SMALLHOLDER FARMERS' PERCEPTIONS AND ADAPTATION TO CLIMATE VARIABILITY IN KENYA; A CASE STUDY OF KAVETA AND MIKUYUNI VILLAGES, KITUI COUNTY

EVELYN JANE MUTUNGA

I501/KIT/20604/2015

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ENVIRONMENTAL MANAGEMENT, SOUTH EASTERN KENYA UNIVERSITY

2017

DECLARATION

I understand that plagiarism is an offense and I therefore declare that this thesis is my original work and has not been presented in any other institution for any other award.

Signature________________________________ Date_________________

Evelyn Jane Mutunga
Registration Number: I501/KIT/20604/2015

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

Signature________________________________ Date_________________

Dr. Charles Ndung'u

Lecturer, South Eastern Kenya University

Department of Environmental Science and Technology

Signature________________________________ Date_________________

Dr. Patricia Muendo

Lecturer, Machakos University

Department of Biological Sciences

DEDICATION

I would like to dedicate this work to my dear parents, John Mutunga and Eunice Wayua and all my siblings for their love, support and encouragement during the entire study period. May the Almighty God bless you abundantly.

ACKNOWLEDGEMENT

I would like to express my heartfelt and sincere gratitude to Dr. Charles Ndung'u, Department of Environmental Science and Technology, School of Environment and Natural Resources Management, South Eastern Kenya University, for his interest, guidance, supervision, patience, tireless efforts and advice which were invaluable in the success and quality of this research work.

I would also like to extend my gratitude to Dr. Patricia Muendo, Department of Biological Sciences, School of Pure and Applied Sciences, Machakos University, for her advice and guidance which made the study a success.

I owe indebtedness to all my course lecturers in the school of Environment and Natural Resources Management for their encouragement and advice during my research period.

I would also like to tender my sincere thanks to my research assistants, Tracy Musyoka and Matthew Kyongo, whose tireless efforts enabled me to complete data collection in time.

I sincerely thank Kaveta and Mikuyuni farmers for their willingness to freely give information that made this work viable. Am also indebted to Mr William Ndegwa and Mr Stanley Mulei of the Kitui Meteorological Department as well as Mr John Mwikya, Technologist in the Department of Meteorology, SEKU, for their assistance in acquiring meteorological rainfall data for the purpose of this study.

Further, I would like to extend my warm thanks to my course mates for their support, criticism, advice and encouragement which helped improve the quality of this work.

This acknowledgement would not be complete without my sincere gratitude to South Eastern Kenya University for awarding me a scholarship for my Masters studies. May the Almighty God bless SEKU.

Finally, I would like to appreciate my dear friends, Nathan Kasamba, Catherine Mbusya and Zacharia Nyaribo for their sincere love, support and encouragement during my entire study period. May the Almighty God bless you abundantly.

ABSTRACT

The productivity of the agricultural sector has been highly challenged by the effects of climate change and variability. The increasing temperatures and erratic rains, as well as diseases and pests have significantly reduced crop yields in the arid and semi-arid regions of Kenya. Many farmers in the grassroots have hardly adopted any response options and have continued to suffer losses in their agricultural outputs. The present study sought to assess the perceptions of smallholder farmers on climate variability in selected Villages in Kitui County, identify adaptation measures adopted by the farmers as well as the factors and constraints influencing their adaptation measures. Descriptive survey design was used. A total of 177 households were randomly selected to constitute the study sample. Data was coded and analysed using Ms Excel and SPSS version 20 statistical packages. Logit regression model was used to analyse factors influencing farmers' adaptation to climate variability. The results established that most farmers had perceived a changing climate with more than 70% and 100% of the respondents in Kaveta and Mikuyuni Villages respectively, reporting that they noted an increase in temperature and a decrease in annual rainfall over the years. Results from Logit regression analysis showed that age, household size, education level, farming experience, off- farm income, access to extension services, access to credit facilities, access to climate information and weather forecasts significantly ($p<0.05$) influenced farmers' adaptation to climate variability in both Kaveta and Mikuyuni Villages. Inadequate technological capacity (78.2%), limited access to credit facilities (72.2%), limited access to extension services (68%) and high cost of adaptation (66.8%) were reported as the major constraints to farmers' adaptation to climate variability in Kaveta Village while lack of access to irrigation water (89.6%), lack of labour (86%), high cost of adaptation (81.4%), unreliable weather forecasts (81.4%), inadequate land resources (76.4%) and inadequate financial resources (74%) were the major constraints to the farmers' adaptation to the increasing temperature and changing rainfall patterns in Mikuyuni Village. From the study, it can be deduced that farmers from the drier area were more conscious of climate variability and thus adapted more to climate variability than farmers in the wetter areas.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ABBREVIATIONS AND ACRONYMS

ASALs - Arid and Semi-Arid Lands

CGoK-County Government of Kitui

FAO- Food and Agriculture Organization of the United Nations

GDP-Gross Domestic Product

GoK-Government of Kenya

IFAD- International Fund for Agricultural Development

IPCC- Inter-governmental Panel on Climate Change

ISDR- International measure for disaster reduction

MEST- Ministry of Environment, Science, and Technology

MLFD- Ministry of Livestock and Fisheries Development

NGOs-Non-Governmental Organizations

SPSS-Statistical Package for the Social Sciences

UNFCCC- United Nations Framework Convention on Climate Change

DEFINITION OF TERMS

Climate change: Defined as the statistically significant variations in weather elements such as temperature, wind patterns and precipitation that persist for an extended period of time, typically decades or longer (IPCC, 2001).

Climate variability: Refers to the way climate fluctuates yearly above or below long-term average value (ISDR, 2008).

Smallholder farmers: Are farmers who cultivate small areas of land (usually less than 10 ha, often less than 2 ha), use family labor, and depend on their farms as their main source of both food security and income generation (Cornish, 1998; Nagayets, 2005).

Adaptation: Is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2001).

Adaptive capacity: Is the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2007).

Perception: Refers to the process by which organisms interpret and organize sensation to produce a meaningful experience of the world (Lindsay and Norman, 1977).

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background information

Climate change and variability have been reported as the world's most complex environmental challenges of the day. The Inter-governmental Panel on Climate Change (IPCC) (2001) defines climate change as the statistically significant variations in weather elements such as temperature, wind patterns and precipitation that persist for an extended period of time, typically decades or longer. Climate variability on the other hand refers to the way climate fluctuates yearly above or below a long-term average value (ISDR, 2008). According to Zoellick (2009), rainfall patterns shift, extreme events such droughts and floods, forest fires, pests and disease outbreaks have become more frequent in the warming planet resulting to poor and unpredictable agricultural yields thereby increasing farmers vulnerability, particularly in Sub Saharan Africa (UNFCCC, 2007).

Farmers in Sub Saharan Africa are more vulnerable to climate change and variability because of the several predisposing factors such as poverty, geographic exposure, and heavy dependence on rain fed agriculture and issues of poor governance and social infrastructure (IPCC, 2001). The agricultural sector is reported to employ 60% to 90% of the total labor force in the Sub Saharan Africa (Thornton *et al*., 2006). Since climate variability has direct impacts on agricultural production due to the climate-dependent nature of agricultural systems, the impact of climate variability is significant in Africa where agriculture constitute employment and income sources for the mjority of the population (Zoellick, 2009).

The effects of climate variability on agriculture are far much pronounced on smallholder farmers living in smallholder households in rural areas where their livelihoods depend on agricultural activities (World Bank, 2008). According to Word Bank (2008), agriculture is the principle source of livelihood for 1.3 billion smallholder farmers worldwide. "Smallholder farmers" cultivate small areas of land (usually less than 10 ha, often less than 2 ha), use family labor, and depend on their farms as their main source of both food security and income generation (Cornish, 1998; Nagayets, 2005). According to IFAD (2013), smallholder farming is estimated to represent 85% of the world's farms and provide more than 80% of the food consumed in the developing world. FAO (2014) also reported that smallholder farmers occupy a significant portion of the world's farmland ranging from 62% in Africa to 85% in Asia.

Changes in temperature, rainfall and the frequency or intensity of extreme weather events (droughts and floods) are expected to directly affect crop and animal productivity consequently affecting smallholder farmers' food security, income and wellbeing (Gregory *et al.,* 2005, Agwu *et. al.,* 2010, Urama and Ozor, 2011). Although some studies have shown that climate variability may increase the productivity of certain crops (Tubiello and Fischer, 2007; Fuhrer and Gregory, 2014), several studies have reported that the productivity of many crops (e.g., maize, rice, sorghum, cassava) grown in developing countries are expected to be significantly reduce in the future with the increasing climate change and variability (Jones and Thornton, 2003).

In Kenya, the agricultural sector is one of the key contributors to Kenya's economic growth contributing to at least 25% of the country's gross domestic product (GDP) and employing 75% of the national labour force (Republic of Kenya, 2005). Like in many other developing countries, the productivity of this sector has however been compromised by the now evident effects of climate change and variability (Adamgbe and Ujoh, 2013). The effects of climate variability on agriculture have been more pronounced on smallholder farmers in the Arid and Semi-Arid Lands (ASALs) of Kenya (Omoyo *et al.,* 2015). ASALs in Kenya cover approximately 80% of the country's land which supports 25% of the country's total human population (Ottichilo *et al.,* 2000, Orindi *et al.,* 2006) that relies on nearly 75% livestock and crop production.

Although many smallholder farmers in the ASALs have been facing adverse climatic events as a result of climate variability and, in most cases taking corresponding action to cope, most are ill-prepared for the challenge of adapting to the increased frequency and intensity of extreme climate events such as droughts and floods (Ndambiri *et al*., 2012; Oremo, 2013, Gullet *et al*, 2006). Morton (2007) and Harvey *et al.* (2014) argued that most smallholder farmers, especially in developing countries, are more susceptible to the effects of climate variability since they have limited capacity to adapt, given their low education levels, low income, limited land areas, and poor access to technical assistance, market and credits, and often chronic dependence on external support. Harvey *et al*. (2014) also reported that since in many regions smallholder farmers farm on marginal lands (e.g., steep hillside slopes, poor soils or areas prone to flooding or water scarcity, they are highly vulnerable to the impacts of extreme weather events that can cause landslides, flooding, droughts or other problems. Moreover, many smallholders in developing countries live in highly remote areas with low-quality infrastructure that further hampers their access to markets, financial assistance, disaster relief, technical assistance or government support (Harvey *et al.,* 2014).

Füssel *et al*. (2006) reported that adaptation is the most efficient way to cushion smallholder farmers against the adverse effects of climate variability.

Adaptation to climate change and variability refers to the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2001). The adaptation measures in the agricultural sector include use of new crop varieties, crop diversification, adoption of mixed crop and livestock farming systems, changing planting dates and irrigation (Ndungu and Bhardwaj, 2015; Ndambiri *et al.,* 2012; Kurukulasuriya *et al.,* 2008; Deressa *et al.,* 2008).

IPCC (2007), defines adaptive capacity as the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. The adaptive capacity of farmers is influenced by an interaction of socio-economic and institutional factors (Gbetibouo, 2009; Deressa *et al.,* 2008; Nhemachena and Hassan, 2007). Understanding the influence of these factors on farmers' choice and adoption of adaptation measures is therefore imperative in guiding climate variability planning and policy implementation.

Maddison (2006) reported that farmers will first perceive a changing climate and then device practices in response to the perceived change. Similarly, Doss and Morris (2001) reported that the perspectives of the local people, the way they think and behave in relation to climate, as well as their values and aspirations play a significant role in addressing climate change and variability. The perception of local farmers on climate variability is therefore an important aspect towards effective adaptation to climate variability by the farmers.

Recent research efforts on the effects of climate change and variability on agriculture and farmers' adaptation have focused on regional and national assessments with little focus at the local levels (Fischer *et al.*, 2002; Charles and Rashid, 2007). According to Komba and Muchapondwa (2015), there is need for each nation to understand the scope of climate change and variability and the drivers of adaptation, particularly amongst its smallholder farmers, owing to the difference in vulnerability and sensitivity of each country as well as the difference in accessibility of adaptation methods. Ndamani and Watanabe (2015), also highlighted that investigations need to be downscaled to accommodate realities at the farm level. This study therefore focused on using a bottom-up approach which sought to gain insight on smallholder perceptions and adaptation to climate variability from the farmers themselves based on a farm household survey with Kaveta and Mikuyuni Villages in Kitui County as case studies.

1.2 Statement of the Problem

The effects of climate variability on agriculture are more pronounced on smallholder farmers in the ASALs due to higher vulnerability in these regions. Extreme and more frequent weather events have highly increased the risk of food insecurity in the ASALs (IPCC, 2007). Recurrent droughts and floods, pests and diseases have reduced livestock and crop yields causing a significant reduction in the country's agricultural production (Ndambiri *et al.*, 2012).

Just like many other farmers in ASALs, smallholder farmers in Kaveta and Mikuyuni Villages in Kitui County have suffered significant losses from reduced crop yields season after season due to the increasing temperatures and unpredictable rainfall patterns. Though some farmers have adopted various measures to cope with climate variability, most farmers have not been adequately prepared for the challenge.

Although there are several research efforts on the effects of climate change and variability on agriculture and possible adaptation measures (Maddison, 2006; Kabubo-Mariara, and Karanja, 2006), the focus has been on the regional and national levels (Ndamani and Watanabe, 2015). Thus, there exists a knowledge gap on whether farmers at the local level are aware of the climate variability and whether they have adopted the vast adaptation measures enumerated in the literature. Additionally, little research has been done on the difference in perceptions and adaptation to climate variability between farmers in dry and wet areas. This study therefore sought to examine and compare climate variability perceptions and adaptation by farmers in wet and dry areas.

1.3 Assumptions of the Study

The study hypothesised that farmers in Kaveta and Mikuyuni Villages were still not aware of the climate variability phenomenon and or were faced with various challenges in adopting necessary measures to cope. Smallholder farmers in Kaveta Village, which is relatively wetter than Mikuyuni Village, were presumed to perceive the changing rainfall and temperature patterns differently as compared to farmers in Mikuyuni Village, and therefore adopt different adaptation responses. The study also assumed that smallholder farmers in Kaveta Village faced different challenges in their efforts to respond to the changing climate as compared to those in Mikuyuni Village.

1.4 Significance of the Study

The results of the study would be significant to both governmental and non-governmental entities in the planning and implementation of climate variability adaptation measures for smallholder farmers in Kitui County based on their needs. The results of the study would also provide base line data for governmental or non-governmental entities that would like to carry out any climate variability adaptation initiatives or projects in the areas. Academically, the findings of the study would be useful as a reference for future studies.

