explicitly or implicitly intended to affect exposure units of climate change.

Adaptations are processes of entities and systems, or adjustments of human systems. The action theory refers only to human systems, individuals and collective actors. Action requires actors and an intention. The intention is directed towards an impact of climate change. Furthermore, adaptations require the use of resources as means to achieve the intended ends. (Smit et al., 2000)

The action theory of adaptation proposes a new way to analyze adaptations from an action-oriented perspective. It emphasizes the interconnectedness of complex activities that address societal consequences of climate change along means-ends-chains. It is crucial for analysis to spell out the purpose of adaptations, and to consider that operators and receptors of adaptation may be different from the exposure units. Based on this theory, adaptations are defined as individual or collective actions that are explicitly or implicitly intended to affect exposure units of climate change, or that indirectly achieve this end. This framework makes it easier to determine key variables for understanding the concept and governance of decisions leading to adaptation (Eisenack et al., 2011). These theories will guide the study as it seeks to investigate actual adaptations at the farm level, as well as the factors that appear to be driving them. The action theory will be useful in Mwala as it will shed light on the farmers' actions towards adaptation while faced with unpredictable climatic variables.

2.5 Conceptual Framework

The conceptual model below depicts the linkage between climatic variables with livelihood outcomes such as agricultural production and food security. Climate change affects the type of policy measures that governments take and the adaptation strategies that farmers adopt. Mwala Constituency is characterized by low, erratic and poorly distributed bimodal rainfall that makes crop production difficult under rain fed conditions. The long rains commence in mid March and end in May while short rains start in mid October and end in late November. The mean annual rainfall for Mwala Constituency is 630 mm (Ngugi et al., 2011). The knowledge, attitudes and practices of farmers determine the adaptation strategies adopted by farmers and these in turn determine the productivity and the food security status of a household. An integral approach, in addition to actions taken by different actors in the agricultural sector will influence the adaptation strategies taken up by farmers in the area. This includes capacity building by the government and non-governmental organisations, creating awareness through education and sharing climate data and knowledge on various adaptation strategies Adaptation strategies through policy responses will result into positive outcomes of increased food production in Mwala Constituency. Effective adaptation coupled with policy responses will lead to outcome of higher crop yield, drought resistant crops, increased farm income, increased awareness, and climate smart agriculture in Mwala Constituency. The value of this study will be in incorporating the knowledge and practices of the smallholder farmers in Mwala into national agricultural policies and ensuring policy-makers involved in engaging the public in the issue of climate change develop workable adaptation policies. This requires an understanding of the multiple social realities and responses to climate change as illustrated below.

Figure 2.1: Conceptual Framework

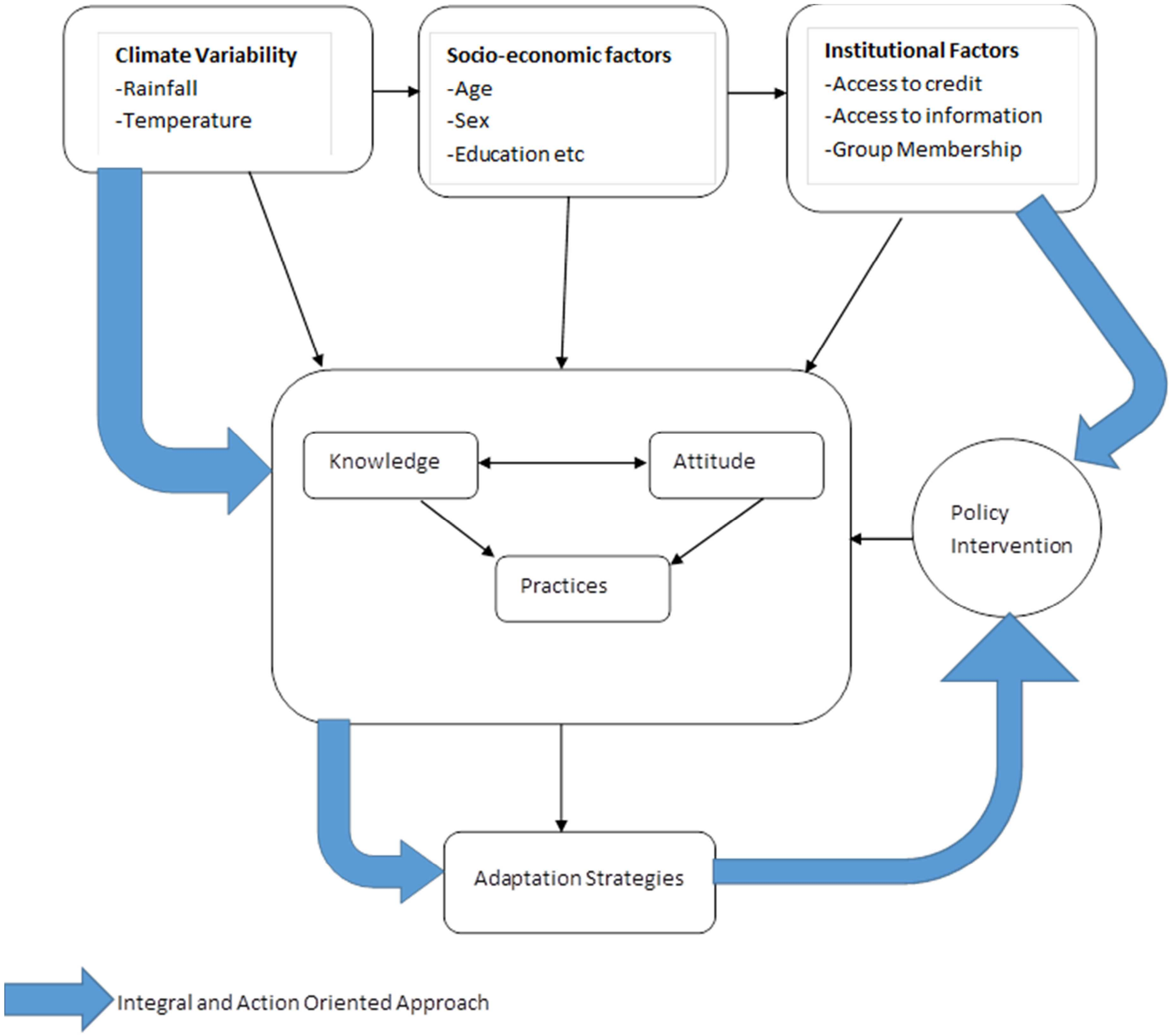

Figure 2.1: Conceptual Framework showing the interaction on climate variability, institutional factors and socio-economic factors on the adaptation practices of farmers

Source: (Modified from DFID Livelihoods, 2004)

CHAPTER THREE: STUDY AREA AND METHODS

3.1 Introduction

This chapter outlines in detail the methodology used in answering each of the research questions. It discusses the issues relating to both primary and secondary data collection, their sources and outlines in detail the empirical models used to analyze the data.

3.2 Study Area

The study was undertaken in Mwala Constituency, Machakos County (Fig 3.1). Machakos County stretches from latitudes 0º 45’ south to 1º 31’ South and longitudes 36° 45’ East to 37° 45’ East; and covers an area of 6,208 square Km. Mwala Constituency is one of the six Constituencies in Machakos County. It comprises four administrative divisions, namely Masii, Mwala, Yathui and Kibauni. It borders Kathiani constituency to the west, Kangundo to the North West, Yatta to the East and Mbooni to the South. Mwala constituency covers an area of 1,017 sq. Km most of which is semi-arid: The constituency receives low, unevenly distributed and unreliable rainfall ranging between 250mm-1300mm per year . (District Development Plan, 2008-2012). The total population of the Constituency stands at163,032 and a density at 160 per square kilometer (G.O.K, 2009).

Mwala constituency covers an area of 1,017 sq. Km most of which is semi-arid: only 40% supports agricultural activities and water mass occupies 15sq. km, mostly perennial rivers and dams. The constituency receives low, unevenly distributed and unreliable rainfall ranging between 250mm-1300mm per year. The area experiences frequent crop failure and water shortage. The fertile and high rainfall areas of Masii and Mwala have higher population density. The constituency is predominately rural with most of the population engaged in agricultural activities especially in high potential areas.

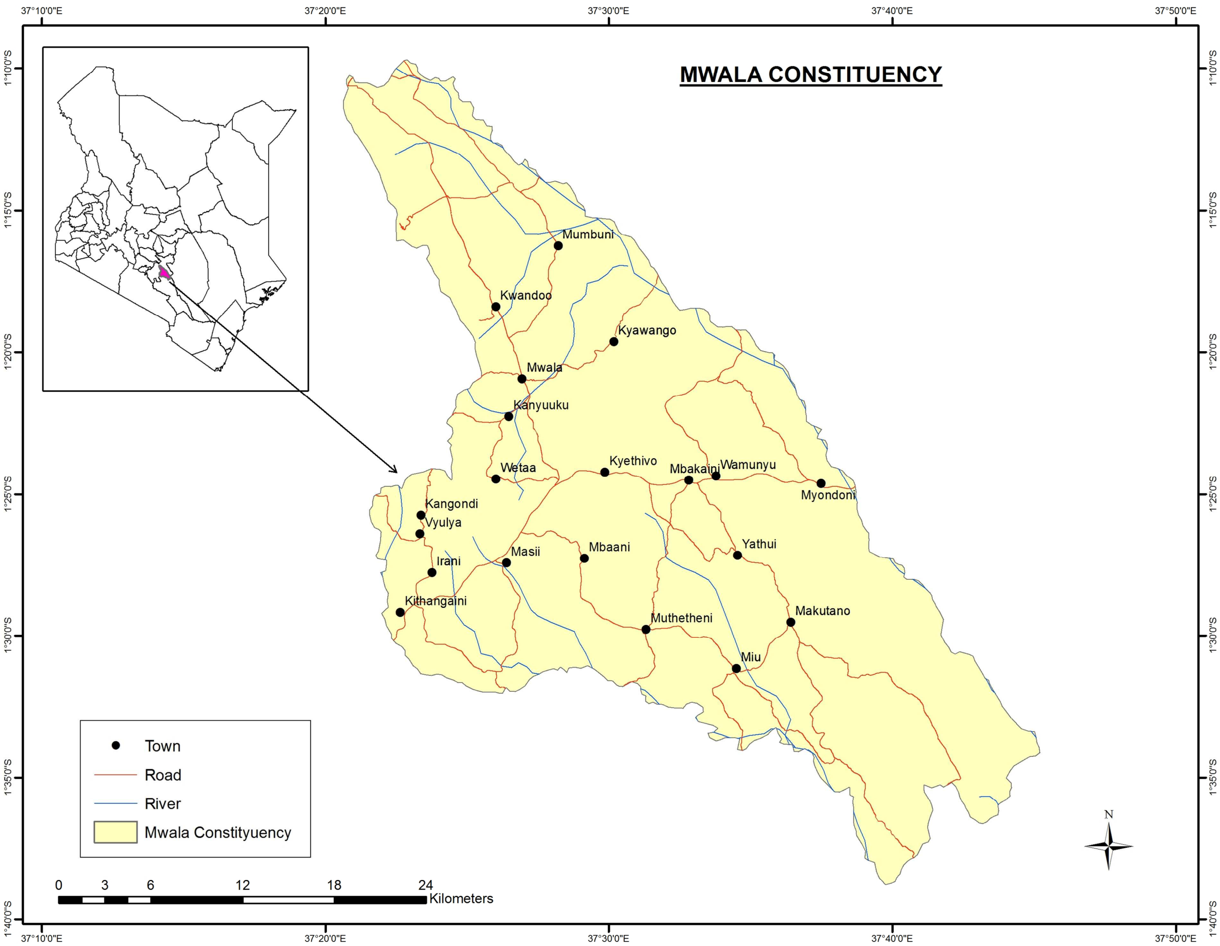

Figure 3.1: Map showing the location of Mwala Constituency in Kenya (GOK 2005)

The rationale for the choice of Mwala in Machakos County for the study was based on the fact that due to the unreliability of rain, there has been low production of maize leading to food insecurity and famine. Despite the fact that rainfall amounts and distribution rarely meet crop water requirements, rain-fed agriculture constitutes 70% of rural employment and economic activities. The greatest challenge to sustainable stable crop production in the area remains how to cope with recurrent droughts and prolonged dry spells. Mwala has been experiencing dry spells for a long period and therefore forcing many residents to depend on food relief due to the unpredictable rainfall for the better part of the year (ROK, 2013).

3.3 Research Design

A mixed method research design for both quantitative and qualitative data was employed in the study. The study also used descriptive survey design. To address the objectives of the study, both primary and secondary data was used specifically to assess the relationship between climate change and maize production in Mwala and to determine the adaptation strategies of maize farmers. The information collected by this method included: maize production figures, and climatic data (temperature and rainfall).

Obtaining data from different sources, such as observations, documentations and interviews helped to harnesses diverse ideas about the knowledge, attitudes and practices employed by maize farmers in the study area and assisted in cross-checking the results, and consequently helped to increase the validity, reliability of the findings and eases data analysis. The study involved the collecting of data from primary sources (field observation, interviews with households, government officials and local administrators) and secondary sources (government documents, meteorological data and crop production data). Questionnaires were administered to randomly selected households in Mwala Constituency. The Key Informants included agricultural officers from the Ministry of Agriculture in Machakos County, representatives of the Food and Agricultural organization, and village and church elders in Mwala Constituency.

3. 4 Study Sample

The sample design for the household survey was a two stage stratified random sample design in which the first stage was selection of Primary Sampling Unit (PSU), i.e. Mwala Constituency. Smallholder farmers in the wards were selected and a responsible member of the selected household of 15 years or more asked to answer the questionnaire. Random sampling was used to select respondents from a list of farmers that was obtained from the Ministry of Agriculture, Machakos County.

3.5 Sample Size

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

$$n = \frac{pqZ^2}{E^2}$$

Where; *n* is the sample size, Z is confidence level (*a = 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 will be 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 of Q of 0.5 (1- 0.5). An error of less than 10% is usually acceptable according to Kothari, 2004. The study had an expectation of an error of 0.08 to approximate a sample size of 296 households. However, not all the households in Mwala are small holder farmers. Almost half the number of households are engaged in formal or informal employment and thus not relevant to the study. Based on this, and due to financial constraints, the questionnaires were administered to a sample of 106 respondents, who were representative of the household population in Mwala Constituency.

3.6 Sampling Procedure

This research involved gathering data from Mwala in Machakos County. Interviews and questionnaires were administered to maize farmers in the County who were randomly selected, based on the information on the number of farmers in the region from the agricultural officers, to find out the effects of climate change on their staple crop production and their knowledge attitudes and practices that drive their adaptation and coping strategies to deal with these impacts.

3.7 Data Collection

3.7.1 Primary data

Key Informant and Personal Interviews

The Key Informant interviews involved interviewing a broad variety of stakeholders including both private and public agencies. This included interviewing agricultural officers, and local Non-Governmental Organizations dealing with maize farmers in the study area. The interviews were aimed at getting insights into various policies and trends in the County and their capacity to respond to different climate scenarios. Questionnaires were administered to maize farmers in Mwala Constituency with the objective of getting information about the impacts of climate change on maize production and what methods farmers in the area are employing to cope with these impacts.

The study made use of interviews as it enabled the collecting of reliable information since there was personal contact with the people holding the information and hence the possibility for clarifications and follow-up questions. In order for the required information to be collected, a questionnaire with open-ended questions was used. The questions were asked in a way that their responses would answer the objectives of the research. The questionnaires also sought to get maize production figures from Machakos County.

3.7.2 Secondary Data

Secondary data information was obtained through reading of different literature from libraries and Internet. From both sources, the major materials were books and articles that have information on maize production in Mwala Constituency in Machakos for the past twenty years, climatic conditions and how it is affecting agriculture and different theories on the adaptation measures that can be implemented by different groups of people.

Maize yield data was sourced from the Ministry of Agriculture and the climate data detailing trends in temperature and rainfall in the County over the last twenty years from the. Climate data for the study was obtained for the Katumani station which covers the larger Machakos area. The data was obtained from the Ministry of Agriculture for the years 1984 to 2014. The increase or decrease in the Maize yield data for the period was then used to analyze association between climate change and maize production in the County.

Time was also spent reading policy documents, legislation, and other action plans that are in place dealing with climate change and agriculture. This method helped have deeper understanding of the issue of how climate change will affect maize production in the county through different documents that are available so far and check whether the issues discussed through interviews are documented.

3.8 Validity and reliability of Research Instruments

3.8.1 Validity

The quality of the research will depend to a large extend on the accuracy of the data collection procedures which in turn rely on the validity of the instruments used. Mugenda & Mugenda (1999) defined validity as the degree to which results obtained from analysis of the data actually represents the phenomenon under the study. If the data is true reflection of the variables, then inferences based on the data will be accurate and meaningful.

