RESPONSE TO EFFECTS OF CLIMATE VARIABILITY AND WILLINGNESS TO PAY FOR INSURANCE BY SMALLHOLDER FARMERS IN LAIKIPIA WEST SUB - COUNTY, KENYA

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

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DECLARATION AND RECOMMENDATION

DECLARATION

I hereby do declare that this research thesis is my original work and to the best of my knowledge, has not, wholly or in part, been submitted for an award of a Master's degree in any other institution.

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RECOMMENDATION

This Research thesis has been submitted to the Graduate school of Egerton University for examination with our approval as University supervisors.

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This thesis is heartily dedicated to my parents, wife, lectures and friends.

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ABSTRACT

The impact of climate variability on societies around the world is increasingly evident. Kenya is one of the most vulnerable countries and economic sectors and livelihoods are already frequently experiencing the manifestations of the problem. Households engage in adaptation strategies in order to mitigate the negative effect of climate variability. The extent to which these effects are felt depends mostly on the level of adaptation in response to climate variability. A better understanding of the local dimensions of adaptation is therefore essential to develop appropriate response measures that can mitigate these adverse consequences. The general objective of this study was to contribute to knowledge and the enhancement of smallholder farmer response mechanisms to climatic variability for sustainable livelihoods and food security in Laikipia West Sub- County Kenya. Specifically was; to identify the adaptation strategies employed by households, to analyze factors influencing the choice of adaptation strategies by households and to determine the factors influencing willingness to pay for selected crop insurance as a response to climate variability. A multi- stage sampling technique was used to obtain a sample size of 392 households. A semi-structured questionnaire was used to collect primary data. Statistical Package for Social Scientists (SPSS) and STATA software were used for data analysis. Principal component analysis, Multivariate Probit, and Double bounded dichotomous choice model were used for data analysis. According to the results 63.11% of those who were willing to pay for insurance were male, 81.15% had formal education and 66.39 were pure farmers. The mean age of those willing to pay for insurance was 53.83 with mean household size of 6 people and mean land size of 4.96 acres. 44.26% had received weather information, 69.67% received extension services, 56.56% received credit and 77.05% were members to a group. The Multivariate Probit results indicate that; Male headed households, access to weather information, access to extension services, large land size and group membership had a positive impact on responding to climate variability through different strategies. Access to credit had a negative impact on use of crop risk reduction practices while household size, distance to market, occupation of household head, age of household head and agro ecology had mixed effects on adoption of different strategies. The mean willingness to pay without covariates was KSH 55923.38 and KSH 58552.22 with covariates. Occupation of household head and group membership had a positive effect on willingness to pay for crop insurance while access to extension services had a negative effect. Therefore, the study recommends stakeholders to develop policies geared towards massive campaign on the reality of climate change and its serious consequences on food production. This can be achieved through provision of meteorological reports and alerts to farmers in understandable forms. There is a need for investment in the provision of affordable and quality formal education, up to date, relevant demand-driven extension services that provide localized response solutions depending on the agro ecology. There is also need to invest in training about crop insurance and its importance as a response strategy.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND ACRONYMS

ASALs	Arid and Semi-arid Lands
ATPS	African Technology Policy Studies Network
DDP	District Development Plan
FAO	Food and Agriculture Organisation
GoK	Government of Kenya
IPCC	Intergovernmental Panel on Climate Change
KES	Kenya Shillings
NACOSTI	National Commission for Science, Technology and Innovation
NAPA	National Adaptation Programmes of Action.
NOAA	National Oceanic and Atmospheric Administration
SSA	Sub - Saharan Africa
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WTP	Willingness to Pay

CHAPTER ONE

INTRODUCTION

1.1 Background information

Africa's population is projected to double by 2050, and globally food production will need to double in order to meet the needs of increasing urban populations. Urbanization is occurring rapidly in SSA, but large rural populations are projected for at least another generation (Lamboll *et al*., 2011). In SSA, greater areas of land are typically under range lands and are marginal for agriculture. Such areas are increasingly unable to support rain fed agriculture, due to challenges posed by climate variability and increasing population.

Climate variability has come with a variety of changes in rainfall levels and distribution patterns, temperature intensities (African Technology Policy Studies Network [ATPS], 2013), wind speeds, extreme weather events like droughts and floods (Clark *et al.*, 2006), and emerging pests and diseases (FAO, 2009). Mitigating and adapting to climate variability requires collective action of different stakeholders to derive multi-disciplinary approaches to address the situation. Research shows that a variety of climate variability adaptation forms (operational, technical, and financial) have been taken by diverse stakeholders (farmers, climate variability agencies and organizations, and governments) at local, regional and international levels (Smit and Skinner, 2002; Paradhan *et al*., 2015). These stakeholders have recognized the important role of agriculture in contribution to, and mitigation of climate variability.

Farmers have diverse agricultural practices which include use of organic pesticides, agro - forestry (ATPS, 2013), use of local seeds which they believe are better adapted than exotic seeds, crop diversification, minimum tillage, mulching, collecting water in ponds and earth dams for irrigation, and changing their planting times based on rainfall forecasts (Paradhan *et al.,* 2015). However, farmers are reactive dealing with short term challenges rather than being proactive to handle long term problems. This reactive behaviour can be attributed to low information access and low understanding of mitigation and adaptation options.

Although not a universal remedy for adapting to climate variability, enabling smallholder farmers and related stakeholders to reduce their vulnerability to weather variability and adapt to climate variability would be important. Policymakers have been encouraged to consider insurance as part of response strategy by the Bali Action Plan. Formal risk management mechanisms include: agricultural insurance, minimum support price system and futures markets (Hardaker *et al*., 2004). Insurance can be an efficient risk management tool to cover losses arising from yield variability (Roberts, 2005). It has been offered to farmers since the 1920s (Smith and Watts, 2010). It involves insuring crops, livestock, forestry, aquaculture and green housing. Farmers can guard against negative effects of climate variability and stabilize their farm income through adopting agricultural insurance. Crop insurance helps to stabilize farm income and also helps the farmer to recover after experiencing losses due to a bad agricultural year. The major problem associated with insurance is the farmers' willingness to pay the premium. According to Hiwot and Ayalneh, (2014) willingness to pay (WTP) is the amount that must be taken away from the person's income while keeping his utility constant in the same manner, it is influenced by individual tastes and preferences, income attitudes and perceptions of the type of product as well as household, demographic characteristics (Canfield *et al*., 2003).

In the recent past, there has been an increased fluctuations between floods and drought with the distribution and intensity changing leading to severe effects. The normal climatic and weather conditions have deviated greatly from normal patterns leading to more warmer and fewer cold days and nights; (IPCC, 2007). The effects of these changes have manifested in decreased crop yields, water logging, increased pest outbreaks and rampant soil erosion. Drought affected regions have become vulnerable to crop damage or failure, land degradation and increased livestock deaths due to dehydration and lack of forage.

The ability of rural farmers to manage common systemic risks in the presence of more complex risks associated with climate variability definitely needs attention. In highly variable climates where any season can bring harsh conditions, farmers are generally reluctant to invest in more profitable technologies and practices (Hansen *et al*., 2015). This lack of investment, combined with climate variability leading to unpredictable yields, is a major factor in keeping farmers trapped in poverty. Compounding these issues, credit providers are reluctant to lend to smallholder farmers in such a high-risk environment, hence even if farmers want to invest in inputs such as seeds and fertilizers, they often cannot.

Agro-pastoralism in Laikipia County is a production system based on crop production and livestock rearing that is characterized by mobility in an ecologically fragile environment, high degree of flexibility and variability. Livestock represent the major stores of wealth that utilize mobilized environment characterized by highly variable water resources and transient forage. However, over the past three decades agro-pastoralism has been faced with enormous problems as a result of extremes of climate variability. The threat that climate variability poses to agro -pastoralism has necessitated the assessment of the potential effects of climate variability at various scales in the sector in order to reduce vulnerability and secure livelihoods of those who depend on them (Chipanshi *et al*., 2003).

High population growth rate has caused negative effects on the socio-economic development and aggravated the poverty situation in the county. Increased pressure on available resources has often degenerated into conflicts between the pastoral community, large-scale ranching enterprises, smallholder farmers and wildlife. Low productivity due to small land holds coupled with increased occurrence of droughts and extreme weather events has increased the severity of crop failure and land degradation. This has had a larger negative impact on the livelihoods of many local communities in the county. (Laikipia CIDP, 2013)

1.2 Statement of the problem

Over the years farmers in Laikipia County's agro-pastoral systems have faced changes in the climatic environment. Their agricultural activities are most vulnerable to climate variability phenomenon due to the fragile nature of the environment that has been exacerbated by encroachment by increasing human population and unsustainable land-use activities. However, little is known about how the farmers respond to the effects of climate variability and the factors determining their choice. Furthermore, little is known on whether these farmers are willing to pay for crop insurance as a response to the effects. This study sought to fill this knowledge gaps among smallholder farmers.

1.3 Objectives

1.3.1 General objective

The general objective was to contribute to sustainable livelihoods and food security by enhancing smallholder farmer response mechanisms to climatic variability in Laikipia west sub-county, Kenya.

1.3.2 Specific objectives:

1. To determine smallholder farmers responses to effects of climate variability.
2. To evaluate the socio-economic and institutional factors that influence farmers' response to effects of climate variability.
3. To determine the factors influencing willingness to pay for selected crop insurance as a response to effects of climate variability.

1.4 Research questions

1. How are smallholder farmers in Laikipia west sub-county responding to the effects of climate variability?
2. Do socio-economic and institutional factors influence farmers' response to effects of climate variability in Laikipia west sub-county?
3. What are the factors influencing willingness to pay for insurance as a response to climate variability effects among smallholder farmers in Laikipia west sub-county?

1.5 Justification of the study

The dry lands of Kenya including Laikipia are most vulnerable to climate variability phenomenon due to the fragile nature of the environment. Droughts and floods have become more frequent and severe and may increase in the coming years. In these areas, smallholder farming and pastoral livestock production are dominant, but are dependent on the availability of rainfall. This can only be solved by enhancing response mechanisms.

Climate variability constitutes a major risk for all dimensions of sustainable development. Actions to mitigate and adapt to climate variability are likely to have significant implications for most dimensions of sustainable development. Lack of adaptation and mitigation may make targets related to many Sustainable Development Goals (SDGs) more difficult to achieve, and more difficult to sustain over time beyond 2030. Hence, this study contributes towards realization of the Sustainable Development Goal 13 (SDG 13) which emphasizes on the urgency of curbing the effects of climate change.

In line with the SDGs and also Vision 2030 economic pillar (GoK, 2007), climate variability is one among the three most transformational challenges facing developed countries. It is also one of the challenges on which the world at large needs to place a strong emphasis for action so as to eradicate extreme poverty and hunger. The study contributes towards realization of the Laikipia County integrated development plan as Climate variability is one of the major concerns because its effects have been devastating to the county. The study also contributes to the Paris agreement negotiated at the Conference of parties (COP) which is a global agreement on reduction of climate variability through limiting global warming to less than 2 degrees Celsius.

1.6 Scope and limitation of the study

The study targeted cattle, sheep, goats and maize as the selected livestock and crops. Hence only smallholder farmers rearing cattle, small ruminants and growing maize in Laikipia County were considered. Although climate variability effects are observed all over the country Laikipia County was considered for the study. This is because of the effects of recurrent drought and high population growth rate which has led to increased pressure on the available resources. Reliability and quality of the results depended on the respondent's willingness to respond and ability to remember. Use of willingness to pay may have been enhanced by promotion of the strategy in the area. Language barrier also was a problem. This challenges were overcome by using local extension staff in order to enhance the trust of respondents hence their willingness to respond. This also solved the problem of language barrier as the extension staff understood the local language.

1.7 Definition of terms

Climate variability - refers to time scales ranging from months to decades, falling between the extremes of daily weather and the long-term trends associated with climate change.

Agro-Pastoral System: This is a production system that involves both the growing of crops and rearing of livestock.

Agro-pastoralist: These are settled pastoralists who cultivate sufficient areas to feed their families from their own crop production.

Response to climate variability effect: refers to the actions or activities undertaken by the farmer in order to curb, prevent or minimize the effects of climate variability

Smallholder: those farmers owning small-based plots of land (2 hectares or less) on which they grow subsistence crops and one or two cash crops and rear a few number of livestock relying almost exclusively on family labour.

CHAPTER TWO
LITERATURE REVIEW

2.1 Overview of climate variability in Africa and Kenya

'Climate' may be defined as the 'long term average weather' (IPCC, 2007). IPCC defines 'climate change' as 'any change in climate over time, whether due to natural variability or as a result of human activity'. Climate variability is an environmental, economic and social challenge on a global scale (Mendelssohn *et al.,* 2006). Climate variability can be exacerbated by human induced factors/ actions such as; broad scale deforestation, unsustainable land use, major technological and socio-economic shifts with reduced dependence on organic fuel and increased uptake of fossil fuels among others (Millennium Ecosystem Assessment, 2005).

Agriculture is the back bone of most African economies as it employs approximately 65 percent of Africa's labor force. It also contributes to about 60 percent of Africa's total export earnings up to 40 percent of the total gross domestic product (GDP). (International Food Policy Research Institute (IFPRI), 2009). However, key challenges have emerged in the agricultural sector climate variability being the most important. Drought in Africa affect about 220 million people every year and it is projected that by 2020, yields from rain-fed crops could fall by 50 percent in some countries; while net revenues loss from crops could fall by 90 percent **(**Huho and Kosonei 2013**)**. The rampant food crisis that has been recently experienced in most sub-Saharan Africa countries are reminders of the continuing vulnerability of the region to the impacts of climate variability. This has been largely attributed to weak institutional capacity, limited engagement in environmental and adaptation issues, and a lack of validation of local knowledge (Adepoju and Obayelu.2013). Climate variability has the potential to affect development activities in Africa and can hinder the achievement of the Sustainable Development Goal (SDG) no. 13, which focuses on enhancing the resilience of climate change. According to IPCC 5th assessment report, serious impacts are being felt by the poorest people majority of whom are marginalized and live in developing countries (IPCC 2014).