1.5 Study Objectives

1.5.1 Overall Objective

The broad objective of the study was to assess smallholder famers' perceptions and adaptation to climate variability in Kaveta and Mikuyuni Villages, Kitui County.

1.5.2 Specific Objectives

1. To examine smallholder farmers' perceptions of climate variability in Kaveta and Mikuyuni Villages, Kitui County.
2. To examine smallholder farmers' adaptation measures to climate variability in Kaveta and Mikuyuni Villages, Kitui County.
3. To evaluate factors affecting smallholder farmers' adoption of adaptation to climate variability in Kaveta and Mikuyuni Villages, Kitui County.

1.6 Research Questions

1. How do smallholder farmers in Kaveta and Mikuyuni Villages perceive climate variability?
2. How have smallholder farmers in Kaveta and Mikuyuni Villages adapted to climate variability?
3. What factors influence smallholder farmers' adoption of adaptation measures to climate variability in Kaveta and Mikuyuni Villages, Kitui County?

1.7 Scope of the study

Though there are several sub-counties in Kitui County, the present study was limited to Mikuyuni Village in Kitui Rural sub-county and Kaveta Village in Kitui Central sub-county. The respondents were purely drawn from smallholder farmers in Kaveta and Mikuyuni Villages. The study only focused on the effects of rainfall and temperature variability on crop farming. The study was also limited to practices by farmers in response to rainfall and temperature variability and not conventional practices for general increase in agricultural outputs. The study was also limited to socio-economic and institutional factors although there are other factors that may influence adaptation to climate variability by farmers.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The concept of climate change and variability

The global climate has changed significantly in the recent years and the changes are both due to natural phenomena and human activities (Dow and Downing, 2007). According to IPCC 2007, climate change refers to any change in climate over time, whether due to natural variability or/and as a result of human activity. These changes are likely to manifest in four main ways: slow changes in mean climate conditions, increased inter-annual and seasonal variability, increased frequency of extreme events, and rapid climate changes causing catastrophic shifts in ecosystems (Tompkins and Adger, 2004). In their work, Cruz *et al.,* (2007) stated that climate change is defined as changes through increasing in frequency and intensity of extremes weather events including storm, flood, drought and irregular rain over time and irregular climate signal.

While climate change is defined as the statistically significant variations in weather elements such as temperature, wind patterns and precipitation that persist for an extended period of time, typically decades or longer (IPCC, 2001) climate variability on the other hand refers to the way climate fluctuates yearly above or below a long-term average value (ISDR, 2008).

The IPCC, (2001) report predicted that temperature increases in Africa will be greater than the global average with the general predicted rise at 4 ^{0}C by 2080. This increase will lead to increase aridity and drought, wide spread diseases and even floods. Watson (2010) noted that the earth's climate has warmed on average by about 0.7 ^{0}C over the past 100 years with decades of the 1990s and 2000s being the warmest in the instrumental record. Most of the countries are facing the problems of rising temperature, melting of glaciers, rising of sea-level leading to inundation of the coastal areas, changes in precipitation patterns leading to increased risk of recurrent droughts and devastating floods (IPCC, 2007).

Recently, change in rainfall patterns has been observed in different parts of Africa. Among others, the Sub-Saharan African suffers from very variable annual rainfall and a prolonged drought. Annual rainfall during the period of 1931-60 had been between 20% and 40% greater than during the most recent three decades (Hulme, 1992; cited in Hulme et al, 1995). According to the database of the EM-DAT, flood, droughts/famine, windstorms, extreme temperature and wildlife killed 15,713 and affected 136,590,000 people in Africa between 1993-2002 (Basher and Briceno, 2005). At the United Nations Climate Change conference in November 2006 in Nairobi, it was reported that climate-related disasters in Africa affected and killed over 36 million people between 1993 and 2002 (Mulama, 2006).

According to Herrero *et al.* (2010), climate change projections are very heterogeneous for Eastern Africa, especially in Kenya. Temperatures are expected to increase by 3-4°C by the end of the 21st century with precipitation projections having a higher spatial variability. For the highlands in Northern Kenya an increase is suggested by approximately 0.2 to 0.4% per year (Herrero *et al.,* 2010). However, an increase of rainfall doesn't necessarily lead to an increase in agricultural production, as temperature rising might have a significantly negative impact on water availability by increasing evapotranspiration and exacerbating drought conditions (Herrero *et al.,* 2010). Heavy precipitation events (rainfall events that occur once every 10 years) are projected to increase all over Eastern Africa and might damage crop production (Herrero *et al.,* 2010).

2.2 Effects of climate variability on the agricultural sector in Kenya

Climate variability has dramatically reduced agricultural production in the Sub-Saharan Africa due to increased frequencies and severity of droughts and floods (Deressa *et al.,* 2008). More frequent droughts and floods have reduced crop and livestock production putting most countries in the Sub-Saharan Africa at very high risk of food insecurity (FAO, 2011).

According to Herrero *et al.,* 2010, Kenya's economy is expected to suffer greatly from the adverse effects of climate change and variability since it is highly dependent on climate sensitive sectors including agriculture, tourism, and energy (Mutai *et al.,* 2011).

Agriculture accounts for 25% of the country's GDP and 65% of Kenya's total exports in 2009 (Republic of Kenya, 2005).While Kenya already experiences an increase in rainfall variability, 75% of the agricultural output remains dependent on rain-fed small-scale agriculture (Herrero et al., 2010). According to Obunde (2007), droughts and floods in the recent years have not only claimed lives of people in Kenya, but has also reduced livestock and farm outputs. In their research, Maitima *et al.* (2009) noted that Kenya has recorded 28 major droughts over the last 100 years with three major ones in the last decade which have caused serious water shortage, energy crisis and food insecurity. The effects of these droughts have been more severe in the ASALs regions of the country which receive annual sporadic rainfall. In their study, Huho and Mugalavai (2010) found that dependence on rain-fed agriculture in the ASALs has a very high risk of crop failure (75%) with most farmers in these areas resorting to mixed farming (crops and livestock) or only livestock production. With limited water availability and inadequate pasture in ASALs, livestock production has become highly vulnerable to climate variability as the sole source of livelihoods (Parry *et al.*, 2012).

Predictions by the IPCC (2007) show that global warming will lead to increased temperatures of about 4^0C and cause variability of rainfall by up to 20% in Kenya by the year 2030. From these predictions, droughts will be responsible for crop water stress leading to a decline in crop yields as flooding results to water logging in both the ASALs and high potential areas. In their research, Kabubo-Mariara and Karanja (2006) noted that severe droughts in Kenya have continued to interrupt rainfall patterns, leaving behind serious consequences such as harvest failure, deteriorating pasture conditions, decreased water availability and livestock losses. Increasing temperatures have also lead to increased heat stress making livestock vulnerable to diseases, reduced fertility and reduced milk production (McCarl, 2007).

2.3 Farmers perceptions of climate variability

Farmers' perceptions about the changing climate play a significant role in influencing farmers' choice and adoption of adaptation measures. In his research, Maddison (2006) noted that farmers first perceive climate variability and then innovate and implement practices and technologies to cope with the changes. Lindsay and Norman (1977) defined perception as the process by which organisms interpret and organize sensation to produce a meaningful experience of the world.

According to Harig *et al.* (2001), a person's perceptions are based on experiences with natural and other environmental factors that vary in the extent to which such perceptions are enabled. Rao *et al.* (2011) noted that farmers' perceptions of rainfall and temperature influence farm management decisions. Decisions on which crop variety to grow, how much land, what inputs to use and what soil and water management measures to adopt are influenced by farmers' expectations of rainfall amount and distribution during the season (Rao *et al.,* 2011). Farmers make these decisions based on their knowledge and experiences from previous years (Rao *et al.,* 2011).

From previous studies, it has been reported that people's perceptions of the changing climate and variability vary across different social groups, geographic locations, and seasons of the year, with men, women, and children all experiencing different levels of hardship and opportunity in the face of climate change (Ndamani and Watanabe, 2015). Since adaptation practices in agriculture are location-specific, it is important to understand farmers' views on climate variability and the risks presented to them by the changing climate (Luni *et al.,* 2012).

According to Maddison (2006), farmers' perception on whether the climate is changing or not is determined by several factors. In his research on farmers' perception and adaptation to climate change in South Africa, Maddison (2006) noted that farmers who had vast experience in farming were best placed to perceive a changing climate as compared to those with low farming experience. Ndambiri *et al.* (2012) also found that farmers with high farming experience had observed frequent droughts and increasing temperatures.

While Gbetibouo (2009) noted that education decreases the probability that farmers will perceive long term changes in rainfall, Ndambiri *et al.* (2012) noted that majority of farmers who perceived fluctuations in temperature and rainfall patterns had attained post primary education. According to Gbetibouo (2009), access to extension services increases the probability of perceiving change in temperature and rainfall patterns.

2.4 Farmers' adaptation to climate variability

For farmers to cope with the changing climate and reduce agricultural losses due to unreliable and erratic rainfall patterns, adoption of practices and technologies for adaptation is crucial (Ndamani and Watanabe, 2015). According to IPCC (2007), implementation of adaptation measures by farmers would be necessary to address the inevitable impacts of climate variability on agriculture.

The success of adaptation measures by farmers is determined by the adaptive capacity of the farmers as it greatly influences the vulnerability of communities and regions to the effects and hazards of climate change and variability (Kates, 2000). Nhemachena and Hassan (2007) noted that adoption of agricultural technologies in agriculture is synonymous with the adaptation measures that farmers adopt in response to the adverse effects of climate variability and climate change. Thus, adoption literature can be applied in studies regarding climate variability adaptation (Ndambiri *et al.,* 2012). Maddison (2006) however, raised a concern on distinguishing between technologies that have already been adopted elsewhere because of more favourable agro-ecological conditions and those adopted in response to climate variability and climate change. Adoption of measures in response to climate variability should therefore involve introduction of 'internal' technologies as opposed to 'external' ones (Maddison, 2006; Somda *et al.*, 2002).

According to Bryant *et al.* (2000), adoption of adaptation measures in agriculture are determined by how farmers' perceptions of climate variability are translated into agricultural decisions. Several studies have reported adaptation measures in agriculture such as diversification of crops, use of hybrid varieties, use of drought resistant crop varieties, changing of planting dates, water harvesting, irrigation, switching from crop farming to livestock keeping and soil conservation measures (Shashidahra and Reddy, 2012; Deressa *et al.,* 2008; Ndambiri *et al.,* 2012; Macharia *et al.,* 2012; Ndungu and Bhardwaj, 2015).

2.5 Socio-economic and institutional factors influencing farmers' adaptation to climate variability

According to Maddison (2006), farmers' adoption of adaptation measures in agriculture is influenced by several socio-economic and institutional factors. Studies have shown that age can influence adoption of agricultural technologies both positively and negatively (Gbetibouo (2009); Adesina and Zonah 1993). Older farmers may be more risk-averse and therefore, less likely to be flexible to adopt a new technology than younger farmers. On the other hand, age may have a positive effect on the decision of the farmer to adopt because older farmers may have more experience in farming and therefore, better able to assess the features of a new farming technology than the younger farmers.

In relation to gender, Asfaw and Admassie (2004) noted that households headed by males have a higher probability of getting information about new farming technologies and also undertake more risky ventures than female-headed households. In their study, Ndambiri *et al. (*2012) found out that male-headed households had higher probability to adapt to climate change than their female-headed households. In their study however, Nhemachena and Hassan (2007) had contrary results to the effect that female-headed households were more likely to adopt different methods of adaptation than male-headed households.

Education level is positively correlated with farmers' access to technological information and thus more educated farmers are more likely to adopt new technologies than those with low levels of education (Norris and Batie, 1987; Igoden *et al.,* 1990; Lin, 1991). This was consistent with results from related study by Ndambiri *et al.,* (2012). Similarly, Ndungu and Bhardwaj (2015), noted that education increases farmers' ability to receive, decode, and understand information relevant to making innovative decisions. Just like farmers' perception of climate variability, Maddison (2006), Nhemachena and Hassan (2007) and Gbetibouo (2009) indicated that farming experience increases the probability of adoption of climate variability adaptation measures.

Access to extension services by farmers including climate information and weather forecasts also influence the adoption of adaptation measures. Maddison (2006), Nhemachena and Hassan (2007) and Ndambiri *et al.* (2012) noted that awareness and knowledge by farmers of precipitation and temperature is key in their adaptation decision-making process.

Other factors that influence farmers' adaptive capacity include household size, agro-ecological locations, farmers' income, and accessibility to the market among others (Croppenstedt *et al.*, 2003; Yirga, 2007; Nyangena, 2007; Maddison, 2006). In their study however, Ndungu and Bhardwaj (2015) found that household size, and on-farm income were not statistically significant in influencing farmers' adaptation to climate change and variability.

2.6 Constraints to smallholder farmers adaptation to climate variability

Results from several studies show that though most farmers have perceived climate variability their adaptive capacity has been challenged by several constraints. For instance, high cost of adaptation, lack of knowledge on adaptation measures, lack of early warning information, unreliable seasonal forecasts and lack of access to technological information were found to limit farmers' capacity to adapt to climate change and variability in India (Ndungu and Bhardwaj, 2015).

In their study, Deressa *et al.* (2008) also reported some of the reasons for farmers' failure to adopt adaptation measures as lack of information on climate change and variability and its impacts and adaptation technologies, limited financial resources, labour constraints and land shortages. Similar results from a study by Acquah-de Graft and Onumah (2011) showed that farmers in Ghana identified lack of information on climate change and variability impacts and adaptation options, lack of access to credit, access to irrigation water, high cost of adaptation, insecure property rights and lack of access to sufficient farm inputs as the main constraints to farmers' adoption of adaptation measures.

From the above literature review, various studies have shown that most farmers have perceived climate variability and consequently adopted various response options to reduce agricultural losses from the changing climate (Ndamani and Watanabe, 2015; Ndungu and Bhardwaj, 2015; Deressa *et al.*, 2008; Maddison, 2006). These studies have however been done on regional and national scales with very little knowledge about whether farmers on the local areas are really aware of climate variability and whether they have adopted any adaptation practices in response to the changing climate. The adaptation measures recorded in the vast literature therefore remain to be possible adaptation measures with limited evidence that the options are feasible, realistic or are even practical at the local farm level. There also exists a knowledge gap on whether adaptation and constraints to adaptation by farmers vary within localities.