3.8.2 Reliability

It is the measure of the degree to which a research instrument yields consistent results (Mugenda & Mugenda, 1999). To maintain the consistent results, the researcher will employ the test- reset technique and the split- half technique to ensure the instruments used will be free of random errors.

3.9 Data Analysis

To determine the actual meteorological status, 20-year rainfall data was analysed for trends and anomalies. The data was subjected to a correlation analysis to determine any association between rainfall and maize crop yields during that period. A trend analysis was carried out on the rainfall and temperature data to examine the long-term rainfall trends in the County and how this has affected maize production. Regression analysis was undertaken to show attribution of climatic changes to crop production. Data from household survey will subjected to descriptive analysis to give frequencies and proportions.

Research questions were classified by coding each question separately to determine the frequency of the responses. The study used frequency tables and charts to present the findings. The data collected was edited to ensure its completeness, accuracy and uniformity of the completed questionnaires.

A regression analysis was performed to establish the association between independent variables (Amount of rainfall, Farmers' level of income, Farmers' years of experience, Farm size and Visits by extension agents) with the dependant variable (Maize production).

The regression model was as follows:

$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4\ \beta_5 X_5 + ẹ$

Where :-

Y = Maize Production (Dependent variable)

$\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4\ \beta_5 X_5 + ẹ$ = Explained Variations of the Model.

β_0=constant. It defines the amount of maize produced without inclusion of predictor variables

E = Unexplained Variation i.e. error term, it represents all the factors that affect the dependent variable but are not included in the model either because they are not known or difficult to measure.

X_1= Amount of rainfall

X_2 = Farmers' Level of income

X_3 = Farmers' years of experience

X_4 = Farm Size

$X_{5=}$ Visits by extension agents

β1, β2, β3, β4, β5, = Regression Co-efficient. Define the amount by which Y is changed for every unit change of predictor variables. The significance of each of the co-efficient will be tested at 95 percent level of confidence to explain the variable that explains most of the problem.

CHAPTER FOUR: RESULTS

4.0 Introduction

This chapter presents the results of the data that was collected and analyzed in the study that explored the effects of climate change on maize production. Pie chart and graphical presentations are used to present analyzed data.

Between 1990 and 2014, the mean annual rainfall in Mwala was 630 mm with a standard error of ± 42.22 at 95% confidence interval. Despite annual variations, the mean rainfall declined by 5.8 mm/year ($y= 705.44+5.7815x$, $n= 106$ $p<0.001$) during this period (Figure 4.1).The mean annual short rains were recorded at 228.52 mm with a standard error of ±37.72 while the mean annual long rains were recorded at 401.76 mm with a standard error of ±19.55 (Fig 4.2)

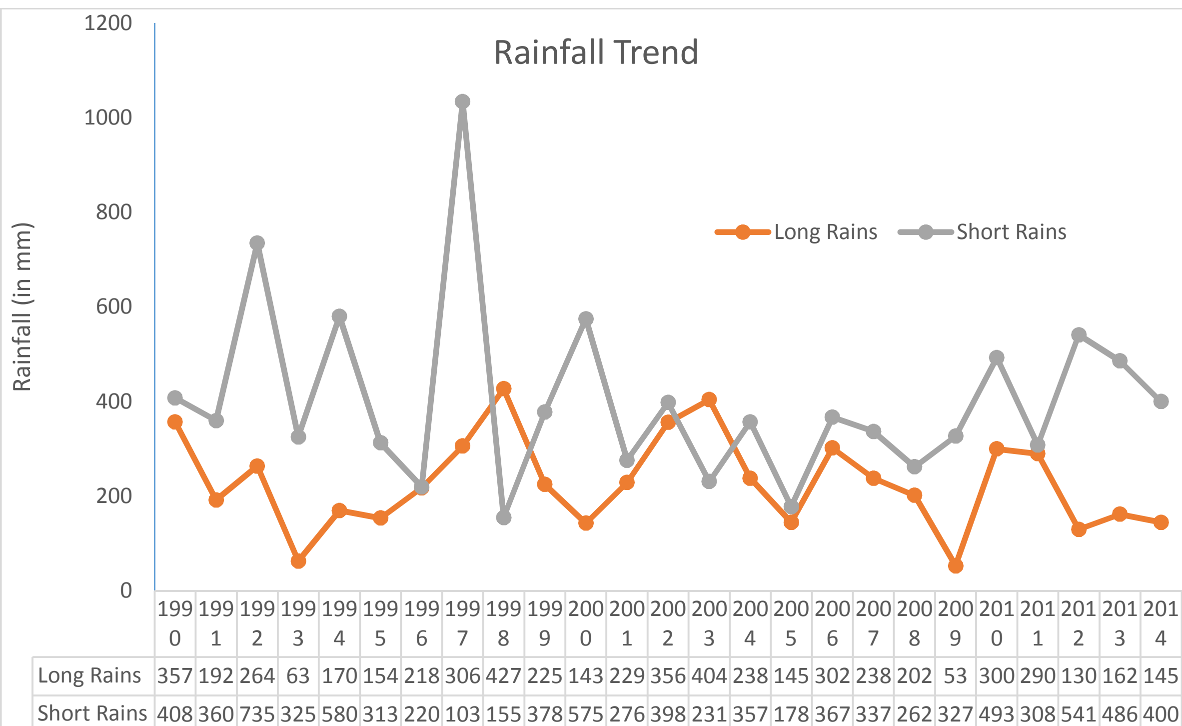

Figure 4.1 Long and Short seasonal rains for Mwala Constituency

Data Source: Kenya Meteorological Department

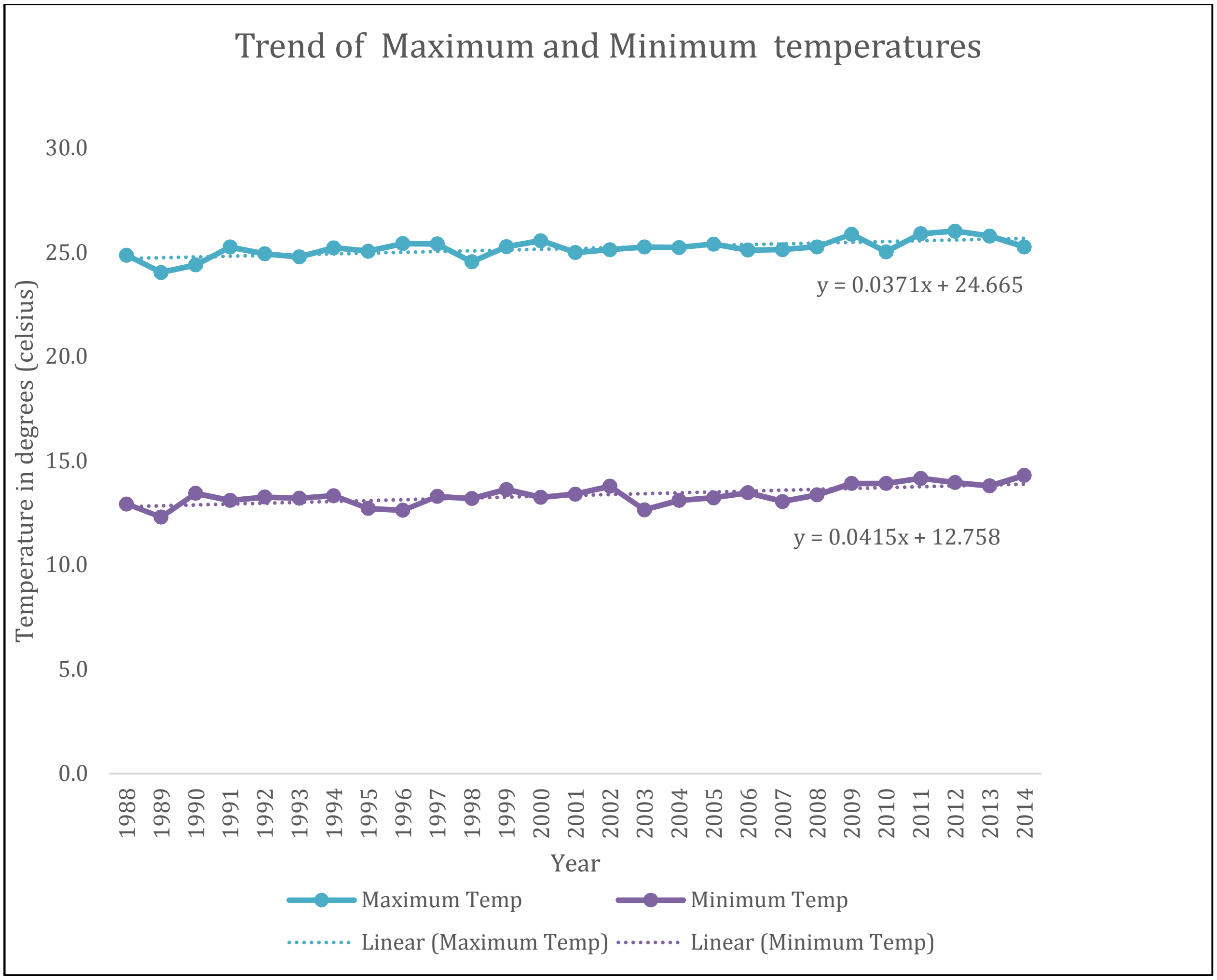

Figure 4.2 Trend of Maximum and Minimum Temperatures

Data Source: Kenya Meteorological Department

The maximum and minimum temperatures in the study area have been on the increase between 1984 and 2014 (Fig 4.2). The mean maximum temperature increased by 0.037 ^{0}C while the mean minimum temperature increased by 0.042 ^{0}C. The perception of the farmers that the temperatures were changing was true as occasioned by the increase.

4.1 Effects of Rainfall and Temperature on Maize Crop Yield

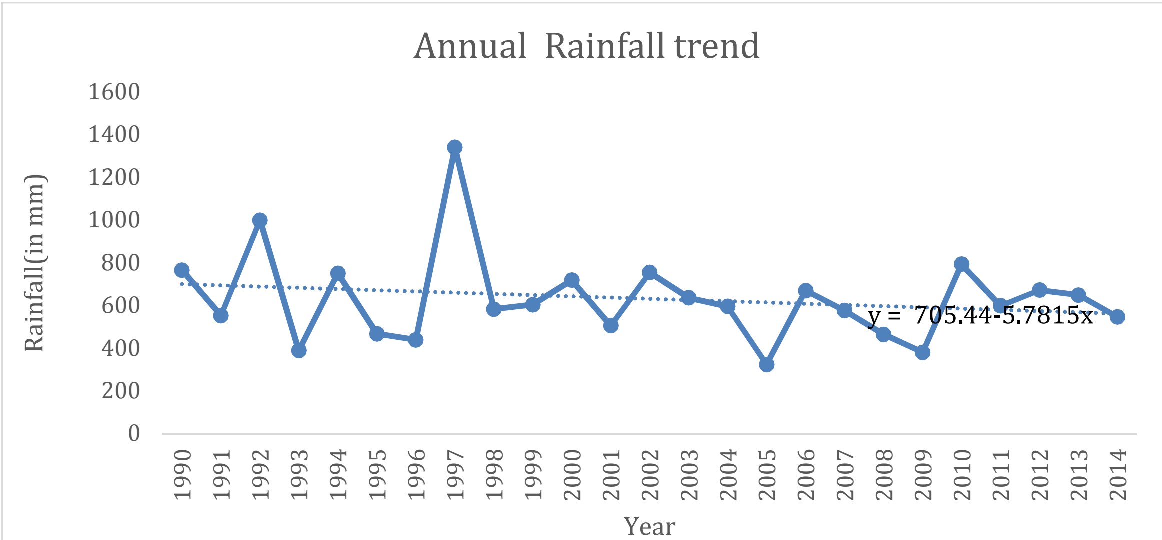

Figure 4.3: Mean Annual Rainfall 1984-2014

Data Source: Kenya Meteorological Department

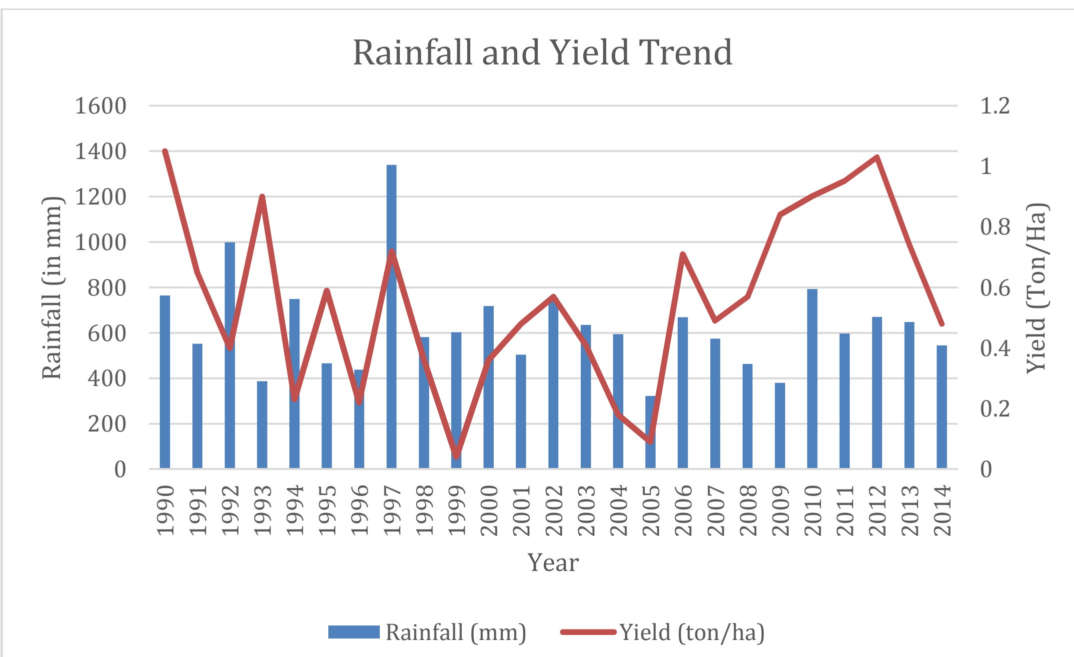

Figure 4.4 Rainfall and Yield Trend

Data Sources: Kenya Meteorological Department & Ministry of Agriculture

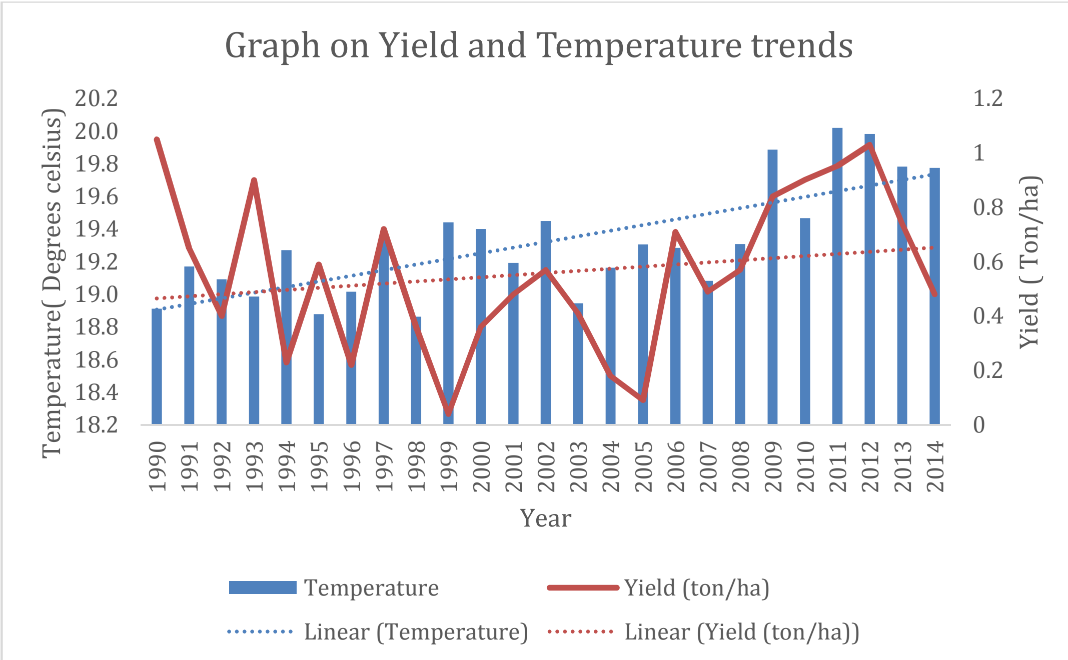

Figure 4.5 Temperature and Yield Trends

Data Source: Kenya Meteorological Department & Ministry of Agriculture

The mean total annual rainfall per year was 630mm with a standard error of ± 42.22with 1997 having the highest rainfall of 1340mm. The average temperature was 19.5° C while the average yield per year was about 0.559 tonnes per hectare per year. Further regression analysis generated the following result:

($y = 5.147 - 0.003x1+0.2881X2$, $r^2 = 0.524$, $P < 0.001$), where y is the Yield measured in bags per hectare,x1 is the total annual rainfall in millimeter's while x2 is the average temperature in degrees Celsius.