Climate variability threatens sustainable economic development and the totality of human existence in Africa. It is one of the most important environmental issues facing the Africa today as the impact is a real and has affected all climate-sensitive sectors including

Agriculture (Maponya *et al*., 2013). Extreme climatic events and climate variability poses a serious threat to the main source of income to majority of countries in Africa because agriculture provides employment to over 70 percent of the labor force in African countries. Stakeholders in the Agricultural sector including farmers have come to a consensus that climate change is a reality and the impacts cannot be ignored any more. The impact of climate change varies globally with small scale farmers being the most vulnerable because of their dependence on rain-fed agriculture, low adaptive capacity, limited financial capacity, and high dependence on natural resources, low technology adoption, limited infrastructure and lack of capacity to diversify (Kurukulasuriya and Mendelsohn, 2006). There is a growing consensus that Africa is the most vulnerable continent to the vagaries of the climate following the scope of the impacts of climate variability over the last three or four decades (IPCC, 2007). Ranking high among the impacts of climate change in Africa is food insecurity triggered by severely compromised agricultural production, dwindling fish stocks due to ecosystem changes, reduced livestock production due to grassland degradation and deforestation among others. These impacts are particularly exacerbated extreme events such as frequent droughts, unpredictable floods and change in rainfall patterns (Collier *et al*., 2008).

The impact of climate variability is intensifying in Kenya at an alarming rate (GoK 2010). According to Sei *et al*. (2009), there is an increase in the mean annual temperatures in the country and the greater East African region which is projected to experience an increase between 1 and 3.5 °C by the year 2050. This warming is likely to lead to depletion of glaciers on Mount Kenya (IPCC 2007), reduction in water levels in many rivers hence reducing the level of electricity generation (GoK 2007). Climate variability in Kenya have been severe and have had tremendous impacts on the key sectors of the economy. The rural poor are the most vulnerable to these impacts because of their dependence on climate-sensitive sectors for survival (Mutimba *et al*., 2010).The impacts of climate variability have been projected to have a negative significant impact on the economy of the country approximated at a loss of about 3 % of the Kenya's GDP each year by 2030 (Sei *et al*., 2009). This will make it difficult for the country to realize vision 2030 due to slow economic growth as a result of over dependence on climate sensitive sectors such as agriculture, tourism, and coastal zones coupled with weak institutions of responding to climate variability hazards (GoK 2007). The average annual rainfall in Kenya is about 687mm which falls during the long rains from March- May and short rains from October- December (McSweeney *et al.,* 2008). The average annual mean temperature between 1970 and 1999 was 23.9^0 C with little variation throughout the year. The highest temperatures of about 35^0C are reached in Northern Kenya, while the lowest values of 10^0C and below are mostly experienced in the central-western parts of the country. According to the IPCC, temperatures in Kenya have risen by 1^0C over the past 50 years and are projected to increase up to 2.8^0C by 2060 and up to 4.5^0C by 2090 (Christensen *et al.,* 2007). With regard to precipitation, no statistically significant trend has been observed since 1960 (Eriksen and Lind, 2009). Yet, the proportion of rain falling in heavy rainfall events has increased. These events are projected to occur more often, resulting in a higher total amount of rainfall and an increase in rainfall variability (Christensen *et al.,* 2007; McSweeney *et al.,* 2008).

The projected trend of increasing temperatures and less reliable rainfall increases the likelihood of floods and drought in Kenya (Few *et al.,* 2006). In ASALs which constitute 80% of Kenya's land area, droughts are a common phenomenon (GoK, 2007). Agro-pastoralists relying on sufficient rain report a sharply contracting drought cycle. According to them, rains used to fail every nine or ten years, while they now experience drought every two or three years. In Kenya, 82% of the total land is classified as arid and semi-arid lands (ASALs) and is largely used for agro pastoralism, extensive livestock production and wildlife. Kenya among other countries of the greater horn shows high potential for extreme climate events under climate change scenarios (Funk *et al*., 2008). The economic impact of these climate change threats to the country is enormous. Increased risk of water shortages will have a major effect on agricultural production. Several regions may need to introduce irrigation or increase the irrigated area to ensure continuous production. But there is no doubt that agriculture has to make further efforts to improve its water use efficiency and reduce water losses, and irrigation plans will need to be based on careful planning and thorough assessments of their effects. (IPCC, 2014).

2.2 Risks faced by agriculture in pastoralist region

Climate variability is mostly characterized extreme weather event mostly droughts and floods. These phenomena destroy plants, depletes the soil hence reducing the yields. The past decades have experienced the increase in occurrence of extreme events which have reduced soil moisture, fertility and water resources for plants resulting in severe water stress. Reduced soil moisture decreases available water for irrigation and hinder plant growth in non-irrigated plants. Drought leads to the death of livestock leaving most small scale farmers trapped in poverty and inability to access and afford basic social amenities. Drought leads to crop failure which leads reduced availability of crop residues. This in turn leads to decreased soil fertility by reducing the organic component of the soil as the amount of crop residues is reduced. This necessitates the application of fertilizers to avoid reduction of crop yields, hence increasing the costs of farming incurred by the households. Floods leads to soil erosion and waterlogging which interfere with release of nutrients resulting to low soil fertility and therefore reducing crop yields. (Shongwe *et al*. 2014) In the recent past there has been incidences of erratic rainfall in many geographical regions in the world. Rainfall frequency and intensity fluctuates, with poor distribution throughout the growing season, such that there is no rain during the maturity stage of most crops. This results in total crop failure even if the crop has been performing well during the early stages of development. (Aydinalp and Cresser, 2008)

Climate change impacts have been most severe to humans in the area of reduced agricultural production. Although, food crisis may be triggered by many other factors, reduced productivity arising from lower yield is mostly triggered by effects of climate variability and related events (Anyoha *et al*., 2013). Volatility of climatic events has made it difficult for farmers to predict incidence of rain based on past observation. The expected long term changes in climatic patterns are expected to have significant negative effects on Agricultural and economic growth in Africa (Nhemachena *et al*, 2010). Climate variability is perceived as being the greatest threat to agricultural production and food security in sub-Saharan countries, especially on livelihood of millions of people in many places of the world (IPCC, 2014). Several studies indicate that agriculture production could be significantly impacted due to increase in temperature (Lobell *et al*., 2012), changes in rainfall patterns (Prasanna *et al*., 2014) and variations in frequency and intensity of extreme climatic events such as floods and droughts (Brida and Owiyo, 2013).

Climate variability threatens the agricultural production and food security of developing countries in complex ways that demand environmentally friendly innovations. Africa's agriculture is vulnerable to climate change (Arslan *et al*., 2015; Juana *et al*., 2013), owing to the impact of climate variables such as temperature, humidity and precipitation (IPCC, 2007, 2011), its sensitivity to projected changes and low adaptive capacity (Benhin, 2008; Hellin *et al*., 2012). According to the IPCC fifth assessment report (2014), most of the effects of climate variability on agriculture come through water, pests and diseases, crop yields and weather hazards. Climate variability is likely to result in a decrease in annual water availability in many parts of the world due to an expected reduction in rainfall which may lead to conflicting demands between agriculture and other users. The increased risk of water shortages will have a major effect on agricultural production.

Climate variability is perceived as being the greatest threat to agricultural production and food security in sub-Saharan countries, it is emerging as a major threat on agriculture, food security and livelihood of millions of people in many places of the world (IPCC, 2014). Effects from increasing frequency of extreme weather events are becoming more common and intense. A succession of El Nino, floods, droughts and storms in recent years has shown Worlds' vulnerability to extreme conditions, and their frequency could increase in the short to medium term. In particular, the risk of drought and the possibility of floods in some areas are expected to rise. Several studies indicate that agriculture production could be significantly impacted due to increase in temperature (Lobell *et al*., 2012; Aggarwal *et al*., 2009), changes in rainfall patterns (Prasanna *et al*., 2014; Mall *et al*., 2006) and variations in frequency and intensity of extreme climatic events such as floods and droughts (Brida and Owiyo, 2013; Singh *et al*., 2013). Adverse effects can also be expected from the likely rise in the spatial distribution and intensity of existing pests, diseases, and weeds, due to higher temperatures and humidity. Farmers face the challenge of dealing with increased pest problems, or new pest challenges, within the constraints of what science can provide and within the pesticide authorization regulatory frameworks.

2.3 Factors affecting response to climate variability.

The age of the head of the household represents experience in farming. Several studies have shown that experienced farmers have a higher probability of perceiving climate variability as they are exposed to past and present climatic conditions over the longer perspective of their life span (Maddison, 2006; Ishaya and Abaje, 2008, Deressa *et al.,* 2009). Thus, this study assumes that older and more experienced farmers have a higher likelihood of perceiving climate variability. Oluwakemi *et al.* (2014) noted that the age of the farmers was negatively related to diversification to non-farm activities, use of improved varieties mixed farming and adjustment of planting period.

Gender of the household head is considered to influence response to climate variability (Mugi-Ngenga *et al*., 2016). Male headed households are more likely to access information on the availability of new technologies than female headed households. Female headed households are mostly limited by traditional barriers in terms of access to land and other resources hence making them unlikely to have the capacity to respond to climate variability. In contrast, Nhemachena and Hassan (2007) argue that female headed households are more likely to adapt to climate variability by taking up coping strategies because they are responsible for much of the agricultural work thus have greater experience.

Education of the head of household is assumed to positively affect awareness of climate variability because exposure to education increases farmers' ability to access, process and use information relevant to adaptation to the effects of climate variability (Deressa *et al*., 2009). It has also been shown that more educated farmers are more exposed to understand new ideas and concepts related to climate variability. This study assumes that more educated farmers are likely to respond to climate variability using diversified methods than the less educated ones. Access to information on climate variability through extension agents or other sources creates awareness and favorable condition for adoption of farming practices that are suitable under climate variability (Maddison, 2006). Access to information on climate variability affects the farmers' attitude and behavioral intention hence they no longer rely on cultural. This makes them to make informed decisions which are reliable basing on the prevailing climatic conditions (Dinku *et al*., 2014). Basing on the above explanation, this study presumes that smallholder farmers who are well informed are more willing to respond than their counterparts without access to reliable information.

Apata (2011), found out that age of the head of the household, farm income, information on climate variability, farmer-to-farmer extension and agro-ecological settings are factors affecting the perception of climate variability. However, findings revealed that most of the explanatory variables affected the probability of adaptation as expected, except farm size. (Oluwakemi *et al.* 2014) found out that the gender of the household heads had a positive influence on the likelihood of diversifying to non-farm activities and adjustment of planting period. The male farmers were also more likely to adapt to climate variability by adjusting their planting period than using soil and water conservation method. This is consistent with the findings of De Graffe and Heller (2004) because women have limited access to information, land and other resources due to traditional social barriers.

Household size had a negative relationship with diversification to non-farm activities and adjustment of planting periods. This is consistent with the findings of Apata *et al.,* (2008). The study further showed that farmers that had more information on climate variability, increased their use of improved varieties, diversified to non-farm activities and adjusted their planting period relative to the use of soil and water conservation measures. This is consistent with existing studies that access to information through extension services increases the likelihood of adapting to climate variability (Maddison, 2006; Nhemachena and Hassan, 2007). Results also showed that increase in farm income improved the use of water and soil conservation measures while non-farm income increased the likelihood of mixed farming.

Large-scale farmers are more likely to adapt because they have more capital and resources (Hassan and Nhemachena, 2008; Aymone, 2009). Productive resources such as capital, land and labor serve as important factors for coping with and adapting to climate variability. Different studies have shown that access to credit increases the likelihood of adaptation (O'Brien *et al*., 2000; Temesgen *et al*., 2008; Aymone, 2009; Temesgen *et al*., 2009). Lack of sufficient financial resources is a major constraint to most farmers responding to climate variability regardless of the many response options that the farmers may be aware of and willing to use (O'Brien *et al*., 2000).

Better access to extension services was found to have a positive influence on the probability of choosing different adaptation measures (Aymone, 2009; Temesgen *et al*., 2009). Aymone (2009) argue that farmers who have access to extension services are more likely to be aware of changing climatic conditions and to have knowledge of the various management practices that they can use to adapt to changes in climatic conditions. Information on weather also has a significant and positive effect on the likelihood of using different crop varieties. Having access to farmer-to-farmer extension increases the likelihood of using different crop varieties and planting trees (Temesgen *et al*., 2008). According to Center for Environmental Economics and Policy in Africa (CEEPA 2006), Greater distance to the market where outputs are sold diminishes the probability of adaptation. It appears that farmers with larger farms are more likely to adapt to climate variability.

Different studies have shown that access to credit increases the likelihood of adaptation (Aymone, 2009; Deressa *et al*., 2009). Lack of income to purchase and facilitate the necessary inputs and requirements for response is a major constraint to farmers willing to respond to the effects of climate variability. The income constraint hinders response regardless of the numerous response options that farmers are aware of and willing to apply. Social capital is an important aspect in accessing information including information relating to climate variability. Membership to social groups can be viewed as a proxy for social capital hence affecting both the behaviour and response options undertaken by farmers (Aldrich, 2012). Farmers in a group develop social trust and thus can easily trust and rely on information passed on by their fellow members (Frankenberger *et al.*, 2013). This can be attributed to the social bond among farmers in a group, the farmers can learn from their colleagues about climate and what they are doing to respond to climate variability.

2.4 Types of Response Strategies to Climate Variability

Over the years farmers have developed strategies through which they respond to climate variability. These response strategies can be autonomous, private and planned or public sector response strategies. When response to climate variability is through actions taken by non-state agencies such as farmers, communities, organizations, firms or a combination of any; then it is referred to as private adaptation. According to Bruin (2011) Response may include changing crop species, staggering planting dates, changing management practices, changing irrigation system and selecting different cropping technologies. Public adaptation is achieved the efforts of local, regional, national government or both. This is achieved through the provision of infrastructure and institutions that reduce the negative impact of climate change. These response strategies may include introduction and development of irrigation infrastructure in dry areas, Improvement and development of effective transport or storage infrastructure, land use arrangements and property rights, water shed management institutions (World Bank, 2010).