2.7 Conceptual Framework

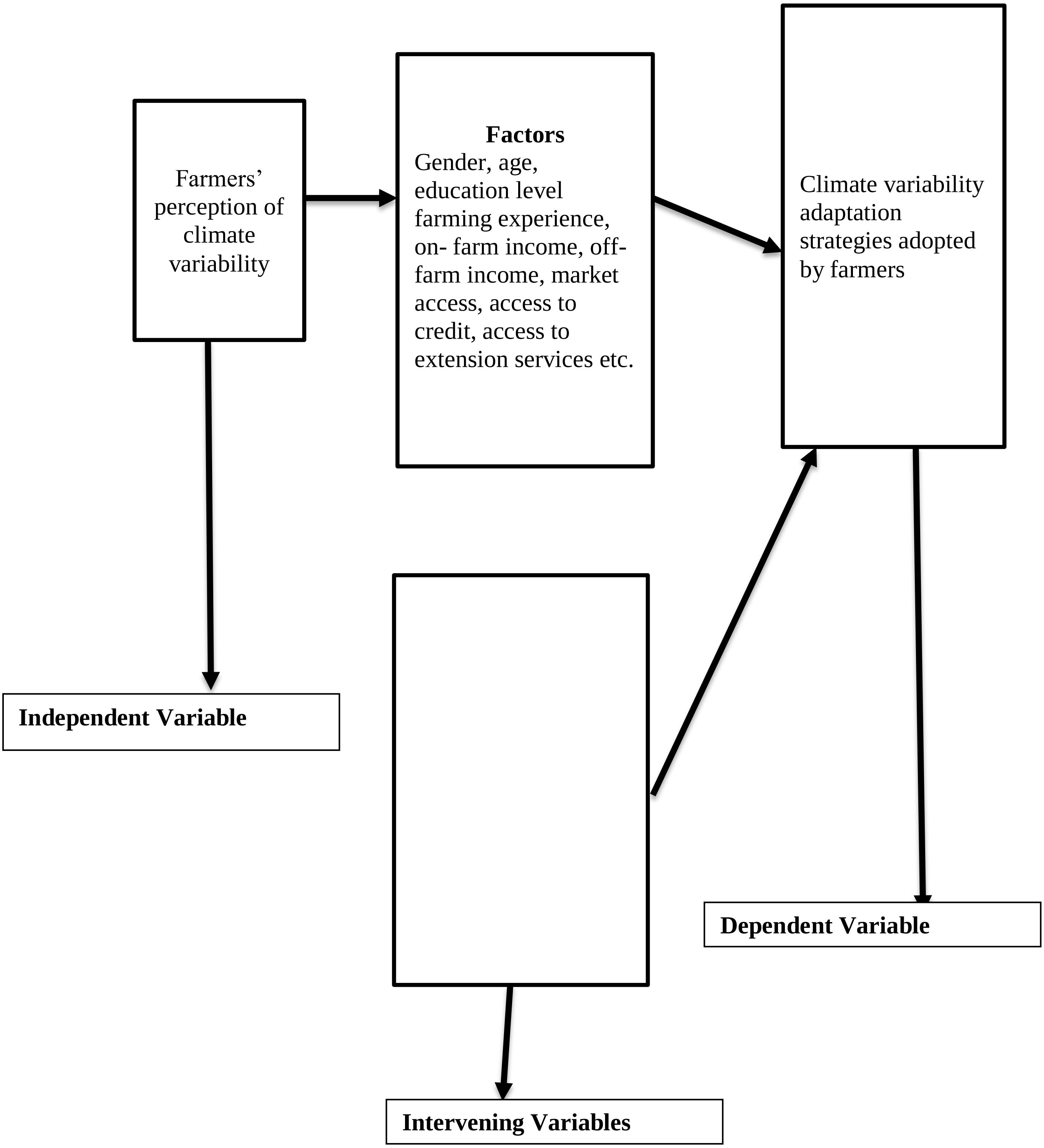

Figure 2.1 Conceptual Framework (Modified from IPCC, 2007 and Maddison, 2006)

The conceptual framework for this study was drawn from empirical evidence that climate change and variability has adverse impacts on agricultural production (IPCC, 2007) and the assumption that farmers' decision to adopt adaptation measures is influenced by how farmers perceive climate change (Maddison, 2006). The study also assumed that several factors including gender, age and education of household head, household income, access to climate information and extension services influence how farmers respond to climate variability. Inadequate technological capacity, lack of early warning information, and unreliable seasonal weather forecasts, high cost of adaptation, inadequate land resources were some of the presumed constraints that smallholder farmers face in their adaptation to climate variability (Ndamani and Watanabe, 2015; Ndungu and Bhardwaj, 2015; Maddison, 2006).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study Area

The study was carried out in two Villages, one from Kwa Vonza-Yatta ward (Mikuyuni Village) and the other from Kitui Township ward (Kaveta Village), in Kitui County. The study sites are shown in Figure 3.1.

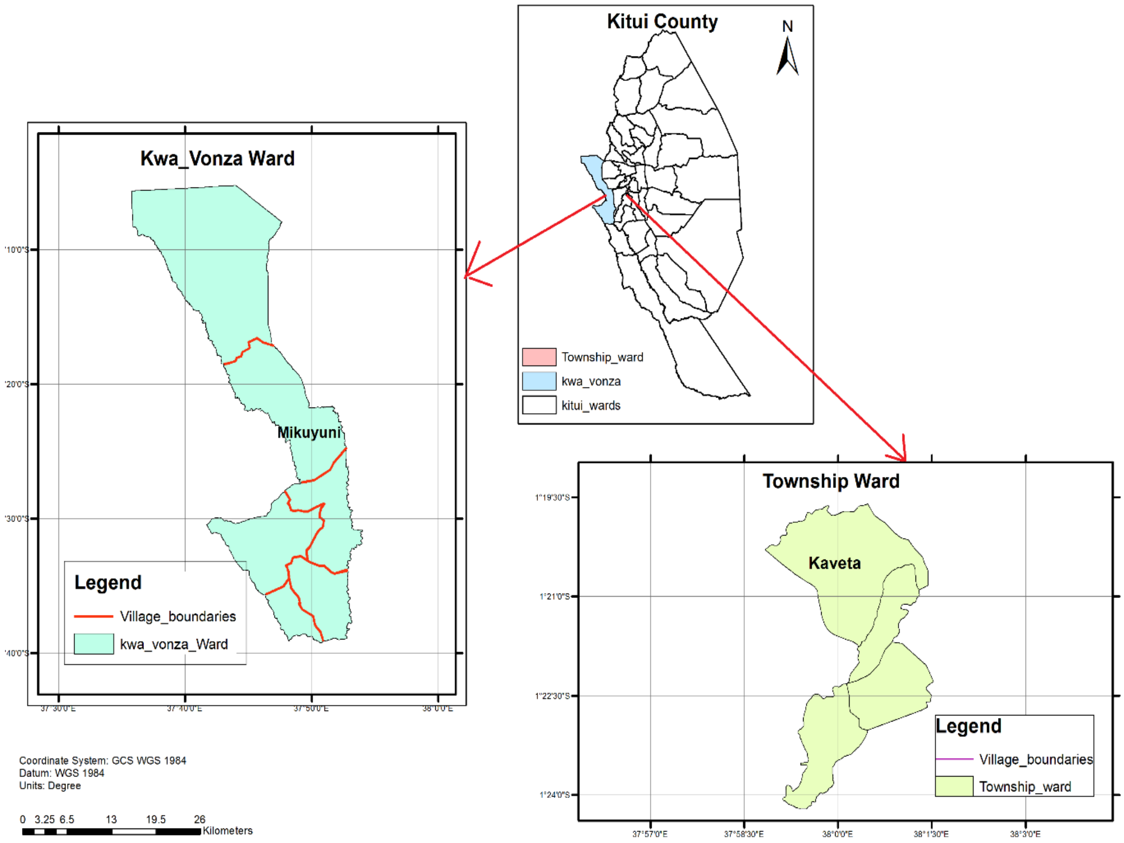

Figure 3:1 Map of Kitui County showing Kaveta and Mikuyuni Villages

Source: Kitui County Ministry of Environment, Energy and Minerals Investments Development; GIS Office

3.1.1 Topography and climate

Kitui County lies between 400m to 1,830m above sea level and generally slopes from the west to east with the highest regions being Kitui Central and Mutitu Hills

(Republic of Kenya, 2002). Mikuyuni Village lies in the Yatta plateau while Kaveta Village is in the Kitui Central region (CGoK, 2014).

The climate of the area is semi-arid with very erratic and unreliable rainfall. The area is hot and dry throughout the year with temperatures ranging from a minimum of 14-22° centigrade to a maximum of 26-34° centigrade. The months of February and September are the hottest months in the year. Rainfall is distributed within two seasons yearly and varies from 500-1050mm with about 40% reliability. The long rains are experienced between March and May and short rains between October and December. The short rains are considered more reliable than the long rains since it is during the short rains that farmers get their main food production opportunity (Republic of Kenya, 2002).

The soil types range from sedimentary rocks, red sandy soils, to clay black cotton soils which are generally low in fertility (Republic of Kenya, 1997).

3.1.2 Population and Economy

Mikuyuni Village has a human population of 7,448 persons and 1,528 households while Kaveta Village has a human population of 4,584 persons and 936 households (CGoK, 2014) with 90% of the population rural based. Livestock production and crop farming are the back bone of the people's economy in the area contributing to nearly three quarters of household earnings (Republic of Kenya, 2005). Cattle, sheep and goats are the most important animals in the area (MLFD, 2005). Various crops such as maize, beans, sorghum, pigeon peas, millet and cassava are cultivated mainly for subsistence while green grams, sweet potatoes, vegetables and fruits (such as mangoes and bananas) are grown for sale (GoK, 2009; Republic of Kenya, 2002).

3.1.3 Study Design and Sampling Techniques

Descriptive survey design was used in this study. The target population of this study was the smallholder farmers in the study area. The unit of study was the household and the head of the household was the respondent.

Purposive sampling was used to select the Villages while simple random sampling was used to select the households. The Villages were selected on the basis of climatic conditions. For the purpose of this study, Kaveta Village was selected to represent relatively wet areas while Mikuyuni Village was selected to represent the dry areas of Kitui County. Analysis of the total annual rainfall for the last 15 years confirmed that there was a statistically significant (t_{15} =8.34, $p<0.05$) difference in precipitation in Kaveta (M=416.33, SD=199.64) and Mikuyuni (M=342.54, SD=146.47) Villages. The main objective of selecting the two Villages was to gain insight into differences in perceptions and adaptation to climate variability between farmers living in wet and dry areas.

The sample size for the study was determined using the following formula by Kothari (2004).

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

Where: n: is the sample size for a finite population (smaller than 50,000)

N: size of the population (936 and 1,528 households for Kaveta and Mikuyuni Villages respectively)

p: population reliability (or frequency estimated for a sample of size n), where p is 0.5 which is taken for all developing countries population and p + q= 1

e: margin of error = 10%

Z- normal reduced variable at 5% level of significance (which is 1.96)

Therefore, the sample size for the study was 177 (87 for Kaveta and 90 for Mikuyuni).

3.1.4 Operationalization of variables

Farmers' perceptions on climate change was the independent variable while adaptation measures adopted by the farmers was the dependent variables for the study. The socio-economic and institutional factors influencing farmers' adaptation to climate change were the explanatory (intervening) variables. The variables were operationalized as shown in Table 3.1.

Table 3.1*: Operationalization of Variables*

Variables	Criteria	Source/Tools	Outcome	Attribute
1. Farmers' perception on climate variability (**Independent variable**)	Farmers' perception of trends on climatic variables such as annual temperature, total annual rainfall and extreme events	Semi-structured interviews using questionnaires	Farmers' perceptions on climate variability established	Household level
2. Farmers' adaptation to climate variability (**Dependent variable)**	Famers' identification of adaptation measures	Semi-structured interviews using questionnaires	Farmers' adaptation to climate variability established	Household level
3. Factors influencing farmers' adaptation to climate variability (**Intervening variables)**	Farmers' identification of factors	Semi-structured interviews using questionnaires	Factors influencing farmers' adaptation to climate variability established	Household level
4. Constraints to farmers' adaptation to climate variability (**Intervening variables)**	Farmers' identification of constraints	Semi-structured interviews using questionnaires	Constraints to farmers adaptation to climate variability established	Household level

3.1.5 Data collection method

Primary data was collected through administration of questionnaires in Kaveta and Mikuyuni Villages. Secondary data on rainfall patterns of the study areas for the last 30 years was also obtained from Kitui Meteorological Department to compare farmers' perceptions on climate variability and the actual rainfall trends.

3.1.6 Data requirement per objective

The required data in each objective are as shown in Table 3.2 below.

Table 3.2: Data requirements per objective

Objective	Required data	Instrument
1. To examine smallholder farmers' perceptions of climate variability in Kaveta and Mikuyuni Villages, Kitui County	Whether farmers have perceived any changes in; • Trends in temperature • Trends in total annual rainfall	• Household survey questionnaire
2. To examine smallholder farmers' adaptation measures to climate variability in Kaveta and Mikuyuni Villages, Kitui County.	✓ Whether farmers have adopted adaptation practices or not ✓ Adaptation practices by the farmers	• Household survey questionnaire
3. To determine how socio-economic and institutional factors affect smallholder farmers' adaptation to climate variability in Kaveta and Mikuyuni Villages, Kitui County.	✓ Factors influencing farmers' adaptation to climate variability	• Household survey questionnaire
4. To determine constraints to smallholder farmers' adaptation to climate variability in Kaveta and Mikuyuni Villages, Kitui County.	✓ Constraints to farmers' adaptation to climate variability	✓ Household survey questionnaire

3.1.7 Data Analysis Procedure

Both quantitative and qualitative data was used. Data was coded and entered into the computer for analysis. The Statistical Package for Social Sciences (SPSS version 20) and Ms Excel packages were used to run both descriptive and inferential statistics. Logit egression model was used to assess the factors determining adaptation measures adopted by farmers.

The model specification as outlined by Gujarati (2004) and applied by Ndungu and Bhardwaj (2015) is presented below, albeit in reduced form.

$Y_i = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + \beta_{11}X_{11} + \beta_{12}X_{12} + \beta_{13}X_{13}$.......................... (1)

Where Y_i is a dichotomous dependent variable (farmer using any climate change adaptation technology or not, specified as yes=1, otherwise = 0). 0 is the Y- intercept whereas 1- 13 is a set of coefficients to be estimated. X_1-X_{13} are explanatory (intervening) variables hypothesised (Table 3.2) based on theory and related empirical work, to influence farmers' adaptation to climate change.

