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ADAPTING TO CLIMATE CHANGE IN KENYA. A CASE STUDY OF NDEIYA DIVISION, KIAMBU COUNTY

BY:

GICHIRA KENNEDY A. MWANGI

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DECLARATION

I declare that this is my original work and has not been submitted to any Institution for an award of a degree or any other award.

……..…… **……**

Signature Date

Gichira Kennedy A. Mwangi

C50/70444/2009

This Project Paper has been submitted with my approval as the University of Nairobi Supervisor:

……..…… **……...…**

Signature Date

Dr. Robinson M. Ocharo

Supervisor

DEDICATION

This study is dedicated to the Almighty God, whose grace is sufficient and has brought me this far and three wonderful women: Charity, Lillian and Esther and to my children Happiness and Louisa for their love, patience, encouragement and understanding that made this possible.

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LIST OF ACRONYMS AND ABBREVIATIONS

ADS	Anglican Development Services
ASAL	Arid and Semi-Arid Lands
CCCEP	Centre for Climate Change Economics and Policy
CCV	Climate Change Variability
DFID	Department for International Development
FAO	Food and Agricultural Organization
FBO	Faith Based Organization
GDP	Gross Domestic Product
GoK	Government of Kenya
IFAD	International Fund for Agriculture and Development
IPPC	Intergovernmental Panel on Climate Change
KNBS	Kenya National Bureau of Statistics
NGO	Non-Governmental Organization
SPSS	Statistical Package for Social Scientists
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Family Planning Association

ABSTRACT

Over the years, climate change has been taking place and is presently a reality that has hit hard all spheres of development. In Kenya Arid and Semi Arid Lands (ASALs) that accounts for an exceeding eighty percent of the total land mass, have suffered greatly due to climate change. This study sought to assess how small holder farmers are adapting to the negative effects of climate change in Ndeiya Division, Kiambu County.

This study assessed the farmers' perceptions, impacts of climate change, adaptation measures adopted by the small holder farmers and the farmers' socio-economic factors that influence the adoption of certain adaptation strategies. The study employed a case study research design and used both qualitative and quantitative research methods. Primary data was collected using interview schedules and key informant interview guides. Secondary data was obtained from existing literature in libraries and internet. Data on socio-economic characteristics of the farmers was analyzed using descriptive statistics and presented in form of frequencies and percentages in tables and charts. Data on farmers' climate perceptions was analyzed through opinion scale and presented as percentages in tables and charts. Finally, data on socio-economic factors that influence the decision of coping strategies was analysed using descriptive statistics and running of Chi Square test of independence to establish their association with climate adaptation strategies and presented in tables.

The study findings revealed high level of awareness on climate variation among farmers. Farmers perceived climate change as an increase in drought frequency, reduction in rainfall, change in temperature and change in precipitation. The study identified loss of crops and animals and shortage of water as key impacts of climate change. Farmers have adopted various climate adaptation strategies for crop and animal production that include: Planting variety of crops, soil cover/ ‘Farming God's Way’, making and use of organic manure, kitchen gardening and planting of drought tolerant crops, stocking of crop residues, rearing of small animals and planting of napier grass. The study also found out that age and group membership are socio-economic characteristics of a farmer that played a key role in their choice of adaptation strategy.

To enhance higher adoption of adaptation strategies, the study recommends intensified capacity building of farmers at the farm level, increased awareness of climate adaptation measures through media (local or vernacular radio and TV stations) and increased community support by government and non-state agencies on water harvesting increase uptake of dry land farming.

CHAPTER ONE: INTRODUCTION

1.0 Background of the Study

According to IPCC 2007 study, the current climate change includes that the heightening temperatures and precipitation changes are monitored on a worldwide scale. UNFCCC views that 95% of climate variations is due to human works of burning hydrocarbon deposits. Climate plays a major role in influencing agricultural output, by supplying the necessary inputs such as solar radiation, temperature and water required for animal and plant growth. The persistent variation on the rainfall cycle and change in temperature domains are likely to negatively affect agriculture. Conway 2009, wrote that climate change with rising consistent and extreme floods and droughts has negative impacts on food security and agricultural production. Climate change has an underhand effect on agriculture by propelling the development and disposition of livestock diseases and crop pests, infuriating the consistency and distribution of extreme weather conditions, enhancing degree of soil despoliation and decreasing water supply and irrigation (IPCC, 2001).

Present studies reveal that people residing in dry lands are generally socially, politically and ecologically marginalized and lag behind economically and in terms of health. Climate change is an undermining aspect in such a sensitive place due to their low incomes, geographic exposure and the heavy dependence on climate and their low adaptive capacity (Verchort et al, 2007). However, the discussions on climate change variation policies and models that deal in the necessity to reduce gas emissions from greenhouses are still ignored (Ibid 2007). The current focus is mainly on carbon discharge and the wealthy nations reimbursement on carbon credit.

Not withholding the effect of climate change and variability on agricultural output being a major concern globally, the effect is particularly felt in Africa. This is influenced by Africa's weak adaptive capacity, over-reliance agriculture and the marginal climates (Collier et al 2008). Ibid 2008 writes that Africa has already experienced the negative effects of climate change such as droughts, change in the agricultural systems and floods. Sub-Saharan Africa's agriculture is believed to be the most affected (Kurukulasuriya and Mendelsohn, 2007).

Climate change in Sub Saharan Africa is likely to affect water and food resources that are essential human needs and it is even worse felt by a poor population that relies on climate sensitive supply systems. Interference of predominate water and food systems have adverse effects on development and livelihood that disrupt poverty eradication measures (Ajayi O.C.et al 2006).

Agriculture is a key economic activity in Kenya and it mostly relies on rainfall hence its dependence on climate variations. The common calamities in Kenya are, floods, droughts and landslides. Most food shortage Kenyan incidences are as a result of rainfall deficits. The Kenyan-Arid and Semi-Arid Lands (ASALs) are majorly affected by drought and the frequency of drought has continued to increase annually in the recent past. In Kenya, where agriculture relies in rain, on a good rainy period there is increased crop output, a healthy economy and increased food security.

However, in case of rain failure and natural catastrophes such as droughts and floods, there is low crop production, famine, food insecurity, massive migration and low economic growth (World Bank, 2008). These factors are a threat to Kenya's Sustainable Development Goals and the Kenya Vision 2030. Despite these factors it is possible to control the adverse impacts of such events by making efficient and effective adaptive mitigation strategies that are necessary to deal with these risks. Adaptation enables farmers to meet their food, income and livelihood goals in times of climate change, periodic disruption of large-scale and local markets and adverse conditions such as floods and droughts (Kandlinkar and Risbey, 2000). This study provides meaningful understanding on how Kenyan smallholder farmers can adapt to climate change.

1.1 Statement of the Problem

Climate uncertainties is a serious threat to households, communities and the country at large because of its negative effects on agriculture (UNDP, 2007). According to UNFCCC (2012), evidence points out that global climate has changed and is having devastating impacts particularly on developing countries and the poor. Maddison (2006), notes that smallholder constitute the largest population of the poor in Africa who rely on rains for agricultural activities

being one of the most notable economic activity. It is estimated that agricultural productivity will range from 10 to 20% by 2050 or go up to 50% as a result of climatic changes (Jones & Thornton, 2003), since agriculture depends on rain and this high depends on weather patterns. As Africa work towards overcoming poverty, weather changes is a huge threat undermining these achievements (Zoellick, 2009).

In Kenya, agriculture includes smallholders' mixed farming who accounts for an exceeding 65% of the total agricultural production (Kanyua, 2004) and just like Africa is primarily driven by agriculture with its output influenced by distribution and rainfall variability that leads to substantial risks and uncertainties during production a result of climate change (Short and Gitu, 1990). However, according to (Oluoch-Kosura and Karugia (2004), more than 70% of Kenya is dry and this place receives small amount (510 mm) of annual rainfall and merely 12% of the cumulative land area is grouped to have high and medium potential and the remaining 88% is classified to have a lower potential, arid and semi-arid area. IPCC (2007) shows that local small-scale farmers in arid and semi-arid places experience numerous climatic change risks as well as climatic unpredictability as well as recurrent droughts, prolonged dry seasons, strong rainfall, even floods and an increase in heat stress and disease outbreaks all which have devastating negative effects on national food security.