Response can also be viewed as proactive or reactive depending on the time it is undertaken. If it is undertaken before the climate variability phenomena then it is proactive and if it is carried out after the impact is felt then it is reactive. Reactive adaptation strategies addresses effects of climate change after they have been experienced, while proactive adaptation strategies are engaged in anticipation of climate change (Bruin, 2011). In crop production**,** reactive response strategies may include control of soil erosion as a result of foods, construction of irrigation dams in response to drought, improving soil fertility in response to erosion, development of new varieties which can adapt to prevailing conditions, shifting planting time due to unreliable rainfall. Proactive response strategies on the other hand involve the development of adaptable species and research and development. However in order to enable smallholder to respond to climate variability, the government should provide the necessary support and conducive environment for response (Gbetibouo, 2009)

2.4.1 Climate variability response in agro-pastoral systems

Climate variability is currently affecting many parts of the world as manifested through the frequency of extreme events like drought and floods. Response can be defined as adjustment in natural or human systems in resulting from actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of response can be distinguished, including anticipatory, autonomous and planned (IPCC 2007). Responding to the weather and climate is a characteristic of all human societies, but climate variability is presenting new and increasing challenges. Smallholder farmers all over the world including Kenya, use a range of options to respond to the negative effects of climate variability. Response to climate variability can either be through adaptation or mitigation. Adaptation is motivated from local priorities or regional risks and it helps reduce the impact of climate variability in the short to medium term. On the other hand mitigation is concerned about solving the root cause of climate variability through reducing the sources of greenhouse gases. Mitigation is concerned about controlling the cause of climate variability while adaptation is concerned about controlling climate variability effects (Bewuket, 2009). The time-lagged nature of climate variability implies that the currently observed climate variability is as a result of the greenhouse gas emission that was experienced in the past. This implies that the effects of current greenhouse gas emission will also lag into the future. As a result focusing on mitigation alone will not address the inevitable impacts of currently observed climate variability. (Anyoha *et al*., 2013)

Mitigating and adapting to climate variability requires collective action of different stakeholders to derive multi-disciplinary approaches to address the situation. Research shows that a variety of climate variability adaptation forms (operational, technical, and financial) have been taken by diverse stakeholders (farmers, climate change agencies, organizations, and governments) at local, regional and international levels (Paradhan *et al*., 2015). These stakeholders have recognized the important role of agriculture in contribution to, and mitigation of climate variability.

Response measures are being implemented by a range of public and private organizations through policies, investments in infrastructure and technologies, and behavioral change (Adger *et al.,* 2007).Farmers in developing countries are already using their existing experience, knowledge and resources to manage climate risks on their own account and these actions are not easily distinguished from a range of other factors (social, demographic and economic) influencing livelihood decisions and development trajectories (Adger *et al.*, 2003). Planned response initiatives are also often not undertaken as standalone measures, but are embedded within broader sectoral initiatives. Since response strategies to climate variability and barriers to response are local specific, identified response measures may not necessarily translate into changes, (Aemro *et al*, 2012). This underlines the importance of understanding local dimensions of climate variability so as to develop response measures that are appropriate in mitigating adverse consequences of climatic variability. In order to enhance relevant policies towards tackling the challenge that climate variability is posing on farm households which have little response capacities, it is necessary to have knowledge of the response choices and factors affecting the response methods to climate change.

According to Olarinde *et al*. (2014), failure to implement response options and poor agricultural performances by many African farmers has been blamed on lack of information and resources Southern Africa for example, has early warning units and meteorological departments, but the information does not reach all intended users. Response policy measures need to consider how information concerning adaptation measures, forecasts, and production cycles can best reach farmers to help them respond to changes in climate.

Agro-pastoralism has encouraged integration of more livestock in agricultural systems. This complements their sources of income and also improves crop production through incorporation of the animal manure which improves soil fertility. There is increasing agreement among scientific research that agro-pastoralism make significant contributions to local, national and regional economies. Agro-pastoralism is more productive per hectare than commercial ranching and sedentary livestock keeping in similar environmental conditions, and the high productivity of livestock in pastoral systems not only supports millions of pastoralist but also contributes significantly to other sectors of national and regional economies of Africa (Hesse, 2009).

2.4.2 Willingness to pay for insurance

Agricultural insurance is one of the financial tools used to manage the various risks that may arise in agricultural production. The purchase of insurance policy on a farm eliminates the uncertainty regarding the financial loss in the event of climate variability. Insurance can be used to minimize financial consequences of many adverse events, it does not decrease the uncertainty for the individual farmer as to whether the event would occur nor does it alter the probability of occurrence, but it does reduce the probability of financial loss connected with the event (Danso-Abbeam *et al*., 2014). For a crop insurance program to be successful, some conditions must be fulfilled. First there must be acceptable level of demand among farmers for crop insurance, secondly the farmers must be capable to meet insurance policies and lastly the insurer must be capable and willing to pay the farmers' claims. This calls for stakeholders including the government and insurance companies to have a clear understanding of the needs of farmers that affect their willingness to participate and pay for crop insurance. This awareness of will help the policy makers to the structure the insurance policies according to the needs of people (Zemp *et al*., 2015)

Insurance can be viewed as an economic device which helps an individual pay a small cost known as the premium to cover for a large uncertain financial loss that would exist if it were not for the insurance .It operates by transferring the risks associated with farming to a third party via payment of a premium that reflects the true long-term cost of the insurer assuming those risks. In other words, the insurance agency is able to pool the risks by accepting appropriate premiums from a large number of clients. Perception on the ownership of the property right over the resource in question may influence an individual's willingness to pay (Carson *et al*., 2001) and is influenced by individual tastes and preferences, income, attitudes and perceptions of the type of product as well as household demographic characteristics. This is computed by asking how much people are willing to pay for a non-market goods (WTP) or how much they are willing to give up having a specified non-market goods quality improvement happen (Freeman, 2003). WTP is a small fraction of income and may be influenced by recent experiences e.g. farmers are more likely to express high demand of insurance if the weather has been adverse in the recent period.

2.5 Theoretical and conceptual framework

2.5.1 Theoretical framework

Utility maximization Theory

Farmers are willing to make and pay for preferences that maximize their utility. Utility is defined as a function of both market goods, denoted as *x*, and non-market items denoted as q. The utility function for an individual may be written as $u(x, q)$ and the utility is maximised subject to income y. the direct utility function is therefore given by:

$$\mathrm{V}(\mathrm{p}, \mathrm{q}, \mathrm{y}) = \max\{u(x.p)|p.x \leq y\}$$

(1)

The indirect utility function depends on prices of market goods, *p*; an income of an individual, *y*; individual characteristics, *s*; and stochastic component, *e*, representing the notion of random utility maximization. Indirect utility function can be written as: $v(p,q,y,s,e)$. An individual maximizes utility subject to income y. The indirect utility function $v(p,q,y,s,e)$ is as shown in equation 2.

$$v(p,q,y,s,e) = \max\{\ u(x,p) \mid p,x \le y\}$$

(2)

The properties of both the indirect utility and expenditure function are well known (Deaton and Muellbauer, 1980). The derivative of the expenditure function yields the Hicksian or utility-constant (compensated) demand function, with the subscript indicating the partial derivative. The negative of the ratio of derivatives of the indirect utility function yields the Marshallian or ordinary demand curve as depicted by equation.

$$u_i(p,q,u) = mp_i(p,q,u)$$

(3)

The decision on WTP is based on the utility derived from consumption of a good or a service. Formally, WTP is defined as the amount that must be taken away from the person's income while keeping his utility constant (Alberini and Cooper, 2000). The utility function normally reflects the good or a service together with social and demographic characteristics that contribute to the utility of the respondent as presented in equation.

$$u = v(p,q,y,s) + e = v + e$$

(4)

where u represents utility of individual choosing a product, v the deterministic component of indirect utility, y the level of individual's income, s the factors that could affect the utility of individual and e the random component of the utility function. WTP measures the maximum amount of income the individual will be willing to pay for an improvement in their circumstances (utility maximization) or maximum amount an individual is willing to pay to avoid a decline in circumstances. Willingness to pay is defined using the indirect utility function as shown in equation.

$v(p, q^* s, y - WTP) = v(p, q, y)$

(5)

where v denotes the indirect utility function, y the level of individual income, p a vector of prices faced by the individual, and q^* and q are the quantity indexes or alternative levels of good with $q^* > q$, and increases in q^* is advantageous since $\frac{\partial v}{\partial q} > 0$, implying that higher consumption level of q^* leads to higher utility.

2.5.2 Conceptual Framework

Although portfolios promoting adaptation to climate variability are available to farmers, their adoption is constrained by several factors overtime. Farmers are encouraged to take measures that will help curb or reduce the effect of climate variability. However, their decisions are controlled by some exogenous factors determining acceptance of this strategies as shown in figure 1.

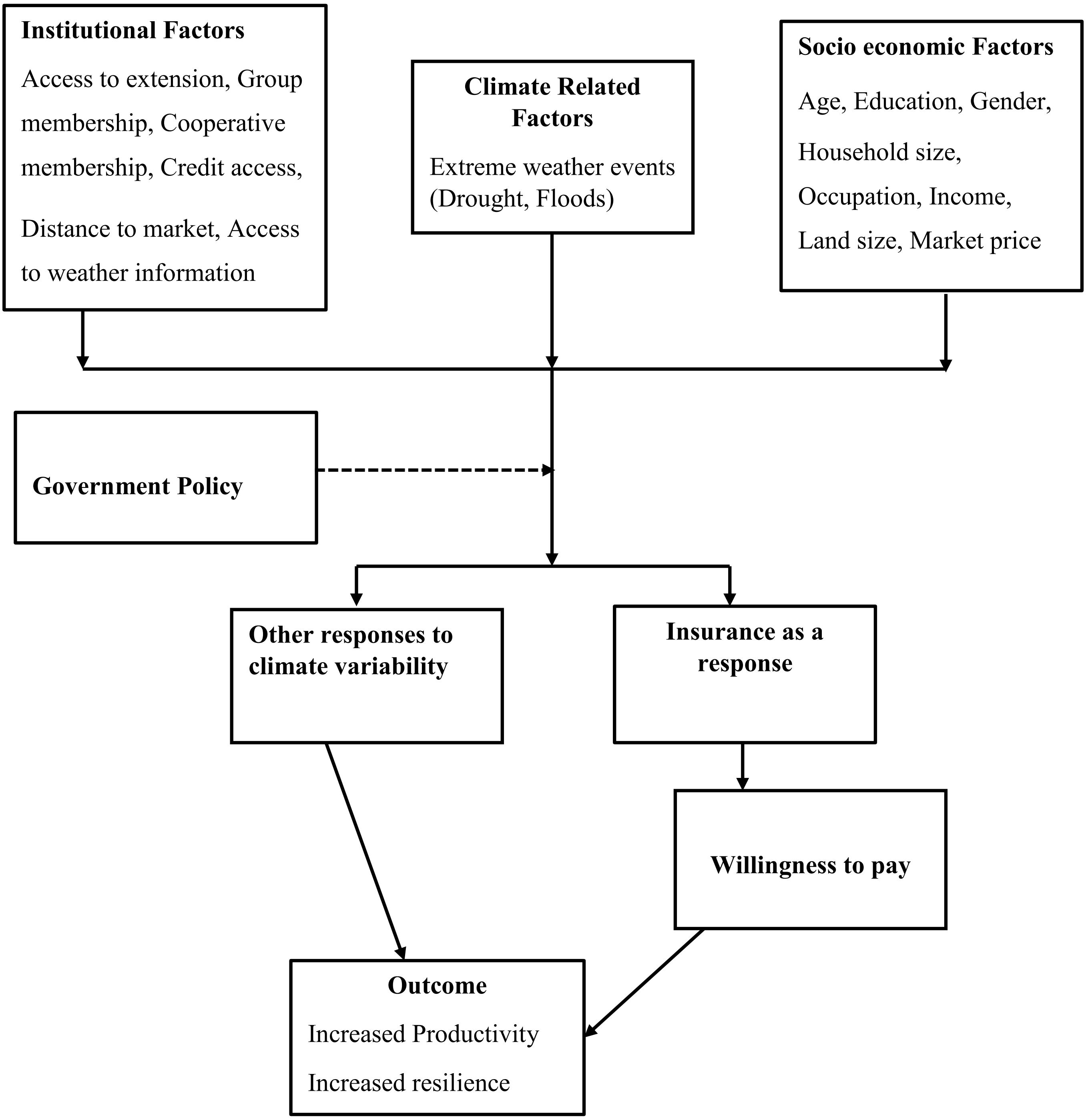

Figure 1: Conceptual Framework

These factors are classified into socio-economic factors, climate related factors and institutional factors. Socio economic factors include household related variables such as household characteristics and land. Climate related factors include extreme weather events experienced in the past that may influence the actions of farmers. Institutional factors include access to the market, information, credit, extension, membership to groups and cooperative and distance to markets. The socio economic, climate related and institutional factors together influence the response of the farmers to climate variability either through the conventional methods or through the purchase of insurance. The response is regulated by government policies which affect the actions that a farmer can undertake while responding to climate variability. Response through the conventional methods can enhance increased resilience to climate variability leading to increased productivity. On the other hand response through insurance is influenced by willingness to pay of farmers, if farmers are willing to pay then they will be able to increase their resilience in turn increasing productivity.

CHAPTER THREE

METHODOLOGY

3.1 The study area

The study area was Laikipia West Sub - County in Laikipia County which lies between latitudes 0°17'S and 0°45'N and longitudes 36°15'E and 37°20'E, occupying an area of approximately 9,666 km^2. The county extends from the western foot of Mount Kenya to the north-eastern base of the Aberdare Ranges. It stretches widely Northwards and descends towards the Rift Valley in the northwest with spectacular complex of fault-line volcanic ridges and escarpments. Figure 2 presents the map of the study area.

The altitude ranges between 1600-2300 m above sea level on a dry land and semi-arid plateau. The long rains occur in April-May, the continental or middle rains in August and November, and a pronounced dry season in January-March. Annual rainfall varies from 400 mm to 750 mm on average with the foot of both Mt. Kenya and the Aberdare Range registering higher values. Based on the2009 census the human population in the county was 399,227. The growth rate between the 1989 and 1999 was approximated at 3.9 percent which was much higher than the national average of 2.4 percent (Laikipia CIDP, 2013).

The area was chosen because of the fragile environment prone to fluctuations in climatic conditions. The effects of recurrent droughts, combined with the low productivity of small and uneconomical land holdings have aggravated the severity of land degradation, with repercussion on the livelihoods of many local communities. Farmers are determined to look for innovative solutions to counter the challenge of climate variability. The aim of the study was to know how the farmers have responded and the factors affecting their responses.