Equation (1) can be rewritten as;

Logit (p) = log (p / 1- p) = $\alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + \beta_{11}X_{11} + \beta_{12}X_{12} + \beta_{13}X_{13}$....(2)

Where p is probability that Y= 1 i.e. p =probability (Y= 1). In terms of probability, equation (2) can be expressed as;

p=exp($\alpha + \beta_1X_1 + ... \beta_{12}X_{12} + \beta_{13}X_{13}$....)/1+exp $\alpha + \beta_1X_1 + ... \beta_{10}X_{10} + \beta_{11}X_{11} + \beta_{12}X_{12} + \beta_{13}X_{13}$..........(3).

Table 3.3 Description of explanatory variables to predict farmers' adaptation to climate variability in Kaveta and Mikuyuni Villages

Variable	Description	Expected sign
X_1	Education level of the household head (Years of schooling)	+
X_2	Age of the household head	+/-
X_3	Household size (number of family members in household)	+/-
X_4	Off-farm income (annual income from none farm activities)	+
X_5	On-farm income (annual income from farming activities)	+
X_6	Farming experience (household head number of years of farming)	+
X_7	Gender of household head (1= male; 0= female)	+
X_8	Access to credit (1= yes; 0= Otherwise)	+
X_9	Access to extension services (1=yes, 0=otherwise)	+
X_{10}	Distance from the market (how far the farmer is from the market in Km)	+
X_{11}	Access to climate change information (1=yes, 0=otherwise)	+
X_{12}	Access to weather forecast (1=yes, 0=otherwise)	+/-
X_{13}	Village (Kaveta =1, Mikuyuni =0)	+/-

3.1.8 Ethical Considerations

The researcher explained to the respondents about the research and that the study was for academic purposes only. It was made clear that participation was voluntary and that the respondents were free to decline or withdraw at any time during the interview period. Respondents were not coerced into participating in the study and were guaranteed that their privacy would be protected by strict standard of anonymity.

CHAPTER FOUR

4.0 RESULTS

The results of the study are presented in frequency tables, percentages, graphs and pie charts in relation to the study objectives.

4.1 Socio-economic characteristics of respondents in Kaveta and Mikuyuni Villages

The socio-economic characteristics of the respondents presented in this section include gender, age and education level of the household head, respondents' household size, annual on-farm income and off- farm income.

4.1.1 Gender of the household heads in Kaveta and Mikuyuni Villages, Kitui County

A total of 177 respondents were sampled from the two study sites with 87 respondents from Kaveta Village and 90 respondents from Mikuyuni Village. The results indicated that 83% and 89% of the households in Kaveta and Mikuyuni Villages, respectively, were male-headed while 17% and 11% of the households were female-headed in Kaveta and Mikuyuni Villages, respectively (Figure 4.1).

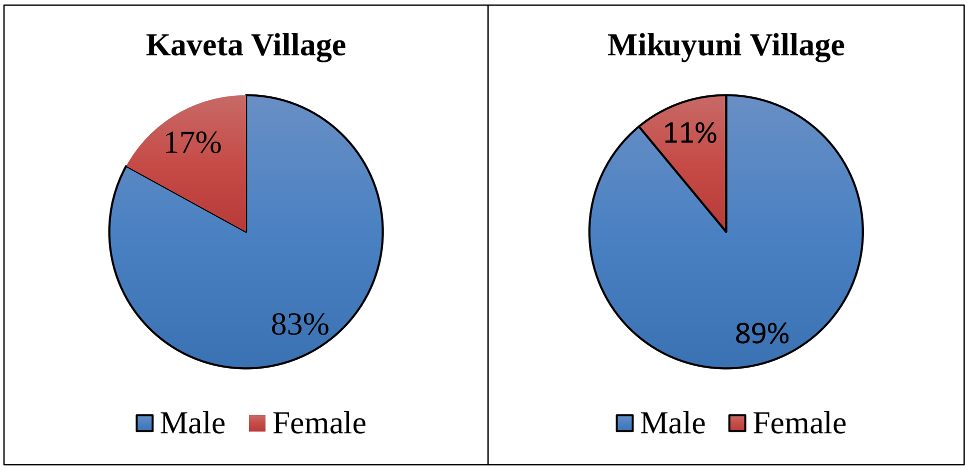

Figure 0.1: Percentage Distribution of Household heads by Gender in Kaveta and Mikuyuni Villages, Kitui County

4.1.2 Age of the household heads and average household size in Kaveta and Mikuyuni Villages, Kitui County

Perusal of data presented in Figure 4.2 revealed that the average family size was 5.29 and 4.89 persons in Kaveta and Mikuyuni Villages, respectively. Further, the results indicated that the mean age of the household heads was 46.77 years and 49.20 years in Kaveta and Mikuyuni Villages, respectively.

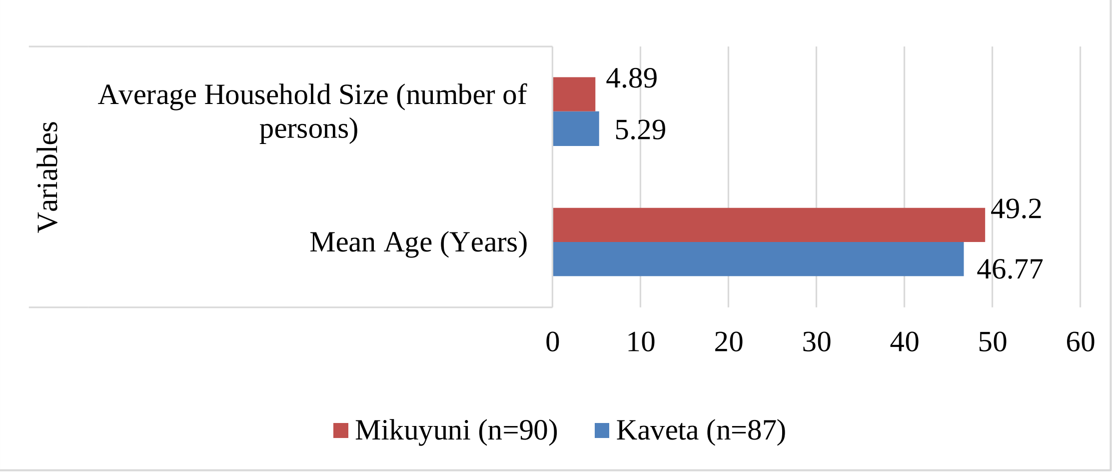

Figure 4.2: Mean Age of household heads and Average Household Size in Kaveta and Mikuyuni Villages, Kitui County

4.1.3 Education levels of the household heads in Kaveta and Mikuyuni Villages, Kitui County

Data presented in Figure 4.3 showed that 46% of the respondents in Kaveta Village had attained primary level education, while 57% of the respondents in Mikuyuni Village had attained secondary level education. Further, the results showed that only 22% and 21% in Kaveta and Mikuyuni Villages, respectively, had attained tertiary level education while only 3% of the respondents had attained postgraduate education in both Villages.

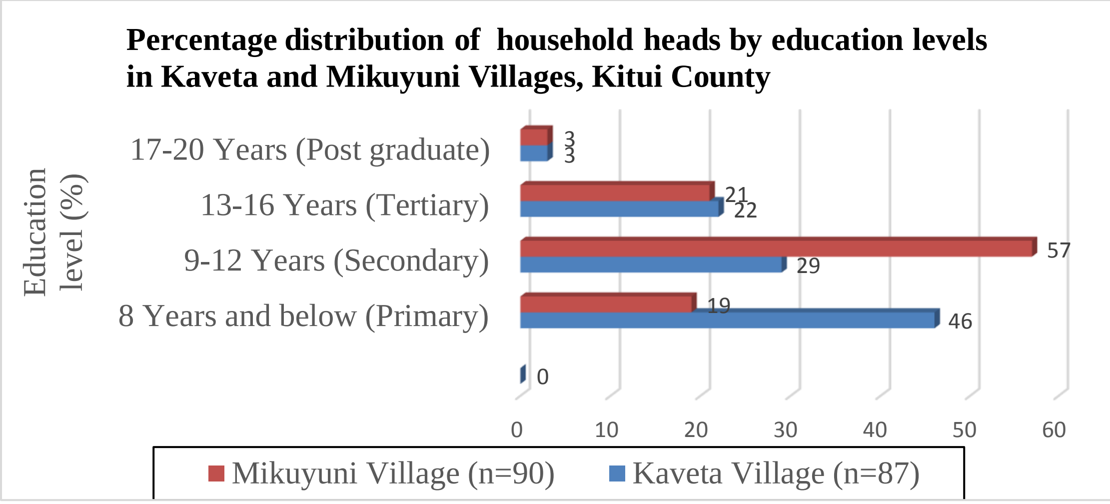

Figure 4.3: **Percentage distribution of household heads by education levels in Kaveta and Mikuyuni Villages, Kitui County**

4.1.4 Farming experience of respondents in Kaveta and Mikuyuni Villages, Kitui County

Data presented in Table 4.1 revealed that 55% and 57% of the respondents in Kaveta and Mikuyuni Villages, respectively, had been in farming for 10 to 30 years while 32% and 36% in Kaveta and Mikuyuni Villages, respectively, had been in farming for less than 10 years.

Table 4.1: Farming experience of respondents in Kaveta and Mikuyuni Villages, Kitui County

Farming experience (in years)	**Kaveta Village (n=87)**	**Mikuyuni Village (n=90)**
	% of respondents	
Less than 10	32	36
10 -30	55	57
Above 30	13	7
Total	**100**	**100**

4.1.5 Annual on-farm and off-farm incomes for respondents in Kaveta and Mikuyuni Villages, Kitui County

The results presented in Table 4.2 showed the mean annual on-farm and off-income of farmers in the two Villages. Further, analysis of the results indicated that the mean annual on-farm and off-farm incomes were statistically different ($t_{99.16}$ =3.350, $p<0.001$ and $t_{149.35}$ =1.324, $p<0.005$, respectively) between Kaveta and Mikuyuni Villages.

Table 4.2: Mean annual on-farm and off-farm incomes for respondents in Kaveta and Mikuyuni Villages, Kitui County

	Mean Annual on-farm income (Ksh.)	**Mean Annual off-farm income (Ksh.)**
Kaveta (n=87)	64, 137.93	98,103.45
Mikuyuni (n=90)	32, 611.11	56, 444.44

Further, results presented in Figure 4.4 revealed that annual on-farm income for most farmers in both Kaveta and Mikuyuni Villages ranged between Ksh.10, 000 to 50,000. From the results, at least 7 % of the respondents had an annual on-farm income of above Ksh. 250,000 in Kaveta Village. The results also indicated that 29% and 36% of the respondents in Kaveta and Mikuyuni Villages, respectively, did not have off-farm income sources.

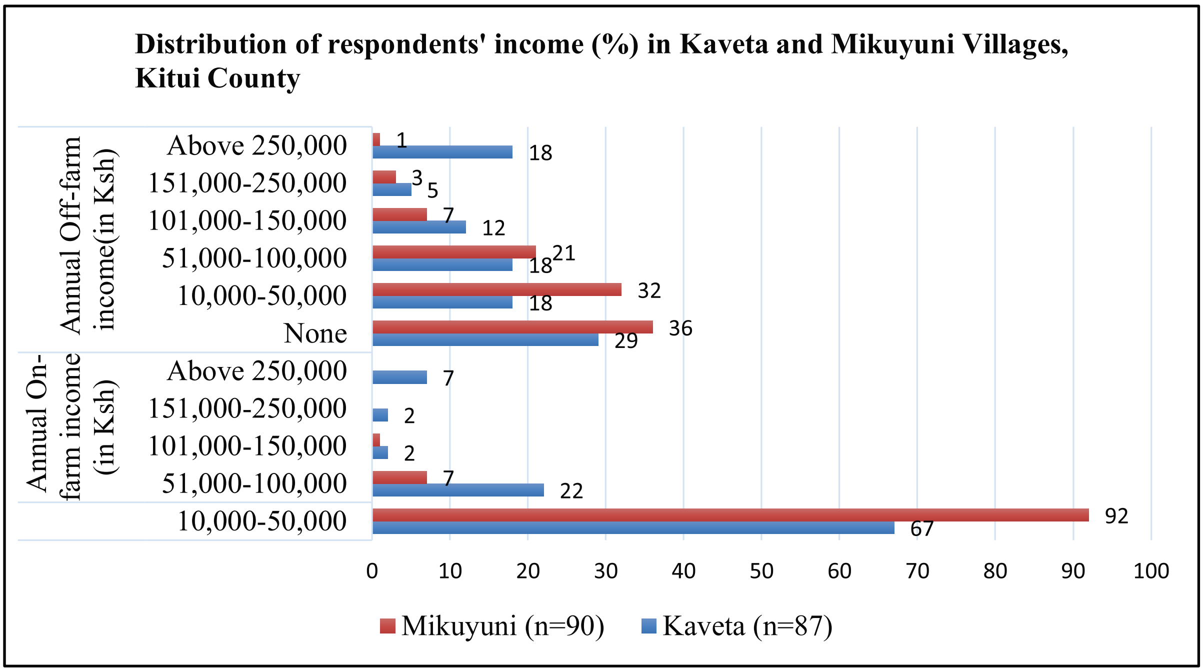

Figure 4.4: Percentage Distribution of Respondents' Income in Kaveta and Mikuyuni Villages, Kitui County

4.1 Institutional characteristics of respondents in Kaveta and Mikuyuni Villages, Kitui County

The institutional characteristics of the respondents that were analysed included respondents' distance from the market and access to credit facilities, extension services, climate information as well as access to weather forecasts by the respondents.

Results presented in Table 4.3 indicated that 77% of the respondents in Kaveta Village were less than two kilometres from the market and 56% in Mikuyuni Village were three to five kilometres away from the market.

The results also indicated that 69% and 39% of the respondents in Kaveta and Mikuyuni Villages, respectively, had access to credit facilities. The results also revealed that all the respondents (100%) in Mikuyuni Village did not have access to extension services and only 3% in Kaveta Village accessed extension services.