Being a semi-arid area, Ndeiya is among the division that is vulnerable to drought in the County of Kiambu in Kenya. Unpredictable rainfall patterns and a significant decline in crop yields as well as death of livestock has led to food shortages, insecurity and dependence on food intervention emergency to take care of local food shortages (GOK, 2005).

However, there is a scarcity of information on agricultural adaptation strategies embraced by smallholder farmers in Ndeiya division. According to the Kiambu CIDP 2013, "there is no documented evidence on the impact of the climate change in the County and hence the need for a comprehensive study in order to identify and adopt operational strategies to address the problem" Hence, the need to examine explicitly how and why they are adapting. This is crucial in designing and implementing integrated policies that will enable the smallholder farmers to

operate sustainable agricultural production systems as identified by the County Government. To address this gap, this study is designed to assess the impacts of climate change, farmer's perceptions of climate change, establish coping mechanisms, and assess socio-economic factors influencing the adaptation among smallholder farmers in Ndeiya division, Kiambu County.

1.2 Research Questions

This study sought to answer the following questions.

1. How do smallholder farmers perceive climate change?
2. What are the impacts of climate change?
3. How are smallholder farmers adapting to the negative impacts of climate change?
4. What socio-economic factors influence the choice of adaptation strategies by smallholder farmers?

1.3 Objectives of the Study

1.3.1 General Objective

The general objective of this study was to understand how smallholder farmers are adapting to the impacts of climate change in Kenya.

1.3.2 Specific Objectives were:

1. To establish smallholder farmers' perception of climate change.
2. To assess the impacts of climate change.
3. To assess how smallholder farmers are coping with the negative impacts of climate change.
4. To identify the socio-economic factors that influence smallholder farmers' uptake of adaptation strategies.

1.4 Justification of the Study

Agriculture is a primary source of livelihood to majority of the poor population (Sarah A.O. etal 2012). Locally, it is considered as an economic activity by 75% of the population who depend on it as a source of income and food. This sector makes a contribution of approximately 26% of

GDP and 60% of foreign exchange earnings (Orodho, 1998). Regardless of Kenya having been a major cash crop exporter of tea, cut flowers and coffee, it is a great receiver of food donations in Africa (Zendera, 2011). Small-scale farmers from the largest part of the population participate in agriculture as the primary economic activity. RoK (2010) indicates that small scale farmers are highly exposed to climatic changes, since, this section of the population increasingly suffers food insecurity and continues to drop deeper into poverty as droughts, floods related to climate change and variability become more frequent.

However, overtime farmers in Ndeiya have been innovative and able to build their own capacity and adopt strategies to shield themselves from negative effects climate dynamism (Kiambu County Department of Agriculture 2014 Report). This study focuses on understanding what and how the smallholder farmers are doing to adapt to these negative effects. This study will contribute to Kenya's Vision 2030 which identifies the need to boost capacity to accommodate changes in the international climate. Further, Kenya's climate change policy is cognizant of the need to advocate for climatic changes with a view of educating farmers on coping mechanisms. Hence, this study on farmers' climate adaptation provides facts to promote evidence-based advocacy. This study also provides vital information on how the small holder farmers can take action to avoid agricultural losses, since their livelihood is dependent on agriculture.

Finally, considering complexity from dynamics of climate, politics, economic situation and social-cultural procedures, this research will be of value to farmers, scholars, policy industry, GoK as well as foreign investors.

1.5 Scope and Limitations of the Study

This research was executed in Ndeiya Division, Kiambu County focusing on smallholder farmers. Specifically, the general goal of this research was to understand how farmers are adapting to impacts of changes in the climate. This study was undertaken based on the premise that: tourism, water, agriculture, ecosystems and biodiversity are affected by climatic variations particularly natural disasters. The study focused on the agricultural sector which is highly susceptible to climate change and dependent largely on erratic and unpredictable rainfall. The

study sought to understand how smallholder farmers perceive climate change, explore mechanisms used by the smallholder farmers to ascertain impacts of climate change and variability, to identify approaches they employ to deal with dynamics of climate and variability and finally investigate the socio-economic factors that impact on the decision of climate adaptation strategies. The study is limited to the following parameters of climatic variations include: temperature variations, precipitation, drought frequency, sources of climate information, family disruption, loss of plant and crop species, changes in cropping patterns and agricultural yields and unpredictability of rainfall seasons.

Climate adaptation mechanisms is limited to measures undertaken by farmers to ensure continued productivity of agricultural practices which include; diversification of crops, diversification to off-farm activities, soil and water management, savings, improved crop and livestock husbandry.

To understand drivers of uptake of adaptation measures the study is limited to analysis of household demographic and socio-economic characteristics including; age, gender, family size, education, sources of income, access to credit, social group membership and access to agricultural extension services.

Finally, this study is limited to Ndeiya Division of Kiambu County due to inadequacy of time and funds, therefore, any generalization to other contexts should be done with this limitation in mind.

1.6 Definition of Key Terms

Climate change: according to UNFCC 1992, it refers to variation of climate to do direct or indirect human activities that changes the global atmosphere composition.

Climate Adaptation: refers to adjusting towards new or unfamiliar climate attributes from the current or changed existing attributes.

Adaptive strategies: these are the long-term measures setup in response to a change on the climatic attributes.

Smallholder farmer: this is a farmer who owns at least four hectares of land

Resilience: refers to the capacity of individuals, households, communities and systems to prevent, mitigate or cope with risk(s) and recover from shocks.

Greenhouse gases: are gases that contribute to the greenhouse effect by absorbing heat (infrared radiations).

Climate: refers to the weather conditions prevailing in an area in general.

Perceptions: refers to the farmer's personal interpretation of events.

Food security: the availability and access to food varieties at all times.

Vulnerability: the inability to withstand the effects of a hostile environment.

Livelihoods: the means of securing the basic life necessities-food, water, shelter and clothing.

Drought - a phenomenon that exists when precipitation is significantly below normal recorded levels, resulting to serious hydrological imbalances that adversely affect land resources and production systems.

Reflexivity- refers to circular relationships between cause and effect.

CHAPTER TWO: LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

According to IPCC 2012, people all over the world began burning large quantities of oil, coal and natural gases over 100 years to power their vehicles, homes and factories. Today most countries globally rely on fossil fuels for energy purposes. A lot of carbon dioxide and heat-trapping gasses released on the surrounding causing climatic changes (UNFCCC, 2012). Heat-trapping gases also referred to as greenhouse gases are present naturally in the atmosphere and provide warmth for animals and plants. Burning of fossils adds more greenhouse gases to the atmosphere warming the earth thus causing atmospheric changes that affects climate that in turn affects plants people and animal ways. It is evident that the intensity of adverse weather conditions and change in rainfall patterns leading to droughts, floods and intense heat waves are more frequent today.

Sustainable food provision for the world growing population remains a major challenge to mankind. About 800 million people in developing countries lack enough food to eat (FAO 2002).in the industrialized countries 41 million people suffer from serious food insecurity. A Large amount of water is required for food production. Bryant 2000 asks if the world is sufficient enough to provide food despite the several uncertainties. The gradual transition of climate conditions that results to increased adverse weather conditions needs some long-term agricultural production adaptation strategies. Nevertheless, copping with adverse climatic variations remains a challenge in relation to food production (Droogers, 2003).

Even though the development units play a major role in echoing for a reduction in greenhouse gas emissions, not all changes can be avoided. Some focus should be given on the ways that nature and the society can adapt to the climate changes (Tearfund UK, 2014). Creating awareness on the reasons and effects of climate change is important to the strategies of empowering people to adapt and conquer the future and current climate conditions. This conflicts to the conditions of poor communities especially to the illiterate people and those who have

limited access to information, who are not able to integrate the current climatic changes with the global phenomenon, yet they are unaware of the potential future changes.

2.2 International Policy on Climate Change

During the 1960's and 1970's there was a chain of serious publicized environmental and climatic occurrences with fatal consequences that displayed the fragile state of the world's food production and systems of trade and their reliance on the earth's climatic cycles. In 1979 the reaction of these climatic occurrences led the first world climate conference by world organizations such as the; UNEP, FAO, WHO, UNESCO, and the WMO. The conference was contemplated to evaluate the element of knowledge of climate and the impact of climate variations on the people. This global climate conference was probed by a chain of UN held conferences in the 1970_s, these included: The UN world water conference that took place in Argentina, Mar Del Plata in 1976; the UN global food conference of 1974 held in Rome, Italy that recognized the major influence of climate on world food production;

The UN environmental conference of 1972, held in Stockholm, Sweden that led to the establishment of the UNEP; the UN desertification conference and the united nations Economic and Social Council (ECOSOC) Resolution that accredited the WMO commencement of a world climate programme that created attention to the world condition. These conferences all ascertained that climate impacts are a point of concern. The world climate programme (WCP) was set-up after 1st world climate conference and had a research unit called the World Climate Research Programme (WCRP).