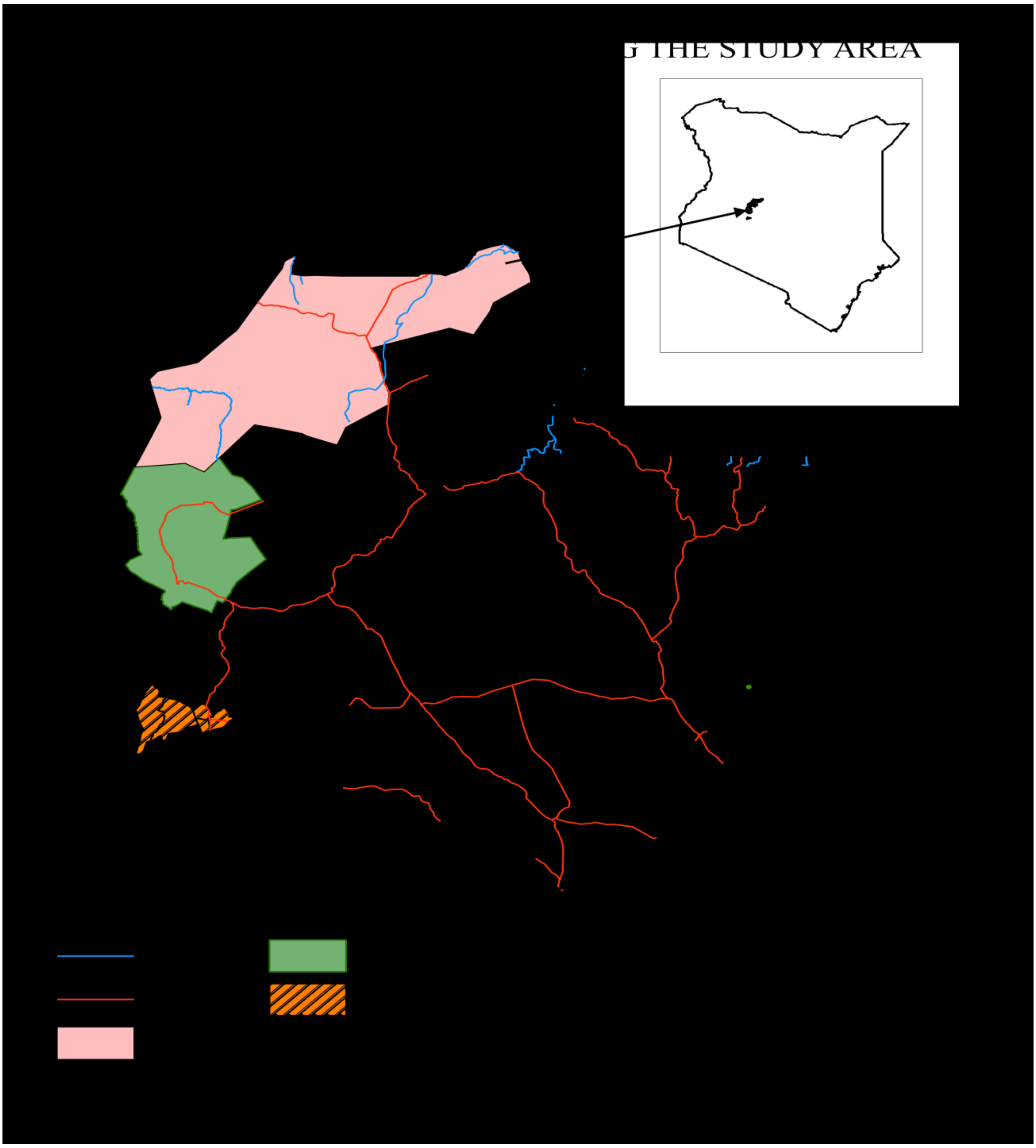

Figure 2: Map of the study area

Source: World resource center (2013)

3.2. Sampling procedure

The study used a multi stage sampling technique. Laikipia County was selected purposefully because of its vulnerability to climate variability. The county is composed of 3 sub counties namely; Laikipia East which has 5 wards, Laikipia West which has 6 wards and Laikipia North which has 4 wards. Laikipia West was selected purposefully because of the fragile environment and vulnerability of the area to drought. Three wards Nyahururu, Ng'arua and Ol Moran were randomly selected for the study**.** Finally the households were randomly selected from a list of households provided by the sub county Agricultural offices.

3.3. Sample size determination

A sample of smallholder farmers was taken as representative of the county's smallholder farmers population. The target population was the maize, cattle and goat farmers. The population data was obtained from the area Agricultural offices in the three selected wards as 19219 farm households. The sample size is determined using the following formula by Bowley's (1977) quoted in Nzelibe, 1999) proportion sample formula assuming a 95% confidence interval as shown:

$$S_{total} = \frac{N}{1+N(e)^2}$$

(6)

Where; S_{total} = total sample size of all respondents

N = total population of farming households in Laikipia west district (19219)

1 = constant

e = level of significance (confidence interval of 95%)

Hence replacing the values into the formula gives

$$S_{,total} = \frac{19219}{1+19219(0.05)^2} = 391.844$$

$$S_{total} \approx 392$$

The population data for the three wards is Nyahururu (11581), Ng'arua (4683) and Ol Moran (2955) therefore the sample size for each ward was calculated using probability proportional to size from the identified wards as shown.

$$\frac{p}{N} \times S_{total}$$

(7)

Where; p = population of the individual ward

N= total population of the three wards

S_{total} = Total sample size (392)

This gives the sample sizes for the three wards as shown in the table;

Table 1**: Sample size for selected Wards**

Ward	Population	Number Sampled
Nyahururu	11581	236
Ng'arua	4683	96
Ol Moran	2955	60
Total	19219	392

3.4 Data and collection methods

Primary data was collected by interview using semi-structured questionnaires. Pre testing was done to ensure that the questionnaire was reliable and necessary adjustments made. Data collected included information on farm and farmer characteristics, institutional, production and market related factors. Socioeconomic and demographic variables of the respondents included farm household head's sex, level of education, marital status, household size, occupation, access to climate information and its source, access to credit, income, and distance of farm to market among others.

Production data included size of farm land, type of farm enterprise, assets on farm, use of fertilizer and other agrochemicals like herbicides, quantity of output among others. Climate adaptation data for the respondent with adaptation, type of adaptation measures used. Observation method was also used. Institutional characteristics collected includes access to market information, access to extension contact and proximity to the extension office, group membership, membership to cooperative and availability of contractual agreements. Secondary data was obtained from books journals and other written literature.

3.5 Analytical technique

Objective one was analyzed using principal component analysis (PCA). Crop and livestock response strategies used in Laikipia West Sub - County were identified and grouped into heterogeneous principal clusters by application of principal component analysis. Homogenous practices were grouped into composite clusters. PCA helps to scale down a complex data set to a lower dimension. This reduction facilitates the identification of sometimes hidden, simplified dynamics that often underlie it (Shlens, 2003). Observed and unobserved factors influencing use of a particular practice are combined to come up with clusters.

The practices were grouped using principal component analysis with iteration and varimax rotation in the model represented as shown below:

$$Y_1 = a_{11}x_{12} + a_{12}x_2 + \dots\dots\dots\dots + a_{1n}x_n$$

.

$$Y_j = a_{j1}x_{j1} + a_{j2}x_2 + \dots\dots\dots\dots + a_{jn}x_n$$

(8)

Where Y_1, Y_2........................Y_j = principal components which are uncorrelated

a_1 - a_n = correlation coefficient

X_1, X_2, Y_n = factors influencing use of a particular strategy

Objective 2 was analyzed using a Multivariate Probit Model. The Multivariate Probit Model helps to model the influence of a set of explanatory variables simultaneously on each of the different response measures while allowing the error terms to be freely correlated (Green 2003; Golob *et al*., 2005). Complementarities (positive correlation) and substitutability (negative correlation) between different options may be the source of the correlations between error terms (Belderbos *et al*., 2004) or the existence of unobservable socio economic factors which are specific to a household and can affect choice of response options but cannot be easily measured such as indigenous knowledge. The Multivariate Probit Model takes into account these correlations.

Studies in Africa have used different empirical methods to analyze the determinants of adaptations to climate variability and choice of adaptation strategies. Most commonly used analytical approaches include discrete choice regression models like the binary probit or logit (Fosu-Mensah *et al*., 2010), Multinomial Probit or Logit and Multivariate Probit (Nhemachena and Hassan, 2007; Hassan and Nhemachena, 2008; Temesgen *et al*., 2008, 2009; Temesgen, 2010; Aemro *et al*., 2012). Other empirical studies have used different methods for example Mandleni and Anim, (2011) used principal component analysis while Kurukulasuriya and Mendelson, (2006) used the Ricardian model. Most of these studies on response to climate variability using different strategies have weaknesses because most of them do not consider the possible inter-relationships between the variousresponse strategies (Yu *et al*., 2008).

The response decision is inherently multivariate and the use of univariate modeling will leave out useful economic information contained in interdependent and simultaneous response decisions. Based on this argument, the study adopted multivariate probit (MVP) econometric technique to simultaneously model the influence of the set of explanatory variables on each of the different strategies, while allowing the unobserved factors to be freely correlated (Belderbos *et al*., 2004; Lin *et al*., 2005). The correlation may be positive correlation or negative correlation between different strategies (Belderbos *et al*., 2004).

Following Lin *et al*. (2005), the multivariate probit model is characterized by a set of *n* binary dependent variables *yi* with observation subscripts suppressed as used in this study. The multivariate probit is an extension of the probit model and is used to estimate several correlated binary outcomes jointly. The model is specified as follows:

$$Y_{im}^{*} = \beta_m X_{im} + \varepsilon_{im}$$

(9)

Where Y_{im}^{*} (m = 1,….,k) represent the unobserved latent variable of adaptation strategies adopted by the ith farmer. (i = 1,…,n), k is the strategies adopted by the farmer. X_{im} is a $1 \times k$ vector of observed variables that affect the strategy adoption decision, the variables include household socioeconomic, institutional factors, willingness to pay and climate related factors.

β_m is a k × 1 vector of unknown parameters to be estimated ε_{im}, m = 1, …, M are the error terms distributed as multivariate normal, each with a mean of zero, and variance-covariance matrix V , where V has values of 1 on the leading diagonal and correlations.

Equation 9 is a system of m equations as shown in Equation 10 below;

$$Y_1^* = X_1\beta_1 + \varepsilon_1 y_1 = 1 \quad if \quad Y_1^* \succ 0 \quad Y_1 = 0 \quad otherwise$$

$$Y_n^* = X_n\beta_n + \varepsilon_n y_n = 1 \, if \quad Y_n^* \succ 0 \quad Y_n = 0 \quad otherwise$$

(10)

This system of equations is jointly estimated using maximum likelihood method. The implicit functional form of the empirical model is specified as follows:

$$Y^*_n = f_X(B_0 + B_1 Occup + B_2 Gender + B_3 Age + B_4 Educ + B_5 hhsize + B_6 Landsize + B_7 Weath\inf + B_8 Exten + B_9 Grpmb + B_{10} Credit + B_{11} Dmkt + B_{12} Ward\ 2 + B_{13} Ward\ 3) + \varepsilon \qquad (11)$$

Objective 3

WTP was analyzed using double bounded dichotomous choice contingent valuation model. The model involves the use of bid levels for insurance which forms the basis for calculating the mean WTP. This model has gone through some stages in the proposition to improve efficiency in measuring willingness to pay for public goods; from single bounded to double bounded and multiple bound. The double bounded contingent valuation method is an improvement of the contingent valuation in terms of efficiency where a second bid is offered to the respondent, higher or lower depending on the first response (Hanemann *et al*. 1986). This method showed an improved statistical efficiency (Loomis *et al*. 1991). Contigent valuation originally was used in the estimation of non-market goods, but it is now widely used to evaluate willingness to pay for new products. This method suits the case of insurance whose market is not fully developed in agriculture and the rural areas like Laikipia West Sub-County.The double-bounded contingent model is appropriate because it takes into consideration the two responses simultaneously.

The respondent was presented with an initial bid and then follow-up bids. The level of the second bid was higher than the initial bid if the response was positive and lower than the initial bid if the response was negative. The second bid is very important as it places an upper and lower bound on the respondents unobserved true WTP (Alberini and Cooper, 2000). There are four possible outcomes from the double-bounded dichotomous choice presented in interval yy, yn, ny and nn, where yy implies that both answers were "yes", WTP is higher than the upper bid, yn first answer was "yes" followed by "no" WTP is between the initial bid and the upper bid, ny a "no" answer followed by "yes" WTP is between the lower bid and the initial bid, and nn both answers are "no" WTP is between zero and the lower bid (Vanit and Schmidt, 2002). The probabilities of these outcomes are denoted as π^{yy}, π^{yn} π^{ny} and π^{nn} . The set of bids may be represented as B_1 for the initial bid, B_0 for the lower bid and B_2 for the upper bid. The probabilities of these four outcomes basing on the dichotomous choice model, is expressed as follows: accepting the first bid the consumer WTP was greater than the bid. If the consumer rejected the first bid, then his/her WTP was less than the initial bid. The probabilities of those outcomes may be expressed as in equations 12 to 15 below.

$$\pi^{yy}(B_{i1}B_{i2}) = \Pr(B_{i1} \leq Max\ WTP \leq B_{i2}) = \Pr(B_{i2} \leq Max\ WTP) = 1 - G(B_{i2}; \theta) \quad (12)$$

$$\pi^{yn}(B_{i1}B_{i2}) = \Pr(B_{i1} \leq Max\ WTP \leq B_{i2}) = G(B_{i2}; \theta) - G(B_{i1}; \theta) \quad (13)$$

$$\pi^{ny}(B_{i1}B_{i0}) = \Pr(B_{i1} > Max\ WTP \leq B_{i0}) = G(B_{i1}; \theta) - G(B_{i0}; \theta) \quad (14)$$

$$\pi^{nn}(B_{i1}B_{i0}) = \Pr(B_{i1} > Max\ WTP < B_{i0}) = \Pr(B_{i0} > Max\ WTP) = G(B_{i0}; \theta) \quad (15)$$

Where $G\ (B, \theta)$ is the cumulative distribution factor (CDF), with parameter vector θ to be estimated (Hanemann *et al.*, 1991). With a sample size of N where B is;

$$L(\theta) = \sum_i^N \{ d_i^{yy}.\pi^{yy}(B_{i1}B_{i2}) + d_i^{yn}.\pi^{yn}(B_{i1}B_{i2}) + d_i^{ny}.\pi^{ny}(B_{i1}B_{i0}) + d_i^{nn}.\pi^{nn}(B_{i1}B_{i0}) \quad (16)$$

Where d_i^{yy}, d_i^{yn}, d_i^{ny} *and* d_i^{nn} are binary valued indicator variables, where $d_i^{yy} = 1$ for yes-yes response 0 otherwise, $d_i^{yn} = 1$ for yes-no response, otherwise 0; $d_i^{ny} = 1$ for no –yes response, otherwise 0; and $d_i^{nn} = 1$ for no- no response 0 otherwise.