The results further established that 36% and 69% of the respondents in Kaveta and Mikuyuni Villages, respectively, had received climate information in the past one year. The media was reported as the main source of climate information by 23% of the respondents in Kaveta Village and 52% in Mikuyuni Village. In Kaveta Village, 1% of the respondents reported to have received climate information from Non-Governmental Organizations (NGOs) and 2% had received climate change information from the County Government of Kitui (CGoK). In Mikuyuni Village, 12% of the respondents received climate information from the NGOs and 3% had received climate information from the County Government of Kitui.

From the results presented in Table 4.3, 64% and 38% of the respondents in Mikuyuni and Kaveta Villages, respectively, had received seasonal weather forecasts. This implies that a greater proportion in Mikuyuni Village had access to seasonal weather forecasts than in Kaveta Village. The results however showed that 98% and 100% in Kaveta and Mikuyuni, respectively reported that the weather forecasts were unreliable.

Table 4.1: Institutional characteristics of respondents (%) in Mikuyuni and Kaveta Villages, Kitui County

Institutional characteristics		**Kaveta Village (n=87)** % of respondents	**Mikuyuni Village (n=90)**
Distance from the market (in km)	Less than 2 Km	77	8
	3-5 Km	18	56
	6-10Km	5	33
	Above 10	0	3
Access to credit facilities		69	37
Access to extension services		3	0
Access to climate information		26	69
Source of climate information	None	74	31
	Media	23	52
	NGOs	2	13
	CGoK	1	3
Access to weather forecasts		38	64
Weather forecast reliability		0	2

Note: The values in the table are not additive since they represent multiple responses.

4.2 Smallholder farmers' perceptions of changing temperature and rainfall patterns in Kaveta and Mikuyuni Villages, Kitui County

Results from the study established that 74% of the respondents in Kaveta Village had observed an increasing temperature, 13% observed a decrease in temperature and 13% had perceived a constant temperature over the years (Table 4.4). In Mikuyuni Village, all the respondents (100%) had observed an increase in temperature over the years.

Results presented in Table 4.4 revealed that all the respondents (100%) in Mikuyuni Village had perceived a decrease in annual rainfall and none had observed an increase in annual rainfall. In Kaveta Village, 97% of the respondents had observed a decrease in annual rainfall over the years and 3% had perceived an increase in annual rainfall. No respondents in both Villages had observed consistency in annual rainfall. The results further showed that 55% and 47% of the respondents in Kaveta and Mikuyuni Villages had perceived unpredictable onset of rains.

Table 4.2: Smallholder farmers' perceptions of changes in temperature and rainfall patterns in Kaveta and Mikuyuni Villages, Kitui County

Weather Element	Farmers' perceptions	Kaveta Village(n=87)	Mikuyuni Village(n=90)
		% of respondents	
Temperature	Increased temperature	74	100
	Decreased temperature	13	0
	Constant temperature	13	0
Precipitation	Increased annual rainfall	3	0
	Decreased annual rainfall	97	100
	Constant annual rainfall	0	0
	Early onset of rains	2	9
	Delayed onset of rains	40	40
	Unpredictable onset of rains	55	47

Note: Values in the table represent multiple responses and therefore not additive.

Linear regression analysis of the total annual rainfall data for the last 30 years from Kitui Central weather station indicated a significant ($p<0.001$) decrease in the amount of precipitation with time ($R^2 = 0.46$) as shown in Figure 4.5.

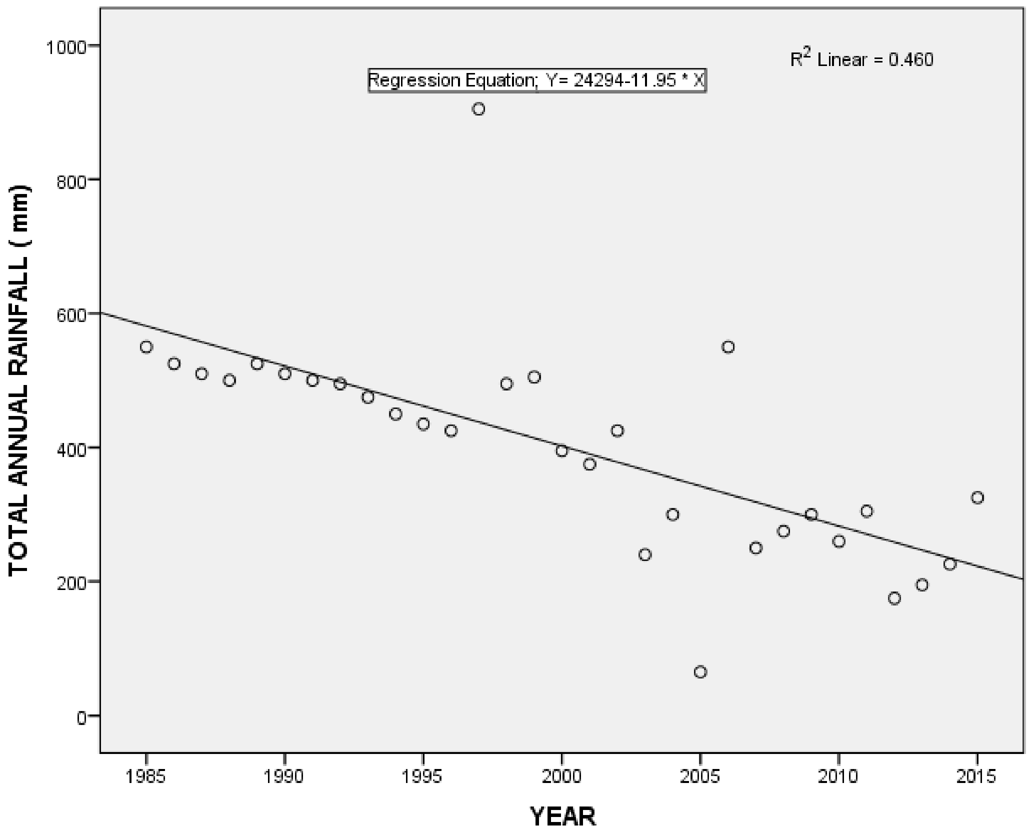

Figure 4.5: Rainfall distribution trend in Kitui County

(Source: Kitui Meteorological department)

Note: The rainfall distribution trend from Kitui Central Weather Station was a representative of the rainfall distribution trend in Kitui County.

4.3 Smallholder farmers' adaptation in response to the increasing temperatures and changing rainfall patterns in Kaveta and Mikuyuni Villages, Kitui County

The results of the survey presented in Figure 4.6 showed that only 10% and 19% of the respondents in Kaveta and Mikuyuni Villages, respectively, had adopted some adaptation measures in response to the increasing temperatures.

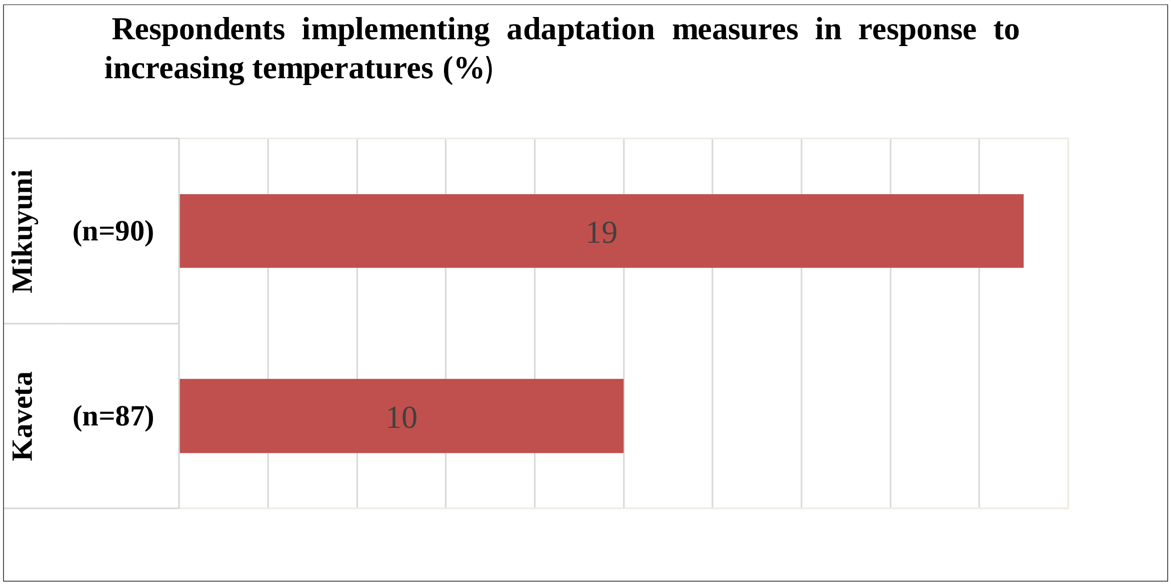

Figure 4.6: Percentage of respondents implementing adaptation measures in response to the increasing temperatures in Kaveta and Mikuyuni Villages, Kitui County

The results in Figure 4.7 showed that 76% and 88% of the respondents in Kaveta and Mikuyuni Villages, respectively, had adopted various adaptation measures in response to the decreasing rainfall and the unpredictable onset of rains.

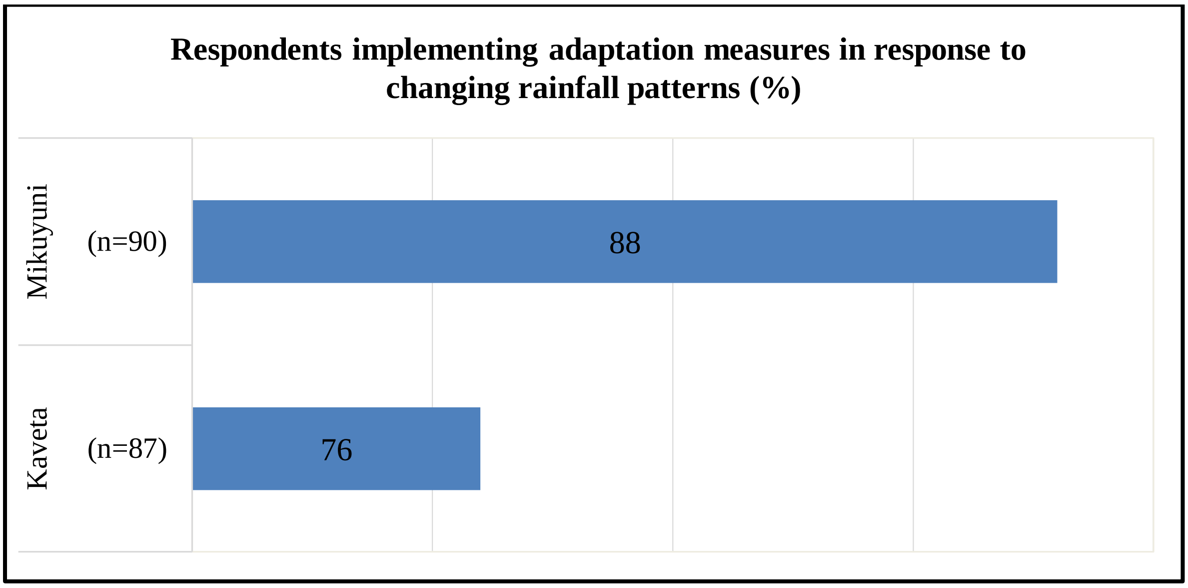

Figure 4.7: Percentage of respondents implementing adaptation measures in response to changing rainfall patterns in Kaveta and Mikuyuni Villages, Kitui County

The results further indicated that there was a significant difference between farmers' probability to adaptation measures in response to climate variability in Kaveta and Mikuyuni Villages (x^2= 4.24, df= 1, p=0.04).

4.4 Smallholder farmers’ adaptation measures in response to the increasing temperature and changing rainfall patterns in Kaveta and Mikuyuni Villages, Kitui County

From the results in Table 4.5, the main adaptation measures adopted by farmers in response to the decreasing precipitation in Kaveta Village included use of hybrid crop varieties (68%), use of pesticides (52%) and use of animal manure (52%). The results also indicated that soil conservation (49%), mixed crop and livestock farming (32%) and crop diversification (16%) were other adaptation practices employed by farmers in Kaveta Village. The results further showed that 38% of the respondents in Kaveta Village opted to plant before the onset of the rains and 35% of the respondents planted just after the onset of the rains in response to the unpredictable onset of the rains.

Table 4.5: Adaptation measures adopted by farmers in response to the increasing temperatures and changing rainfall patterns in Kaveta and Mikuyuni Villages, Kitui County

Weather Element	Adaptation options	Kaveta Village(n=87)	Mikuyuni Village(n=90)
		% of respondents	
Temperature	Planting drought resistant crops	0	14
	Planting just before the onset of rains	8	14
	Planting early maturing crops	9	7
	Irrigation	0	4
	Planting immediately after the onset of the rains	7	4
	Water harvesting	3	3
	Switching from crop farming to livestock keeping	3	0
Precipitation	Planting drought resistant crops	1	22
	Irrigation	0	6
	Planting just before the onset of rains	38	86
	Planting immediately after the onset of the rains	35	14
	Use of hybrid crop varieties	71	87
	Crop diversification	16	27
	Use of pesticides	52	84
	Use of fertilizer	24	6
	Use of manure	52	86
	Water harvesting	15	8
	Soil conservation	49	37
	Mixed crop and livestock farming	32	71
	Switching from crop farming to livestock keeping	6	0

Note: Values in the table represent multiple responses and therefore not additive.

In Mikuyuni Village, use of hybrid crop varieties (87%), animal manure (86%), pesticides (84%) and mixed crop and livestock farming (71%) were the main climate variability adaptation measures adopted by the farmers in response to the decreasing precipitation (Table 4.5). Other adaptation options included soil conservation (37%) and crop diversification (27%). The results also showed that 86% of the respondents in Mikuyuni Village planted just before the onset of the rains while 14% of the respondents planted just after the onset of the rains in response to the unpredictable onset of rains.

The results further established that 22% of the respondents planted drought resistant crops and 6% of the respondents irrigated their crops in Mikuyuni Village. In Kaveta Village, only 1% of the respondents reported to have planted drought resistant crops. No irrigation practice was reported in response to the decreasing precipitation in Kaveta Village. Although no farmer had switched from crop farming to livestock keeping in Mikuyuni Village, at least 6% of the farmers in Kaveta Village had switched from crop farming to livestock keeping.

Though from Figure 4.6, most farmers in both Kaveta and Mikuyuni Village had not adopted adaptation measures in response to the increasing temperatures, at least 8% of the respondents planted early maturing crops, 8% planted just before the onset of the rains and 7% planted just after the onset of the rains in Kaveta Village (Table 4.5). The results further indicated that 3% of the respondents had switched from crop farming to livestock keeping. Interestingly, no farmer in Kaveta Village planted drought resistant crops in response to the increasing temperatures.