In 1988, the UNEP and the WMO formed the IPCC to look into the available scientific materials, to evaluate the different aspects of climate variations and their impact, with the aim of coming up with realistic solutions. The main aim of the IPCC as laid out in December 6^{th} 1988, by the UN General Assembly Resolution 43/53 was to provide a detailed review and give recommendations on the element of knowledge on the science of climate change; the economic and social effects of climate change and the possible solution strategies that can be included in the future global convention on climate. The first IPCC Evaluation report of 1990 had scientific facts that revealed

that climatic conditions was a challenge that needed an international alliance to deal with its consequences. This lead to the decision of forming UNFCCC, whose international role was to minimize global warming and deal with the effects of climate change.

The WMO, UNESCO, UNEP, the UNESCO ICO, ICSU and FAO co-sponsored the Second World Climate Conference of 1990 that was held in Geneva, Switzerland with the aim to analysis the work done in the first decennium of the WCP, the First Evaluation Report of the IPCC and the establishment of the Geosphere-Biosphere Programme (IGBP). the result of the conference after two years led to the formation of the Global Climate Observing System (GCOS). The conference highlights of SWCC recommended four phases of global activities:

I. The future organization of the World Climate Programme (WCP).
II. Unique requirements of the developing countries to promote their abilities.
III. Collaboration of the IGBP, WCRP and other research global programmes on the international research.
IV. Correlated of the international events and policy development activities through research efforts and global measurement, evaluation assignments of the IPCC and a conventional development on climate variations.

The third world climate conference was conveyed in Geneva, Switzerland 2009. The goal of the conference was to work on the needs of beneficiaries and sectors globally to minimize natural calamities, promote security for food and to get accustomed to climate change and variability as outlined in Bali Action Plan and the Nairobi Work Programme.

2.3 Climate Change Impacts

Dynamism in climatic changes impacts on people and their economic activities in numerous ways, this often increases threats that exert pressure on the environment where businesses operate. Nonetheless, this is not an issue that has developed overnight; it has been in existence for over 30 years because scientists first hinted to the word of the risks involved with changes in climate (UNFCCC, 2012). Everybody gets affected by changes in climate since the lives of

human beings exists under a certain climatic condition. Most people across the world especially Africa depend mainly on rainfall for agricultural farming.

Consequently, the vulnerability in climatic changes, change in season and weather patterns including any form of warming will lead to an increase in water stress. Approximately, 70% of the population depends on farming, 40% of exports include agricultural products (WRI 1996). Even though many African countries record the least per capital in emission of global warming on the planet, they tend to suffer severe consequences from changes in weather patterns that might be manifested through drought, famine and population displacement. This might expose the population to poverty and malnutrition. However, it is worth noting that the priority for most of the African nations is to increase access to energy services and to boost the people's economic welfare. Insurance sector makes estimation that the economic damage from global warming amounts to huge losses that could be quantified to billions of US dollars annually.

A third of the revenues generated from agriculture in Africa from production of crops and livestock accounts for 50% of household incomes. Ondigo (1990), report that the poorest societal members are those who depend on agriculture for income and as a source of employment. Farmers have overtime learnt to adapt to this climate, research has demonstrated that carbon dioxide can be held in the atmosphere for almost one century; hence the earth continues to warm. Though, when it gets warmer, there is a high likelihood that more severe changes might erupt to the climate including the system of the earth. While it's very hard to predict the impacts to climatic changes, it is evident that the climate we go through cannot be relied upon to predict what should be expected in the future.

2.4 Climate Change Adaptation

UNFCCC (2012) notes that some of the changes to the climate are avoidable and w**e can** presently mitigate risks that farmers might experience from climatic changes, by making decision that mitigate pollution of greenhouse and making preparations for changes that are in the process of adoption. Climatic adoption seeks to mitigate climatic change effects and

variability while taking advantage of opportunities that presents themselves. Adaptation might take two forms: Autonomous and Planned.

2.4.1 Planned Adaptation

This is a product of thoughtful policy decisions based on the awareness that conditions could have changed or are expected to change such that some human actions might be needed in maintaining the expected state. These kind of actions involve: selection of crops and distributing strategies through different agro-climatic areas, substituting new breed of crops to old ones and substituting resources that are induced by scarcity (Easterling, 1996).

2.4.2 Autonomous Adaptation

This can be described as reacting to change of weather patterns; a farmer might change crops and use different variety of plants and harvest dates. Adopting to change in climate seeks to address a wide-range of change in individual behaviours and groups including technological developments. The capacity to depend high depends on the amount of resources at disposal. This adaptive capacity is defined as the capability of a system to adjust to climatic variability so as to grasp opportunities as they present themselves and cope with the environment (IPCC, 2007).

Adapting to climactic conditions involves the ability to survive or function more depending on the kind of climatic situations and options that are open to the population and the ability to exploit such alternatives. It entails building the capacity to adopt thus building the ability to cope with changes for example communicating and relaying useful information regarding climatic changes, increasing awareness on the effects and adopting coping strategies to deal with these circumstances (Adger etal, 2009). These changes in climatic conditions are categorized into two essential camps these include ex-ante responses; whereby actions are taken upon realization of a given exposure. Pandey et al., (2007) insist on the need for ex-ante adaptation to counter changes in the environment as well as diversification to mitigate the different impacts that climate could have on various variety of crops or activities annually.

2.5 Climate Adaptation in Africa

In the African continent, majority of the farmers have a vast history on the various approaches they have implemented in their efforts to respond to climatic changes. Bohle et al. (1993), aver that in Africa a few communities have coincidentally survived recording a faster growth in population as a result of devising ways of survival and mechanisms to mitigate risks emanating from changes in the environment. Implementation of conventional and adoption of contemporary approaches enable farmers to effectively cope with the expected changes in future. De Chavez and Tauli-Corpus, (2008) observe that in Africa, farmers implement zero-tilling in cultivating among other soil management approaches. These practices are capable of moderating soil temperatures, suppressing diseases and harming pests and conserving soil moisture.

Nhemachena (2007) argues that coping measures to climatic changes among societies are looked at from two broader perspectives; these include micro-level (farmer level) and macro-level (national, regional and global levels). At a macro-level, there's need to adopt and implement policies and strategies that try to mitigate negative impacts of climatic change in various industries of economic development. At a micro-level, coping strategies might take place through the manner in which the farmer uses land and how changes in crop and livestock management are conceived.

Stringer et al (2006) indicated that intra-rural and rural-urban migration in Malawi is the key strategy which has been implemented to effect manages the effects of low crop production, flooding and damage of the ecosystem including biodiversity. Thomas et al. (2007) further reveal that there are increasing efforts to take advantage of spatial diversity of the landscape. As indicated by Thomas and colleagues, it is evident that gaining access to land results into better yields even during times when drought is at its peak, this is achieved through irrigation at plot level.

A comparison between Roslgen, Sweden and Mbulu Highlands in Tanzania, Tengo and Belfrage (2004) demonstrated huge resemblances in adoption of practices that were aimed at addressing short-term drought at the field. For example, farmers from Sweden and Tanzania opt for cover

crops to boost survival of seedlings, equally, the control soil erosion with the help of delineation planting and mulching. Use of cut-off drains and sluices is commonly applied in Mbulu highlands, whereby the fields are in sloppy areas.

2.5.1 Climate Adaptation in Kenya

Ngigi et al (2000) explain that in semi-arid places in Kenya, an increase in efficiency of water use has been recorded by blending water harvesting approaches and drip irrigation; this has enhanced diversification of cropping systems and minimization of risks from drought and unpredictable rainfall. Ndambiri et al (2012) uncovered that 85% of farmers in Kyuso district cope with climatic conditions as compared to fifteen percent who were reluctant to adopt. A number of adaptation approaches were implemented by farmers whereby the popular adaptation approach included planting of diverse crops and change of land that was under cultivation, each comprised of 64% of the respondents. The least implemented adaptation approaches by the farmers included switching from farming to other activities (9%) such as business and an increase in the use of irrigation (8%)

Kiteme et al (2009) in Makueni District established that popular adaptation methods among farmers who perceived increases in temperature were: changing land under cultivation, planting different crops, crop diversification and migrating to a new site. Coping strategies implemented by farmers who deemed extended duration of temperatures included planting dissimilar variety of crops, conservation of water, improving livestock management and increasing the size of land that was under cultivation. On the other hand, coping strategies were least utilized by farmers who expected changes in temperatures an example was increasing irrigation and diversification from farming to non-farming.