From this analysis, it is clear that a unit increase in rainfall increased the yield by 0.003 units while unit increase in temperature increases yield by 0.2881 units. This was statistically significant at p<0.001. , $R^2 = 0.524$ clearly shows that 52% of the change in dependent variable i.e. yield can be explained by the independent variables (Rainfall and temperature).

4.2 Characteristics of the Respondents

4.2.1Demographic Information of the farmers

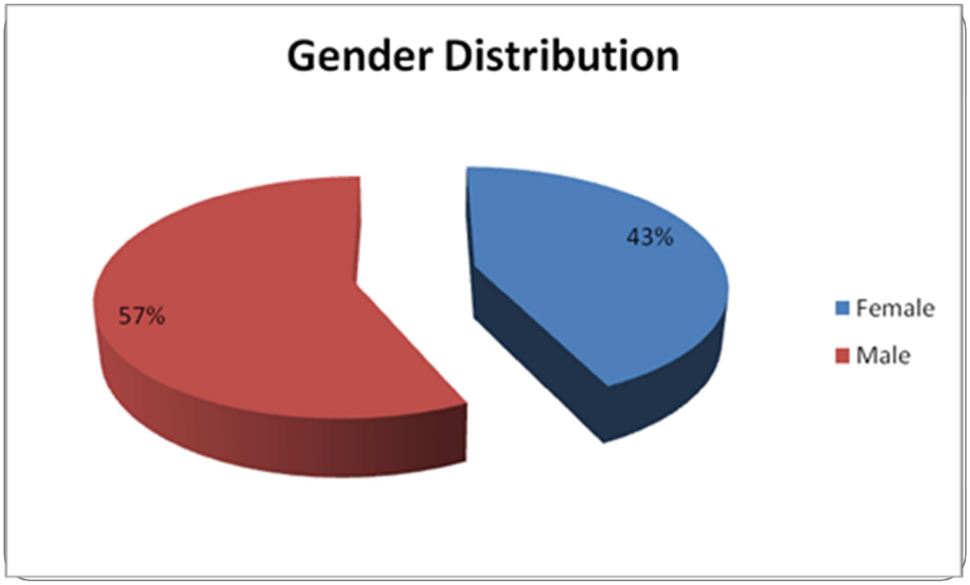

Figure 4.6: Household Heads' Gender Distribution

Gender is an important factor that affects adoption strategies to climate change. Out of the respondents interviewed, 57% were male while 43% were female implying that there was adequate gender representation in the research study (Figure 4.6).

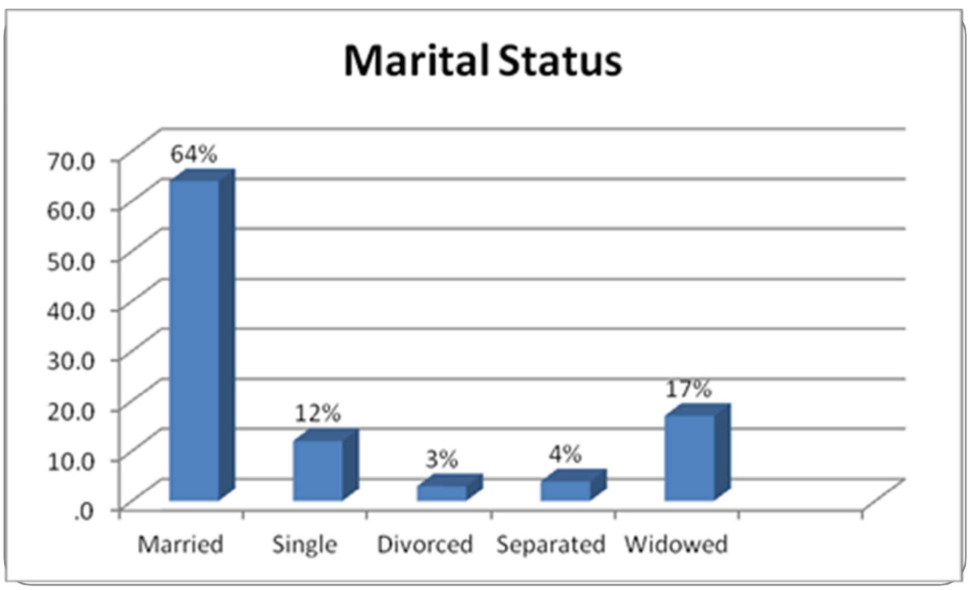

Figure 4.7: Marital Status of the respondents

Out of the households interviewed, 64% indicated that they were married, 12% were single,3% divorced, 4% separated while 17% were widowed. The findings imply that a greater proportion of the respondents were in family settings and therefore farming was a major subsistence activity to sustain livelihoods.

Table 4.1: Respondents Family Sizes

Number of Children	F	%
0-3	14	14
4-7	39	39
8-11	27	27
12 and above	20	10
Total	**100**	**100%**

Family size has a significant impact on adoption strategies taken by households. A large family size is associated with higher labour endowment, which would enable a household to accomplish various agricultural functions, such as tilling and harvesting. It was established that out of the respondents, 39% had 4-7 children 27% had 8-11 children, 14% had 0-3 children while 20% had 12 children and above. The findings imply that there was a high dependency rate in Mwala and therefore farming was a vital activity to sustain family livelihoods (Table 4.1).

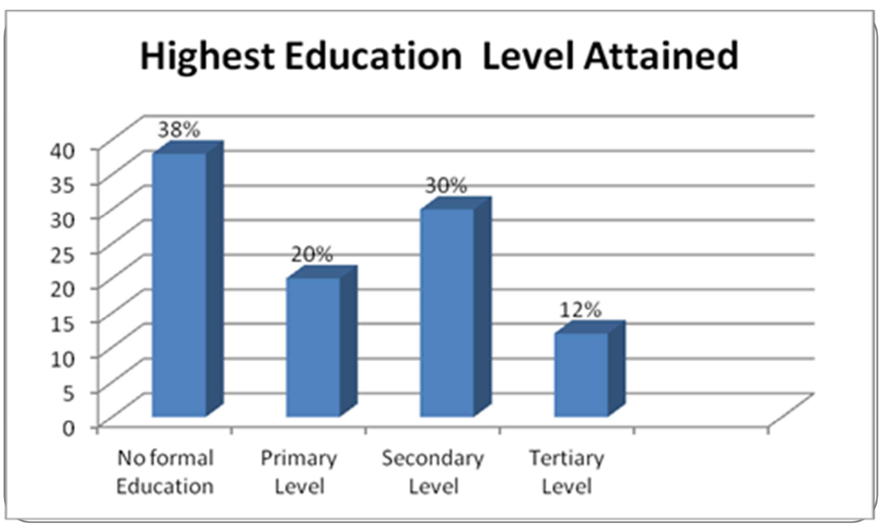

Figure 4.8: Respondents' Level of education

With regard to the highest level of education attained by the respondents, a greater proportion of the respondents (38%) had no formal education, 20% had primary education, and 30% had secondary education while only 12% had tertiary education (Figure 4.9). The findings implies that that a greater proportion of the respondents were knowledgeable on issues relating to climate change and mitigation strategies to enhance maize production in Mwala as 62% of the household heads interviewed had some formal education. (Figure 4.8)

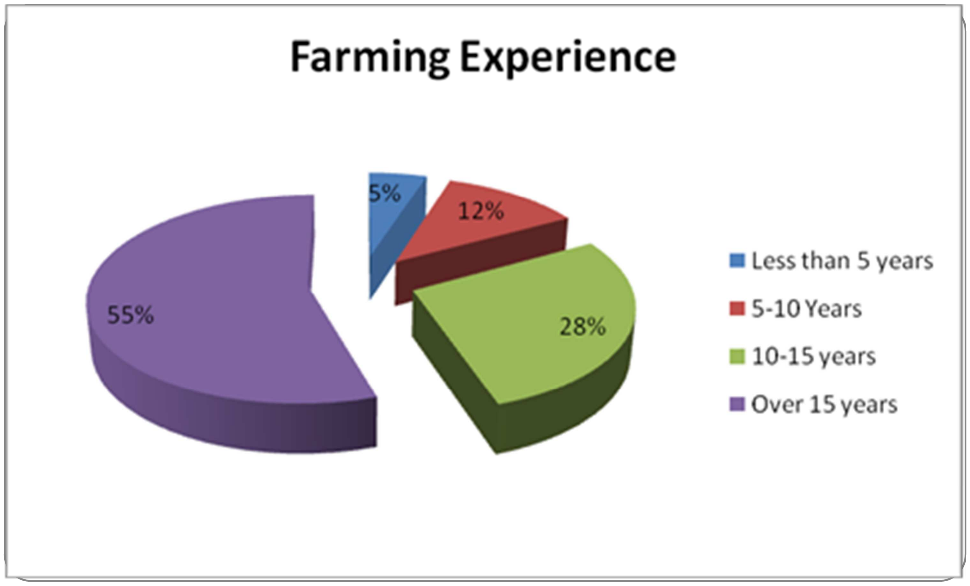

Figure 4.9: Farming Experience

Years of farming experience had a significant impact on the adoption decisions taken by the farmers. 55% of the respondents had more than 15 years' experience in farming, 28% had 10-15 years' experience, and 12% had 5-10 years' experience while 5% had less than 5 years' experience (Figure 4.9). The farmers in this area had been practicing farming for a while and were able to identify changes in the rainfall, temperature and yield. This highly influenced the steps they took to deal with climate variability and their farming.

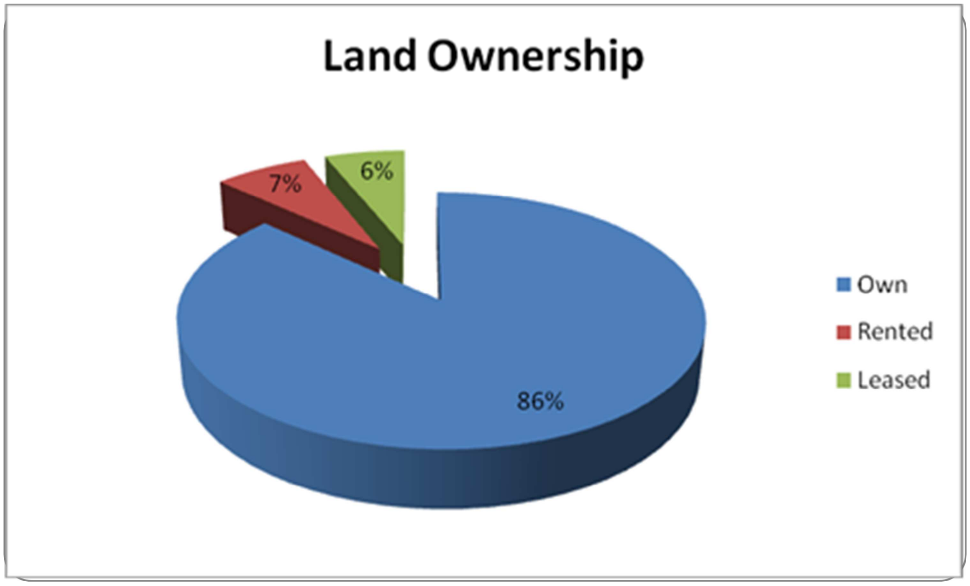

Figure 4.10: Land Ownership

On land ownership by the respondents, it was established that, 86% of the respondents owned the land they were using for farming either through private owership with title deeds or ancestral land, 7% rented land from land owners for a short period of time while 6% had leased the land over long term lease-hold agreements as provided under the Land Registration Act. Land ownership determined the kind of decisions the farmers could make in order to cope with the effects of climate variability on crop production.

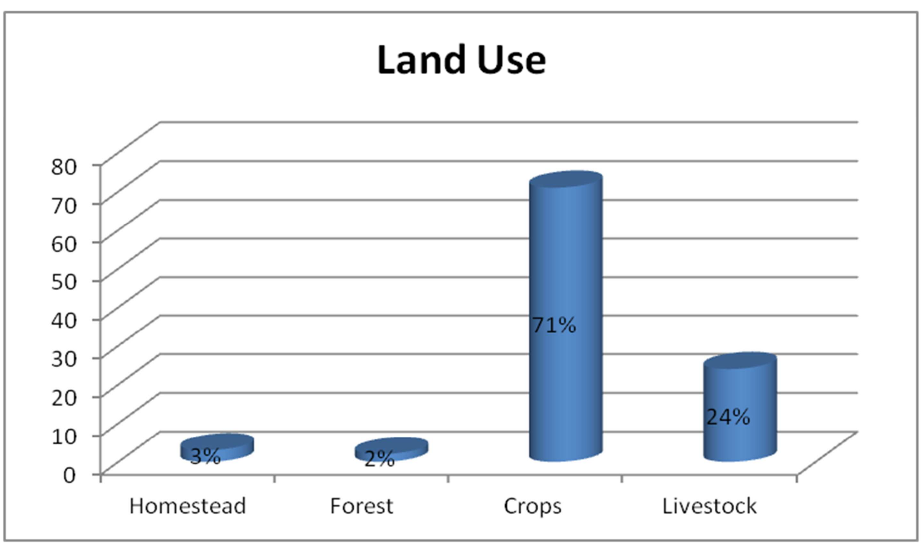

Figure 4.11: Land Use

It was established that 71% of the land owned by respondents was used for crop cultivation, 24% for livestock rearing, 3% for homestead and only 2% was covered by forest. This implies that a greater proportion (95%) of the land owned by the respondents was being used for the purposes of crop production (Figure 4.11).

Table 4.2: Sources of Income

Sources	F	%
Livestock and Livestock products	39	39
Crops	28	28
Home Industries	4	4
Agro-forestry products	7	7
Off farm employment	22	22
Total	**100**	**100%**

Thirty nine percent of the respondents reported that their main source of income was from livestock and livestock products, 28% made their income from crops while 22% obtained income from off farm employment. This implies that a greater promotion of the respondents were highly dependent on farming as a principal source of income.

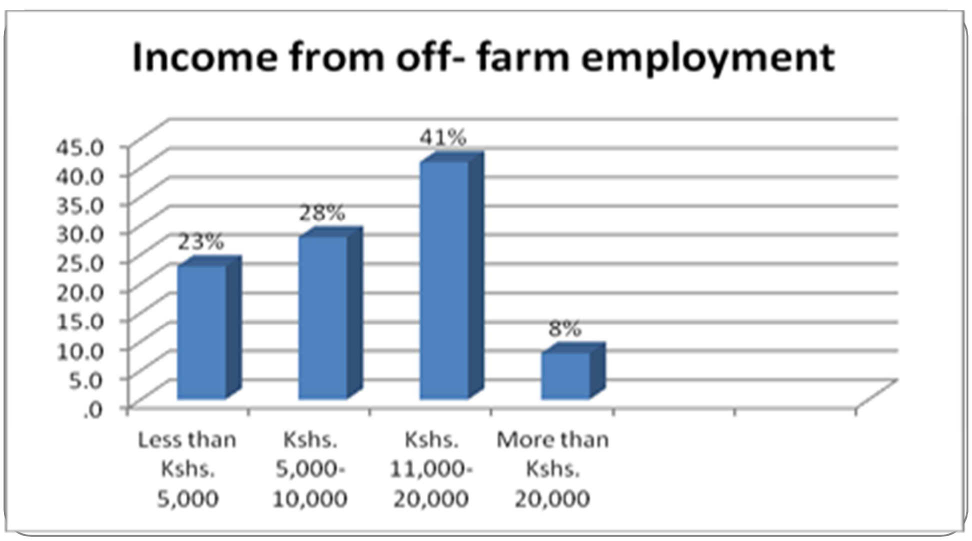

Figure 4.12: Income from off-farm employment

A greater proportion of the respondents who had off-farm employment reported an income of between Kshs. 11,000-20,000. Twenty eight percent reported an income of between Kshs. 5,000-10,000 while only 8% reported an income of above Kshs. 20,000. (Figure 4.12)

Table 4.3: Total monthly income for the household heads

Level of Income	**F**	**%**
Less than Kshs. 2,000	4	4
Kshs. 3,000-5,000	13	13
Kshs. 6,000-10,000	22	22
Kshs. 11,000-20,0000	43	43
Above Kshs. 20,000	18	18
Total	**100**	**100%**

Crop production is the major source of livelihood in the study area. Most of the households depended on crop farming as the principal source of income 43% of the respondents had their average income ranging between Kshs. 11,000-20,000, 22% had an income ranging between Kshs.6,000-10,000 while only 4% had an income below Kshs.2,000 (Table 4.3). The findings imply that the respondents were not gaining much income from crop production, which could be attributed to changes in rainfall and temperature over the years because of climate change.