Planting of drought resistant crops (14%), planting of early maturing crops (7%) and changing of planting dates which included farmers planting just before the onset of rains (14%) and just after the onset of the rains (4%), were the only adaptation measures adopted by farmers in response to the increasing temperatures in Mikuyuni Village (Table 4.5).

4.5 Socio-economic and institutional factors influencing smallholder farmers' adaptation to climate variability in Kaveta and Mikuyuni Villages, Kitui County

Results of the Logit regression analysis showed that education level, farming experience, off- farm income, Village, access to credit facilities, access to climate information and weather forecasts significantly ($p<0.05$) influenced farmers' adaptation to climate variability in Kaveta and Mikuyuni Villages. Age and gender of the household head, household size, on-farm income, distance to the market and access to extension services were however not significant (Table 4.6). Box Tidwell (1962) test was run in SPSS to test for multi-colinearity of independent variables and linearity between continuous independent variables and the logistic transformation of the dependent variable.

The results indicated that education level of the household head (coefficient=0.81,p= 0.01; odds ratio=2.25), farming experience (coefficient=0.16; p=0.00;odds ratio=1.17) off-farm income (coefficient=1.36; p=0.01; odds ratio=3.89), access to credit facilities, (coefficient=3.79; p=0.01; odds ratio=3.02), access to climate information (coefficient=1.89; p=0.01; odds ratio=6.62) and access to weather forecasts (coefficient=1.14; p=0.01; odds ratio=3.13) influenced farmers' adoption of adaptation measures to climate variability positively in Kaveta and Mikuyuni Villages.

The results however, showed that the Village (coefficient=-0.01, p= 0.00; odds ratio=0.90), negatively influenced farmers' adoption of climate variability adaptation measures in Kaveta Village and Mikuyuni Villages.

The results further indicated that the age and gender of the household head, household size, on-farm income and access to extension services did not have a significant influence on farmers' adaptation to climate variability.

Table 4.6: Socio-economic and institutional factors influencing farmers' adaptation to climate variability in Kaveta and Mikuyuni Villages, Kitui County

Factor	Coefficient	P Value	Odds Ratio
Age	0.65	0.23	1.92
Gender	0.16	0.40	1.17
Household size	0.01	0.23	1.01
Education level	0.81	0.01*	2.25
On- farm income	0.00	0.20	1.00
Off-farm income	0.00	0.01*	1.00
Farming experience	0.16	0.00*	1.17
Market distance	0.45	0.10	1.57
Access to credit facilities	1.36	0.01*	3.89
Access to extension services	0.39	0.40	1.48
Access to climate information	1.89	0.01*	6.62
Access to weather forecasts	1.14	0.01*	3.13
Village	-0.01	0.00*	0.90
Constant	-20.16	0.04	0.00

Note: * Significant at 0.05 significance level, (n=177)

4.6 Constraints to smallholder farmers' adaptation to climate variability in Kaveta and Mikuyuni Villages, Kitui County

Using a scale of 1-5, 5 being the most influential constraint, the farmers in Kaveta Village ranked inadequate technological capacity (78.2%), lack of access to credit facilities (72.2%), lack of access to extension services (68%) and high cost of adaptation (66.8%) as the major constraints to their adaptation to increasing temperature and changing rainfall patterns as shown in (Table 4.7).

In Mikuyuni Village, lack of access to irrigation water (89.6%), lack of labour (86%), high cost of adaptation (81.4%), unreliable weather forecasts (81.4%), inadequate land resources (76.4%) and inadequate financial resources (74%) were the major constraints to farmers' adoption of adaptation measures to the increasing temperature and changing rainfall patterns.

Table 4.7: Constraints to smallholder farmers' adaptation to climate variability in Kaveta and Mikuyuni Villages, Kitui County

Constraints to adaptation	**Kaveta Village (n=87)** % respondents	**Mikuyuni Village (n=90)**
Inadequate financial resources	66.4	74
Inadequate technological capacity	78.2	68.8
Lack of access to irrigation water	58.4	89.6
Inadequate land resources	61.6	76.4
Lack of access to credit facilities	72.2	55.2
Lack of access to extension services	68	65.4
Lack of labour	57	86
High cost of adaptation	66.8	81.4
Lack of early warning information	61.8	72
Unreliable weather forecasts	59.8	78

Note: Values in the table represent multiple responses and therefore not additive.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Farmers' perceptions of climate variability in Kaveta and Mikuyuni Villages, Kitui County

From the results, it can be deduced that farmers were generally aware of climate variability since most farmers in both Kaveta and Mikuyuni Villages reported that they had perceived changes in temperature and precipitation trends over the last two decades. Most farmers from the two Villages reported an increase in temperature and a decrease in precipitation.

The results are consistent with findings from a similar study in Kyuso District (Ndambiri *et al*, 2012*)* and Mutomo and Yatta Districts (Oremo, 2013). Findings by Kabubo-Mariara and Karanja (2006) also found that most Kenyans were aware of short-term changes in climate. Okonya *et al*. (2013) in their study also reported that nearly all households in agro-ecological zones of Uganda had observed climate change and variability. A similar study by Deressa *et al*. (2008) also found out that farmers in the Nile Basin of Ethiopia were highly aware of climate variability.

Comparison of rainfall data from the Meteorological Department showed that farmers' perceptions of changes in precipitation were consistent with rainfall trends over the last three decades. The meteorological rainfall data indicated that precipitation was decreasing with time in Kitui County. Similar studies in India (Ndungu and Bhardwaj, 2015) found out that farmers' perceptions of precipitation in mid-hills of Himachal Pradesh were in accordance with rainfall statistical data from weather stations in the region. Findings by Oremo (2013) are also consistent with the current study findings that farmers' perceptions corresponded with meteorological climate data.

An important finding from the study was that farmers from Kaveta Village had different perceptions of the changing climate as compared to those in Mikuyuni Village. While an equal percentage (13%) of the respondents in Kaveta Village perceived a decreasing and constant temperature over the years, all the respondents in Mikuyuni Village reported an increase in temperature over the years. The difference in perception between farmers from the two Villages was also observed in changing precipitation patterns. While all the respondents in Mikuyuni Village had observed a decrease in precipitation, some farmers in Kaveta Village reported to have observed an increase in precipitation over the years. The difference in perceptions could be explained by findings by the Ministry of Environment, Science, and Technology (MEST) of Ghana (2010), that people's experience on climate shocks varies across different social groups, geographic locations and seasons of the year. The findings concur with findings from a similar study by Kusakari *et al.* (2014) who found out that perceptions of farmers on changing temperature and rainfall patterns as well as frequency of extreme events such as drought and floods in Wa-West District of the Upper West Region of Ghana were significantly different across different localities. Luni *et al.* (2012) and Macharia *et al*. (2012) also emphasized that smallholder farmers do have varying levels of perception and attitudes towards climate change and its impact which are intertwined with non-climatic forces as well as pervasive social, economic and political changes.

From the present study, it can therefore be deduced that farmers in drier areas are more conscious of climate change and thus perceive climate change more, compared to those in wetter areas, thus, the difference in farmers' perceptions of climate variability in the two Villages.

5.2 Farmers' adaptation to climate variability in Kaveta and Mikuyuni Villages, Kitui County

The current study established that an overwhelming majority of farmers in both Kaveta and Mikuyuni Villages had adopted various adaptation measures in response to the decreasing amount of precipitation. The results concurs with findings from a similar study by Ndamani *et al*. (2012) who found out that 85% of the respondents in Kyuso District had adopted several adaptation measures. Similar studies by Wamalwa *et al*. (2016) also established that 74% of the respondents in Kisii County had employed several adaptation measures in response to the changing climate.

From the results, it can also be deduced that most farmers had employed adaptation measures in response to the decreasing precipitation in both Kaveta and Mikuyuni Villages as compared to the increasing temperatures. The present study findings are similar to those by Kabubo-Mariara and Karanja (2006) that most households in Kenya had made efforts to counter long-term precipitation changes as compared to the case of changing temperatures.

The results further indicated that there was a significant difference between farmers' probability to adopt adaptation measures in response to climate variability in Kaveta and Mikuyuni Villages (x^2= 4.24, df= 1, p=0.04). The results showed that more farmers in Mikuyuni Village had adopted adaptation measures than in Kaveta Village. The variability in adaptation between the Villages could be attributed to the fact that being relatively drier, Mikuyuni Village received relatively lower amounts of rainfall as compared to Kaveta Village. This could be explained by the significant difference in on- farm income between farmers in Kaveta and those in Mikuyuni Village ($t_{99.16}$ =3.350, $p<0.001$). The significant difference in on-farm could imply that crop yields in Mikuyuni Village were relatively lower than those of farmers in Kaveta Village. Thus, farmers in Mikuyuni Village were more conscious of climate variability and were more susceptible to the effects of increased temperatures and decreasing rainfall amounts therefore more likely to adopt measures to cope.

The difference in adaptation in the two Villages could also be attributed to other factors such as access to climate information and weather forecasts by farmers in the two Villages. For example, most respondents in Mikuyuni Village reported to have had access to climate information (69%) and weather forecasts (64%) as compared to only 36% and 34% of all the respondents who had access to climate information and weather forecasts, respectively, in Kaveta Village.

The results of the present study indicated that the main adaptation measures employed by farmers in both Villages in response to the decreasing amounts of precipitation included hybrid crop varieties, use of pesticides and animal manure, soil conservation, mixed crop and livestock farming, crop diversification and changing of planting dates, water harvesting and irrigation. In response to the increasing temperatures, farmers in

Kaveta Village planted early maturing crops, changed planting dates and switched from crop farming to livestock keeping. Interestingly, no farmer in Kaveta Village planted drought resistant crops in response to the increasing temperatures. In Mikuyuni Village, farmers planted drought resistant crops and early maturing crops in response to the increasing temperature.

The results are in consonance with findings by Oremo (2013) who indicated that farmers in Mutomo and Yatta districts responded to the decreasing precipitation and increasing temperatures through implementation of soil conservation schemes, changing crop varieties, reducing the number of livestock, diversification of crop types and varieties, different planting dates, diversification to non-farming activity, water harvesting schemes and reducing the size of land under cultivation.

Studies by Ndambiri *et al*. (2012), Ndamani and Watanabe (2015), Benedicta *et al.* (2010) and Ndungu and Bhardwaj (2015) also indicted that farmers adopted growing of different crop varieties, use of different planting dates, practicing crop diversification, switching from crops to livestock farming, changing land area under cultivation, adjusting the number and livestock management measures, switching from farming to non-farming activities, increased use of irrigation, increased use of fertilizers and pesticides, increased use of water conservation technologies, practicing soil conservation, mulching and use of manure as well as switching from farming to non-farming enterprises as ways of adapting to climate variability.

However, from the present study, it can be noted that despite the decreasing amounts of precipitation, while at least 22% of the respondents in Mikuyuni Village planted drought resistant crops such as sorghum, millet, cowpeas, green grams among others, most farmers in the Kaveta Village (99%) did not plant drought resistant crops. This could be attributed to inadequate information from extension officers on the type of crops to plant as well as unreliable weather forecasts.

From the results, it can also be noted that most farmers (86%) in Mikuyuni relied on use of organic manure as compared to those in Kaveta Village where at least 24% of the respondents used inorganic fertilizers. This could be explained by the significantly higher income in Kaveta as compared to that in Mikuyuni Village. Thus, farmers in

Mikuyuni Village invested in the affordable organic manure as opposed to the expensive inorganic fertilizers.

The results also pointed out that very few farmers in both Villages had adopted irrigation of crops as an adaptation measure. This could be attributed to lack of access to irrigation water and inadequate financial and technological capacity among the farmers in both Villages. The findings of the present study are in line with those by Oremo (2013) and Ndambiri *et al*. (2012) who found out that inadequate financial and technological capacity were some of the constraints of farmers' adaptation to climate variability.

5.3 Socio-economic and institutional factor influencing farmers adaptation to climate variability in Kaveta and Mikuyuni Villages, Kitui County

Results of the Logit regression analysis showed that Village, education level, farming experience, off- farm income, access to credit facilities, access to climate information and weather forecasts significantly ($p<0.05$) influenced farmers' adaptation to climate variability in both Kaveta and Mikuyuni Villages.

The results showed that the gender of the household head did not have a significant (co-efficient=0.16, p=0.40, odds ratio=1.17) influence on farmers' adaptation to climate variability. The results however showed that households headed by male were 1.17 times likely to adapt to climate variability as compared to female-headed households.

The results are in line with findings by Asfaw and Admassie (2004) and Deressa *et al*. (2008) who noted that male-headed households are often considered to be more likely to get information about new technologies and take risky businesses than female-headed households thus more likely to invest in climate change adaptation technologies than their female counterparts. The results however contradict findings by Ndambiri *et al.* (2012) who found out that the probability to adapt of the male-headed households was lower than that of the female-headed households in Kyuso District.

The influence of age of the household head was also found to be insignificant on farmers' adaptation to climate variability in Kaveta and Mikuyuni Villages (coefficient=0.65; p=0.23, odds ratio=1.92). The odds ratio however implies that a unit increase in age of the household head increased the probability of farmers to adapt to climate change by a factor of 1.92. The results corroborate findings by Ndambiri *et al.* (2012), Gbetibouo (2009), Deressa *et al*, (2008) that the probability to adapt to climate change and variability was higher for older farmers as compared to that of younger farmers. The results are however contrary to findings by Ndamani and Watanabe (2015) and Uddin *et al.* (2014) who found out that the likelihood of adaptation to climate change decreases in older farmers as older farmers generally are lacking interest and incentive to adapt to climate variability.

In regard to education level, the results indicated that education level of the household head had a significant (coefficient=0.81; p=0.01, odds ratio=2.25) positive influence on farmers' adaptation to climate variability. The findings indicated that farmers with high education level were more likely to adapt as compared to farmers with low education levels. In support, Ndungu and Bhardwaj (2015) asserted that higher level of education leads to an increase in the adoption of new technologies since it increases one's ability to receive, decode, and understand information relevant to making innovative decisions.