While there exists considerable literature on adaptation strategies adopted by farmers across the globe and in Kenya, there is minimal literature on strategies being adopted by farmers in the drier Central Kenya to deal with climate change particularly the recurrent droughts. Through this study, the researcher will be able to obtain information on adaptation strategies on micro-level

being employed by smallholder farmers to shield themselves from the negative effects of climate change**.**

2.6 Factors Influencing Adoption of Adaptation Strategies

WWF (2012), calls for action against climate change impacts, it states that, "decisions made today shape the world and has an impact on the generations to come. Interestingly, communities have different ways that they use to make decisions based in the independence and thus such decisions are aligned to key entities of national development. Decision by farmers on whether to adapt climatic changes or not high relies on the climatic stimuli among other important issues such as personal, policy and economic motivations (Smit et al, 1996).

In addition, the perception by farmers regarding climatic changes impacts on adaptation decisions. Farmers who are cognizant about the risks of possible effects on climatic changes might respond as opposed to farmers who are not informed about these climatic conditions. Thus, the choice of adoption of climatic changes might be anchored in the view whether the system is susceptible or flexible (Reilly & Schimmelpfennig, 2000). In case the system is deemed to be vulnerable, adaptation measures could be considered (Adger et al, 2009).

In Kenya, there is general understanding that climate has changed as outlined by various studies undertaken across Kenya and as documented in the Kenya's climate change policy (GoK, 2010). While various studies have found out that numerous factors have a contribution on how a farmer adapts, this study will specifically focus on how the following variables: socio-economic, land accessibility and use and institutional factors influence the farmer adoption of adaptation strategies.

2.7 Perception to Climate Change

Perception is described as a means through which individuals might seek an understanding of a given phenomenon as they work towards achieving more resources and an efficient response to hazards (Wehbe et al, 2006). Gbetibouo (2009) argue that farmers' internalization of climatic

change is considered to be a critical precondition for farmers aspiring to cope with climatic changes.

Maddison (2006) explains the process by which farmers arrive at decisions might be influenced by direct experience from the environment, science as well as mass media. Climatic changes heighten the likelihood of implementation of coping strategies. Farmers who are well informed about the fluctuations in climatic conditions record high chances of adopting measures to respond to changes observed. Perception is regarded as an essential precondition to farmers who intend to take up measures in order to adopt (ibid 2006). Martine etal, (2013), found that small holder farmers in Malawi farmers are increasingly aware of the threat of climate change, particularly in perceptions of increasing numbers of dry spells and floods.

Several studies in Kenya have found out that farmers perceive climate to have changed; a study by Thorlakson (2011) in Western Kenya revealed that most farmers observed a climatic shift, 88% of the participants that were interviewed recorded a negative change over previous decades. It was unearthed that the key common changes involved shifting in rainfall patterns, increased complains from farmers on rainfall variability and a decline in frequency. Kitinya etal (2012) uncovered that all the farmers faced variations in climatic changes in different forms. It was unraveled that majority (75%) farmers experienced a decline in crop yields corresponded to the climatic changes especially onset and interruption of rain impacted greatly to this decline.

Therefore, while there is relatively an agreement on various studies that Kenyan farmers are realizing that climate is changing, the results of the studies are however mixed; as farmers in different climatic zones perceive climate to have changed in different ways. Hence, there is no uniformity on how Kenyan farmers perceive change to climate. This study therefore sought to provide scientific evidence on how farmers in Ndeiya understand climate change which has been cited by various studies as an ingredient to farmers' adoption of climate change strategies.

2.8 Theoretical Framework

A theory is defined as a statement that is reasoned or a litany of statements that are supported by evidence that is intended to explain a phenomenon. A theoretical framework comprises of

interlinked ideas and concepts anchored by theories. It is logical set of propositions obtained from empirical arguments (Kombo & Tromp, 2006). Theories guiding this research include Reflexivity and Induced Innovation Theories.

2.8.1 Reflexivity Theory

Reflexivity theory is propounded by Margaret Archer (a British sociologist) who borrows heavily from Pierre Bourdieu's and Anthony Giddens's structuralism but differs with them in that according to her, structure and agency operate at different timescale (Caetano, 2014). The theory focuses in self-dialogue that exists in society that stirs the causal strength of structures and permits individuals to act depending on personal concerns or their achievable circumstances. Internal dialogues consist of conversations that people have inwardly and through which they establish and clarify their attitudes, beliefs and goals, analyze social circumstances and determine projects that suit their interest. Thus, in relation to climate change the theory holds that the individuals undertake internal dialogues reflecting on the changes in their environment and seek measures to address these challenges.

A key element of this theory is that even though reflexivity is considered to be common to all individuals, different people exercise it differently. This theory identifies a typology of four modes of reflexivity: 1. Communicative, 2. Autonomous, 3. Meta and, 4. Fractured.

1. Communicative reflexivity- emanates from internal communications that need a clarification from others before resulting into a specific course of action.
2. Autonomous reflexivity- can be described as self-contained inner communication that results to action where there lacks need for validation by other people.
3. Meta-reflexivity is defined as a critique which is subjected directly through internal discussions which heightens individual stress and social disorientation.
4. Fractured reflexivity is practiced by people whose internal communication limits them in dealing with social circumstances.

This theory will be based on the first two typologies; the first one being reinforced by the participation of farmers in development projects where their reflections on climate change are

confirmed by other members in the common interest groups as experiencing the similar issues and hence collectively seeking actions to address the identified challenges to agricultural production. Further, based on the second typology it will seek to understand individual farmers take autonomous adaptation actions to address negative climate change effects after personal reflections and the contribution of this autonomous reflexivity contributes to the adaptation model.

This theory is therefore, relevant to the study because it gives insights to why there farmers adapt to climate change and its impacts based on communicative and adaptive reflexivity by undertaking planned and autonomous adaptation measures to cushion themselves from the negative climate impacts in the study area and beyond following internal reflections.

2.8.2 Induced Innovation Theory

This study is also grounded on the theory of induced innovation which according to Easterling, (1996) has emerged as a basis for understanding potential future agricultural adaptation to climate variability and change. It is predominantly used in economics to explain that innovations are motivated by certain incentives. This theory refers to the process by which societies develop technologies that facilitate the substitution of relatively abundant factors of production for relatively scarce factors in the economy. It is premised on the role of climate as a stimulant for technological innovation.