The final model, selected to analyse the dependence of WTP on socio-economic characteristics, is as shown in equation 17 below.

$$WTP = B_0 + B_1 Occup + B_2 Gender + B_3 Age + B_4 Educ + B_5 Hhsize + B_6 Landsize + B_7 Weath\inf + B_8 Exten + B_9 Grpmb + B_{10} Credit + B_{11} Dmkt + B_{12} Cropinc + B_{13} Ward2 + B_{14} Ward3 \quad \ldots\ldots\ldots\ldots(17)$$

Table 2: Definition of variables that are used in the study

Variables	Definition	Measurement	Expected sign
Dependent variable			
Response	number of strategies used per farmer	Continuous	
WTP	Farmers willingness to pay	1= Yes 0 = No	-
Explanatory Variables			
Age	Age of household head	Continuous	+/-
Credit	Access to credit for the use of adaptation strategies	1 = Yes 0= No	+
Gender	Gender of household head	1 = Male 0 = Female	+/-
Educ	Education level of household head	Years spend in school	+
Hhsize	Total number of members of the household	Continuous	+/-
Landsize	Size of land owned by the household	Continuous	+
Occup	Whether respondent mainly into farming or not	1 = Yes 0 = No	+/-
Exten	Number of visits received from any extension	Continuous	+
Dmkt	Distance to the main market	Continuous	+/-
Grpmb	Membership to a group	1 = Yes 0 = No	+
Weathinf	Access to weather information	1= Yes 0 = No	+
Cropinc	Income from sale of maize	Continuous	+/-
Wards	Ward dummies with Ward1 as reference category	1= Yes 0 = No	+/-

CHAPTER FOUR
RESULTS AND DISCUSSION

This chapter discusses empirical findings of the study and is divided into two major sections. It starts by presenting descriptive statistics for socio-economic and institutional characteristics of smallholder farmers based on their willingness to pay for crop insurance. Then it also presents results of Multi Variate Probit model on factors influencing the farmers' response to effect of climate variability and double bounded dichotomous choice model on factors influencing farmers' willingness to pay for crop insurance as a response to climate variability. In general, 69.04% of the interviewed farmers were not willing to pay for crop and livestock insurance while 30.96% expressed their WTP for crop insurance.

4.1 Descriptive statistics

4.1.1 Farmer and farm characteristics

Table 3 presents results of household head's main occupation, gender and education level by willingness to pay. The main occupation of 66.39% of the households' heads who were willing to pay for crop insurance was farming as compared to 65.44% who were not willing. Farmers who exclusively depend on agriculture may have high experience in farming, hence aware of risk and uncertainties associated with climate variability. This makes them knowledgeable on the different available alternatives to respond to climate change, therefore they are ready to pay for insurance because they depend exclusively on agriculture and are ready to invest in order to maximize the agricultural profits. Shongwe *et al*. (2014) noted that when households are fully engaged in farming, they will have enough time to explore more adaptation options and focus all their resources to farming since it is their livelihood than those with other sources of income.

In terms of the gender of the household head, 63.11% of those willing to pay were male as compared to 65.07% of those who were not willing to pay. Having a male as the head of household may increase willingness to pay because men may have access to information, land, and other resources, which women may lack due to traditional social barriers. The gender of the household head influences the household's access to land, credit and other productive resources in Africa and other developing countries (FAO 2011). Temesgen *et al*. (2009) found that male-headed households adapt more readily to climate because they have more access to improved technology, information on climate, credit and extension services than female headed household. This helps them to respond to the impacts of climate variability. Male-headed households are often considered to be more likely to get information about new technologies and take risky businesses than female-headed households (Asfaw and Admassie, 2004).

Table 3: Education level, occupation and gender of the household head (%)

Variables	**Description**	**Willing to pay**	**Not willing to pay**	***Chi* Square**
Gender	Male	63.11	65.07	0.1411
	Female	36.89	34.93	
Education	Informal	18.85	21.30	
	Primary	47.54	62.50	
	Secondary	13.93	11.40	30.9048***
	College	9.84	4.40	
	University	9.84	0.40	
Occupation	Farmer	66.39	65.44	0.0339
	Otherwise	33.61	34.56	

*** = Significant at 1% level

There was a significant association between farmers' level of education and farmers' willing to pay for crop insurance at 1% significance level. In terms of educational level, majority about 79% of the farmers had formal accessed education as compared to 21% that had not accessed formal education. Results in Table 3 indicate that 47.54% of farmers willing to pay went to primary school compared to 18.85%, 13.93% and 19.68 % who had no formal education, secondary school and tertiary education, respectively. Among those not willing to pay 21.3% had no formal education, while 62.5% went to primary school, 11.4% secondary school, and only 4.8% had attained tertiary education in the category. Farmers with higher level of education are likely to be more aware of the problems associated with climate change and importance of insurance, hence would exert more effort to pay for insurance cover to reduce the impact of climate change. Danso-Abbeam (2014) noted that better educated farmers are more likely to understand the insurance policy and therefore, are likely to buy insurance policy than their counterparts with less education level. Educated and experienced farmers are expected to have more knowledge and information about climate change and agronomic practices that they can use to respond to effects of climate variability (Maddison, 2006). Education level of farmers is assumed to increase the ability to obtain process and use information relevant to the use of improved agricultural technologies (Anley *et al.,* 2007)

Table 4 presents results of mean age, household size, land size and distance to market**.** Household heads who were willing to pay for insurance had lowest mean age of 46.49 years as compared to 53.82 years for those not willing to pay. There is a significant difference in the mean age of farmers by willingness to pay at 1% level of significance. Younger farmers are more flexible in adapting to new ideas, less risk averse, and more innovative, hence are more willing to pay for insurance than older farmers who are more conservative to adopt new technologies. Wairimu *et al*. (2016) found that younger farmers had higher probability of adopting *Kilimo Salama* insurance than older farmers in Kenya. This was attributed to older farmers' high experience in farming and consequent awareness of risk and uncertainties, they had put in place other risk management strategies other than *Kilimo Salama* insurance.

Table 4: Mean age, household size, distance to market and land size of the respondents

Variable	**Willingness to pay**	**Mean**	**Std. Err.**	***t-Stat***
Age	No	53.82	0.78	5.9496***
	Yes	46.49	0.63	
Hhsize	No	5.52	0.11	-2.4453**
	Yes	6.05	0.20	
Dmkt	No	5.38	0.17	-0.2172
	Yes	5.45	0.27	
Landsize	No	3.99	0.14	-3.4739***
	Yes	4.96	0.28	

***, **= Significant at 1% and 5% significance level respectively

Households willing to pay for crop insurance had an average of 7 members compared to 6 members for those not willing to pay for crop insurance and was significantly different at 5% level. Higher willingness to pay for larger households may be due to the increased need of being food secure. More household members require more food, hence the need for an assured produce resulting to the demand of insurance. Many family members may generate more income, hence they can be able to pay for insurance. It may also be due to the increased labour force on the farm, which leads to investment in more enterprises in order to increase production, hence more need for cover due to the increased associated risk. Temesgen *et al*. (2008) found larger household size increased significantly the probability of adapting to climate change because large family size is normally associated with a higher labour endowment, which would enable a household to accomplish various agricultural tasks. Households with large numbers have more labour and need more food thus willing to adopt *Kilimo Salama* to increase production (Abdulai *et al*., 2008).

The mean distance to the market for those who were willing to pay for insurance was higher at 5.45 km as compared to those who were not willing to pay at 5.38. Long distance to the market may translate to difficulty in access to important agricultural amenities, particularity if roads are in bad condition, which may lead to increased risk of losses through perishability due to delayed access to the market. This necessitates the need to cushion the farmer against the potential losses that may be incurred, hence the higher willingness to pay. Farmers who are far from markets may experience difficulties in accessing essential services such as inputs, market prices and market trends, which increases risks on the part of the farmer, hence the need to be cushioned by insurance to reduce the risk increasing their willingness to pay. The findings were in contrast to those of Wairimu, (2013) who found that adoption of an insurance scheme decreased as the distance to markets increased by one kilometer.

The mean land size for those willing to pay for insurance is higher at 4.96 acres compared to those not willing to pay at 3.99 acres. There was a significant difference in the land sizes at 1% level. Farmers with larger land sizes may face potentially higher investment risks than those with small sizes and are assumed to have easier access to credit and farm inputs and thus are more likely to pay for insurance. Further, land size is a sign of wealth and those with larger sizes are assumed to have more financial ability to pay for crop insurance. Gbetibouo (2009) showed that farm size positively and significantly increases the likelihood of adapting to climate change. Akhter (2013) noted that farmers with larger landholdings are more willing to participate in food and cash crops insurance because they are at a higher risk than those with small land sizes.

Table 5 presents the results of access to weather information, extension services, credit and group membership. Slightly lower than half of household heads who had received weather information (44.26%) were willing to pay for crop insurance as compared to 55.88% who were not willing to pay. There was a significant relationship between access to weather information and willingness to pay for crop insurance at 5% significance level. The higher percentage of those who received information not willing to pay may be due to their preparedness to deal with anticipated changes using other methods other than insurance. Farmers who are aware of change in climatic conditions have higher chances of taking adaptive measures in response to observed changes. This is an important precondition for farmers to take response measures in adapting to changes in climatic conditions. Climate change awareness especially on the levels of temperature and precipitation is important for adaptation decision making (Maddison, 2006).

Table 5: Farmers access to weather information, extension services, group membership and credit (%)

Variables	Description	Willing to pay	Not willing to pay	Chi-square
Weathinf	Yes	44.26	55.88	4.5584**
	No	55.74	44.12	
Exten	Yes	69.67	33.09	45.6586***
	No	30.33	66.91	
Grpmb	Yes	77.05	54.04	18.7656***
	No	22.95	45.96	
Credit	Yes	56.56	20.96	49.0745***
	No	43.44	79.04	

** and *** denote significant at 5% and 1% level respectively.

The results in Table 5 indicate that 69.67% of those willing to pay for insurance had access to extension services as compared to 30.03% who were not willing to pay. The results show that there is significant relationship between access to extension services and farmers' willingness' to pay for crop insurance at 1% significance level. Willingness to pay for crop insurance can be enhanced by information on agronomic practices as well as on climate variability and availability of different agricultural insurance schemes. Extension service providers may be a source of such information, hence farmers with more access to information and technical assistance on agricultural activities have more awareness about the consequence of climate change resulting to increase in their willingness to pay for insurance. Farmers who have high extension contacts have better chances to be aware of changing climatic conditions and also of the various management practices that they can use to respond to variability in climatic conditions (Nhemachena *et al.*, 2014).

In terms of group membership, 77.05% of those who were willing to pay for crop insurance belonged to a group compared to 54.04% who were not willing to pay. There was a significant relationship between group membership and willingness to pay for crop insurance at 1% significance level. Farmer groups are important channels through which information on new technologies are transferred to farmers and also they facilitate access to financial services to members, this access to finances and information may influence willingness to pay for crop insurance by members. Shongwe *et al.* (2014) noted that social groups such as farmers' cooperatives provide information on farming, credit and resources that can be used when adapting to climate change. Groups may expose individuals to access financial assistance and information about an innovation and causing subsequent adoption (Ndunda and Mungatana, 2013).

Results show that 56.6% of those who were willing to pay for insurance had access to credit compared to 20.96% who were not willing. There was a significant relationship between access to credit and willingness to pay for crop insurance at 1% significance level. Access to affordable credit increases financial resources of farmers, hence they are able to explore increased methods of adapting to climate change including insurance. Farmers with access to credit and markets have high chances of adapting to changing climate conditions. Access to affordable credit increases financial resources of farmers and their ability to meet transaction costs associated with the various adaptation options they might want to take (Nhemachena *et al.*, 2014). With more resources at their disposal farmers are able to change their management practices in response to changing climatic and other factors. They are also able to make use of information they might have on changing conditions both climatic and other socioeconomic factors (Nhemachena and Hassan, 2007).

4.1.2 Principal components for crop and livesock response strategies to climate variability

Table 6 presents the principal component analysis (PCA) for farmer response strategies. PCA was performed on standardized variables to condense all the information from the original interrelated variables to a smaller set of factors called principal components (Abdi, 2007). Factors were rotated using orthogonal rotation (varimax method) so that smaller number of highly correlated variables might be put under each factor and interpretation becomes easier (Field, 2005). In accordance with Kaiser's criterion, all factors exceeding an eigenvalue of one were retained and interpreted. A total of seven components were generated with the clusters found after unrestricted grouping test was done.

Results in table 6 show rotated factor (Varimax) matrix of independent variables for response strategies with factor loadings for each variable. The communality column shows the total amount of variance of each variable retained in the factors. For the interpretation of the Principal components small values indicate variables that do not fit well with the factor solution, and should possibly be dropped from the analysis, variables with high factor loadings and high communality of 0.6 and above were considered from the rotated factor matrix (Harris, 2001).