In the present study, farming experience was found to have a significant positive (coefficient=0.16; p=0.00, odds ratio=1.17) influence on farmers' adaptation to climate variability in Kaveta and Mikuyuni Villages. The results implies that farmers with more farming experience were 1.17 times likely to adapt to climate variability as compared to farmers with less farming experience. The results corroborate findings by Ndungu and Bhardwaj (2015), Deressa *et al.* (2008), Maddison (2006), Nhemachena and Hassan (2007) and Gbetibouo (2009) who indicated that farming experience increases the probability of adoption of climate change adaptation measures and argued that experienced farmers have better knowledge and information on changes in climatic conditions and crop and livestock management practices.

Further, the results showed that the household size in Kaveta and Mikuyuni Villages (coefficient=0.01; p=0.23; odds ratio=1.01) did not have a significant influence on farmers' adaptation to climate variability. The odds ratio however showed that a unit increase in family size increased the farmers' probability to adapt to climate variability by a factor of 1.01. This concurs with findings by Tizale (2007) that household size is a proxy to labor availability, and thus a larger family size is more likely to adapt to climate variability since farmers can take up labour intensive adaptation measures.

While on-farm income was not significant (coefficient=0.00, p=0.20, odds ratio=1.15) in predicting farmers' adaptation to climate variability in Kaveta and Mikuyuni Villages, off-farm income had a significant positive influence (coefficient=0.00; p=0.01; odds ratio=1.00).This implies that a unit increase in off-farm income increased farmers' probability to adapt to climate variability by a factor 1.00 in the two Villages. The results concur with findings by Ndungu and Bhardwaj (2015) who noted that off-farm income is more reliable than on-farm income since it is not affected by climate variability, as it is the case with on-farm income, and thus more instrumental in influencing the households wealth, thereby enhancing risk bearing capacity of farmers. Similar studies by Ndamani and Watanabe (2015); Ndambiri *et al.* (2012); Sofoluwe *et al.* (2011) and Knowler and Bradshaw (2007) also found a positive relationship between farmers' off-income and their adoption of adaptation measures to climate variability.

The results further established that access to credit by farmers in Kaveta and Mikuyuni Villages (coefficient=1.36; p=0.01; odds ratio=3.89) had a significant positive influence on farmers probability to adapt to climate variability. This implies that a unit increase in access to credit increases the probability of farmers to adapt by a factor of 3.89. This could be attributed to the fact that availability of credit offsets financial constraints enabling farmers to purchase improved crop varieties, acquire adequate labour for timely planting, purchase facilities for soil fertility management and water conservation as well as irrigation equipment. The results concur with findings by Yirga (2007) that there is a positive relationship between the level of adaptation of climate variability measures and availability of credit. Thus, interventions by governments and non-governmental entities that contribute to increased availability and accessibility of credit facilities by smallholder farmers in Kaveta and Mikuyuni Villages would go a long way in increasing the adaptability to climate variability and by large to increased food security.

Access to climate information (coefficient=1.89; p=0.01; odds ratio=6.62) had a positive and significant influence on farmers' adaptation to climate variability in the Villages. The results indicated that farmers with access to climate information were 6.62 times more likely to adopt climate variability adaptation measures as compared to farmers without access to climate information. This is because access to climate information increased farmers' awareness and knowledge on the changing rainfall and temperature patterns as well as the possible climate variability response measures.

Maddison (2006) and Nhemachena and Hassan (2007) noted that awareness and knowledge of precipitation and temperature by farmers is key in climate change and variability adaptation and decision-making process. Jotoafrika (2013) also reported that climate science provides valuable sources of information that can help, not only in predicting future weather and climate, but also in developing understanding and skills in managing uncertainty. In addition, Celia *et al.* (2009) stated that climate-related concerns and information have claimed to be among the major factors considered by farmers in their decision making.

The results further showed that access to weather forecasts in Kaveta and Mikuyuni Villages had a positive and significant influence (coefficient=1.14; p=0.01; odds ratio=3.13) on farmers probability to adapt to climate variability. The odds ratio implies that farmers with access to weather forecasts were 3.13 times more likely to adapt to the changing precipitation and temperature patterns as compared to farmers without access to weather forecasts.

Weather forecasts information enables farmers to make informed decisions on what crops and crop varieties to plant and when to do timely planting. Jotoafrika (2013) reported that seasonal weather forecasts are crucial for the provision of early warning information to farmers since they give probabilities of different rainfall scenarios which strengthen the adaptive capacities of farmers. In their study, Bryan *et al.* (2009) also reported accessibility and usefulness of weather information as one factor that affects a farmer's ability to adapt to climate change and variability.

In regard to the Village (coefficient=-0.01, p= 0.00; odds ratio=0.90) of origin, the results showed that farmers from Mikuyuni Village were more likely to adopt climate variability adaptation measures than those in Kaveta Village. This is in agreement with results presented in the previous section that there was a significant difference between farmers' probability to adopt climate variability adaptation measures in Kaveta and Mikuyuni Villages with farmers in Mikuyuni Village being more likely to adopt adaptation measures.

5.4 Constraints to smallholder farmers' adaptation to climate variability in Kaveta and Mikuyuni Villages, Kitui County

From the results, it can be deduced that farmers from the two Villages had different constraints to climate variability adaptation. While inadequate technological capacity, lack of access to credit facilities, lack of access to extension services, and high cost of adaptation were the major constraints to adaptation by farmers in Kaveta Village, lack of access to irrigation water, lack of labour, high cost of adaptation, unreliable weather forecasts, inadequate land resources and inadequate financial resources were the major constraints to the farmers' adaptation in Mikuyuni Village.

From the results, it can be noted that most of the constraints reported by farmers from both Villages are related to financial constraints and inadequate access to climate information. Financial constraints limit farmers' access to hybrid crop varieties, irrigation equipment, water and soil management facilities and labour. This can be explained by observation in the previous section that off-farm income, access to credit as well as weather forecasts and climate information increased farmers' ability to adapt to climate variability. The findings are in line with findings by Ndamani and Watanabe (2015), Ndungu and Bhardwaj (2015), Ndambiri *et al*. (2012) and Deressa *et al.* (2008).

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The present study sought to assess the perceptions and adaptation of smallholder crop farmers to climate variability in Kitui County with reference to Kaveta and Mikuyuni Villages. The study established that majority of the farmers in both Villages were aware of the changing climate in reference to precipitation and temperature trends. However, farmers in the drier area were more conscious of climate variability and thus perceived climate variability more, compared to those in the wetter area. Although most farmers in both locations employed measures to adapt to the changing climate, farmers in the drier area adapted more to climate variability as compared to those in the wetter area.

The most common adaptation measures employed by the farmers in response to the decreasing precipitation included hybrid crop varieties, use of pesticides and animal manure, soil conservation, mixed crop and livestock farming, crop diversification and changing of planting dates, water harvesting and irrigation. In response to the increasing temperatures, farmers in Kaveta Village planted early maturing crops, changed planting dates, switched from crop farming to livestock keeping while those in Mikuyuni Village planted drought resistant crops and early maturing crops.

Age of the household head, household size, education level, farming experience, off- farm income, access to credit facilities, access to climate information and weather forecasts significantly influenced farmers' adaptation to climate variability in both Villages.

Farmers from the two Villages had different constraints to adopt adaptation measures in response to climate variability. While inadequate technological capacity, lack of access to credit facilities, lack of access to extension services, and high cost of adaptation were the major constraints to adaptation by farmers in

Kaveta Village, lack of access to irrigation water, lack of labour, high cost of adaptation, unreliable weather forecasts, inadequate land resources and inadequate financial resources were the major constraints to the farmers' adaptation in Mikuyuni Village.

6.2 Recommendations

From the above findings, the present study makes the following recommendations,

i) More resources in terms of credit facilities, access to climate information and extension services should be availed to farmers, and especially in drier areas to increase their resilience to climate variability.

ii) Smallholder farmers should invest more on planting drought resilient crops as well as soil and water conservation measures in response to the increasing temperature and decreasing precipitation.

iii) The County Government and the central government as well as non-governmental development partners should integrate the factors that determine farmers' adaptation to climate variability into climate change policies, programs and projects.

iv) The meteorological department should provide reliable seasonal weather forecasts to farmers and partner with development agencies to provide technical assistance to enable farmers interpret and respond to the forecasts.

v) The Count Government of Kitui should initiate and steer up projects and programs that enhance farmers' resilience and adaptation to climate variability at the local level.

vi) Climate variability adaptation policies, programs and projects by government and non-governmental policies should be guided by farmers needs in specific locations since constraints to farmers' adaptation to climate variability are location specific.

REFERENCES

Acquah-de Graft, H. and Onumah, E. (2011) Farmers' perceptions and adaptation to climate change: Anestimation of willingness to pay. *Agris*, **3**(4), 31-39.

Adamgbe, E. and Ujoh F. (2013) Effect of variability in rainfall characteristics on maize yield in G Komba and Edwin Muchapondwa boko. *Nigeria J Environ Prot*.;4:881–7.

Adesina, A. and Zonah, M. (1993) Technology characteristics, farmers' perceptions and adoption decisions: A Tobit model application in Sierra Leone. *Agricultural economics*, 9,297-331.

Agwu, E., Egbule, C., Amadu, F., Morlai, T., Wollor, E. and Cegbe, L. (2011) What Policy Options can Promote Agricultural Innovations for Climate Change and Adaption and Food Security in the West African Sub-region? *African Technology Policy Studies Network* TECHNOPOLICY BRIEF No. 29 Website www.atpsmet.org.

Asfaw, A. and Admassie, A. (2004) The role of education on the adoption of chemical fertilizer under different socioeconomic environments in Ethiopia. *Agricultural Economics* **30** (3), 215–228.

Basher, R and Briceno, S. (2005) "Climate and Disaster Risk Reduction in Africa" in Low, Park Sum. (ed) Climate Change and Africa. Cambridge. Cambridge University pp.271-283.

Benedicta, F., Paul, L., Vlek, A. and Manschadi, M. (2010) Farmers' Perceptions and Adaptation to Climate Change: A Case Study in Sekyedumase District of Ashanti Region, Ghana. "World Food System —A Contribution from Europe". Tropentag, Zurich.

Bryan, E., Deressa, T., Gbetibouo, G. and Ringler, C. (2009) Adaptation to climate change in Ethiopia and South Africa: options and constraints. Environ Sci Policy 12: 413-426.

Bryant, R., Smit, B., Brklacich, M., Johnston, T., Smithers,J., Chiotti, Q. and Singh, B. (2000) Adaptation in Canadian agriculture to climatic variability and change. *Climatic Change*, 45(1), 181–201.

Cruz, R.V., Harasawa, H., Lal, M. & Wus, S. (2007) Asia. In: Parry, M., *et al.* (Eds.) IPCC (2007) Impacts, adaptation and vulnerability - *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, UK: Intergovernmental Panel on Climate Change. pp. 469-506.

Celia, M., Sonny, R., Christian, N., Mina, D.and Gonzales, K. (2009) Climate Variability, Seasonal Climate Forecasts and Corn Farming in Isabela Philippines. Ashgate Publishing Limited Hampshire, England

Charles, N. and Rashid, H. (2007) Micro-level analysis of farmers' adaptation to climate change in Southern Africa. IFPRI Discussion Paper 00714, Washington DC, USA.

Croppenstedt, A., Demeke, M. and Meschi, M. (2003) Technology adoption in the presence of constraints: the case of fertilizer demand in Ethiopia. *Review of Development Economics* **7** (1), 58–70.

CGoK (County Government of Kitui). (2014) Kitui County Villages Bill.

Cornish G.A (1998) *Modern Irrigation Technologies for Smallholders in Developing Countries* (Intermediate Technology, London, UK).

Deressa, T., Hassan, R. M. Alemu, T., Yesuf, M., and Ringler, C. (2008) Analyzing the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile Basin of Ethiopia. IFPRI Discussion Paper 00798, September 2008.

Doss, C. and Morris, M. (2001) "How Does Gender Affect the Adoption of Agricultural Technologies? The Case of Improved Maize Technology in Ghana". *Agricultural Economics* 25:27-39.

Dow, K. and Downing, T. (2007) The atlas of climate change. University of California Press.

FAO (Food and Agriculture Organization of the United Nations). (2014) Family Farmers: Feeding the World, Caring for the Earth. FAO, Rome, Italy.

FAO. (2010) Climate change adaptation and mitigation: New initiatives and update on Agriculture, Forestry and Fisheries. Proceedings: Thirtieth FAO Regional Conference for the Near East: December 4-8, 2010, Khartoum, the Republic of the Sudan.

Fischer, G., Mahendra, S. and Velthuizen, H. (2002) Climate Change and Agricultural Vulnerability. A special report prepared by the International Institute for Applied Systems Analysis as a contribution to the World Summit on Sustainable Development, Johannesburg, 2002.

Fuhrer J., Gregory P. J. Climate change impact and adaption in agricultural systems. Cabi Climate Change. 5, 2014, 1-298.

Füssel, H. and Klein, R. (2006) Climate Change Vulnerability Assessments: An Evolution of Conceptual Thinking. *Climate Change* 75: 301-329.

Gbetibouo, G. (2009) Understanding Farmers' Perceptions and Adaptation to Climate Change and Variability: The Case of the Limpopo Basin, South Africa. IFPRI Discussion Paper 00849 February 2009.

Gujarati, D. (2004) Basic econometrics. Fourth Edition. The McGraw-Hill Companies.

Government of Kenya (GoK), (2009) Kenya National Bureau of statistics; The 2009 Kenya Population and Housing Census.

Gregory, P., Ingram, J.S. and Brklacich, M. (2005) Climate change and Food Security *Philosophical Transactions of the Royal Society B*. Vol. 36: 2139-2148.

Gullet, A., Mohamed, A., Abdi, A. and Mwangi, A. (2006) Kenya: Floods Update No. 6. Of 4th December 2006. Operations Update. Kenya Red Cross Society.

Harig, T., Kaiser, F. and Bowler, P. (2001) Psychological restoration in nature as a positive motivation for ecological behaviour. *Environ. Behav*. 33, 590–607.

Herrero, M., Ringler, C., van de Steeg, J., Thornton, P., Zhu, T., Bryan, E., Omolo, A., Koo, J., Notenbaert, A., 2010. *Climate Variability and Climate Change and Their Impacts on Kenya's Agriculture Sector*. International Livestock Research Institute (ILRI), Nairobi, Kenya.

Huho, J. and Mugalavai, E. (2010) The Effects of Droughts on Food Security in Kenya. The International Journal of Climate Change: Impacts Resp. **2**(2):61-72.