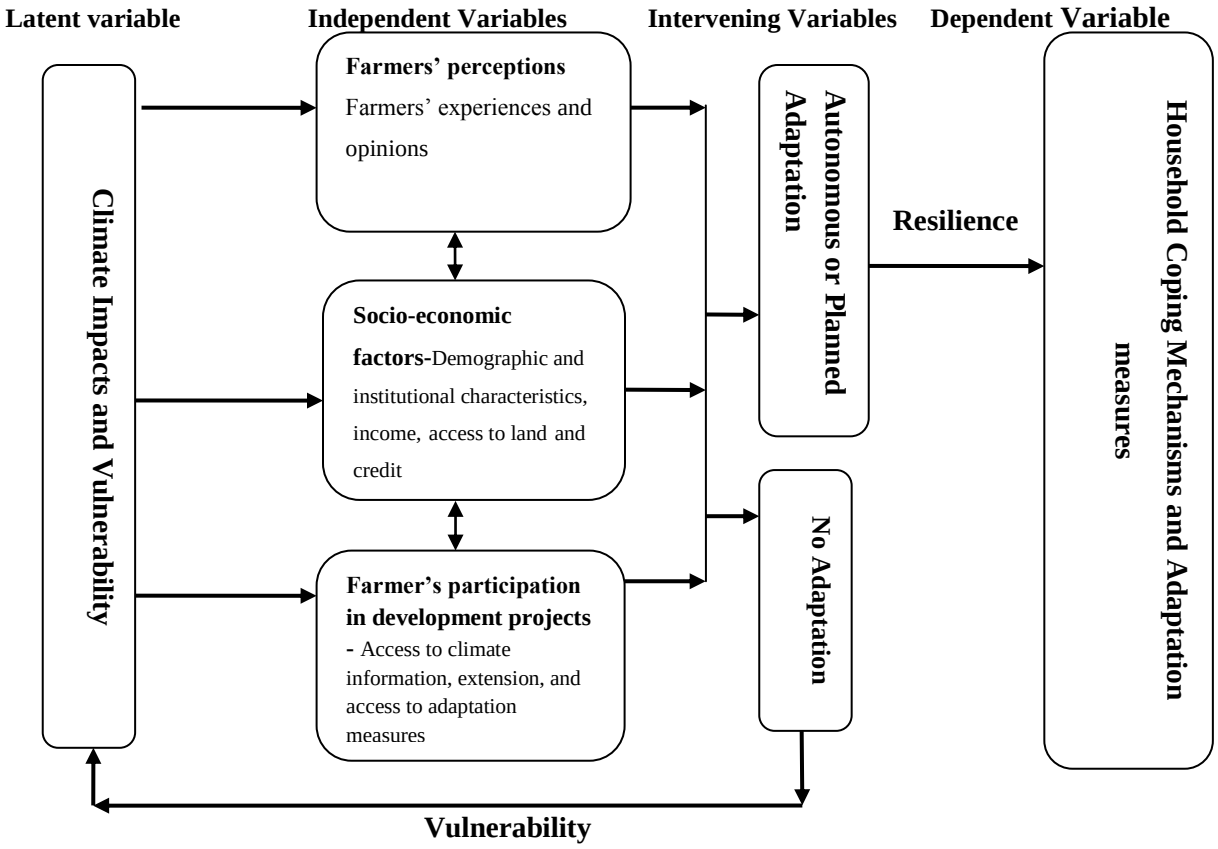
Climate-driven innovations might take place in agriculture and two outcomes could be; in the first place, these innovations could improve knowledge with a view of optimizing available resources to farmers in different places and secondly, there is a potential to improve the farmer's ability to compensate for the limitations caused by climatic changes to boost agricultural productivity. Thus, research demonstrates that climatic stress is a critical step towards achieving gainful insights regarding coping with negative effects of climatic changes. Hence, the rationale for the application of this theory on climatic-induced innovation is assessing the contribution of climatic conditions in enhancing technological innovations in agriculture in Ndeiya.

It was also revealed that the impacts of famine as an incentive to farmers to build their level of creativity and innovativeness to counter negative impacts of climatic changes. The assumption advanced by this theory is that when farmers go through problems emanating from changes in the environment that they live which are brought about by changes in climate. Hence, they might seek new form of knowledge that is helpful in overcoming emerging restraints (Ndambiri et al 2012). For that reason, through investigating this study in Ndeiya Division gave insights and meaning regarding the existing relationships amongst climatic changes and coping strategies adopted by farmers to mitigate negative effects from changes in climatic conditions.

2.9 Conceptual Framework

Under this section, the researcher makes a diagrammatic representation on the underlying conceptual argument on the relationship between the specific variables identified in this research.

Figure 2.1: Conceptual Framework



Source: Researcher

The framework above is illustrating the interplay of various variables because of farmers exposure to climate change impacts and vulnerability.

2.9.1 Farmer's climate perception

The individual farmers perceive climate to have changed from their past climate experiences, and opinions. Through their long duration of exposure to the changes the farmers are able on their own to devise mechanisms to cushion themselves from the recurrent climate shocks (autonomous adaptation).

2.9.2 Household demographics and socio-economic factors

Following exposure to climate impacts and vulnerability; individual farmer household socio-economic factors including; household size, age, educational level of the household head,

occupation and gender of the household head; household income and access to credit play a critical role in determining how the farmer responds to climate impacts and vulnerability. For example, it is assumed that a household with an educated household head may have some higher income and maybe able to invest in certain adaptation measures that the poor households cannot.

Further, a household with some income maybe able to afford some communication gadgets like radios, mobile phones, TV and buy educative materials like magazines and newspapers that form a source of climate change adaptation information. Large households may be able to uptake adaptation measures that require some substantial labour compared to poor small households. All these factors demographic and socio-economic factors are assumed to increase the ability of the farmer to uptake adaptation measures either autonomously or through deliberate action (planned adaptation) overtime building their resilience to climate impacts and if not the household continues to be vulnerable to climate change and variability.

2.9.3 Farmer's participation in development projects

Farmer's participation in development projects raises the farmers' exposure to climate information through interaction with extension workers and other farmers by accessing climate information. This is assumed to lead to improved ability of a household to uptake of adaptation measures (planned adaptation) which increases the farmer's resilience to climate impacts and reduces their vulnerability through the implementation of learnt adaptation measures. The inability of a farmer to adapt either autonomously or through planned action results into an increase in vulnerability to the effects of climatic changes.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the research approach that was employed in this research. It encompasses a description of design for this research, description of the site, sampling approach, instrumentation and analysis of data.

3.2 Study Design

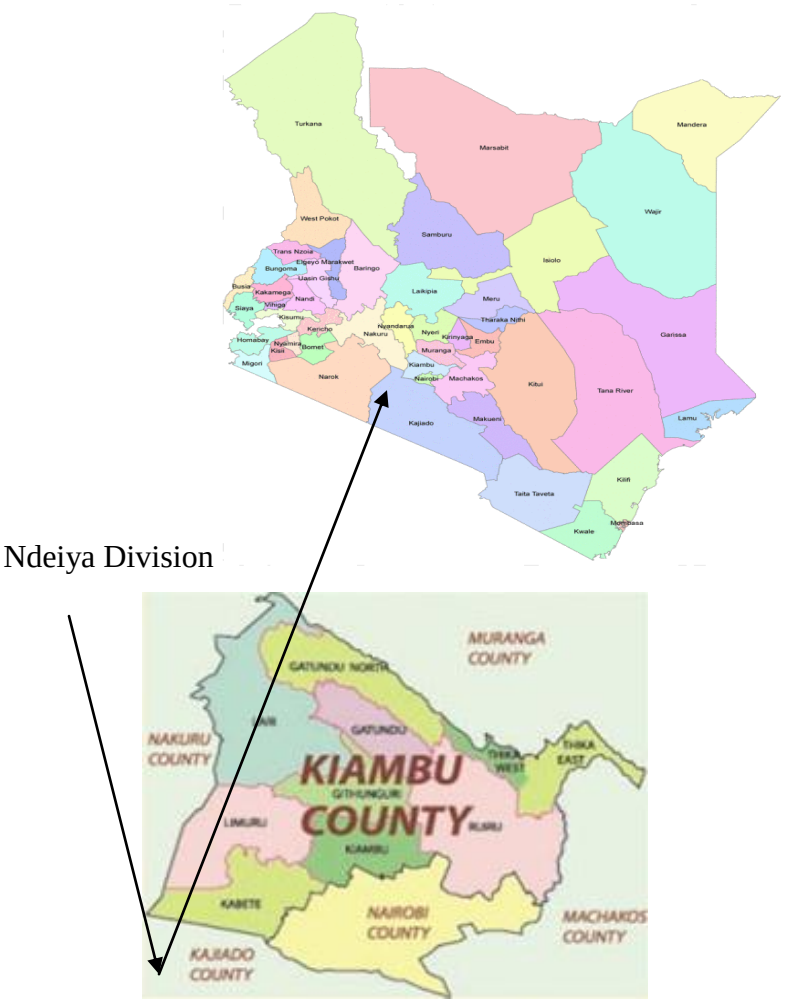
This study employed a case study design and the research employed both qualitative and quantitative research approaches. Data was collected using questionnaires and key informants of this research.

3.2 Site Description

This study was carried out in Ndeiya Division, Limuru Sub-County, Kiambu County. Ndeiya is situated on the Southern part of Kiambu County, Central Kenya next to the cliff of the Great Rift Valley. It covers an area of approximately 51.1 kilometers squared and has three administrative sub-locations namely: Mirithu, Teikunu and Ndiuni. It borders the semi-arid Sub-County of Naivasha, Nakuru County to the West. The area is classified as a marginal zone, given that it receives on average 500mm of rainfall annually (Kiambu District Development Plan 2005). the area has a population of 15,289 people (Kenyan census, 2009).