In total, 20 variables were included in PCA, of which 7 principal components with eigenvalues greater than 1 were retained for further analysis. These seven PCs explained 66.75% of total variability in the dataset. A closer look at each column of Table 6 helps us to define each component according to the strongly associated variables. The first component explains 16.93% variance and is correlated with increased use of organic fertilizers, early planting, water harvesting and irrigation, replanting fenced paddocks, crop rotation and intercropping. Thus the component represents cultural practices. The second component explains 11.84% variance and is correlated with reduction of herd, increase herd, adaptable species and Keeping of browsers. The component can be viewed to represent risk reduction practices. The third component explains 10.44% variance and is correlated with zero grazing, improved fodder and mulching, hence the component represents intensification practices. The fourth component explains 8.83% variance and is correlated with Staggering planting dates and new farm animals thus it represents crop and herd management practices. The fifth component explains 7.68% and is correlated with diversification and abandoning livestock keeping. This can be viewed as diversification strategies. The sixth component explains 5.53% and is correlated with new breeds. The last component explains 5.4% and is correlated with use of terraces, hence the groups formed are: cultural practices, risk reduction practices, intensification practices, crop and herd management practices, diversification practices, new breeds and use of terraces.

According to Bruin (2006), Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) is a measure that varies between 0 and 1, and values closer to 1 are better. A value of 0.6 is a suggested minimum. The Barnett's test of sphericity tests the null hypothesis that the correlation matrix is an identity matrix. These tests together provide a minimum standard, which should be passed before a principal components analysis should be conducted. The KMO value of 0.68 and the Bartlett's test of sphericity with an associated p value of <0.000 indicates that I can proceed with PCA.

Table 6: Principal component analysis for crop and livestock response strategies

Practices	**comp 1**	**comp2**	**comp 3**	**comp 4**	**comp 5**	**Comp 6**	**comp 7**	**Communal-ity**
Water harvesting	**0.52**	-0.11	0.02	0.05	-0.39	-0.26	-0.25	0.60
Increase manure	**0.56**	0.30	-0.22	-0.23	0.27	0.09	-0.01	0.60
Early planting	**0.72**	0.26	-0.23	-0.12	-0.10	0.00	-0.11	0.67
Replanting	**0.48**	-0.25	-0.41	0.34	-0.05	-0.04	0.17	0.60
Staggering planting dates	0.15	0.35	0.02	**0.69**	-0.16	-0.35	-0.01	0.76
Reduction of herd	0.25	**0.78**	0.05	-0.04	0.00	-0.11	-0.20	0.72
Increase of herd	0.45	**-0.56**	-0.39	-0.10	-0.10	0.05	0.07	0.69
New farm animals	0.22	-0.09	0.20	**0.49**	0.16	0.48	-0.03	0.60
Zero grazing	-0.29	-0.19	**0.51**	0.31	0.37	-0.05	0.38	0.76
New breeds of animals	-0.20	0.00	-0.02	0.44	-0.34	**0.58**	-0.32	0.78
Fencing	**0.55**	-0.26	-0.31	0.07	0.38	0.15	-0.19	0.67
Improved fodder	0.43	-0.24	**0.53**	0.06	-0.11	-0.22	-0.01	0.60
Crop rotation	**0.49**	-0.39	0.25	0.04	-0.27	0.19	0.23	0.61
Intercropping	**0.57**	-0.32	0.36	0.18	-0.08	-0.20	0.00	0.64
Adaptable species	0.28	**0.58**	0.29	0.28	-0.04	0.13	0.28	0.67
Divesification	0.41	-0.03	0.08	-0.27	**0.47**	0.05	0.30	0.60
Terracing	0.07	-0.18	0.44	0.11	0.43	-0.22	**-0.52**	0.74
Keep browsers	0.22	**0.42**	-0.42	0.40	0.27	-0.06	0.21	0.67
Abandon livestock	0.30	0.30	0.40	-0.40	**-0.46**	0.15	0.25	0.79
Mulching	0.39	0.23	**0.45**	-0.24	0.25	0.31	-0.24	0.67
Eigenvalues	3.39	2.37	2.11	1.77	1.54	1.11	1.08	
Cummulative	16.93		39.31		55.82	61.35	66.75	
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.								0.68
Bartlett's Test of Sphericity				Approx. Chi-Square				2053.43
					df			190.00
					Sig.			0

Extraction Method: Principal Component Anaysis

Table 7 indicates the components, respective practices and adoption percentage of farmers who use adoption practices. Cultural practices, diversification practices and risk reduction practices were used by majority of farmers at 97.5%, 85% and 74.1%, respectively. These practices may be considered as basic practices that are less technical and mostly do not require much formal expert knowledge, hence can be carried out by many farmers. Intensification practices followed by 69.3% this can be attributed to extension messages and training. Terraces crop and herd management and new breeds were the least adopted at 27% and 13.2% and 9% respectively. This strategies may be constrained by access to technical knowledge, land availability and substantial financial investment to implement, hence only few farmers who can access one of the above are able to implement them. This explains the low level of adoption among the households.

Table 7: Crop and livestock components, respective practices and adoption percentage

Component	**Practices**	**Percentage**	
		Adopters	**Non Adopters**
Cultural practices	Increased use of organic fertilizers Early planting Water harvesting and irrigation Replanting Fenced paddocks Crop rotation Intercropping	97.50	2.50
Risk reduction practices	Reduction of herd Increase herd Adaptable species Keep browsers	74.10	25.90
Intensification practices	Zero grazing Improved fodder Mulching	69.30	30.70
Crop and herd management practices	Staggering planting dates New farm animals	13.20	86.80
Diversification practices	Diversification Abandon livestock	85.0	15.0
New adaptive Breeds	New breeds	9.0	91.0
Terraces	Terrace	27.0	73.0

4.2 Socio-economic and institutional factors that influence farmers' response to effects of climate variability.

To respond to climate change and reduce its negative effects, a combination of strategies are used by the farmers in the study area. The strategies are categorized into groups depending on their use and relatedness as in Table 7. To determine the socio-economic and institutional characteristics that influence the choice of response strategies, Multivariate Probit model was used. The results are presented in Table 8 for choice of crop response strategies.

From table 8 (lower panel), the results on correlation coefficients of error terms indicate that there are complementarities (positive correlation) between different response options being used by farmers. The results supports the assumption of interdependence between the different adaptation options. A likelihood ratio test based on the log-likelihood values indicate significant correlations χ 2 (91) = 306.38; probability > χ 2 = 0.0000 justifying that the explanatory power of the multivariate Probit model had a strong effect.

Table 8: Multivariate probit results for factors affecting the use of crop response practices

	Cultural	**Risk**	**Intense**	**Crop and Herd**	**Diverse**	**New Breeds**	**Terrace**
Variable	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
occup	-0.27(0.33)	0.27(0.16)*	-0.07(0.15)	0.34(0.21)	-0.11(0.18)	0.53(0.20)***	-0.14(0.15)
gender	0.26(0.32)	-0.20(0.16)	0.18(0.14)	0.48(0.23)**	-0.11(0.19)	0.30(0.22)	0.22(0.15)
age	0.02(0.02)	0.01(0.01)*	0.01(0.01)**	0.01(0.01)	0.00(0.01)	0.00(0.01)	0.01(0.01)**
educ	-0.06(0.22)	0.11(0.10)	-0.11(0.09)	0.21(0.11)**	-0.05(0.11)	0.30(0.10)***	0.14(0.09)*
hhsize	-0.17(0.08)**	-0.10(0.04)**	0.01(0.04)	-0.01(0.05)	-0.01(0.04)	-0.03(0.05)	-0.01(0.04)
landsize	0.03(0.07)	0.01(0.03)	0.06(0.03)*	0.10(0.04)***	0.08(0.04)*	-0.05(0.04)	0.01(0.03)
weathinf	0.63(0.40)	0.74(0.16)***	0.49(0.15)***	0.39(0.22)*	0.34(0.19)*	-0.12(0.20)	-0.06(0.15)
exten	-0.21(0.38)	0.10(0.16)	0.27(0.15)*	-0.08(0.21)	-0.21(0.18)	0.18(0.20)	0.42(0.15)***
grpmb	0.51(0.38)	0.14(0.16)	-0.07(0.16)	0.38(0.24)	0.15(0.19)	0.53(0.23)**	0.12(0.16)
credit	1.15(0.65)*	-0.26(0.17)	0.17(0.16)	-0.15(0.22)	-0.05(0.20)	-0.04(0.20)	0.28(0.16)*
dmkt	-0.07(0.06)	-0.06(0.03)**	0.03(0.02)	0.07(0.03)**	-0.08(0.03)***	0.06(0.03)*	0.07(0.03)***
ward2	-0.96(0.34)***	-0.62(0.17)***	-0.40(0.17)**	0.22(0.26)	-1.10(0.20)***	0.73(0.23)***	-0.11(0.17)
ward3	-0.03(0.59)	0.44(0.26)*	-0.72(0.20)***	1.48(0.24)***	-1.06(0.24)***	0.65(0.25)***	-0.73(0.25)***
_cons	2.32(1.14)*	0.42(0.52)	-0.60(0.48)	-4.09(0.73)***	1.88(0.60)	-2.90(0.67)***	-1.96(0.48)***
Rho2	0.24***						
Rho3	0.03***	0.01					
Rho4	0.06	0.16	0.08**				
Rho5	0.20***	0.27***	0.17	-0.13			
Rho6	0.05	-0.13***	-0.17 ***	0.19*	-0.29 ***		
Rho7	0.03**	-0.07	0.26***	0.07***	0.08	-0.07	
Observations						394	
Log Likelihood						-920.34	
Wald χ 2 (91)						306.38	
Prob > χ 2						0.0000	Likelihood

ratio test of rho21 = rho31 = rho41 = rho51 = rho61 = rho71 = rho32 = rho42 = rho52 = rho62 = rho72 = rho43 = rho53 = rho63 = rho73 = rho54 = rho64 = rho74 = rho65 = rho75 = rho> 76 = 0: chi2(21) = 117.229 Prob > chi2 = 0.0000 ***, **, * = Significant at 1%, 5% and 10% significance level, respectively

Figures in parenthesis represent standard errors

Households which exclusively depended on agriculture were more likely to introduce new breeds at 1% significance level and use risk management practices at 10% significance. Farmers who have no other off farm occupation dedicate all their time and resources to agriculture, hence they can, reduce or increase herd size or introduce adaptable species they can also invest in introducing new breeds in order to improve their incomes. Shongwe (2014) argues that when fully engaged in farming, households will have enough time to explore more adaptation options and focus all their resources to farming since it is the main source of livelihood to them as compared to those with other sources of income. Zou (2014) also noted that off farm occupation share most of farmers' time, farmers pay little attention to their farming activity.

Male headed households were more likely to take up crop and herd management practices at 5% significance level. Male house hold heads have more access and control over productive resources hence can make decisions on undertaking activities which require substantial investment in their efforts to curb the effect of climate variability. Male and female headed households perceive and experience climate change in diverse ways because of their distinct socially constructed gender roles, responsibilities, status and identities. This leads to diversified responses to climate variability, with men leaning towards those that need much labour and more long term and require more finance like introducing new animals. This is in line with Atinkut and Mebrat (2016) who found that male headed households have greater preferences to use strategies that require labor, finance and climate information than female headed households. Moreover, Abaje *et al*. (2014) noted that unlike men, women have limited access to information, land and other resources due to traditional social barriers hence have lower probability of adopting response measures. However, other studies Baten and Khan (2010) and Bewket (2010), found that female-headed households are more likely to take up climate change adaptation methods because in most rural smallholder farming communities, much of the agricultural work are done by women while men stay in towns.

Older household heads were more likely to use intensification strategies and introduce terraces at 5% significance and risk reduction practices at 10% significance as response strategies to climate variability. There is higher likelihood of perceiving climate change with increasing age of the head of the household associated with experience, which lets farmers observe changes over time and compare such changes with current climatic conditions. Older farmers are more likely to have more information and knowledge on changes in climatic conditions and crop and livestock management practices. This makes them ready to respond to climate change using different methods. Experienced farmers are usually leaders and progressive farmers in rural communities and are mostly targeted by extension agents and other stakeholders in promoting response adaptation to changing climatic conditions. Mudombi-Rusinamhodzi *et al.* (2012) notes that as household head gets older, more educated and acquires more faming experience; responsiveness to climate variability induced hazards will increase. However other studies had contradicting findings. Kansiime *et al*. (2014) finds that younger household heads are more likely to respond than older ones because of the current speed of climate change which has modified known variability patterns to a great extent. This has resulted into farmers being confronted with situations they are not equipped to handle, despite their farming experience.

More educated household heads were more likely to introduce new breeds, use crop and herd management and construct terraces. There was significant relationship between education level and introduction of new breeds, use of crop and herd management and construction of terraces as response strategies at 1%, 5% and 10% significance level, respectively. Introduction of new breeds, new farm animals and terrace construction are strategies which need higher technical know-how. More educated farmers are likely to be more knowledgeable and progressive, hence can easily implement these strategies. Being more educated improves the ability to access information and interpret the information. This may influence uptake of response strategies such as introducing new farm animals and new breeds. Higher level of education may also enhance access to off-farm employment. The extra income can be used to invest in terraces, introduce new farm animals and new breeds. Higher education level may also influence farmers' attitudes and decisions, making them more open, rational and able to analyze the benefits of response strategies. Onubuogu and Esiobu (2014) found similar results in choosing climate change adaptation options attributed to educated farmers having more knowledge on response to climate change strategies. In contrast, Wardekker *et al*. (2011) found that higher education levels and higher cash earnings put farmers in a less vulnerable situation hence they are less likely to respond to climate variability.

Households with many members were less likely to use cultural practices and risk reduction strategies at 5% significance level to reduce the impact of climate variability. Some of the strategies such as water harvesting, early planting, crop rotation and intercropping, use of paddocks, increasing and reducing herd size do not require much labour which may be provided by a large household. More household members increase pressure on the income of the household heads and the farm incomes. This leads to much income being diverted to the consumption expenditure at the expense of being invested in the response practices. Members of a larger household may be tempted to revert to off farm activities in order to get extra income to cater for the increased needs. This leaves them with less time to concentrate on farming activities. The findings are in line with the finding of Legesse *et al*. (2013) who found that households with large family sizes and who are currently using these strategies will have a likelihood of falling back to the base case. This is however in contrast to the findings of Zou (2014) who argued that, large family size is normally associated with a higher labour endowment, which would enable a household to accomplish various agricultural tasks, which are labour intensive.