4.3 Level of Awareness on Climate Change Adaptation

Table 4.4: Service Providers for crop and Livestock Production

Service Provider	Crop Production		Livestock Production	
	F	**%**	**F**	**%**
Public Extension agent	18	18	19	19
NGO	7	7	8	8
Neighbour/Farmer	31	31	36	36
Private Extension	11	11	9	9
Radio/Television	5	5	8	8
Mobile Phone	2	2	-	-
Farmer organization	24	24	19	19
Private Engineer	3	3	1	1
Total	**100**	**100.0**	**100**	**100.0**

With regard to the service providers for crop and livestock production for the farmers in Mwala, it was established that a greater proportion of the respondents (31% and 36% respectively) obtained services from the neighbours' for crop and livestock production.18% and 19% obtained information from public extension agents on crop production and livestock production respectively (Table 4.4). The findings imply that the government has not put up efficient mechanisms to ensure that the level of awareness among farmers on crop and livestock production through the public extension agents has not been sufficient.

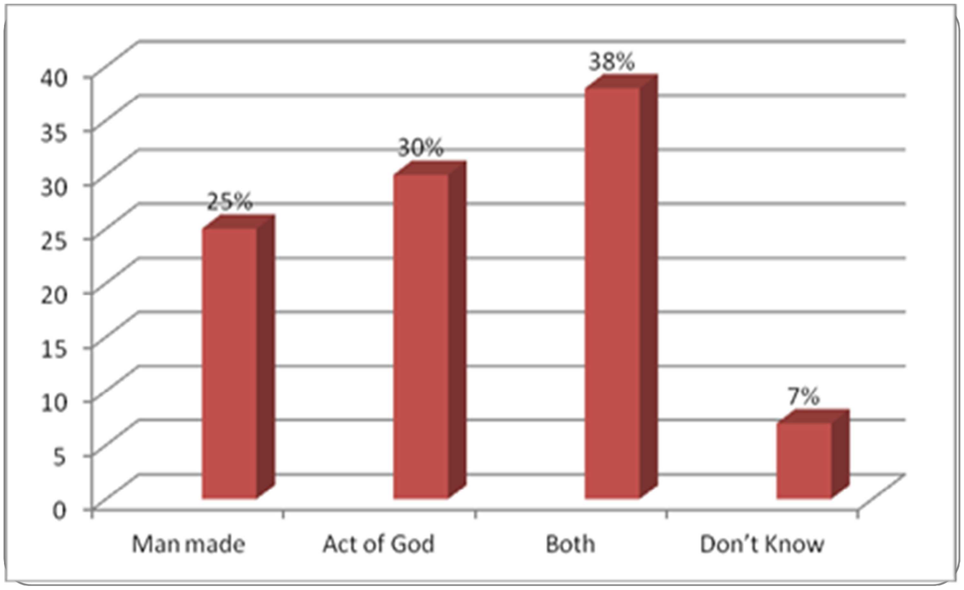

Figure 4.13: Awareness on the Causes of Climate Change

While 38% of the respondents felt that climate, change was both man-made and an act of God, more farmers reported that that it was an act of God (30%) than of man (25%). The findings imply that the respondents were fully aware of the occurrence of climate change and that there was an external factor causing it (Figure 4.13). However, there seemed to be lack of knowledge on the actual causes of climate change.

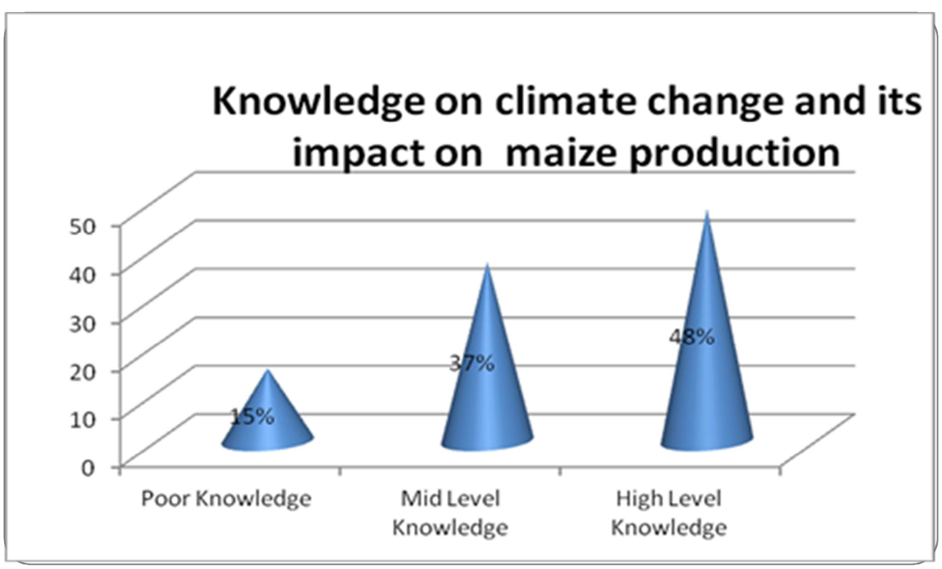

Figure 4.14: Knowledge of Climate change and its Impacts on Maize Production

The study determined that farmers had different levels of knowledge and awareness of climate change and its impacts. Male farmers with poor level of education/knowledge reported to be aware of climate change unlike their female counterparts. Female farmers with middle level knowledge reported to have information on climate change unlike the ones with poor knowledge. Farmers with high-level knowledge reported to have a substantial knowledge on climate change and its overall impact on maize production in Mwala Constituency and Kenya at large.(Figure 4.14)

Table 4.5: Relationship between education level and level of awareness on climate change

	Education Level			
Level of Awareness	**No Education**	**Primary**	**Secondary**	**Tertiary**
Not Aware	19.6%	18.3%	14.6%	14.5%
Somewhat Aware	33.4%	37.2%	47.4%	50.7%
Aware	47.0%	44.4%	38.0%	34.8%
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**

A cross-tabulation of household respondents' education level and preparedness for climate-related hazards revealed that there is a statistically significant difference ($\chi 2$ (4) = 12.845, p = .012) among persons of different education levels in relation to how prepared they were for climate-related hazards. Persons educated at the tertiary (50.7%) and secondary (47.4%) levels were more prepared when compared to persons educated at the primary levels (Table 4.5).

Table 4.6: Relationship between gender and climate change awareness

	Gender	
Level of Awareness	**Male**	**Female**
Don't Know/Not sure	11.5%	15.4%
Hardly Anything	18.1%	21.7%
Not Much	38.8%	35.9%
A fair Amount	23.6%	18.4%
A great deal	8.0%	8.8%
Total	**100.0%**	**100.0%**

Regarding their community's risk associated with climate change, a majority of the respondents (37.3%) indicated they did not know much about their community's risk (table 4.9). A similar percentage knew either a fair amount (21.1%) or hardly anything (20.0%) about their community's risk. There was also a significant difference ($\chi2$ (4)=11.071, p = .026) between males and females in relation to how much they knew about their community's risk associated with climate change. The study established that male household heads were more likely to be knowledgeable about climate change due to their level of education and the fact that they participated more in information sharing sessions with other farmers through group memberships.

4.4 Attitudes to Climate Change

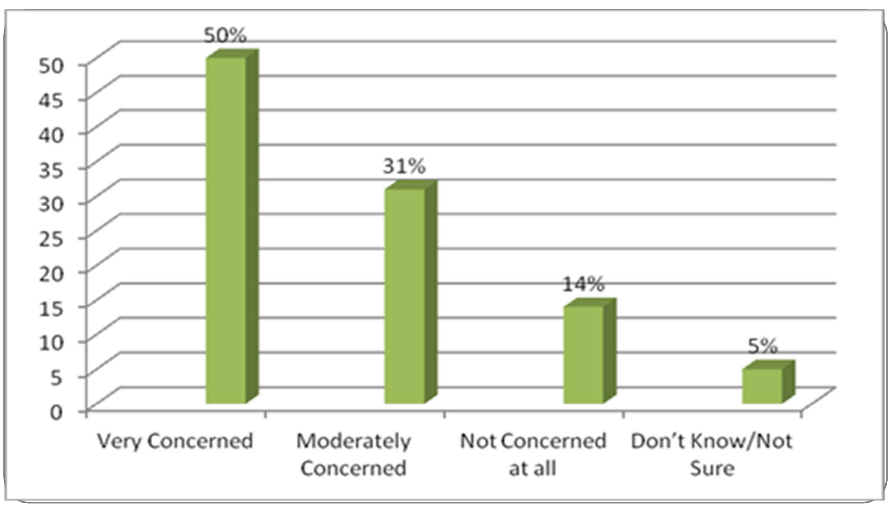

Figure 4.15: Concern about Climate Change

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. Various changes have been witnessed in the weather patterns in Mwala over the past 20 years. This was actually a cause of concern for the farmers as half of the respondents were very concerned about climate change. Specifically, 50% of the respondents were very concerned about climate change with another 31% being moderately concerned; 14% were not concerned at all. 5% however were not sure. (Figure 4.15)

Table 4.7: Attitudes towards Mitigating Climate Change

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The government should take a stronger role in addressing impacts of climate change	44%	42%	7%	2%	5%
I am prepared to pay a little or put up with some inconvenience to help preserve the environment	17%	46%	8%	15%	14%
There is nothing small scale farmers can do about climate change	10%	13%	10%	37%	30%
Small scale farmers have little or no control over climate change because it's an act of God	15%	14%	5%	37%	29%
Small scale farmers should play a leading role in addressing climate change in their communities	20%	46%	12%	20%	2%

In terms of the role that farmer and the Government should play in addressing climate change, the respondents were asked their levels of agreement with some statements. Over 80% of the respondents agreed (42.1%) or strongly agreed (44.3%) that the government should a take a stronger role in addressing the impacts of climate change on communities. In terms of paying more or tolerating some inconvenience to help preserve the environment, only 16.5% strongly agreed to this, while another 45.5% agreed. Many disagreed (37.2%) and strongly disagreed (29.5%) that there is nothing a small-scale farmers could do about climate change. In fact, many agreed (46.1%) and strongly agreed (20.4%) that small scale should play a lead role in addressing climate change issues in the area.(Table 4.7)

4.5 Strategies to Cope with Climate Change

Table 4.8: Service Climate Change and Marketing Information

Service Provider	Climate Change		Marketing	
	F	%	F	%
Public Extension agent	16	16	14	14
NGO	10	10	7	7
Neighbour/Farmer	33	33	29	29
Private Extension	13	13	18	18
Radio/Television	7	7	4	4
Mobile Phone	-	-	-	-
Farmer organization	31	31	27	27
Private Engineer	3	3	1	1
Total	**100**	**100.0**	**100**	**100.0**

Based on the data presented on table 4.8, 31% of the farmers obtained information on climate change from farmer organization, 29% obtained information on marketing from neighboring farmers while only 14% were given information on marketing by public extension agents. The findings imply that farmer organizations in Mwala were playing a critical role in raising awareness among farmers on both climate change and issues relating to farm produce marketing.

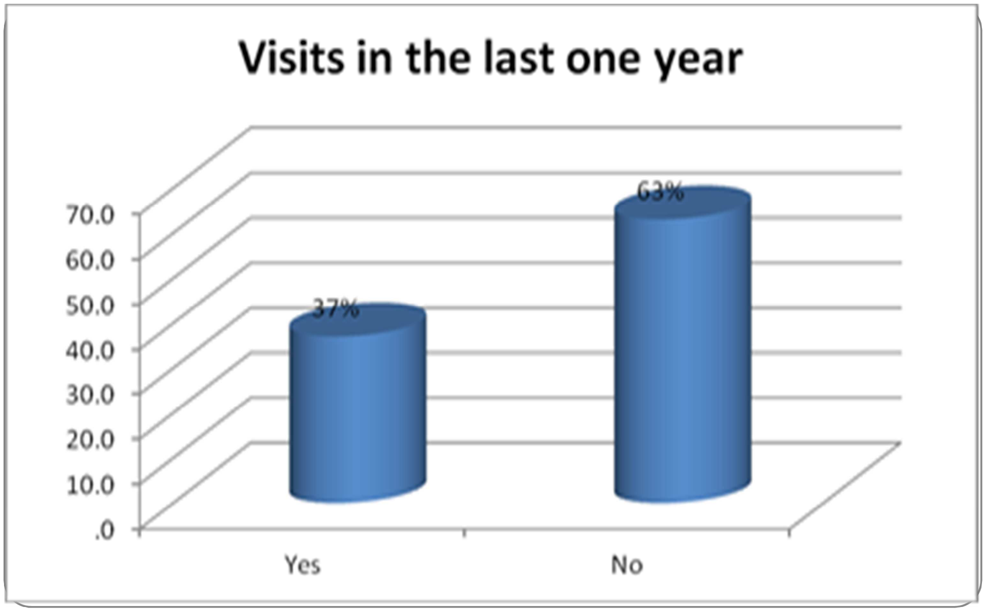

Figure 4.16: Farm Visits

Sixty three percent of the respondents reported that they had not been visited in the last one year, only 37% reported having been visited. The findings show that the level of awareness being raised among farmers on climate change adaptation through farm visits is very low and this influenced the level of farm production. This has pushed farmers to seek extension service from NGOs and other private sources.

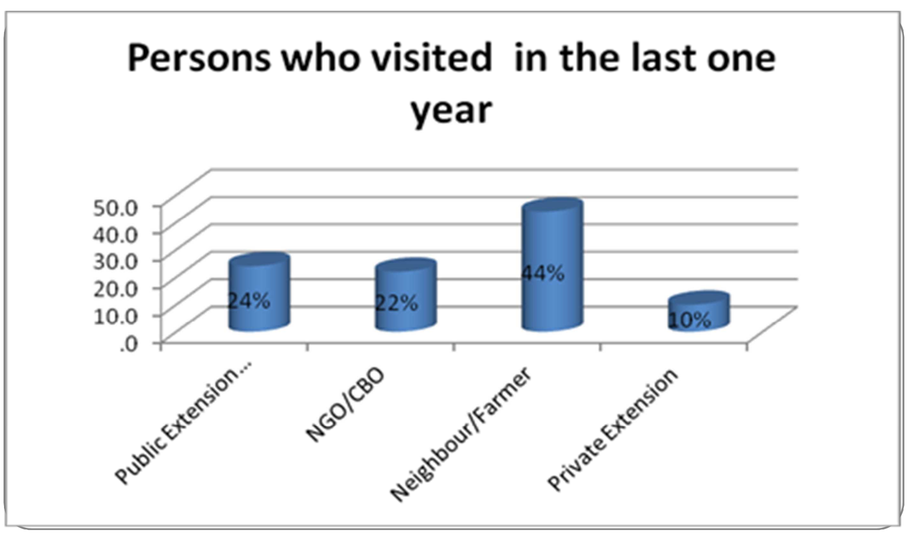

Figure 4.17: Persons who visited in the last one year

Access to extension services usually has significant impact on crop production. The study established that 44% of the respondents had ben visted by neighbouring farmers, 22% had been visted by CBOs/NGOs, 24% had been visited by public extension officers while only 10% had been visted by private extension. The findings show that there was lack of government commitment in visiting farmers and raising awareness on climate change and crop production in Mwala Constituency through public extension officers. This forced farmers to seek other ways of getting the services offered by extension officers especially through groups run by Non Governmental organisations. (Figure 4.17)

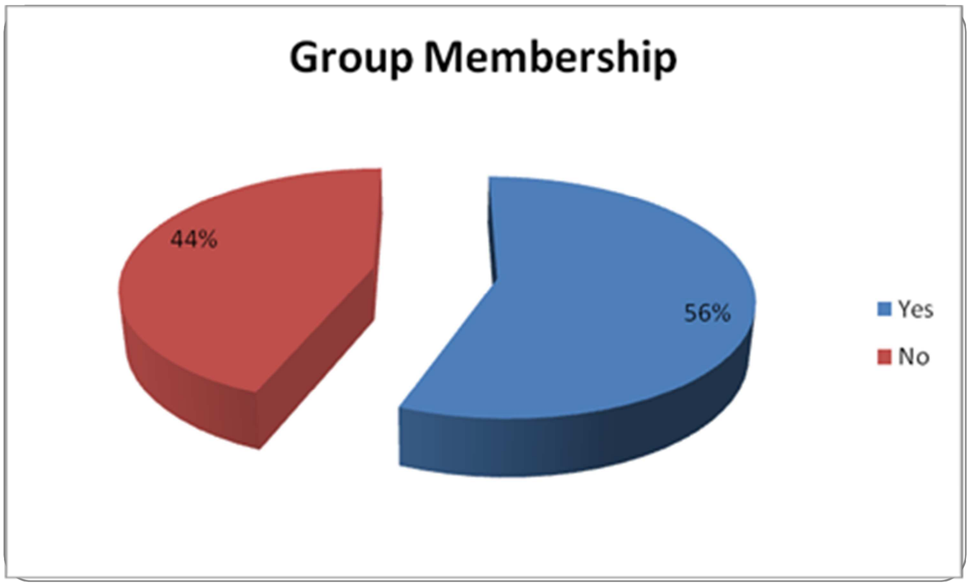

Figure 4.18: Group membership

Informal institutions and private group membership play major roles in adaptation to climate change strategies as they act as conduit for information about new strategies. It was established that 56% of the respondents indicated that they belonged to a group while 44% indicated that they did not belong to a group (Figure 4.18). Membership to social group increases the likelihood of learning different strategies to adapt with climate change and ways to diversify agricultural production.