The area does not have any flowing rivers and relies heavily on boreholes as the main sources of water. In the last two decades, the area has experienced recurrent droughts and subsequent crop failure making the area a top recipient of the County's relief (GoK, 2010). The area was purposively selected because of its extreme climatic conditions in the county and the fact that the area has remained food insecure despite the past efforts of both government and development agencies. Farmers are mainly smallholder practicing rain-fed agriculture.

Figure 3.1: Site Location



3.3 Population and Sampling

3.3.1 Target Population

This study targeted smallholder farmers practicing rain-fed agriculture and aimed at assessing the technologies and adaptation measures put in place to cushion themselves from the negative effects of climate change.

3.3.2 Sampling Procedure

This research utilized probabilistic and non-probabilistic sampling. The study used stratified random sampling to select the study subjects (smallholder farmers) and purposive sampling to select key informants. From a sampling frame of 300 farmers participating in an Anglican

Development Services- Mt. Kenya Project distributed as follows: Ninety-six (96) from Mirithu sub-location, one hundred and twenty (120) in Teikunu sub-location and eighty-four (84) in Ndiuni sub-location a sample of 60 farmers was proportionately selected from the three sub-locations as indicated in Table 3.1.

Table 3.1: Sample distribution

Sub Location	**No. of Participating Farmers**	**20%**	**Total Participating Farmers Selected**
Mirithu	96	96*20/100	19
Teikunu	120	120*20/100	24
Ndiuni	84	84*20/100	17
Total			**60**

Additionally, for every participating farmer an immediate non-participant farmer was purposively picked giving a total of 60 non-participating farmers as control. Mugenda & Mugenda, (2003), recommends that a sample size of more than 30 or at least 10% is usually appropriate for social sciences. Hence, the selected sample of 20% of the participating farmers and an equal number of non-participating farmers making a grand total of 120 farmers (60 participating and 60 non-participating) formed the sample of this study. Finally, four Governments' and three non-state actors were purposively selected as key informants.

3.4 Data Collection

This study collected both qualitative and quantitative data using the following methods and instruments.

3.4.1 Data Collection Methods and Instruments

This study used both household interviews and key informant interviews as the main methods to collect data and questionnaires and key informants interview schedules as data collection tools.

Table 3.2: Study methods, instruments and sources of information

Method	Tool	Source
Household Interview	Questionnaire	Participating Farmer Household Non-Participating Farmer Household
	Key Informant Interview Guide	GoK Livestock Extension Officer, Agricultural Extension Officer, Social Development Officer, Meteorological Officer, ADS-MK Agricultural Officer, Kenya Rain Water Association Officer, Nachu CBO Chairman

3.5 Data Analysis

Household characteristics (demographic and socio-economic) data collected in this study including; the age of the household head, gender, occupation, source of income, marital status, household size; access to extension services, access to farming information- sources of and type of farming information and access to credit was analyzed through descriptive statistics and presented in form of frequencies and percentages in tables and charts.

Data on famer's perception of climate change was analyzed through opinion scale and presented as percentages in tables and charts.

Given that the study was investigating several adaptation choices, it used Chi Square test of independence to establish the relationship of socio economic variables (gender, age, group membership) and adaptation strategies (soil cover, crop diversity, planting of napier grass, storage of crop residues and rearing of small animals).

Qualitative data was edited, transcribed and classified on the basis of common characteristics and presented in a prose report and direct quotes.

3.6 Ethical Consideration

The researcher was cautious in his process of administering research questionnaires to the participants by maintaining privacy and respondents' rights. Prior administering the instruments, a discussion on the purpose of the study, expected duration of participation and procedure to be followed, benefits to the participants, and assurance of confidentiality was held with the

respondents in a language that they understood. This helped them to provide informed consent to participate in the study.

CHAPTER FOUR: DATA ANALYSIS AND INTERPRETATION

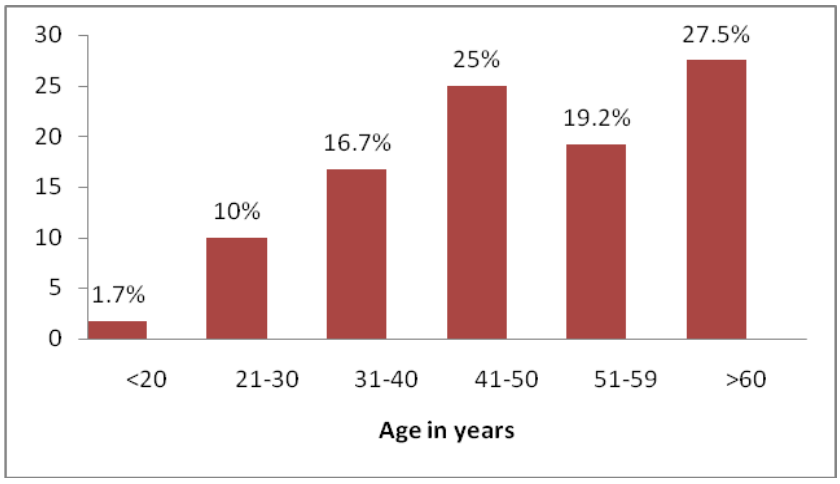
Discussed under this chapter includes three main components: the first section presents the descriptive results on household demographic and socio-economic characteristics. The second section shows climate change perceptions. The third section presents results on the impacts of climate change. Section four presents results on adaptation strategies employed by farmers to deal with climate change for both animals and crops production. Section five presents results on farmers' key socio-economic factors affecting their choice of adaptation strategy.

4.1 Demographic and socio-economic characteristics of the respondents

4.1.1 Age

Age is a key factor in agriculture since it has a relationship to ownership of land resource and one's ability to provide labour and farming experience. The age distribution of the respondents was as follows: Those 20 years and below were 1.7%, those between 21-30 years were 10%, 31-40 years 16.7 %, 41-50 years were 25%, 51-59 years 19.2% and those above 60 years were 27.5%.

Figure 4.1: Distribution of respondents by age



N=120

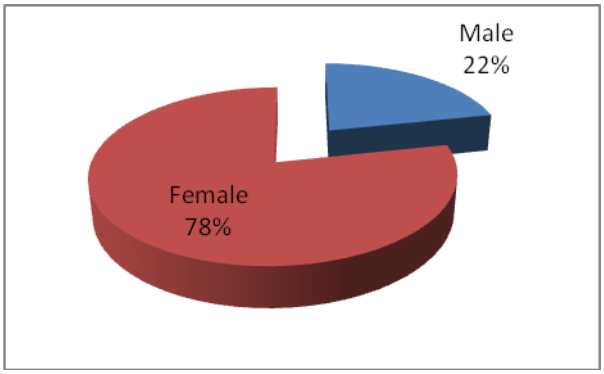
From the above results it is evident that most farmers, 72.6% attained the ages <20-59 years since only 27.5% were aged above 60 years. Therefore, from these findings it clear that farming is a practice by both the young and the aged. However, in agreement with national literature on

agriculture, this study found out that the youth mostly aged below 30 years do not engage in agriculture despite the being the majority cohort in the country; they were only slightly above 10%.

4.1.2 Gender

Gender is a critical social factor to consider in climate adaptation since it impacts adoption decisions and access to adoption resources. The respondents of this were from both genders as shown in Figure 4.2:

Figure 4.2: Distribution of respondents by gender



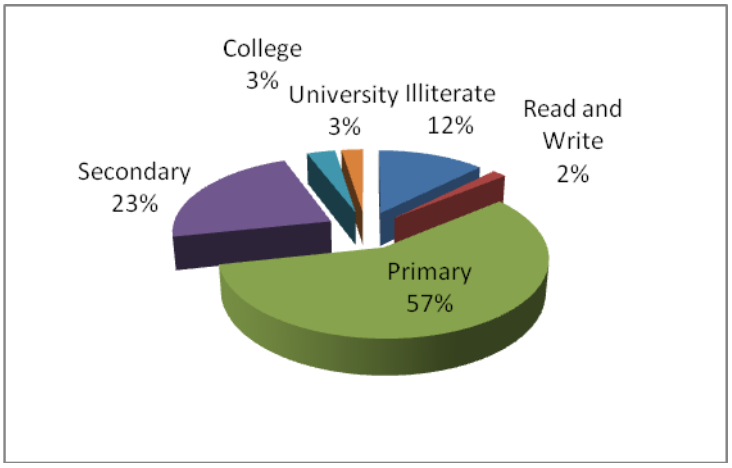
N=120

From Figure 4.2, it is evident that majority (78%) were female and only 22% were male. The above findings agree with findings of previous studies that women actively participated in agricultural undertakings unlike men and have major role to play in climate change adaptation. These findings are in line Nhemachena and Hassan (2007) who found that more women were involved in farm activities than men, whose majorities were engaged in off-farm activities in the nearby capital-Nairobi and local town centers.