Households with large land sizes are more likely to use crop and herd management practices, intensification practices and diversification as responses to climate variability. There was significant relationship between land size and use of crop and herd management practices, intensification practices and diversification at 1% and 10% significance level respectively. Large farm size allows farmers to diversify farm enterprises to minimize climatic and agricultural risks. Zero grazing also needs land for pasture and fodder cultivation in order to minimize the production costs. Land is an asset an particularly during the dry spells may be used by farmers to access credit and other resources that can enable the implementation of capital intensive response strategies like zero grazing, planting improved fodder, introduction of new animals. Mugonola *et al*. (2013) noted that land size has been reported to influence the adoption of new technologies. This is because land is a form of saving for smallholder farmers, which may be used to enable the farmers to buy the inputs like fertilizers, improved seeds and other necessary inputs.

There was significant relationship between access to weather information and use of risk reduction practices and intensification practices at 1% significance level, crop and herd management and diversification at 10% significance level. Practices such as staggering planting dates, introducing adaptable species, mulching, reducing herd size and abandoning livestock may depend on prior knowledge of the farmer about the anticipated variability in climate. Access to information on variability is likely to enhance their probability to perceive climate variability and take-up adaptation techniques. If farmers receive information about rainfall, they are more likely to adjust planting time, reduce herd size, perform mulching plant improved fodder or keep browsers depending on the nature of the information. This is in agreement with Aemro *et al*. (2012) who noted that getting information about seasonal forecasts and climate change increase the probability of using a combination of adaptation strategies. Farmers make comparative decisions among alternative adaptation practices and hence choose the best.

Households with access to extension services were more likely to us terraces and intensification practices. The results indicate there is a significant relationship between access to extension and use of terraces and intensification practices at 1% and 10% significance level respectively. Extension agencies act as a link between the innovators (researchers) of the technology and users of that technology. They focus on the provision of training, which improves the skills of household members to improve their own situation and adaptive capacity. Farmers who have significant extension contacts have better chances to be aware of changing climatic conditions and also of the various management practices that they can use to adapt to changes in climatic conditions. Mulching, planting improved fodder, zero grazing and terrace construction are some of the practices that most extension agents encourage farmers to practice because they are considered to be the basic practices that can be easily implemented by farmers. Extension agents transfer modern agricultural technologies to farmers to help them counteract the negative impact of climate change. Atinkut and Mebrat (2016) found that increased extension contacts is likely to increase the probability of the farmer to adapt crop-diversification, soil and water conservation and seasonal migration because farmers who have access to extension services are more likely to be aware of climatic conditions. Aymone (2009) also noted that extension on crop and livestock production represent access to the information required to make decision on adaptation to climate change.

Farmers who belonged to a group were more likely to introduce new farm animals to respond to climate variability. There was a significant relationship between group membership and introduction of new farm animals 5% significance level. In technology adoption, group membership enhances social capital which plays a significant role in information exchange. Information about new farm animals among others can be found through the interaction of different group members who have different experiences. Membership to a group encourages farmers to engage in a united strategies orientation, hence they share knowledge and innovative ideas, discuss problems and challenges with others and engage in collaborative decision making. Groups also increase the chances of members accessing credit and hence enhancing their financial muscle to invest in buying new farm animals which are adaptive to prevailing climatic conditions. Farmers within a social group learn from each other the benefits and usage of a new technology (Mignouna *et al*., 2011). Mwangi and Kariuki (2015) noted that although many researchers have reported a positive influence of social group on technology adoption, social groups may also have a negative impact on technology adoption especially where free-riding behavior exists.

Access to credit increases the likelihood of implementing cultural practices and terrace construction at 10% significance level. Credit increases finances available to the farmers to take up different response strategies especially those that command substantial investments like water harvesting and irrigation, increased use of organic fertilizer and terrace construction. This is in line with the findings of (Nhemachena *et al*., 2014) who found credit to have a positive impact on adaptation strategies. They argued that with more financial and other resources at their disposal, farmers are able to change their management practices in response to changing climatic and other factors. They are able to make use of all the available information they might have on changing conditions both climatic and other socioeconomic factors. However the result is in contrast to other studies, Nyanga (2011) noted that relatively rich farmers often have better access to credit but are less likely to adopt conservation agriculture. This may be explained by the more livelihood options that resources rich farmers may have as compared to the resource poor ones.

Distance to the market reduces the likelihood of using diversification practices at 1% significance and risk reduction practices at 5% significance. While it increases the likelihood of using terraces, crop and herd management and new farm animals at 1%, 5% and 10% significance level respectively. Access to markets by smallholder farmers has a strong impact on agricultural production through its influence on the profitability of agricultural output and household incomes. Any surplus incomes obtained may be invested in diversification and risk management technologies provided the required inputs that complement the technologies are also accessible in the markets. Longer distances tend to increase transaction costs, hence minimizing the surplus that can be used in responding to climate variability. This is in line with Zou (2014) who noted that distant farmers have higher transaction cost for acquiring input and output thereby reducing the relative advantage of adopting new technologies.

Proximity to market is an important determinant of adaptation, presumably because the market serves as a means of exchanging information with other farmers (Maddison, 2006). On the contrary, longer distance to the market increases the likelihood of using crop and herd management, new breeds and terraces. Farmers who are further from the market may encounter problems of information asymmetry on both input and output markets. This may increase the costs incurred by the farmers making them to stagger planting dates in order to reduce risk. On the other hand, farmers may decide to respond by introducing new farm animals and new breeds in order to reduce the costs of accessing from the market. Seifu (2016) found similar results and attributed the remoteness from markets to favor multiple cropping over specialized crop cultivation.

In terms of regional effects, farmers living in Ng'arua were significantly likely to introduce new breeds as a response to climate variability at 1% significance level relative to Nyahururu farmers. Nyahururu farmers by contrast were likely to uptake cultural practices, risk reduction and diversification practices at 1% significance level and intensification at 5% significance level than Ngarua farmers. Ng'arua and Nyahururu are both classified as Mixed Farming (MF) zones GoK (2016) but Ng'arua borders Marginal Mixed farming zones which differentiates it from Nyahururu. Farmers in Ng'arua have substantially larger land sizes hence are able to introduce new breeds of animals on the farm. They are mainly wheat and maize farmers which could be used to facilitate access to fodder for new breeds of animals through crop residues. Inadequate grazing lands necessitate the need for new breeds that can utilize the available feeds. In Nyahururu farmers mainly plant maize and horticultural crops and had relatively small plots. This makes it easy for them to practice mulching, crop rotation, replanting and increased use of organic fertilizer. There is also need to practice zero grazing because of limited space and promotes simple irrigation for the crops.

Olmoran farmers were likely to adopt crop and herd management practices and introduce new breeds as responses to climate variability at 1% and risk reduction practices at 10% significance compared to their Nyahururu counterparts. Nyahururu farmers on the other hand are likely to uptake intensification diversification and terraces at 1% significance level. Olmoran is classified as a Marginal Mixed Farming (MMF) zone, while Nyahururu is classified as a Mixed Farming (MF) zone (GoK, 2016). Olmoran is drier, receives more unreliable rainfall and characterized with more harsh conditions than Nyahururu. This makes more farmers in Olmoran to revert to planting adaptable species, reducing herd sizes, keeping browsers or introducing new animals and breeds which can thrive in the harsh environmental conditions. However, the farmers may not abandon livestock, practice zero grazing or plant improved fodder. This can be attributed to the preservation of cultural and traditional systems of agriculture within Olmoran and also the continuous human wildlife conflicts in the region. A report by the GoK (2016) noted that some parts of MMF (Olmoran) are still recording deteriorating body condition of livestock due to lack of pasture contributed to by inadequate rain.

4.4. Socio economic factors affecting willingness to pay for selected crop insurance

Double bounded dichotomous choice model was used to estimate the factors affecting farmers' willingness to pay for crop insurance Double bounded dichotomous choice questions expand the information base of the WTP estimates and provides efficient assessment than Single bounded dichotomous choice questions (Haneman *et al*, 1991). This is because; the number of responses is increased so that a given function is fitted with more data points, the sequential bid offers for yes-no and no-yes responses yields clear bounds on WTP. Finally, the no-no and yes-yes combinations, improves efficiency as they indicate where the respondent's WTP are likely to reside. The results of the double bounded dichotomous choice model are presented in table 9. According to the results, the model chi-square tests applying appropriate degrees of freedom indicate that the overall goodness of fit of the model was statistically significant Prob > chi2 0.0001 combined with a log likelihood of -176.64283 indicate the strong effect of double bounded dichotomous choice model.

Table 9: Double bounded dichotomous choice model results for factors affecting farmers' willingness to pay for crop insurance.

Variables	Coefficients	Standard error	P>Z
Occup	0.161**	0.078	0.039
Gender	-0.111	0.077	0.151
Age	-0.006	0.005	0.219
Educ	-0.031	0.035	0.378
Hhsize	-0.009	0.016	0.593
Landsize	0.003	0.012	0.791
Weathinf	0.077*	0.084	0.357
Exten	-0.145*	0.084	0.084
Grpmb	0.153	0.086	0.075
Credit	0.039	0.076	0.610
Dmkt	0.015	0.014	0.265
Cropinc	0.055	0.049	0.266
ward2	-0.070	0.096	0.467
ward3	-0.574***	0.136	0.000
_cons	10.555***	0.610	0.000
Cons	0.362	0.030	0.000

Number of obs	131
Wald chi2 (14)	42.88
Log likelihood	-176.64283
Prob > chi2	0.0001

From table 9, households which exclusively depended on agriculture were more willing to pay for insurance as compared to household heads who have other off farm occupation. There is a significant relationship between occupation of the household head and willingness to pay for crop insurance at 5% significance level. This is because a pure farmer entirely depends on agriculture for income hence is willing to invest in different adaptation options including insurance in order to increase or at least safeguard the yields. Farmers who have other off farm occupation may have extra income that can be used to cushion them from any eventual risks, hence reducing the willingness to pay for crop insurance. Also having off farm occupation reduces the amount of time available for agricultural activities this leads to an individual investing less in agriculture hence less willing to pay. Previous studies (Adebe and Ayalneh, 2014; Shongwe, 2014) found that when fully engaged in farming, households will have enough time to explore more adaptation options and focus all their resources to farming since it is their livelihood than those with other sources of income. This is in contrast to the findings by Olarinde *et al*. (2014), who found out that farming as main occupation reduce the chances of using climate change adaptation strategies among the respondents.

Access to extension affected willingness to pay negatively and significantly at 10% significance level. Access to extension may improve the knowledge of a farmer about the several available options of responding to climate change making the farmer to have many available options, hence reducing the willingness to pay for insurance. Extension message is important and extension officers may promote other methods of responding to climate variability other than insurance. The willingness of farmers to pay for crop insurance is sensitive to the information provided regarding the attributes of insurance products. If extension agents portray it as expensive then this reduces the farmers' willingness to pay. Ali (2013) found that non-participants in Insurance had better access to extension services because they learn different methods of responding to climate variability apart from insurance. In contrast Falola *et al.* (2014) noted that access to extension services can provide farmers with crucial information on modern methods of managing risks, such as taking crop insurance.

Households which belong to a group were willing to pay for crop insurance as compared to those who are not members of a group. Group membership affects willingness to pay positively and significantly at 10% significance level. Groups provide information and resources such as farming management systems, credits for inputs and adaptation resources that can be important when adapting to climate variability. Farmers in groups learn about a new technology through other farmers and are likely to get information about climate change and insurance from their fellow members, hence they are likely to adopt. Many stakeholders have promoted the formation of groups in order to access different services. As a result most technologies and new ideas are disseminated through groups and hence a household belonging to a group have higher chances of accessing crucial and important information regarding insurance and hence increase their willingness to pay. These results are consistent with results reported in a study by Giné *et al*. (2008) on patterns of adoption of rainfall insurance producers in rural India, where participation in village networks positively correlated with participation in insurance. Shongwe (2014) noted that being a member of a social group significantly influence the choice of adapting to climate change using all adaptation strategies and the probability that the household will adapt using all adaptation strategies is increased by 13.9%.

Living in Olmoran is significant at 1% but it negatively affects willingness to pay. This implies that farmers living in Olmoran are less likely to pay for crop insurance than an individual living in Nyahururu. Olmoran is classified as a Marginal Mixed Farming (MMF) Zone as it borders Pastoral zones (GoK, 2016). The zone is characterised by very minimal and unreliable rainfall compounded by human wildlife conflicts making it difficult for the farmers to access reliable insurance. In addition most farmers practice traditional ways of farming like communal grazing and pastoral farming. This decreases the need for formal crop insurance.

The results of the contingent valuation model in Table 10 indicate that the mean willingness to pay for crop insurance without covariates for the respondents was KES 55923.38 per ha, while with covariates was KES 58552.22 per ha. This indicates that some socio economic and institutional factors have a positive impact on an individual’s willingness to pay for selected crop insurance. Covariates are included in order to eliminate some systematic variance outside the control of the researcher that can bias the results and account for differences in response due to unique characteristics of the respondents. However, the estimated mean willingness to pay was the highest at KES 63930.79. This indicates that mean WTP changes when including control variables evaluated at their mean values.

Table 10: Parameter estimates for willingness to pay model for crop insurance

Parameter	**Estimate (KES)**
Mean WTP (Without covariates)	55923.38
Mean WTP (With covariates)	58552.22
Mean WTP (Estimated)	63930.79
Number of observations	131

Willingness to pay may vary depending on several factors or conditions that a farmer may be subjected to. A change in some factors may lead to an increase or a reduction in the amount an individual is willing to pay for insurance. Table 14 indicates the results on sensitivity analysis of farmers mean willingness to pay for insurance on major policy variables. Farmers who received extension had a lower willingness to pay (KES 53,222.62) as compared to those who did not receive (KES 57,592.52). The *t-value* indicates a significant difference at 1% between those who received extension and those who did not receive extension in terms of their willingness to pay. Nature of extension messages and delivery mechanisms affect farmer's choice of a response mechanism to climate change. Through extension the farmers may have learned other methods of responding to climate variability other than insurance. Abebe and Ayalneh (2014) concurred that access to extension service indicates the availability and existence of technical advices to farmers which, has a positive impact on household farm and decision for willingness to pay for rainfall based insurance.