Table 4.9: Group Type

Group Type	F	%
Self-help Group	4	4
Welfare Group	13	13
Cooperative Society	22	22
Farmers Group	43	43
Climate change group	18	18
Total	**100**	**100%**

For the respondents who reported that they belonged to a group, a greater proportion (43%) belonged to farmers groups, 22% belonged to cooperative societies, and 13% belonged to welfare groups while 18% belonged to climate change groups. The findings imply that the farmers were getting information on climate change and crop production through the groups in which they belonged.

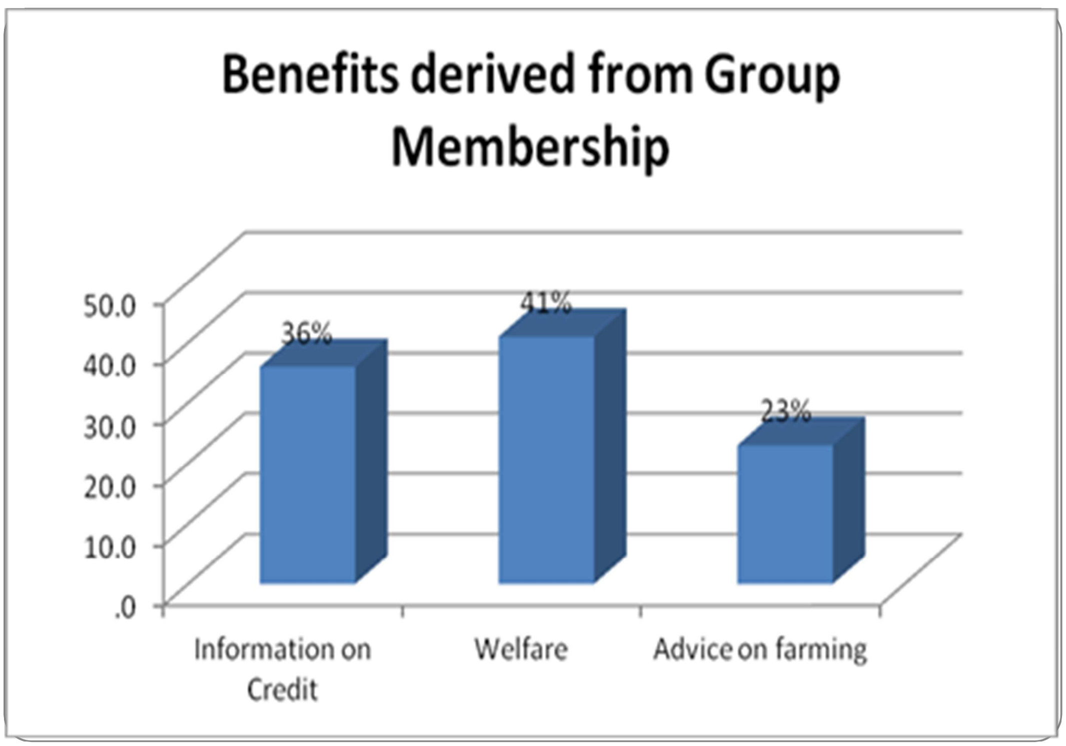

Figure 4.19: Benefits Derived From Group Membership

Regarding the benefits derived from group membership, a greater proportion (41%) of the respondents derived welfare benefits, 36% derived information on credit while 23% received advice on farming from the groups. The findings imply that most of the groups in which the farmers were members only focused on the members' welfare and therefore they were not raising the needed awareness on climate change and crop production among farmers in Machakos.

Table 4.10: Group Activities

Activities	**F**	**%**
Farming	14	14
Business	23	23
HIV/AIDS Awareness	20	20
Advocacy	43	43
Total	**100**	**100%**

Forty three percent of the farmers reported that their groups were involved in advocacy activities, 23% reported business activities 14% reported farming activities while 20% reported HIV/AIDS awareness activities (Table 4.10). The findings imply that the groups were not primarily focused on raising awareness among farmers on climate change and crop production.

Table 4.11: Farming Objectives

Objectives	**F**	**%**
Making Profits	24	4
Support family	36	13
Reduce risk of hunger	22	22
A way of life	10	10
Have no other option	8	8
Total	**100**	**100%**

One of the questions of the study was to determine the objectives for which the farmers were engaged in farming. Based on the findings presented on table 4.14, 36% of the respondents were engaged in farming with an objective of supporting their families, 24% were engaged in farming to make profits, 22% were engaged in farming to reduce the risk of hunger while only 8% were engaged in farming because they had no other option (Table 4.11). The findings imply that most farmers in Mwala are focused on subsistence farming to support their families and they are not engaged in commercial farming of crops such as maize because of the adverse climatic conditions in the area.

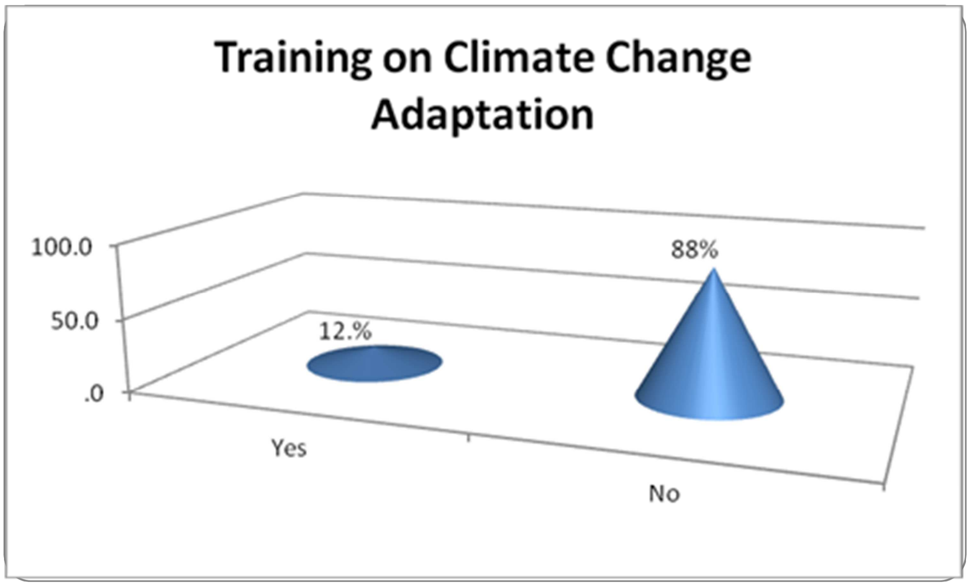

Figure 4.20: Attendance of Training on Climate Change Adaptation

Training on appropriate adaptation strategies is a key factor on the practices farmers employ to deal with the effects of climate change. Figure 4.20 shows that only 12% of the respondents had attended training on climate change, the remaining 88% had not attended any training on climate change. The findings imply that the government as well as local institutions has not reached out to farmers to train them on climate change adaptation. Most farmers resorted to joining groups such as welfare groups, sacco societies and church groups where they shared information on improving their welfare, including farming.

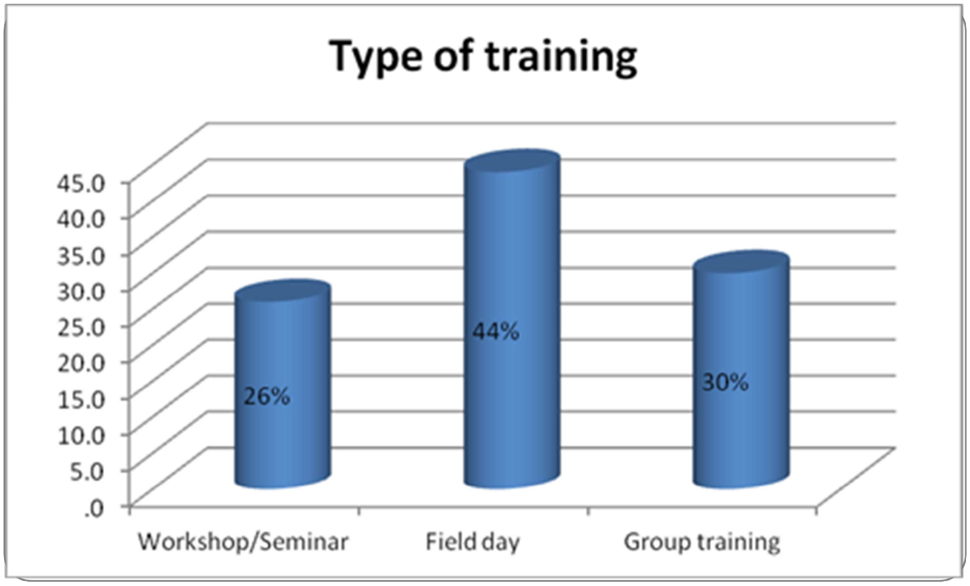

Figure 4.21: Type of Training

For the respondents who had attended training, 44% had been trained through field days, 30% through group training and 26% through workshops/seminars.

Table 4.12: Activities undertaken during training

Activity	Yes		No	
	F	%	F	%
Sought advice on climate adaptation	53	53	47	47
Implemented the advice	59	59	41	41
Applied for credit	23	23	77	77
Credit Availed	12	12	88	88

Training on crop production and information on climate represent access to information required to make the decision to adapt to climate change. Some of the activities the respondents undertook during the trainings are seeking advice on climate change (53%) and applying for credit. 59% of the respondents implemented the advice. While 12% obtained credit. (Table 4.12). The 88% who failed to obtained credit did not have securities or good financial records implying that majority of farmers in Mwala cannot access credit to improve crop production.

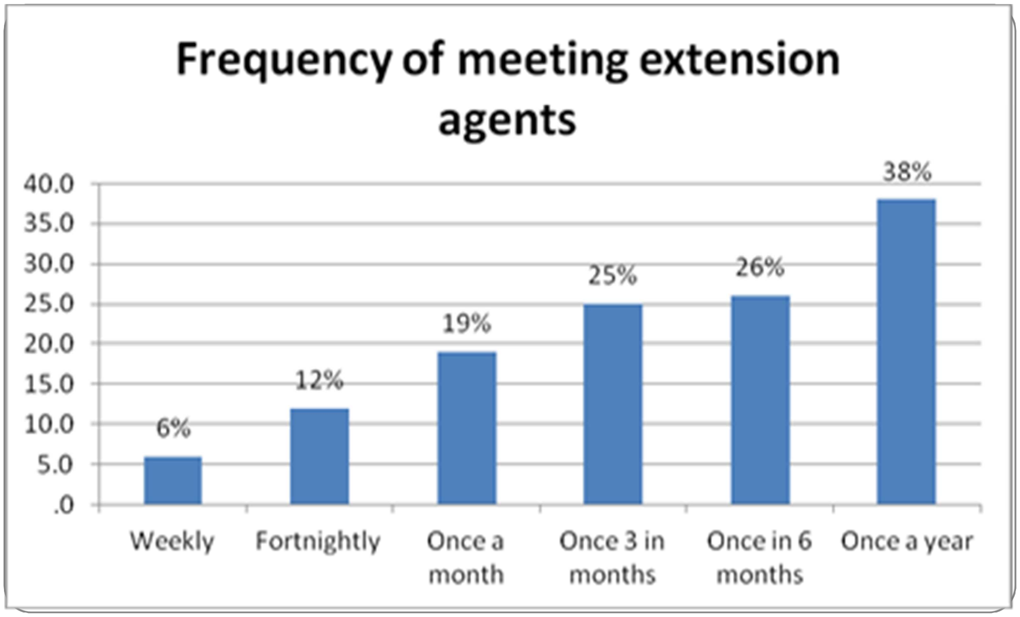

Figure 4.22: Frequency of Meeting Extension Agents

As expected, access to extension services had significant impact on adaptation.A greater proportion of the respondnets(38%) reported meeting the extension once a year while only 6% reported meeting the extension agenst weekly (Figure 4.22). The findings show that there was low level of awareness among farmers on climate change adaptation and maize production in Mwala since the extension agents in the region had not put up effecient mechanisims to ensure frequent meetings with the farmers.

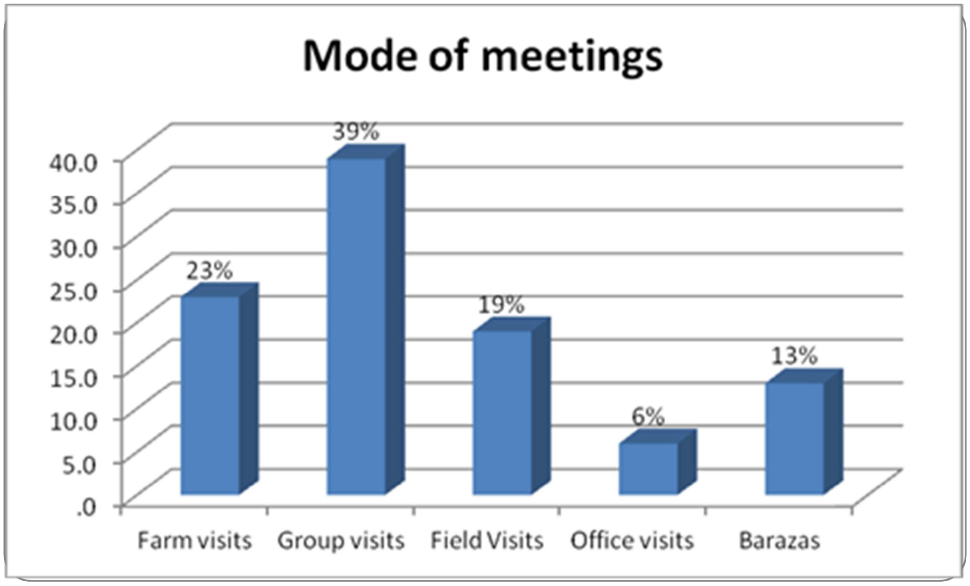

Figure 4.23: Mode of Meetings

Regarding the mode of meetings with the extension agents, 39% reported that they had attended group meetings, 23% reported attending farm visits, 19% reported attending field visits while 13% reported attending barazas. The findings imply that there was low level of individual arwarenes and knowledge on climate change adaptaion and maize production since the extension agents were not giving individualized attention to the farmers during meetings.

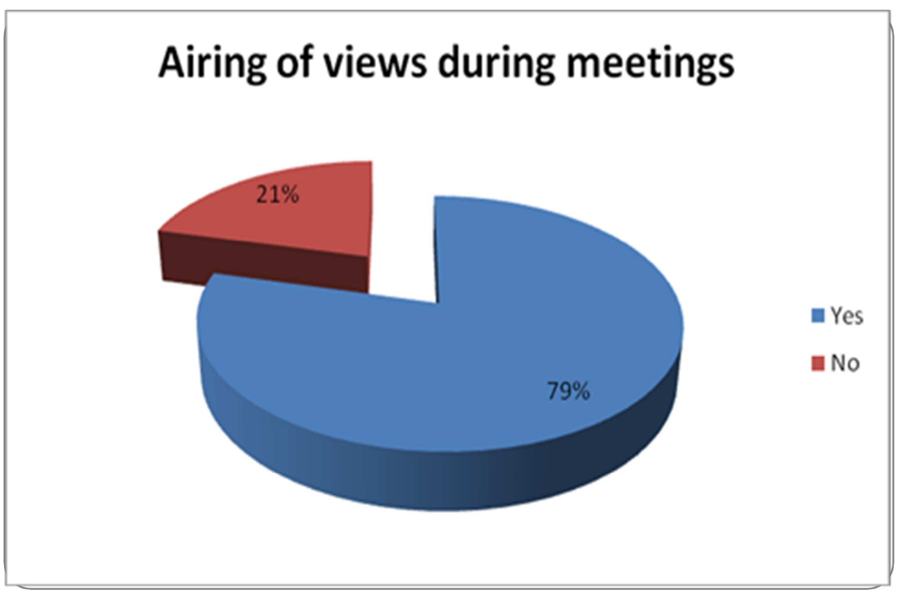

Figure 4.24: Airing of views

Based on the data on figure 4.24, 79% of the respondents reported that they aired their views during the meeting while only 21% did not air their views. This shows that the farmers had initiative and share their experiences in order to learn from other farmers and the experts on how to adapt to the effects of climate change.