4.1.3 Level of education

Level of education is closely related to ones' exposure and ability to seek new information and knowledge. This study revealed that majority of the farmers had attained primary level of education (57%). Twenty three percent had secondary education, while those with college or university level of education had 3% each and 2% had some form of literacy but had not completed primary level of education. Finally, 12% were illiterate as illustrated below.

Figure 4.3: Highest level of education



N=120

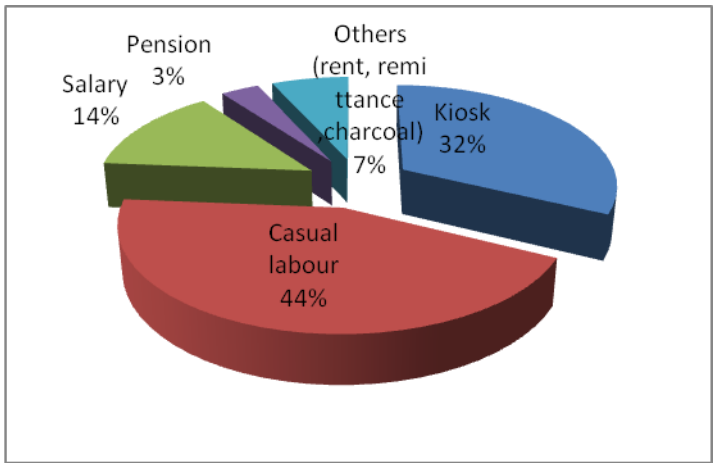
From Figure 4.3 above, it is evident that majority of the farmers had some level of education 88%, ranging from some primary to the university. Hence the illiterate ones only composed of 12%. It is thus deduced that this high level of literacy among the farmers contribute significantly to the enhanced the magnitude of awareness regarding climatic conditions in the study area since the farmers were able to get climate information from media (both print and audio/visual and through their interactions with their peers in groups) which is in concurrence with a study by Noris in 1987, that found out that associated high literacy rates in accessiing information concerning climatic changes and higher agricultural productivity.

4.1.4 Occupation

Occupation of a household head is closely linked with family income and hence the family's ability to access basic needs. Occupation either formal or informal is closely associated with whether a household has the requisite resilience towards climatic shocks.

It was revealed that majority (85%) farmers practiced mixed farming (rearing animals and growing crops) as their main occupation while 15%, practiced crop farming. In addition to the two the above occupations; the study also found out that several farmers had some off-farm sources of income as highlighted in Figure 4.4.

Figure 4.4: Source of off-farm income



N=120

From the findings as indicated in Figure 4.4, majority 44%, were involved in provision of casual labour and 32% were running kiosks. Only 14% of the farmers were in salaried employment. Based on the findings it is evident that majority of the farmers were engaged in employment that can hardly shield them from climate shocks given that the earnings from this kind of employment (casual labour) is limited, irregular and unpredicatable. This study therefore, agrees with findings by Rutaisire et al (2010) who identified that occupation of the household head affects their income and the availability of labour for agricultural activities hence climate adaptation.

4.1.5 Family size

The number of family members is closely associated with availability of family labour which is critical in small scale farming. The family sizes of the respondents were as shown in Table 4.1;

Table 4.1: Family size

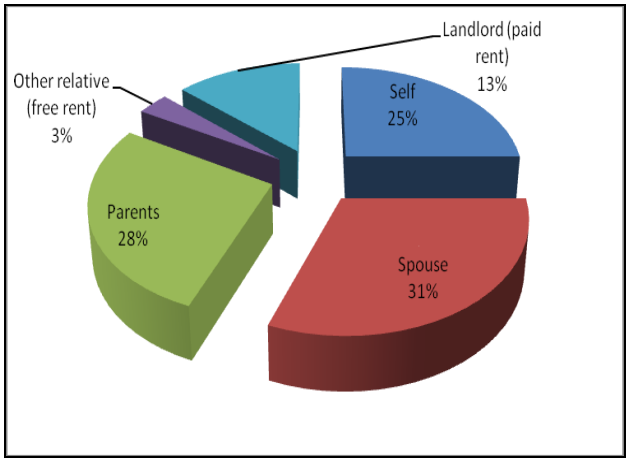
Family Size (X)	Frequency(F)	Percent
2	1	**0.8**
3	10	**8.3**
4	21	**17.5**
5	20	**16.7**
6	28	**23.3**
7	12	**10.0**
8	8	**6.7**
9	8	**6.7**
10	7	**5.8**
11	1	**0.8**
12	4	**3.3**
Total	**120**	**100.0**

From Table 4.1, it is evident that family sizes ranged between 2 and 12 members. The average per household is= $\sum$ XF/$\sum$ F =733/120= 6.1 people per family. This finding is consistent with the national statistics that place the average family size at 6.

4.1.6 Land size and ownership

Land size and ownership are associated with wealth and owner's ability to uptake climate adaptation strategy. This study found out that farmers land holdings range between 1/8 to 12 acres. Sixty percent have land sizes less than 1 acre of land owned as follows; 31% belong to spouses, 28% parents and 25% is owned by self. Thirteen percent of the land is rented and 3% are allowed access to its use by relatives.

Figure 4.5: Land ownership



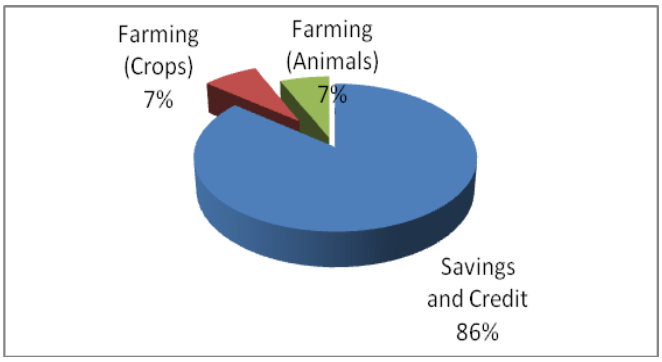
N=120

From the findings as identified in Figure 4.5, it is evident that majority of the respondents are small-scale farmers and do not hold direct ownership to the land they practice agriculture on. Succession was identified as the main reason behind why 25% of the farmers are practicing agriculture in land owned by their parents. A study by Waithaka (2010) in Western Kenya identified that, as landholdings get smaller and the pressure for household food crop production increases, farmers are devising climate smart ways of increasing productivity. He found out that farmers were practicing crop intensification, conservation agriculture and nutrients restocking to increase soil nutrients and crop yields as a buffer to climate change. In concurrence, this study found out that small holder farmers in Ndeiya had resulted to crop diversity and conservation agriculture as mechanisms to shield themselves from the negative impacts of climate change.

4.1.7 Group membership and activities (social capital)

In this study, 88% of the farmers belonged to a certain group while 12% did not belong to any group. Eighty six percent of the groups the farmers belonged to were mainly involved in savings and credit activities, the rest were involved in crop farming and animal farming at 7% each.

Figure 4.6: Group activities



N=105

It is evident from the chart above that majority of the farmers belong to a group engaged in savings and credit. It is thus deciphered that majority of the farmers have access to a source of credit and in agreement with a study by Yirga in 2007, this study found out that availability of credit eased the cash constraints and allowed farmers to purchase improved crop varieties, manage soil fertility and preserve feeds.

Further, the study found out that extension officers from both government and non-governmental agencies were able to access farmers through these groups. The area County Government Extension Officer affirmed that, *".....through these groups, we were able to provide each member with 10 KARI Improved chickens, which could have been something difficult to undertake if the groups were not existing".*

4.2 Perceptions on climate change

4.2.1 Climate change awareness

Climate change awareness also shapes farmer's perception of climate whether they see it as threat or not; and dictates whether they adapt or not (Maddison, 2006). The study found out that; majority of the farmers 94% had heard about climate change and only 6% had not. The sources of this information were identified as follows; media (mainly radio and TV) 46% and friends at 21% friends were the main sources of information on climate change. NGOs and GoK extension agents as sources of climate information were ranked a distant third and fourth at 3% and 2% respectively.