Hulme, M., Conway, D., Kelly, P., Subk, S. and Downing, T. (1995) "The Impacts of Climate Change on Africa", CSERGE Working paper GEC 95-12

IFAD (International Fund for Agricultural Development). (2013) Smallholders, Food Security, and the Environment. IFAD, UNEP, Rome, Italy.

Igoden C., Ohoji P. and Ekpare J. (1990) Factors associated with the adoption of recommended practices for maize production in the Lake Basin of Nigeria. *Agricultural Administration and Extension*, **29** (2): 149-156.

Intergovernmental Panel on Climate Change (IPCC). (2001) Climate Change Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the 3rd Assessment Report Cambridge University Press, Cambridge

IPCC (2007) Summary for Policymakers. In: 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, 7-22.

ISDR (2008). Climate change and disaster risk reduction. *International measure for disaster reduction.* Geneva: United Nation International measure for Disaster reduction.

Jotoafrika. (2013) Adapting to climate change in Africa. http://www.care.org/jotoafrika-adapting-climate-change-africa.

Kabubo-Mariara, J. and Karanja F. (2006) The Economic Impact of Climate Change on Kenyan Crop Agriculture: A Ricardian Approach. Paper prepared for the Third World Congress of Environmental and Resource Economics: Kyoto Japan, July 3-7, 2006.

Kates, R. (2000) "Cautionary Tales: Adaptation and the Global Poor." *Climate Change*, **45** (1), 5-17.

Knowler, D., Bradshaw, B. (2007) Farmers' adoption of conservation agriculture: a review and synthesis of recent research. *Food Policy* **32** (1), 25–48.

Komba C. and Muchapondwa E. (2015) Adaptation to Climate Change by Smallholder Farmers in Tanzania. *Environment for Development. Discussion Paper Series*

Kurukulasuriya, P., Rosenthal, S. (2003) Climate change and agriculture: A review of impacts and adaptation. Climate change series paper no. 91. Environment Department and Agriculture and Rural Development Department, World Bank, Washington, DC.

Kusakari, Y., Asubonteng, K., Jasaw, G., Dayour, F., Dzivenu, T., Lolig, V., Donkoh, S., Obeng, F., Gandaa, B. and Kranjac-Berisavljevic, G. (2014) Farmer-perceived effects of climate change on livelihoods in Wa West District, Upper West region of Ghana. *Journal of Disaster Research,* 9: 516-528

Lin, J. (1991) Education and innovation adoption in agriculture: evidence from hybrid rice in China. *American Journal of Agricultural Economics*, **73** (3): 713–723.

Lindsay, P. Norman, D. (1977) Human Information Processing: an Introduction to Psychology. 1977, New York: Academic Press.

Luni, P. Maharjan, K., Joshi, N. (2012) Perceptions and realities of climate change among the Chepong Communities in rural mid-hills of Nepal. J. Contemp. India Stud. Space Soc. 2, 35 50.

Macharia, P., Thuranira,E., Ng'ang'a L., Lugadiru1 J., and Wakori S. (2012) Perceptions and adaptation to climate change and variability by immigrant farmers in semi-arid regions of Kenya. *African Crop Science Journal,* **20**(2): 287– 296.

McCarl, B. (2007) Adaptation Options for Agriculture, Forestry and Fisheries. A report to the UNFCCC Financial and Technical Support Division. Bonn: United Nations Framework Convention on Climate Change. Obtained from: http://unfccc.int/files/cooperation_and_support/fi nancial_mechanism/ application/pdf/mccarl.pdf

Maddison, D. (2006) The perception of and adaptation to climate change in Africa. CEEPA. Discussion Paper No. 10. Centre for Environmental Economics and Policy in Africa. University of Pretoria, Pretoria, South Africa.

Maitima, J., Kariuki, P., Mugatha, S. and Mariene, L. (2009). Adapting East African ecosystems and productive systems to climate change. Report for the Economics of Climate Change Adaptation in Africa. 2009.

Ministry of Environment, Science and Technology (MEST) of Ghana, "Ghana Goes for Green Growth: Discussion document – Summary" Accra: MEST, pp. 8-15, 2010.

Ministry of Livestock and Fisheries Development (MLFD). (2005) Department of Livestock Production, Kenya.

Mulama, J. (2006). "*Environment-Africa: Changing Climate, Changing, Lives*", [available on online at http://ipsnews.net/news.asp?idneews=35448]

Mutai, C. C., Ochola, S.O., Mukiira, H. K., Gachimbi L. N., Otiono, M., King'uyu, S. M., and Marigi, S.N., (2011) Chapter 3: Climate change and variability. In: *State of the Environment and Outlook 2010*. *Supporting the Delivery of Vision 2030*. National Environment Management Authority (NEMA), Nairobi, Kenya.

Ndambiri, H. Ritho, C. Mbogoh, S. Ng'ang'a, S. Muiruri, E and Cherotwo, F. (2012) Assessment of farmers' adaptation to effects of climate change in Kenya. *Journal of economic and sustainable development*: 3(12).

Nagayets, O., (2005) Small farms: current status and key trends. The Future of Small Farms: Proceedings of a Research Workshop, IFPRI, Wye, UK, pp. 355–367.

Ndamani, F. and Watanabe, T. (2015) Farmers' Perceptions about Adaptation Practices to Climate Change and Constraints to Adaptation: A Micro-Level Study in Ghana *Int. J. Agric. Sci.*5, 367–374.

Ndungu, C. and Bhardwaj, S. (2015) Assessment of People s Perceptions and Adaptation to Climate Change and Variability in Mid-Hills of Himachal Pradesh, India. *Int.J.Curr.Microbiol.App.Sci* **4**(8): 47-60.

Nhemachena, C., and Hassan, R. (2007) Microlevel analysis of farmers' adaptation to climate change in Southern Africa. IFPRI, Environment and Production Technology Division, Washington, DC: International Food Policy Research Institute.

Norris, E., Batie, S. (1987) Virginia farmers' soil conservation decisions: an application of Tobit analysis. *Southern Journal of Agricultural Economics*, **19** (1): 89-97.

Nyangena, W. (2007) Social determinants of soil and water conservation in rural Kenya. Environment, Development and Sustainability.

Obunde P., Maitima, and Olson J. (2007) Adaptation to Climate Change: A Case of Kenya. Climate Land Interactions Project working paper 63 pages.

Omoyo, N., Wakhungu, J. and Oteng, S. (2015) Effects of climate variability on maize yield in the arid and semi-arid lands of lower eastern Kenya. *Agriculture and Food Security*, 4:8

Oremo, F. (2013) Small-Scale farmers' perceptions and adaptation Measures to Climate Change in Kitui County, Kenya. Master Thesis. Nairobi University.

Orindi, V., Ochieng A., Otiende, B., Bhadwal, S., Anantram, K., Nair, S., Kumar,V. and Kelkar, U. (2006) Mapping climate vulnerability and poverty in Africa.

Ottichilo W, de Leeuw J, Skidmore A, Prins H and Said M. Population trends of large non-migratory wild herbivores and livestock in the Maasai Mara ecosystem, Kenya, between 1977 and 1997.AfrJEcol. 2000;38:202–216.

Parry, J., Echeverria, D., Dekens, J. and Maitima, J. (2012) Climate Risks, Vulnerability and Governance in Kenya: A review, (United Nations Development Programme (UNDP); International Institute for Sustainable Development (IISD).

Rao, K., Ndegwa, W., Kizito, K. and Oyoo, A. (2011) Climate variability and change: farmer perceptions and understanding of intra-seasonal variability in rainfall and associated risk in semi-arid Kenya. *Experimental Agriculture*, 47: 267–291.

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

Republic of Kenya (2002) Kitui District Development Plan 2002 -2008.

Republic of Kenya (1997) Kitui District Development Plan 1997-2001.

Shashidahra, K. and Reddy, B. (2012) Farmers perceptions and adaptation about changing climate and its variability in UKP area of Karnataka. *Indian Res. J. Extension Edu.,* 1: 196 201.

Sofoluwe, N., Tijani, A., Baruwa, O. (2011) Farmers' perception and adaptation to climate change in Osun Satte, Nigeria. *Afr. J. Agricult. Res, 6*: 4789- 4794.

Somda, J., Nianogo, A., Nassa, S., and Sanou, S. (2002) Soil fertility management and socioeconomic factors in crop-livestock systems in Burkina Faso: A case study of composting technology. *Ecological Economics* 43: 175–83.

Tompkins, E. and Adger, W. (2004) Does adaptive management of natural resources enhance resilience to climate change? *Ecology and Society* **9** (2):10.

Thornton, P., Jones, P., Owiyo, T., Kruska, R., Herrero, M., Orindi, V., Bhadwal, S., P Kristjanson, A Notenbaert, N Bekele, and Omolo A. (2008) Climate change and poverty in Africa: Mapping hotspots of vulnerability. AfJARE 2(1), 24–44.

Tizale, C. (2007) The dynamics of soil degradation and incentives for optimal management in the Central Highlands of Ethiopia. PhD thesis. Faculty of Natural and Agricultural Sciences, University of Pretoria; Pretoria, South Africa.

Tubiello, F., and Fischer, G. (2007) Reducing climate change impacts on agriculture: Global and regional effects of mitigation, 2000-2080. *Technol. Forecast. Soc. Change*, **74**, 1030-1056, doi:10.1016/j.techfore.2006.05.027.

UNFCCC, (2007) Climate change: the Scientific Basis. Cambridge University Press, Cambridge, UK.

Urama, K. and N. Ozor (2011) Agriculture innovations for climate change adaptation and food security in western and central Africa. *Agro-Science,* Vol. **9**(1), pp. 1-6.

Wamalwa I., Mburu, B. and Mang'uriu, D. (2016) Perception of climate change effects and its influence on uptake of Climate Smart Practices among Smallholder Farmers of Kisii County, Kenya. *International Journal of Information Research and Review*, **3**(5):2409-2417.

Watson, B. (2010) Climate change: An environmental, development and security issue. Livestock and global climate change international conference proceedings, Tunisia, 17-20 May 2008: 6-7.

World Bank (2008) World Development Report 2008: Agriculture for Development

Yirga, C. (2007) The dynamics of soil degradation and incentives for optimal management in Central Highlands of Ethiopia. PhD thesis. Department of Agricultural Economics, Extension, and Rural Development. University of Pretoria, South Africa.

Zoellick B (2009). A Climate Smart Future. *The Nation Newspapers. Vintage Press Limited, Lagos, Nigeria. 18*

APPENDICES

APPENDIX I: SAMPLE QUESTIONNAIRE

Household Survey Questionnaire on Farmers' Perceptions and Adaptation to Climate Variability

Questionnaire No.____ **Name of Interviewer:**

Village_____________ **Date:______________**

SECTION 1

Personal Details

1. Gender of the household head (Male ☐ Female ☐)
2. What is the age of the household head?_______
3. What is the level of education of the household head (In terms of schooling years)
   a) Below 8 Yrs ☐
   b) 8-1 ☐
   c) 12-16 Yrs ☐
   d) 16-18Yrs ☐
   e) Above 18 Yrs ☐
4. What is the size of your household (in terms of number of family members)________
5. What agricultural activities do you engage in?
   a) Crop farming ☐

b) Livestock keeping ☐

c) Mixed crop and livestock production ☐

6. What type of farming do you practice?
   a) Subsistence farming ☐
   b) Cash crop farming ☐
   c) Both ☐

7. What types of crops do you grow for
   a) Subsistence____
   b) Sale____

8. What is your annual on-farm income (in Ksh)?______________________
   a) 1-50,000 ☐
   b) 51,000-100,000 ☐
   c) 101,000-150,000 ☐
   d) 151,000-250,000 ☐
   e) Above 250,000 ☐

9. How long have you been in farming?
   a) Less than 5Yrs ☐
   b) 5-10Yrs ☐
   c) 10-20 Yrs ☐
   d) 20-30 Yrs ☐
   e) 40-50 Yrs ☐
   f) Above 50 Yrs ☐

10. Do you engage in any off-farm activities? Yes ☐ No ☐

11. What is your annual off- farm income (in Kshs)? ________
   a) 1-50,000 ☐
   b) 51,000-100,000 ☐
   c) 101,000-150,000 ☐

d) 151,000-250,000 ☐

e) Above 250,000 ☐

12. How far are you from the market?

a) Less than 2km ☐

b) 3-5Km ☐

c) 6- 10Km ☐

d) Above 10Km ☐

SECTION B

Farmers' perceptions and adaptation to climate variability

13. What changes in annual temperature have you noticed over the last 20 years?

a) Increased temperature ☐

b) Decreased temperature ☐

c) Constant temperature ☐

14. What changes in rainfall patterns have you noticed over the last 20 years?

a) Increased precipitation ☐

b) Decreased precipitation ☐

c) Early onset of rains ☐

d) Delayed onset of rains ☐

e) Unpredictable onset of rains ☐

f) Constant rainfall patterns ☐

15. Have you adopted any adaptation measures in your agricultural practices in response to the changing temperatures? Yes ☐ No ☐

If yes, what practices have you adopted?

i. Diversification of crops ☐

ii. Use of hybrid varieties ☐

iii. Changing of planting dates ☐

iv. Planting of drought resistant crops (such as sorghum, millet, cowpeas) ☐

v. Switching from crop farming to livestock keeping ☐

16. Have you adopted any adaptation measures in your agricultural practices in response to the changing rainfall patterns? Yes ☐ No ☐

If yes, what practices have you adopted?

i. Diversification of crops ☐
ii. Use of hybrid varieties ☐
iii. Changing of planting dates ☐
iv. Planting of drought resistant crops (such as sorghum, millet, cowpeas) ☐
v. Switching from crop farming to livestock keeping ☐
vi. Use of pesticides ☐

17. Do you receive any services from extension officers? Yes ☐ No ☐

If Yes, what kind of services and from which departments/organizations?

18. Do you have access to credit services? Yes ☐ No ☐

If Yes, from which facilities?

19. Have you received any climate change information in the last year? Yes ☐ No ☐

If Yes, list the sources of the information.

20. Have you received any weather forecasts in the past one year? Yes ☐ No ☐

If Yes, was it reliable?

21. What are the major constraints to your climate change adaptation? Rank them using a scale of 1-5 (5 to be the most influencing Constraint).

Constraints	**Rank**
Inadequate financial resources	
Lack of technological capacity	
Lack of access to credit facilities	
Lack of access to extension services	

Lack of labour	
High adaptation cost	
Lack of early warning information	
Unreliable weather forecasts	
Access to irrigation water	
Inadequate land resources	

THANK YOU.

APPENDIX II: JOURNAL PAPER