4.6 Practices

Table 4.13: Strategies to Adapt to Climate Change

Strategies	**Mean**	**Standard Deviation**	**N**
Planting Different Varieties of crops	4.765	0.943	100
Different (staggering)time of planting	4.604	0.831	100
Rearing different breeds of livestock	4.234	0.954	100
Soil fertility and water management	4.125	1.945	100
Feed preservation	3.442	1.053	100
Agro-forestry	4.784	0.564	100
Use of seed banks	2.561	0.763	100
Intensification of production	3.432	0.673	100
Changing from farming to non-farming activities	3.423	0.645	100
Irrigation	2.417	0.784	100

The respondents were asked to give the practices they have adopted to deal with the effects of the changing climate. Planting different varieties of crops (M=4.765; SD=0.943), different (staggering) time of planting (M=4.604; SD=0.8031), and rearing different breeds of livestock (M=4.234; SD=0.954), were ranked highly. The farmers also practiced soil fertility and water management (M=4.125; SD=1.945) and agro-forestry (M=4.784; SD=0.564). Strategies that were not highly favored were use of seed banks and irrigation as access to these services requires funds which most farmers did not have (table 4.13).

Table 4.14: Challenges Faced by Farmers in Adapting to Climate Change

Hindrances	**Mean**	**Standard Deviation**	**N**
Lack of improved seeds/breeds	4.642	0.785	100
Lack of access to water for irrigation farming	4.931	0.563	100
Lack of current knowledge on adaptation methods	4.463	0.784	100
Lack of information on weather incidence	2.641	1.045	100
Lack of money to acquired modern techniques	4.732	0.243	100
There is no hindrance to adaptation	2.678	0.831	100

Some of the constraints faced by farmers in adapting to climate change included lack of improved seeds/breeds (M=4.642; SD=0.785); lack of access to water for irrigation farming (M=4.931;SD=4.931) and lack of current knowledge on adaptation methods(M=4.463;SD=0.784). Another major constraint included lack of funds to acquire modern techniques (M=4.732;SD=0.243). Lack of information on weather incidence (M=2.641; SD=1.045) was reported as having a moderate hindrance. (Table 4.14)

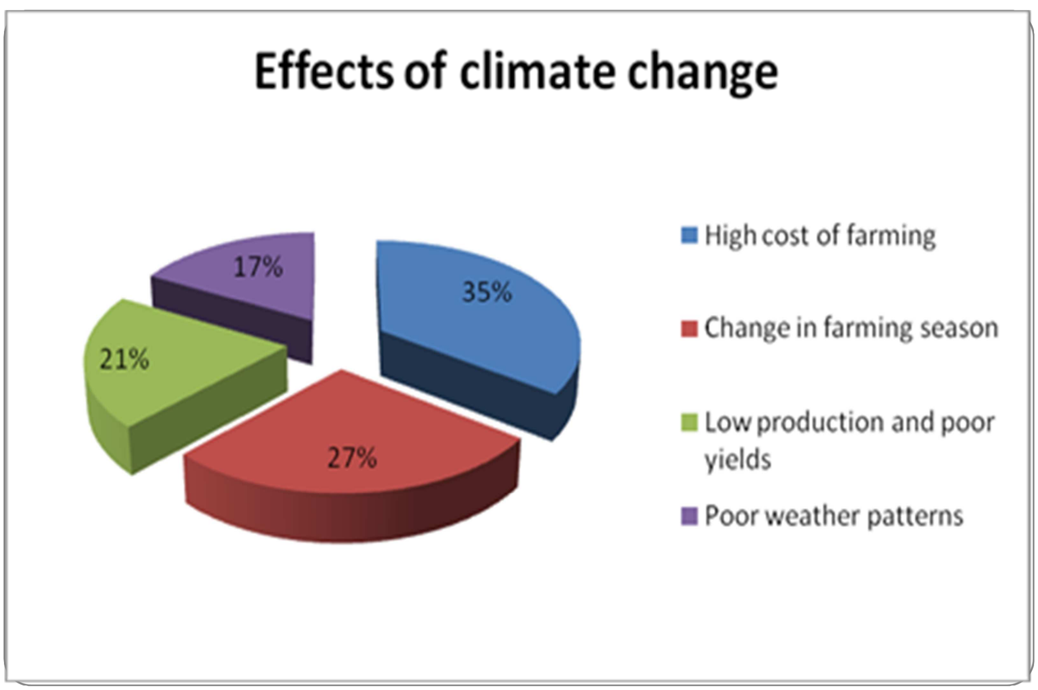

Figure 4.25: Effects of Climate Change in Mwala Constituency

The analysis above summarizes the effect of climate change on maize production in Mwala Constituency. At 35%, high cost of farming was the greatest effect with most farmers incurring cost on insurance, new farming technology, new farming knowledge and other hidden cost related to farming. At 27.4%, change in farming season was the other effect of climate change with most farmers reporting a speculative season start and season end which also leads to low and poor maize being harvested.

Table 4.15: Factors Affecting Maize Production

Factors	**Mean**	**Standard Deviation**	**N**
The environment in this area is changing due to human activities.	4.452	0.674	100
The Climate is changing	4.870	1.245	100
Temperature is rising.	4.542	0.973	100
Rainfall is decreasing every year	4.785	1.872	100
There is rainfall variability	4.945	0.892	100
The weather is becoming drier every year.	4.484	0.565	100
The yearly rains are not supporting crop production as before	4.456	0.784	100
Climate change has led to crop pest infestation and diseases	4.892	0.685	100
Food production has been affected by climate change	4.874	1.234	100
The cost of food is increasing because of climate change.	4.630	1.345	100
The Environment suffers from decreased vegetation due climate change.	4.756	0.564	100
There is now Fuel wood scarcity.	3.542	0.973	100
Climate change has led to rural-urban migration	4.485	1.872	100
Climate change has led to the decline of forest resources	4.845	0.892	100
Climate change has led to the change of livelihood system	3.584	0.565	100
There have been increase incidences off loads during the raining season	4.456	0.784	100
There have been increase incidences of droughts during the dry season	4.599	0.584	100
The incidence of climate change will affect the Sustainability of our environment.	4.573	1.021	100
There is serious awareness on climate Change	3.630	0.945	100

The respondents felt that some of the major factors affecting maize production in the area were decreasing rainfall, changes in the environment due to human activities and incidences of drought during the dry season. The farmers did not view fuel wood scarcity, change of livelihood and lack of awareness of climate change as major factors affecting maize production. The following factors affected maize production in Mwala Constituency moderately, fuel wood scarcity; changes of livelihood systems and a serious awareness on climate Change.

4.7 Regression Analysis

Table 4.16: Model Summary

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	93.144	4	23.286	79.730	.000[a]
	Residual	53.739	96	.292		
	Total	146.883	100			

a. Predictors: (Constant), Amount of rainfall, Farmers' level of income, Farmers' years of experience, Farm size and Visits by extension agents

b. Dependent Variable: Maize Production

The results on table 4.16 shows a significant ($p<0.005$), this implies that there is correlation between the predictor's variables (Amount of rainfall, Farmers' level of income, farmers' years of experience, farm size and visits by extension agents) and response variable (Maize Production). An F ratio is calculated which represents the variance between the groups, divided by the variance within the groups. A large F ratio indicates that there is more variability between the groups (caused by the independent variable) than there is within each group, referred to as the error term.

Table 4.17: Coefficients of Regression Equation

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	(Constant)	.061	.258		.930	.354
	Amount of rainfall	.775	.077	.297	3.798	.002
	Farmers' level of income	.430	.070	.188	3.290	.001
	Farmers' years of experience	.413	.062	.013	.215	.001
	Farm size	.514	.077	.406	5.445	.000
	Visits by extension agents	.124	.034	.002	.345	.001

a. Dependent Variable: Maize Production

The established multiple linear regression equation becomes:

$Y = 0.061 + 0.775X_1 + 0.430X_2 + 0.413X_3 + 0.514X_4 + 0.124X_5$

Based on the regression coefficients of the variables, it can be concluded that Amount of rainfall, Farmers' level of income, Farmers' years of experience, Amount of land owned and visits by extension agents all had a significant influence on maize production in Mwala, with a P-Value was 0.000 which is less than the confidence level of 0.005**.** The constant = 0.061, implied that with the other variable (that Amount of rainfall, Farmers' level of income, Farmers' years of experience, Farm size and visits by extension agents) maize production in Mwala would be would be at a rate of 6.1%.The amount of rainfall had the highest value of coefficient of 0.775, implying that a unit change in rainfall resulted to a 77.5% increase in the amount of maize produced. Amount of land owned by farmers had a coefficient of 0.514 implying that a unit increase in the farm size contributed to 51.4% increase in the amount of maize produced. Visits by extension had the lowest value of coefficient of 0.124 implying that a unit change in the number of visits by the extension agents contributed to 12.4% increase in maize production in Mwala Constituency.

CHAPTER FIVE: DISCUSSIONS

5.1 Introduction

This chapter presents summary of findings as discussed in chapter four and interpretations of the data analysis, conclusions, and recommendations based on the findings.

5.2 Climatic trend and maize production in Mwala

The analysis of meteorological data indicated a change in climatic variables between 1984 and 2014. During this period, the mean daily minimum and maximum temperatures increased at the rate of 0.03 and 0.042°C, respectively (Figure 4.2) while the long term mean annual rainfall for Mwala declined at the rate 5.8 mm per year (Figure 4.3). These contributed to a decline in maize production at the rate of 0.559 tons/ha/yr (Figures 4.4 & 4.5). Similar findings were recorded in Ghana (Klutse et al, 2013), and Mozambique (Osbahr et al, 2008).

The respondents explained that they used to receive the first rains in November or late October but all this had changed as they could no longer predict when the rains would be expected. The farmers indicated that they used to plant crops in late October or early November but now have to wait till January or February in order to plant maize. The respondents also said that the change of climate has also led to the widespread of pest and diseases on crops due to an increase in temperature. The respondents reported an increase in frequency of drought. In addition to that all the respondents highlighted that there was an increase in temperature in the area.

5.3 Impact of climate variability on maize yield

Farmers in Mwala are exposed to climate variability and change. The increasing temperatures and fluctuation in rainfall have serious implications for maize production in Mwala Constituency. An important finding of this study is the attribution of climate variability and change to crop production. Maize crop yield fluctuated between 1984 and 2014. During the same period, rainfall had declined from 1062 to 318 mm (Fig 4.4). The two traditional crop growing period in Mwala coincides with long and short rains. Rainfall distribution in Mwala Constituency is moderate and is received in the short rainy season (October/November–January/February) and the long rainy season (March–August/September). The mean rainfall for each of the two seasons had a range from 200 to 350 mm (half of the annual precipitation). The mean monthly temperature varied between 18°C and 25°C; the hottest months being February and October, and the coolest being July. Because of the fluctuating climatic conditions in the area, the maize production is low and farmers are continuously looking for strategies to adapt to this.

Farmer perceptions of long-term changes in precipitation were consistent with rainfall data. This was done by comparing the recorded meteorological data with climate change as perceived by farmers in the region. The results of the analysis showed that the factors that highly affected maize production in Mwala included decrease in rainfall, increased incidences of drought during the dry season and a changing environment due to human activities such as charcoal burning. Similar findings were recorded in a study conducted in Kenya by Kabubo et al, (2006), indicating that climate change affected agricultural productivity. While adverse climatic conditions has hindered maize production in Mwala, the government and non-governmental institutions in the area have not put in place mechanism to educate farmers and raise their awareness on climate adaption strategies as a results maize production continues to decline with time since only a few farmers are reached by the extension agents in the region.

5.4 Demographic and Socio-Economic Characteristics of the Respondents

This study underscore the importance of educational attainment, membership to social and economic group, household size, access to extension service, access to water, farm size and proximity to markets on household adoption decisions. Household and farm characteristics and institutional factors had differential influence on uptake of adaptation options. Farmers who had attained some sort of formal education were likely to perceive and adapt to climate change. The household size of farmers has a positive coefficient on the likelihood to increase the size of land under cultivation. Large household were found to be more likely to adopt labour-intensive technologies. In western Kenya (Marenya & Barrett, 2007) and Uganda (Nkonya et al., 2008), it was observed that family rather than hired labour provided most farm operations. Therefore, large households are more likely to overcome labour constraints and adopt new farming practices.

Membership to social and economic groups influences the adoption of farm management practices and diversification of livelihoods. This suggests that government support to social groups is crucial in enhancing livelihood diversification and adoption of sustainable agricultural technologies.

5.5 Level of Awareness

The results of the study suggest that a majority of farmers in Mwala Constituency were aware of methods for combating climate change and most of the farmers many had begun practicing these methods to improve the level of maize production in the County. The farmers were however not sure of what exactly the causes of climate variability were and most of them attributed it to acts of God. The farmers did not show high level knowledge on the technical matters of climate change but they have shown several evidences, which demonstrate that they have perceived, felt and experienced about its effects. The amount and patterns of rainfall, the frequency and extent of droughts, the trends of crop failure due to emergence of new crop diseases, etc were some of the visible impacts. This underscores the important need for capacity building and training of smallholder farmers in Mwala by the government and civil society on what climate change is and its impacts on crop production.

5.6 Attitudes toward Climate Change

There were strong feelings and attitudes with regard to just how willing the farmers would be to become prepared for climate change. Several cultural attitudes especially with regard to traditional role of women in decision making need to be changed to ensure women play a role in making informed decisions with regard to climate change. Social status is a major hindrance in the culture that needs to be addressed. A change in culture is needed so that people will see the value of climate friendly activities. A further attitudinal change cited by the respondents was the need to foster community spirit and collaboration in mitigating the adverse effects of climate change. The respondents felt that climate change resilience require greater community spirit and cooperation.

There was a strong perception among the respondents that the government should play a major role in climate change mitigation and assist farmers. Interestingly, although many of the respondents felt that they were at risk from climate change, they did not think others took the risk seriously enough, unless a disaster happened and they suffered directly from the effects of climate change. They did not feel that other members of the community were adequately sensitized to the risks involved.

This study has shown that there is a significant association between smallholder farmers' perceptions of extreme climatic events and adoption of traditional methods to cope with climate change. Similar findings were recorded by Nhemachena & Haassan, (2007) in Sub Saharan Africa generally. Farmers often digressed during discussions and interviews to talk about their problems regarding poor access to reliable markets for their produce, limited access to hybrid seeds, chemical fertiliser, veterinary services and animal draft power. Immediate need for household food security was also among farmers' major concerns. These sentiments imply that the problem of climate change is not the most pressing one among smallholder farmers. Mertz et al (2009) asserts that change in land use and livelihood strategies is driven by a range of factors of which climate change appears not to be the most important. This therefore shows that an action theory approach needs to be taken by the farmers initially to adapt in their own way and then have the government and other actors come in order to effectively deal with the adverse effects of climate change.

The findings also indicated that most farmers were practicing farming to support their families while only a few practiced farming for commercial purposes this is due to the fact that the climate in Mwala does not favour commercial production of crops such as maize, and the farm sizes were too small to support commercial crop production. This underscores the need for farmer education on the best crops to be grown in the area to enhance productivity and food security.

5.7 Strategies to adapt to Climate Change

Faced with unpredictable climatic variables, farmers in Mwala have adopted an action-oriented perspective to adopt different responses to climate change. Much of this response is reactive, in the sense that it is triggered by past or current events (e.g., decreased rainfall) but it is also anticipatory in the sense that it is based on some assessment of conditions in the future (e.g., rainfall occurrences). Many farmers were part of groups that shared information on climate change and best practices in farming and this highly influenced their choice of adaptation strategies. The farmers sought advice on climate change applied for credit to develop their farms and attended trainings to gain more knowledge on new and efficient farming methods. The practices adopted by smallholder farmers in Mwala, have shown that multiple actors play different roles to influence strategies adopted to deal with the effects of climate variability and change.

In order to escape from continuous crop failure from unusual rain and frequent droughts, farmers in Mwala are forced to seek some alternatives. This is consistent with Boko et al. (2007) who highlight the critical importance of new strategies and technologies for adaptation to climate change. Some of the strategies used by the farmers to adapt to climate change include planting different varieties of crops, staggering planting time, rearing different breeds of livestock, Soil fertility and water management and farm forestry. Use of seed banks and irrigation were ranked low by the farmers. The farmers explained that these strategies were labour intensive and required resources which were not readily available to the farmers to be put in practice. The climate change research community has identified different adaptation methods. The adaptation methods mostly commonly cited in literature as explained by 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

Finally, the results indicated that the major hindrances faced by farmers in adapting to climate change included lack of improved seeds/breed and lack of access to water for irrigation farming. In addition, lack of current knowledge on adaptation methods and lack of money to acquired modern techniques hindered the farmers from taking up adaptation strategies. This shows that there is need for farmers in the area to receive resources in terms of funding to be able to acquire the appropriate techniques for adaptation. Further, there is need for collaborative efforts amongst players in the agricultural sector to build the capacity of farmers in Mwala and increase their knowledge on the best adaptation methods to employ in their farms. Adger et al., (2003) advocate for this by providing that the adaptive capacity is influenced by factors such as knowledge about climate change, assets, access to appropriate technology, institutions, policies and perceptions.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Climate change was a not new phenomenon in the study area and smallholder farmers' perception of climate change was that temperatures were rising while level of precipitation was declining. Most of the farmers 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 in Mwala Constituency, and it is very probable that climatic conditions will continue to approach new extremes to which farmers in the area have never been forced to adapt. The farmers have not effectively adapted to climate changes and therefore maize production continues to decline drastically.