Table 11: Mean willingness to pay for crop insurance for different groups

Variable	Willingness To Pay		t value	P value
	Yes	No		
Extension	53,222.62	57,592.52	-7.1681***	0.0000
Group	58,661.88	50,909.84	-4.4277***	0.0000
Credit	56,721.40	55,148.59	-7.4681***	0.0000
Weather Info	56,228.85	55,019.02	2.1421***	0.0328

Those who belonged to a group had higher willingness to pay at KES 58,661.88 as compared to those who did not belong to a group at KES 50,909.84. There is a significant difference at 1% in willingness to pay for those who belonged to a group and those who did not belong to a group. Adaptation measures for climate change depend on the level of understanding of the issue and consequences, the degree of impact and technological capacity of farmers. Groups are an important source of this kind of information to farmers and can help disseminate new technologies to its members. Wairimu *et al*. (2016) noted that farmers' groups are one of the channels through which new technologies and methods of production are transferred to farmers. They are also the main source of information for input and output markets and it is expected that farmers who belong to groups facilitate adoption of insurance scheme.

The willingness to pay of farmers who accessed credit was KES 56,721.40 as compared to those who did not access credit services at KES 55,148.59. The t test results indicate a significant difference in willingness to pay between farmers who received credit and those who did not receive at 1% significance. Farmers who access credit have the financial muscle to invest in insurance as opposed to those who do not access credit. Studies on adoption of agricultural technologies indicate that there is a positive relationship between the level of adoption and the availability of credit (Pattanayak *et al*., 2003; Yirga, 2007). A study by Gine *et al.* (2007) notes that when households are less credit constrained, their chances of participating in insurance is higher.

Access to weather information has a positive impact on willingness to pay as farmers who accessed information had higher mean willingness to pay (KES 56,228.85) as compared to those who did not access weather information (KES 55,019.02). The willingness to pay of those who received weather information and those who did not receive is statistically different at 1%. Availability of weather information makes the farmer to be prepared for the anticipated eventuality, hence have knowledge to judge which response suits better for the change. Kansiime *et al.* (2014) noted that even if the climate is perceived to be changing, at local level availability of information plays a big role in informing farmers' perceptions, attitudes and practices with regard to the observed changes.

CHAPTER FIVE
CONCLUSION AND RECCOMMENDATIONS

5.1 Conclusion

1. The results indicate response to climate variability in the area was mostly through cultural practices, risk reduction practices, diversification practices and intensification practices. With use of terraces, new breeds and crop and herd management the least used strategies.
2. The results indicated that likelihood of use of the different strategies was positively influenced by gender, education level, access to extension, access to weather information and agro ecology. Male headed households who had higher level of education, accessed extension services and accessed weather information were more likely to respond to climate variability using the various response strategies. However, credit access was associated with low use of crop risk reduction practices as it negatively influenced likelihood of using these practices while, agro ecological zones had a mixed effect on the decision of the farmers to undertake specific response strategies.
3. Access to weather information influences the willingness to pay for crop insurance positively. The mean willingness to pay by farmers was improved by group membership and access to credit.

5.2 Recommendations

1. Extension being a demand driven service, farmers should be sensitized to seek extension services from both government extension agents and private extension service providers so as to get services regarding climate variability and response mechanisms. Farmer education should be enhanced through frequent trainings, seminars and field demonstrations by concerned stake holders on different ways of responding to climate variability in crop and livestock enterprises.
2. Most response strategies have been offered on a generalized basis and sometimes they don’t work in all agro ecological zones because of the difference in the climate related challenges faced. A better understanding of the local dimensions of vulnerability is therefore essential to develop appropriate response strategies that will mitigate these adverse consequences. Future policy has to aim at providing region specific response strategies. Information on appropriate response strategies should be made available depending on the agro ecological zones.

3. It is imperative that policy makers and other stakeholders collaborate with insurance providers to sensitize farmers through provision of timely and reliable information about agricultural insurance to increase awareness. Institutions dealing with provision of credit should be strengthened to increase adaptive capacity.

5.3. Suggestions for future research

While this research only covered the factors affecting farmers' response to climate change impacts and willingness to pay for crop insurance, further research may focus on the effects of the response strategies on household income and food security. Further studies can also focus on the extent of use of the response strategies which is not covered in this research. Information is also lacking on the economy-wide implications of particular response strategies on economic growth.

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APPENDIX

Farmers Questionnaire.

Questionnaire for: Evaluation of response to effects of climate variability and willingness to pay for crop insurance by smallholder farmers in Laikipia west Sub-County Kenya.

No………

Dear sir/ madam

My name is Atsiaya Godfrey a postgraduate student at Egerton University, Njoro Campus. In partial fulfilment of the requirements for the Master of Science in Agricultural Economics, I am conducting a research entitled: "***evaluation of response to effects of climate variability and willingness to pay for insurance by smallholder farmers in Laikipia West Sub - County, Kenya***". I would like to kindly request for your assistance to provide information, by filling in the questionnaire provided below, as your views are considered important to this study. Please note that your participation is voluntary and that any information given was be treated with utmost confidentiality and was only be used for the purpose of this study.

Sub-County: ________________________ Ward: _____________________________

Village: _____________________________ Date: _________________________________

SECTION A: RESPONDENT INFORMATION

A.1 Information of the household head

1. Name of household head ………………………………………………………………
2. Name of respondent if not the household head …………………………………………
3. Occupation of household head and other livelihood sources
   ____

Household information:

Gender of household head	**Age in Yrs.**	**Marital status**	**Level of Education**	**Household size** (People living in the homestead over the last one year)	**Source of energy most frequently used** (Can tick more than one)	**Source of water** (Can tick more than one)
1=Male 2=Female		1=Married 2=Single 3=Divorced 4=Widowed	1=Primary 2=Secondary 3=Tertiary 4=University	1.Over 18 years 2. Under 18 years	1= Wood 2=Charcoal 3=Kerosene 4=Gas 5=Solar 6=others	1=River 2=Bore–hole 3=Tap water 4= Rain water 7=Spring 8=Other (Specify)

A2. Land tenure system

Tenure	Tick
1. Freehold with certificate/title	
2. Freehold without certificate	
3. Communal	
4. Family	
5. Lease	
6. Others (specify)	

A.3 Land size (Acres) ……………………..

SECTION B: EFFECT OF CLIMATE VARIABILITY IN PREVALENT FARMING PRACTICES

Awareness

B1) Have you noticed any changes in mean temperatures over the last 25 years?

1. Yes [ ]   0. No [ ]

If Yes explain i.e. has the number of hot days stayed the same, increased or declined**?**

1. Stayed the same [ ]   2. Increased [ ]   3. Declined [ ]

B2) What changes in the rainfall patterns have you noticed in the last 25 years?

1. Drier [ ]   2. Wetter [ ]   3. No change [ ]

B3**)** Have you noticed any long term changes in mean annual rainfall over the last 25 years?

rf1. Yes [ ]   0. No [ ]

If yes Explain i.e. has the number of rain days stayed the same, increased or declined?

1. Stayed the same [ ]   2. Increased [ ]   3. Declined [ ]

B4) Have you noticed any changes in the onset of long rains in the last 25 years?

Yes [ ]   No [ ]

If yes, how has this affected planting times?

1. Stayed the same [ ]   2. Earlier [ ] 3. Later [ ]

B5**)** What in your opinion are the causes of climate variability?

Causes	
1. Excessive cutting down of trees	
2. Overgrazing	
3. Burning of farm wastes	
4. Others (*specify)*	

B6) What extreme events have you experienced in your area in the last 20 years?

Event	**Year of occurrence**	**Effects**
1.Strong winds		
2.Elnino rains		
3.Severe drought		
4.Floods		
5.Livestock loss		
6.Others (specify)		

- *If event occurred more than once, indicate all the years*

B7) Do you receive weather information?

Yes [ ] No [ ]

If yes, through what means do you receive weather information?

Means of information	Tick
1. Radio	
2. Television	
3. Friends	
4. Fellow farmer	
5. Internet	
6. Mobile SMS	
7. Extension officer	
8. Others (specify)	

B8) In your opinion, has the yield of maize improved/ declined since you started farming?

1. Improved [ ] 2. Remained the same [ ] 3. Declined [ ]

B9) What do you think caused the above changes?

1. Soil Fertility [ ] 2. Rainfall [ ] 3. Drought [ ] 4. Pests and Diseases [ ]

B10) What were your maize yields in bags/acre in the long rain seasons?

Crop	**2014**	**2000**	**1990**
Maize			

1 = 0-2 bags 2 =2-5 bags 3 = 5-7 bags 4 =7-10 bags

Coping strategies

B11**)** What coping strategies have you used in crop and animal production on your farm?

Coping strategies			
Maize	Tick	**Animals (Cattle, Sheep, Goats)**	Tick
Water harvesting		Reduction of herd size,	
Terraces		Increase of herd size	
Increased use of manure		New farm animals	
Increased use of fertilizer		Zero grazing	
Early planting		New breeds of animals	
Drought tolerant crops		Fencing	
Crop diversification		Improved fodder	
Replanting		Others (specify)	
Irrigation			
Staggering planting dates			
Planting agroforestry trees			
Others (Specify)			

B12) Which water harvesting structures do you have on your farm for crop production and state how long you have continuously used each structure

Water harvesting Structures	***Length of time in use continuously***					
	Tick (if in use)	1 season	2 seasons	3 seasons	4 seasons	More than 2 years
1. Planting pits						
2. Water pans						
3. Furrows						
4. Retention ditch						
5. Terraces						
6. Road run off						
7. Roof catchment						
8. Trenches						
9. Others (specify)						

SECTION C: HOUSEHOLD ADAPTATION PRACTICES AND LIVELIHOOD STRATEGIES AS INFLUENCED BY CLIMATE VARIABILITY.

C1. What are the farmer's response strategies to climate variability?

	Livelihood Strategy CROPPING	**Response Strategies**	
	Low yields/Crop failure		Tick
		Diversification of crops grown	
		Drought tolerant varieties	
		Local varieties	
		Adaptable species	
		Application of fertilizers/ manure	
		Use of pesticides	
		Use of herbicides	
	Low rainfall		
		Irrigation	
		Livestock production	
		Migration	
		Open up larger fields	
		Use of greenhouses	
		Water management practices	
	Late onset of rains		
		Change crop variety	
		Harvest and store water	
	Few number of rain days		
		Water management practices	
		Short season crops	
	Increased Droughts	Transhumance	
		Nomadism	
		Abandon livestock keeping	
		Alternative livelihoods	
		Keep browsers e.g. goats/ sheep	

SECTION D: SOCIO ECONOMIC INFORMATION

D1. Did you receive extension contacts in the last year? (*1 = Yes, 0 = No*) exten_________

D2. If yes in **D1** how many times from January to December 2014 extentim________

D3. Has anyone in the household attended a farmers training last year? (*1 = Yes, 0 = No)* train______

D4. What is the distance from your home to the agricultural extension provider? dexten_______

D5. Do you belong to a group? (*1 = Yes, 0 = No*)

grpmb______

D6. Does the group address issues to do with climate variability? (*1 = Yes, 0 = No*) grpclc_______

D7. If yes in **D6** what aspects of climate variability are addressed? (*1 = Awareness, 2 = Mitigation strategies, 3 = Effects/impacts, 4 = others [specify*]) grpclcadd______

D8. Are you a member of a cooperative? (*1 = Yes, 0 = No*)

copmb_____

D9. If yes in **D8** what are the benefits (*1= higher prices, 2 = Access to inputs, 3 = Financial aid, 4=Security, 5=Insurance, 6 = others [specify*]) copben_____

D10. If no in **D8** what is the reason of not joining (*1= Not aware 2= Lack of trust 3= Additional costs 4= Not satisfied with enterprises covered 5 = others specify*)

____

D11. Did you access credit in the last year? (*1 = Yes, 0 = No*)

credit________

D12. If yes in **D11** which is the major source from which you borrow money……………..*?* *(1= Cooperatives, 2=Microfinance institutions 3=bank, 4=merchants, 5=friends 6= money* *lenders, 7=Agricultural Finance Corporation8=others specify* credsoce______

D13. For what purposes do you use the credit............? *(1=to buy farm inputs, 2=for trade, 3=livestock rearing, 4=consumption, 5 others, specify……………)*

D14. Do you repay back your loan on time…………? *(Yes=1, No =0)*

D15. If No in **D14** what is the major challenge………? *(1=Due to insufficient return, 2=due to crop failure and unfavourable weather, 3=Due to price failure 4=others specify)*

D16. Is the credit facility adequate in meeting your needs……………? *(1=Yes, 0=No)*

D17. Have you faced a problem of getting a loan………………? *(1=Yes, 2= No)*

D18. If yes in **D17**which is the major problem…………? *(1=Administrative problem 2=collateral 3=others, specify)*

SECTION E: MARKET INFORMATION

A. Maize and Tomatoes

E1. What is the distance to the nearest market?

demkt______

E2. How long do you take to move from your homestead to the nearest market? motif______

E3. What is the market price for your produce Maize?

E4.What is the distance to the nearest livestock market?

demkt__________

E5. How long do you take to move from your homestead to the nearest market? motif_________

E6.What is the market price for your produce? (Mktpr)

Cattle	Goats	Sheep

E7.On average how much do you get from produce sales in a year? _______________

SECTION F: MITIGATION (INSURANCE)

F1. Are you aware of insurance crop and livestock insurance as a mitigation strategy (1 = Yes, 0 = No) in saw________

F2. If yes in **F1** have you adopted an insurance scheme? (1 = Yes, 0 = No) insadpt_______

F3. If yes in **F2** what can you say about the premium you are paying? (1= High, 2= Low, 3= Reasonable, 4= can't say) insprp_______

F4. If no in **F2** which are some of the reasons why you have not adopted an insurance scheme.

1.Lack of information	
2,Not comfortable with types of enterprises covered	
3.Lack of trust of intermediaries	
4.Complicated process to apply	
5.Lack of trust of insurance company	
6.Expensive	
7. Not available	
8.Others Specify	

Willingness to pay for insurance

A) Maize

F5. Are you willing to pay some amount to cover the cost of risk as crop and livestock insurance? (Insurance) ………? (*Yes=1, No=0)*

F6. If Yes in **F5** would you be willing to pay X……….. KES/ha/yr. for Maize insurance

F7. If Yes to the First bid ask the respondent if He/she would you be willing to pay BX………… KS /ha/yr.? Where BX>X.

F8.If no to the first bid, ask the respondent if he/she was be willing to pay BC………. KES/ha/yr. where BC<X

F9.If No to the second lower bid, ask the respondent the maximum amount he/she would be willing to pay KES……………………………………….