Based on the analysis, it can be concluded that amount of rainfall, farmers' level of income, farmers' years of experience, amount of land owned and visits by extension agents had a significant influence on maize production in Mwala Constituency. The p-Value was 0.001, which is less than the confidence level of 0.005 showing that the variables had positive influence on the level of maize production.

6.2 Recommendations

Community based adaptation is capable of reducing the vulnerability as well as improving on the resilience of the local people to climatic variability and change. Although smallholder farming have a long history of coping and adapting to some of these changes, effective adaptation strategies and actions should therefore be aimed at securing the well-being of the subsistence farmers in the face of climatic changes. However, most adaptation efforts have been top-down, and little attention has been paid to communities' experiences of climatic variability and their efforts to cope with their changing environments. Effective adaptation strategies aimed at securing the well-being of smallholder farmers requires the involvement of multiple stakeholders ranging from policy makers, extension agents, Non-Governmental Organizations (NGOs), researchers, communities and to a greater extend the subsistence farmers

The current strategies in used by the subsistence farmers should be considered in the countries national adaptation plan of action. For local and indigenous knowledge serve as a sink and could act a springboard in the formation strategies that could aid local farmers.

Through research, new crop varieties and hybrids that are able to withstand severe droughts, tolerate higher temperatures and mature early, could enable the farmers to be ready to meet the challenges of climatic variability and change Mwala Constituency. New technologies, such as irrigation techniques, early warning systems could be developed. Education of the farmers in the area is very much imperative if they need to adapt to climate change. Successful agricultural adaptation requires better and clearer information combined with investments and advisory services to disseminate the information to the local farmers. Adequate extension information services are essential to ensure that farmers receive up-to date information about climatic patterns in the forthcoming season so that they can make well informed decisions about their planting dates. They could also play a role in land use changes and crop-farm management practices of subsistence farmers that could play a role in adaptation and concomitantly mitigation of climate change.

The identified indigenous adaptation strategies namely: crop diversification, mixed crop and livestock farming agro-forestry, planting different varieties of crops and staggering the planting time should be promoted by the Government, the donor community as well as the Civil Society organizations in order to give an integrated approach to fighting the adverse effects of climate change and come up with the most appropriate adaptation polices. This will go a long way if smallholder households are to build resilience or adaptive capacity against climate change impacts.

In order for maize production in the country to persist and thrive sustainably, it is necessary for agriculturists to take real action to mitigate the adverse effects of climate change, and to exploit any potential advantages. In order to do so, several things are required: First, maize farmers in Mwala need to be continuously informed. Without knowledge, no successful, sustainable adaptation can take place. Therefore, dedicated capacity building and expansive outreach initiatives regarding adaptation are necessary in order to achieve total, large scale success in adaptation in the region. The most effective means for the dissemination of adaptation strategies should be utilized widely to maintain an ideal level of local awareness on climate-related issues and appropriate measures for adaptation. These most common channels for outreach, as observed by this study, included radio broadcasts, barazas, farmer group meetings and field days, as well as farmer-to-farmer conversations.

Continuation of agricultural research is an absolute necessity for adaptation. As climate changes continue to effect farms, research can continue to be of vital importance especially considering the rising global population, and the resultant increase in demand for agricultural goods.

The development of infrastructure must precede any successful, sustainable protocol for adaptation on the long term. In Mwala, where for years the road network has been of very poor quality, the lack of basic infrastructure has delayed the development of resources such as agricultural extension offices and agricultural research centers.

6.3 Suggested areas of future studies

Future study should be undertaken to compare the performance of the strategies undertaken to adapt to climate changes and the extent to which farmers have implemented the strategies. Despite awareness and increasing concern of the possible adverse impacts of climate change, little quantitative evidence is available on the cost implications from the impacts of climate change on households. Future research should specifically focus on the cost implications of climate change on household in other parts of Kenya that experience adverse climate.

REFERENCES

Adger, W. N. 2003. Social Capital, Collective Action, and Adaptation to Climate Change. *Economic Geography* 79(4): 387-404.

Adger, W. N., S. Agrawala, M. M. Q. Mirza, C. Conde, K. O'Brien,J. Pulhin, R. Pulwarty, B. Smit, and K. Takahashi. 2007.Assessment of adaptation practices, options, constraints and capacity.

Boko, M., I. Niang, A. Nyong, C. Vogel, A. Githeko, M. Medany, B. Osman-Elasha, R. Tabo and P. Yanda, 2007: Africa. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds.,Cambridge University Press, Cambridge UK, 433-467.

Burke M., & Lobell D., 2010, Food Security and Adaptation to Climate Change: What Do We Know? *Climate Change and Food Security*, vol. 37, Springer, Netherlands

Carr, E.R., 2006. Postmodern conceptualizations, modernist applications: Rethinking the role of society in food security, *Food Policy* 31 (2006) 14–29.

DFID, EC, UNDP and World Bank (2002). *Linking Poverty Reduction and Environmental Change Environmental Management: Policy Challenges and Opportunities*, Consultation.

Eisenack, Klaus and Rebecca Stecker. 2011. An Action Theory of Adaptation to Climate Change. Earth System Governance Working Paper No. 13. Lund and Amsterdam: Earth System Governance Project.

Eriksen, S. H 2005, The dynamics of vulnerability: Locating coping strategies in Kenya and Tanzania." *Geographical Journal*; Vol. 171: 287-305

Factors and the causal links among agro-pastoral households in semi-arid Makueni County, Kenya', *Global Environmental Change Part A: Human & Policy Dimensions*, 18, 1, pp. 220-233

Falco .S, Veronesi. M. & Yesuf M, 2011, Does adaptation to climate change provide Food security? *A micro-perspective from Ethiopia: American Journal of Agricultural Economics Advance* Downloaded from ajae.oxfordjournals.org at London School of economics on March 17, 2011

FEWS NET Production and Trade Flow Maps: Kenya first season maize FEWS NET Market

Food security in Kenya August 2009, Ministry of Agriculture: Romano Kiome, (Phd, Cbs) Permanent Secretary, Ministry of Agriculture and Trade Flow Analysis, accessed August 2010

Hellmuth, M.E., Moorhead, A., Thomson, M.C., and Williams, J. (eds). 2007. Climate Risk Management in Africa: Learning from Practice. International Research Institute for Climate and Society (IRI), Columbia University, New York, USA. http://www.unhabitat.org

Ingram, J.S.I, Gregory P.J & Izac A,M 2008, the role of Agronomic research in climate change and food security policy. *Agriculture, Ecosystems and Environment;* vol. 126: 4-12

Inter-governmental Panel on Climate change (IPCC). 1990. The First Assessment Report.

Inter-governmental Panel on Climate change (IPCC). 1996. Climate Change 1995. The Science of Climate Change. Contribution of the WGI to the Second Assessment Report of the Intergovernmental Panel on Climate Change J.T Houghton et al. (ed.) Cambridge University Press, Cambridge, United Kingdom.

Inter-governmental Panel on Climate change (IPCC). 1997. Stabilization of Atmospheric Greenhouse Gases: physical, biological and socio-economic implications.

Intergovernmental Panel on Climate Change (IPCC). 2001. Annex B: glossary of terms

Inter-governmental Panel on Climate change (IPCC). 2007. Climate Change: Impacts, adaptation and vulnerability. Contribution of Working Group II to the 4th Assessment Report of the IPCC. Cambridge University Press

Inter-governmental Panel on Climate change (IPCC). 2009. A Report of working Group I of the Intergovernmental Panel on Climate Change, Summary for Policy Makers.

IPCC., 2007. New Assessment Methods and the Characterization of Future Conditions: In Climate change 2007: Impacts, adaptation and vulnerability, pp: 976. Contribution of working group II to the fourth assessment report of the Intergovernmental panel on climate change Cambridge university press, Cambridge, UK

Kabubo-Mariara, J., & Karanja, F., 2007. The economic impact of climate change on Kenyan crop agriculture: A Ricardian approach. *Global and Planetary Change*, 57: 319–330.

Katz, R.W. and B.G. Brown, 1992. Extreme events in a changing climate: variability is more important than Climatic Change, 21: 289-302.

Kenya Food Security Steering Group (KFSSG) (July 2008.) "The Impact of Rising Food Prices on Disparate Livelihood Groups in Kenya" http://documents.wfp.org/stellent/groups/public/documents/ena/wfp182903.pdf. (Accessed May 2, 2013)

Ketiem et al, modeling effects of climate change on maize production in Kenya: A case study of two agro-climatic zones, KARI, 2008

KIPPRA, Dec 2007 Kenya Agricultural Sector Data Compendium; pg. 75

Klein R.J.T & Smith J.B. 2003, "Enhancing the capacity of Developing countries to adopt to climate change: A policy relevant research agenda," In Smith, J.B et al (eds) 2003 *Climate Change, Adaptive Capacity and Development*, London: Imperial College Press 317

Klutse et al,(2013) Farmer's observation on climate change impacts on maize (Zea mays) production in a selected agroecological zone in Ghana, , Research Journal of Agriculture and Environmental Management. Vol. 2(12), pp. 394-402, December, 2013 Available online at http://www.apexjournal.org ISSN 2315 - 8719© 2013 Apex Journal International

Kurukulasuriya, P & Rosenthal, S, 2003. Climate change and agriculture: A review of impacts and adaptations. Paper No. 91 in Climate Change Series, Agriculture and Rural Development Department and Environment Department, World Bank, Washington, DC.

Lobell, D.B., Burke, M.B., Tebaldi, C., Mastrandrea, M.D., Falcon, W.P., & Naylor, R.L. 2008, Prioritizing climate change adaptation needs for food security in 2030. *Science* 319 (5863): 607–10.

Maxwell, S., & Smith, M., 1992. Household food security: A conceptual review. In: Maxwell

Mugenda O.M. & Mugenda A.G. (2003). Research Methods Quantitative and qualitative approaches. Nairobi: Acts Press.

Muthamia JGN, Musembi F, Maina JM, Okuro JO, Amboga S, et al. 2001. Participatory on-farm trials on weed control in smallholder farms in maize-based cropping systems.

Proceedings of Seventh Eastern and South Africa Regional Maize Conference. 11th – 15th February

Ngugi, R.K., Mureithi, S.M. & Kamande, P.N. 2011. Climate forecast information: the status, needs and expectations among smallholder agro-pastoralists in Machakos District, Kenya. International Journal of Current Research 3(11), 6 – 12

Nhemachena C., and Hassan ,R . 2007. Micro-Level Analysis of Farmers' Adaptation to Climate Change in Southern Africa. IFPRI Discussion Paper No. 00714. International Food Policy Research Institute. Washington DC.

Nyangweso, P.M., Serem, A.K. Kipsat, M.J. & Maritim, H.K. Implementing Kenya's Food and

Nyariki, DM 2011, 'farm size, modern technology adoption, and Efficiency of small holdings in developing countries: evidence from kenya', *Journal Of Developing Areas*, 45, 1, pp. 35-52

O'Brien, K., & Hochachka, G. 2010. Integral Adaptation to Climate Change. Journal of Integral Theory and Practice, 5(1), 89-102.

Oluoko-Odingo, A. 2011. Vulnerability and Adaptation to Food Insecurity and Poverty in Kenya. *Annals of The Association Of American Geographers*, *101*(1), 1-20

Osbahr, H., Twyman, C., Adger, W, N., Thomas, D. 2008. 'Effective livelihood adaptation to climate change disturbance: Scale dimensions of practice in Mozambique, Geoforum, 39: 1951-1964.

Oseni T.O & Masarirambi M.I, 2011: Effect of Climate Change on Maize (*Zea mays*) Production and Food Security in Swaziland

Palma C. A., Smuklera S. M, Sullivana C. C, Mutuoa P. K, Nyadzia B, & Walsha M. G. 2010, Identifying potential synergies and trade-offs for meeting food security and climate change objectives in sub-Saharan Africa Climate Mitigation and Agricultural Productivity in Tropical Landscapes Special Feature PNAS 2010

Republic of Kenya 2005. Economic Survey 2005. Government Printer, Nairobi

Republic of Kenya, 2013: Machakos County Development Profile

Republic of Kenya, Agricultural sector development strategy 2010 – 2020

Republic of Kenya, National Food and Nutrition Policy 2010

Republic of Kenya. 1986. Sessional paper No. 1: Economic Recovery for Renewed growth

Republic of Kenya. 1981. Sessional Paper No. 4 of 1981 on National Food Policy. pp.1-52 Nairobi: Government Printer

Republic of Kenya. 1996. *County Development Plan, Machakos County, Eastern Province, Kenya*, pp 29-95.

Republic of Kenya., 1994. Sessional paper No. 2: Food Policy, Ministry of Agriculture

Rosenzweig, C. and Parry, M. L. 1994, Potential impact of climate change on world food supply, *Nature,* 367:133- 138. Accessed on JSTOR

S., Frankenberger, T. (Eds.), Household Food Security: Concepts, Indicators, Measurements. United Nations Children's Fund – International Fund for Agricultural Development, New York, pp. 1–72

Smit, B. and M.W. Skinner. 2002. Adaptation options in agriculture to climate change: a typology. Mitigation and Adaptation Strategies for Global Change. 7: 85-114. [pdf]

Smit, B., I. Burton, R. Klein and J. Wandel. 2000. The Anatomy of Adaptation to Climate Change and Variability. Climatic Change, 45: 223-251.

Sowunmi F.A & Akintola J.O, 2010: Effect of climate variability on maize production in Nigeria

The State of Food Insecurity in the World 2001, FAO, 2001. www.fao.org

Valenzuela. E. & Anderson .K., Climate Change and Food Security to 2030: A Global Economy wide Perspective April 2011, *Centre for International Economic Studies, Discussion Paper* No.1102 http://www.adelaide.edu.au/cies/

Visser, Frank. 2003. Ken Wilber: Thought as passion. Albany, NY: SUNY Press. - See more at: http://integrallife.com/integral-post/overview-integral theory

World Meteorological Organization, WMO. 1996. Climate, Weather and Agriculture. A paper presented at World Food Summit-Rome, 13-17th November (1996)

Ziervogel Gina, Ericksen Polly J. Adapting to climate change to sustain food security. *WIREs Climate Change* 2010, 1: 525-540. doi: 10.1002/wcc.56

APPENDICES

Appendix I: Household 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 knowledge, attitudes and practices on climate change adaptation by small holder farmers in Mwala constituency. The information you will give will be strictly confidential.

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

AGENERAL 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)

Rank, Tick

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"	Seed costs	Fertilizer costs	Harvesting costs	Total labour	Total variabl	Total revenue	Gross margin

Crop codes

1= beans

2= bananas

3=Watermelon

4= Soya beans

5= Green peas

6= pigeon peas

7= sugarcane

8= cowpea leaves

9 = maize(Dry)

10 = Maize (Green)

11 = sorghum

12= finger millet

13=Tomatoes

14 = mangoes

15 =Avocado

16= Local vegetables

17= onions

18= cassava

19= sweet potatoes

20= kales

21= groundnuts

22=Oranges

23=passion fruit

24=Other(specify)____

A8. Ask the following questions for all livestock reared in the last season

Livestock	Input costs	Vet drug	Treatment costs	Total labour	Other costs	Total variabl	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 visits ☐ 3.Field day ☐ 4. Office visits ☐ 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: KNOWLEDGE, ATTITUDE AND PRACTICES ON 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). Before this interview, had you heard about climate change?

(explain in case the terms are unfamiliar)

[ ] yes [ ] no [ ] don't know

What have you ALREADY heard about the possible FUTURE effects of climate change in Kenya?

[7.1] Increased rainfall [7.2] increased erosion

[7.3drought

[7.4] more storms [7.5] more rain [7.6] less rain [7.7] hotter temperatures

[7.8] more disease [7.9] trees may die

[7.15] don't know [7.16] other ____

What are your thoughts or attitudes about the following statements about Climate Change? I will read a sentence, then *please tell me whether you agree, disagree or are unsure*

	Agree	**Disagree**	**Unsure**
Climate CHANGE *is* happening			
Every individual can do something to adapt to climate change			
Living for today is more important than worrying about the effects of Climate Change in 50 years' time			
Climate Change will reduce the quality of life of my children & grandchildren In the future			

H5). FEELINGS/ATTITUDES ABOUT CLIMATE CHANGE

How do you feel about climate change?

[a] fearful/afraid [b] disbelief [c] confused

[d] Angry [e] powerless e.g. I can't do anything

[f] Hopeful i.e. we can do some things to adapt

[g] Sad i.e. we might lose our culture & lands

[h] Don't know

[i]other…………………………………………………………………………………………………

……

……

……………………………………………………………………………………………

H6) HOW THE FARMERS LEARN ABOUT CLIMATE CHANGE

Through which media have you heard about climate change

[a] radio [b] radio [c] newspaper

[d] TV [e] computer/internet

[f] Government [g]None

H7: 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. Agrofoestry	[ ]	[ ]
g. Use of seedbanks	[ ]	[ ]
h. Intensification of production	[ ]	[ ]
i. Changing from farming to non-farming activities	[ ]	[ ]
j. Irrigation	[ ]	[ ]

H8: 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	[ ]	[ ]

H9: List the challenges that you have been facing when 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 II: Informed Consent

(The following statement must be read to every respondent)

CONSENT FORM

Hello Sir/Madam,

My name is Linda Awuor Ochieng. I am a graduate student of Environmental Policy at the University of Nairobi doing a research on determine the knowledge, attitudes and practices on climate change adaptation by smallholder farmers within Mwala Constituency in Machakos County, Kenya. In order to meet this objective, it is important to obtain information from the Mwala residents such as you.

This information is being collected for academic purposes only, and there are no personal benefits or risks to your participation. It is possible that some of the questions asked, are of a sensitive nature, but please note that your name will not be recorded in the questionnaire, and any details related to your privacy will be kept confidential. The interview will take approximately 30 minutes, but with your cooperation it can be done quicker. For more information about this study, please contact the researcher on ..., or email...

May I have your permission to undertake this interview?

Yes . (proceed with interview)

No .(thank the person and look for next respondent).

Appendix III: Climatic Data

Station_ID	Station_N	Element	YEAR	1	2	3	4	5	6	7	8	9	10	11
9137089	MACHAKO	Precipitation	1984	24.2	0.0	3.4	51.4	0.6	0.0	7.0	6.4	15.7	154.4	211.2
9137089	MACHAKO	Precipitation	1985	5.3	110.5	78.7	278.3	84.6	0.0	1.4	1.9	0.2	56.0	75.1
9137089	MACHAKO	Precipitation	1986	59.0	0.0	59.4	192.4	72.7	5.7	0.4	0.3	0.0	2.6	180.8
9137089	MACHAKO	Precipitation	1987	31.7	0.0	23.3	56.7	39.4	61.9	3.6	11.6	0.0	0.3	93.5
9137089	MACHAKO	Precipitation	1988	93.7	13.8	109.3	203.7	23.6	10.1	0.0	3.0	15.4	33.5	120.8
9137089	MACHAKO	Precipitation	1989	133.2	4.0	51.1	193.7	37.0	0.0	3.8	14.6	0.3	96.9	106.0
9137089	MACHAKO	Precipitation	1990	42.8	23.2	217.3	251.5	64.9	5.1	0.0	3.4	0.0	48.8	208.5
9137089	MACHAKO	Precipitation	1991	29.3	13.3	43.5	80.5	57.5	3.1	1.4	8.9	3.4	46.5	119.9
9137089	MACHAKO	Precipitation	1992	12.0	6.1	5.0	192.9	32.0	1.1	6.8	0.0	0.7	31.0	141.2
9137089	MACHAKO	Precipitation	1993	256.5	84.9	60.9	20.8	13.7	6.3	0.5	3.1	0.6	26.0	150.8
9137089	MACHAKO	Precipitation	1994	0.0	103.5	75.3	82.4	29.8	8.2	3.3	9.9	4.3	110.9	406.3
9137089	MACHAKO	Precipitation	1995	28.5	83.3	150.1	49.6	33.1	0.9	4.1	3.2	5.1	103.7	46.0
9137089	MACHAKO	Precipitation	1996	22.4	56.5	73.7	96.4	42.8	19.3	2.2	2.2	0.7	0.0	187.7
9137089	MACHAKO	Precipitation	1997	3.8	0.0	46.0	208.5	21.2	0.5	1.2	4.3	0.0	83.2	270.3
9137089	MACHAKO	Precipitation	1998	290.8	219.4	118.0	123.0	162.6	38.7	15.4	2.9	1.8	3.2	113.9
9137089	MACHAKO	Precipitation	1999	16.1	2.2	121.0	113.8	9.8	5.0	2.4	4.9	0.0	20.6	257.0
9137089	MACHAKO	Precipitation	2000	7.0	0.0	52.5	68.5	15.6	6.2	0.3	1.8	2.3	41.0	189.8
9137089	MACHAKO	Precipitation	2001	244.8	0.0	113.0	88.9	15.3	4.3	4.3	2.5	0.0	7.3	169.0
9137089	MACHAKO	Precipitation	2002	79.5	7.5	98.9	120.4	126.6	1.4	0.0	0.2	8.8	21.2	144.3
9137089	MACHAKO	Precipitation	2003	31.6	17.2	115.2	153.2	133.8	0.0	0.0	26.3	21.5	31.8	121.1
9137089	MACHAKO	Precipitation	2004	48.0	47.9	83.1	121.5	59.8	0.7	0.0	0.0	1.0	47.6	161.3
9137089	MACHAKO	Precipitation	2005	12.2	19.2	101.7	165.1	100.5	0.0	0.5	1.5	0.0	8.4	93.4
9137089	MACHAKO	Precipitation	2006	30.9	53.1	105.0	175.9	107.5	2.4	0.6	17.5	2.1	10.7	328.4
9137089	MACHAKO	Precipitation	2007	61.4	44.8	20.5	143.9	41.7	2.7	26.8	5.0	4.3	18.3	128.2
9137089	MACHAKO	Precipitation	2008	117.4	7.3	73.0	129.3	4.5	0.3	1.3	0.2	9.1	23.9	122.8
9137089	MACHAKO	Precipitation	2009	74.2	26.3	3.2	145.4	29.7	5.2	0.0	0.0	1.2	41.3	34.4
9137089	MACHAKO	Precipitation	2010	57.1	64.1	232.0	107.9	120.9	1.4	2.7	1.3	0.6	29.3	116.0
9137089	MACHAKO	Precipitation	2011	9.1	71.8	209.8	1.0	37.8	0.0	3.4	0.7	5.9	50.2	180.2
9137089	MACHAKO	Precipitation	2012	0	4.6	1.6	286.7	113.5	36.9	0.2	11.8	0.6	22.3	119.7
9137089	MACHAKO	Precipitation	2013	50.4	0.0	117.1	184.1	20.1	0.3	3.0	0.6	2.5	6.4	106.7
9137089	MACHAKO	Precipitation	2014	0.0	31.8	206.8	44.0	14.8	9.7	0.9	33.5	13.6	42.5	105.6
9137089	MACHAKO	Temperature; daily maximur	1988	26.7	28.7	27.8	25.0	23.7	23.0	22.6	22.7	24.2	27.1	23.7
9137089	MACHAKO	Temperature; daily maximur	1989	24.6	25.8	27.2	23.8	23.7	22.6	21.3	21.3	24.7	25.5	23.6
9137089	MACHAKO	Temperature; daily maximur	1990	24.7	27.5	25.8	24.4	24.0	22.5	22.1	21.7	25.2	26.6	24.3
9137089	MACHAKO	Temperature; daily maximur	1991	25.9	28	28.4	26.2	24.6	24.2	22	22.4	25.4	27.3	24.6
9137089	MACHAKO	Temperature; daily maximur	1992	25	28.7	28.8	26.5	24.3	22.9	21.9	21.7	25	26.3	24.2
9137089	MACHAKO	Temperature; daily maximur	1993	23.5	24.4	26.4	26.3	26.2	23.3	21.8	23.1	25.6	26.9	25.3
9137089	MACHAKO	Temperature; daily maximur	1994	27.1	27.9	27.5	26.6	24.9	23.8	22.8	22.7	25.4	26.6	23.9
9137089	MACHAKO	Temperature; daily maximur	1995	25.8	27.1	25.6	25.7	24.9	24.4	22.4	23.4	25.8	26.4	24.5
9137089	MACHAKO	Temperature; daily maximur	1996	26.6	28.3	28.2	25.7	24.7	22.6	22.2	23.6	26.1	27.1	24.4
9137089	MACHAKO	Temperature; daily maximur	1997	27.5	29.5	28.7	25.3	23.9	23.3	23	24.5	26.6	25.3	23.3
9137089	MACHAKO	Temperature; daily maximur	1998	24.1	26	26.1	26	24.6	23.2	20.9	21.3	24.5	27	24.6
9137089	MACHAKO	Temperature; daily maximur	1999	27.9	28.9	27.2	25	24.8	23.7	22.4	23.1	25.7	26.6	24.4
9137089	MACHAKO	Temperature; daily maximur	2000	25.8	28.7	28.8	26.5	25.2	23.2	22.4	23.7	25.4	27.2	25.1
9137089	MACHAKO	Temperature; daily maximur	2001	24.6	26.4	26.9	24.9	25	23.6	21.9	24.5	26.7	27.1	24
9137089	MACHAKO	Temperature; daily maximur	2002	25.9	28.1	26.4	25.8	24.5	23.5	23.8	22.2	25.7	26.7	24.9
9137089	MACHAKO	Temperature; daily maximur	2003	25.3	28.8	28.6	26.8	23.9	23.2	22.3	22.8	25.1	26.4	24.5
9137089	MACHAKO	Temperature; daily maximur	2004	25.9	26.7	27.3	25.4	25.1	23.5	24.2	23.6	26.4	25.9	24.7
9137089	MACHAKO	Temperature; daily maximur	2005	26.7	28.4	28.4	26	25.1	23.5	22.4	23.0	25.7	26.6	24.5
9137089	MACHAKO	Temperature; daily maximur	2006	25.8	27.7	27.6	25.9	24.8	23.5	21.7	24.2	25.1	27.1	23.8
9137089	MACHAKO	Temperature; daily maximur	2007	24.7	27.2	27.4	26.2	24.6	24.2	22.8	23.1	25.8	26.5	24.4
9137089	MACHAKO	Temperature; daily maximur	2008	25.6	26.6	27.3	24.7	24.7	23	22.2	23.6	26.7	27.2	25.3
9137089	MACHAKO	Temperature; daily maximur	2009	26.4	27	29.1	27.1	25.1	25.4	23.6	23.6	26.6	25.7	25.9
9137089	MACHAKO	Temperature; daily maximur	2010	25.7	27.4	25.2	25.4	24.6	23.3	22.7	23.3	25.5	27.5	24
9137089	MACHAKO	Temperature; daily maximur	2011	27.9	28.2	27.7	26.3	25.8	25.4	25.1	23.3	25.7	25.6	24.5
9137089	MACHAKO	Temperature; daily maximur	2012	28.4	29.1	29.4	25.9	24.6	23.2	22.2	24.5	26.7	27.4	25.7
9137089	MACHAKO	Temperature; daily maximur	2013	27.5	29.1	28.6	27.1	24.7	22.3	23.5	23.0	26.6	27.5	25.3
9137089	MACHAKO	Temperature; daily maximur	2014	24.0	27.1	26.5	25.6	25.2	24.1	23.5	24.5	25.2	27.2	25.4
9137089	MACHAKO	Temperature; daily minimun	1988	14.0	14.3	14.1	14.7	13.1	12.0	11.0	11.2	11.3	12.4	13.4
9137089	MACHAKO	Temperature; daily minimun	1989	12.6	11.5	12.9	13.3	12.4	10.5	9.8	10.3	11.1	13.0	15.1
9137089	MACHAKO	Temperature; daily minimun	1990	13.6	14.7	15.5	15.3	14.4	11.5	10.3	11.9	11.0	14.1	15.0
9137089	MACHAKO	Temperature; daily minimun	1991	12.3	12.4	14.2	14.6	15.1	13	11.6	10.6	10.8	13.6	14.6
9137089	MACHAKO	Temperature; daily minimun	1992	13.3	13.2	15	15.5	13.6	12.5	11.1	11	11.4	13.5	14.6
9137089	MACHAKO	Temperature; daily minimun	1993	14.2	12.8	13.2	15.2	13.9	13.5	10.6	11.5	10.6	13.6	14.8
9137089	MACHAKO	Temperature; daily minimun	1994	13.3	13.4	14.7	15	14.2	11.6	11.2	12	12.1	14.2	14.5
9137089	MACHAKO	Temperature; daily minimun	1995	12.8	12.9	14.4	14.7	13.9	10.9	10.3	10.5	11.5	13.5	13.6
9137089	MACHAKO	Temperature; daily minimun	1996	12.5	13.3	14.6	14.3	13.7	12	10.6	10	10.8	12.5	14.2
9137089	MACHAKO	Temperature; daily minimun	1997	13.4	13.2	14.8	14.9	13.1	12.3	11.2	11.3	12.1	13.6	14.8
9137089	MACHAKO	Temperature; daily minimun	1998	14.9	14.3	14.6	15.3	14	11.6	10.2	11.2	11.4	12.5	14.3
9137089	MACHAKO	Temperature; daily minimun	1999	14	13.7	15.5	14.8	13.6	12.1	12	12.6	12.5	13.3	14.7
9137089	MACHAKO	Temperature; daily minimun	2000	12.6	12.1	15	14.5	13.5	12.4	11.8	11.8	11.7	13.4	15.4
9137089	MACHAKO	Temperature; daily minimun	2001	14	14.3	14.3	15.2	14	12	10.9	11	12.5	13.6	14.6
9137089	MACHAKO	Temperature; daily minimun	2002	14.1	13.9	15.3	15.8	14.2	12.2	10.9	12.3	12.2	14.1	15.1
9137089	MACHAKO	Temperature; daily minimun	2003	12.9	12.4	13.3	14.1	14.4	11.9	10.1	10.4	12	13.3	13.8
9137089	MACHAKO	Temperature; daily minimun	2004	13.9	14.4	14.7	15.2	13.3	11.2	9.4	10.7	12.1	13.7	14.6
9137089	MACHAKO	Temperature; daily minimun	2005	13	13.6	15.3	14.7	14.1	12.1	10.9	11.2	11.7	13.5	14.5
9137089	MACHAKO	Temperature; daily minimun	2006	13.4	13.3	14.6	14.9	13.9	12.1	11.5	11.7	12.3	14	14.9
9137089	MACHAKO	Temperature; daily minimun	2007	13.5	13.2	14	15	13.8	11.1	10.8	12.2	11.5	13.5	14.4
9137089	MACHAKO	Temperature; daily minimun	2008	12.8	13.4	15.2	14.6	13.3	12	11.4	11.9	12.1	14.8	14.9
9137089	MACHAKO	Temperature; daily minimun	2009	13.7	14.4	15.1	15.7	14.7	12.8	10.6	11.8	12.7	14.5	15.5
9137089	MACHAKO	Temperature; daily minimun	2010	14.8	15.7	15.4	15.8	14.4	12.5	10.9	12.1	12.2	13.8	15.3
9137089	MACHAKO	Temperature; daily minimun	2011	13.5	13.5	14.9	16	15	13.5	11.2	12.8	13.4	15.4	15.4
9137089	MACHAKO	Temperature; daily minimun	2012	13.4	14.7	14.8	15.7	14.3	12.9	11.5	12	12.5	14.8	15.5
9137089	MACHAKO	Temperature; daily minimun	2013	13.7	13.1	15.8	16.4	13.8	12.1	11.4	11.9	13.0	14.0	15.6
9137089	MACHAKO	Temperature; daily minimun	2014	14.6	15.1	15.4	15.2	14.5	13.6	12.4	12.8	13.0	14.8	15.5

Appendix IV: Maize Yield Data

Year	Area (ha)	yield (tons)	Tons/ha
1975	110017	48712	0.44
1976	137815	58557	0.42
1977	136019	141081	1.04
1979	158000	142200	0.9
1980	150000	16650	0.11
1981	137552	173355	1.26
1982	158000	180698	1.14
1983	135491	121942	0.9
1984	106000	38375	0.36
1985	230000	174000	0.76
1986	178873	178783	1
1987	173000	182010	1.05
1988	172000	111100	0.65
1992	133216	53952	0.4
1993	123000	110700	0.9
1994	148981	33521	0.23
1995	142443	84228	0.59
1996	158890	35750	0.22
1997	165000	118800	0.72
1998	165170	59461	0.36
1999	166000	5976	0.04
2000	162000	58320	0.36

2001	163880	78034	0.48
2002	153580	87645	0.57
2003	145000	59850	0.41
2004	152000	27765	0.18
2005	170000	15300	0.09
2006	167225	119330	0.71
2007	145500	71295	0.49
2008	138750	78578	0.57
2009	170000	142800	0.84
2010	133540	120330	0.90
2011	150899	143700	0.95
2012	130470	134365	1.03
2013	133408	99566	0.74
2014	139089	67542	0.48