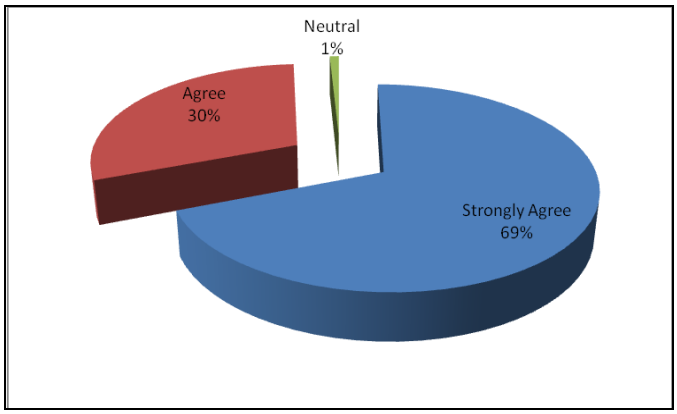
Therefore, from the above findings, it can be deduced that the use of mainstream media is an excellent opportunity to disseminate information on climate change adaptation in addition to extension to extension services provided by the government and NGOs.

4.2.2 Changes in weather conditions

Climate variability has made it difficult for farmers to plan their agricultural production activities throughout the cycle from planting to harvesting due to the unpredictability of weather conditions leading to food insecurity.

This study revealed that majority of farmers, were in agreement that climate was changing and had experienced extreme weather conditions. An overwhelming 99% agreed that climate was indeed changing and only 1% neither agreed nor disagreed as illustrated in Figure 4.7.

Figure 4.7: Distribution of Respondents who have experienced climate variability in the last 20 years



N=120

From Figure 4.7, it is evident that majority of the farmers had experienced climate change variability. This is illustrated by confirmation of a majority that raining times have changed and cold seasons have also become common and unlike in the past when the area was generally warm. A key informant affirmed that; *"it is now not uncommon to see people wearing heavy/warm clothing in months like August that were traditionally very warm*". Therefore, based on these experiences farmers are adopting climate adaptation strategies to shield themselves these climate extremes.

4.2.3 Change in temperature as either too cold or hot

Climate variability involves weather conditions being extreme. The cold weather becomes too cold and the hot weather becomes extremely hot beyond the normal range. This implies that crops take longer to grow and may suffer extremes such as frost or wilt and die due to extremely high temperatures. This study found out that in the last two decades farmers have experienced extreme changes in temperature either being too cold or hot- for instance; the cold season extending beyond the usual period, the hotter periods setting in earlier and being hotter than usual. Ninety eight percent of the respondents agree that temperature has changed while on 2% disagree as illustrated in the Table 4.2.

Table 4.2: Respondents who have Experienced Extreme Temperatures in the last 20 years

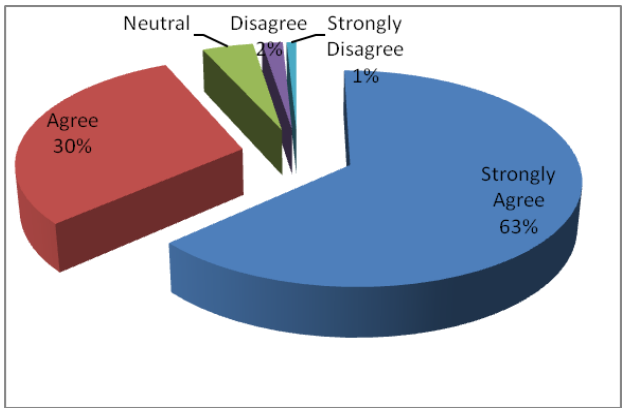
	Frequency	Percent
Strongly Agree	80	**67**
Agree	38	**31**
Disagree	2	**2**
Total	**120**	**100.0**

The mean is 80*5+38*4+2*2/120=4.633 from the probable score of 5. The fact that the mean value was in between scale points of 4-5 denotes that majority of the farmers agree (98%) that they have experienced changes in temperate range and only 2% disagree. From these results therefore it is deduced that the study area has been experiencing variability in temperatures. This finding is further, validated by data from the county meteorological department which indicates increased variability in the last 10 years.

4.2.4 Reduction in rainfall

Reduction in rainfall is a major drawback to farmers who depend on rainfed agriculture since it means lack or depressed yields, hence food insecurity and loss of income. This study found out that 93% agree that rainfall decreased in the last twenty years. However, 3% disagreed and 4% were neutral as indicated by the chart below.

Figure 4.8: Reduction in rainfall in the last 20 years



N=120

To calculate the mean; 76*5+36*4+5*3+2*2+1*1/120= 4.5. The fact that the mean value was in between scale points of 4-5, it was interpreted as to denote the fact that most of the farmers strongly agreed that there has been remarkable reduction in amount of rainfall received in Ndeiya. The above results agree with data collected from the County meteorological department that shows that the amount of rainfall received in the area has been on the decline since the early 1990s. However, there have been periods of enhanced rainfall that have been attributed to the El Nino phenomenon. The disagreement on whether there has been reduction in rainfall is partly attributed to the fact that this study was undertaken in June 2016, a time when the area had received above normal rainfall for two consecutive seasons, thus the farmers could have misconstrued this in their response.

4.2.5 Increase in frequency of drought

Drought is considered as a phenomenon that takes place when precipitation is lower than normal and causes soil hydrological imbalances leading to crop failure and loss of pasture for animals. Ninety one percent of the farmers agree that recurrence of drought has increased in the last two decades. However, 6% disagree and 3% neither agree nor disagree as indicated in Table 4.3.

Table 4.3: Increase in drought frequency in the last 20 years

Response	Frequency	Percentage
Strongly Agree	79	65.8
Agree	30	25.0
Neutral	4	3.3
Disagree	7	5.8
Total	**120**	**100.0**

To calculate the mean, *79*5+30*4+4*3+7*2/120 =541/120=4.5.* Therefore, from the calculation of the mean (4.5) it shows that there was strong agreement among farmers that the frequency of drought has increased in Ndeiya in the last two decades. This finding was colloborated by information given by key informants who observed that...*" the main challenge for farmers here in Ndeiya is the recurrent drought periods. Farmers without enough assets have really suffered since they are less resilient. This has called for the government and non-governmental agencies to respond and assist such farmers and their families".*

4.3 The Impacts of Climate change

Changes in climate impacts on agriculture through change in temperature, the moisture of the soil fertility, duration that the plants takes to grow and a possibility of an increase in extreme climatic conditions (Oloo, 2013). Findings on the change in climate have an effect on Ndeiya as outlined below:

4.3.1 Crop failure

Extreme change in precipitation which is a major cause of crop failure due to flooding or wilting during drought. This disclosed majority of the farmers 97.5% identified loss of crop as a key impact of change in climate particularly due to variability of precipitation. Low precipitation was cited as the major cause of crop failure. Consequently, they reported that this led to loss of income and increased the risk of household food insecurity. This finding was corroborated by the local area chief who affirmed that…*"... since my positing to this area ten years ago, I have*

identified failure of crops as a major impact of climate variability specifically during drought, and a main cause of famine".

The farmers have also noticed an increase in new species of invasive weeds that are uncommon to the area that compete with their crops at times chocking them and leading to crop failure and reduced yields.

Photo 1: Mary displaying one of the invasive weeds from her farm

4.3.2 Loss of livestock

Recurrent drought affects pasture regeneration. Decline in pasture means that animals have less feeds and was identified as the main cause of livestock loss.

This study found out that 66% of the respondents recorded loss of livestock as key impact of climate change. Depressed household income aggravates the situation since the farmers are unable to supplement animal feeds leading to losses.

4.3.3 Fall back to social networks

Social networks are invoked during times of drought as safety nets, where relatives or neighbours support the affected members. This study found out that 80% of the farmers had witnessed relatives taking the burden of supporting their heavily affected members by drought. Mainly the elderly were supported by their children or other close relatives or the general community since they are more vulnerable to climate shocks. Therefore, from these findings it is evident that social glue is still existent in the rural areas as members come to the aid of their affected members.

4.3.4 Shortage of water

Boreholes are the main source of water for domestic use since the area does not have flowing rivers. The study found out that 90% of the respondents identified shortage of water as a key impact of climate change since the existing boreholes dry up or record decline in available water mainly during droughts. Therefore, from the above findings, it is deduced that the respondents spend more time traveling to longer distances in order to access this basic commodity.

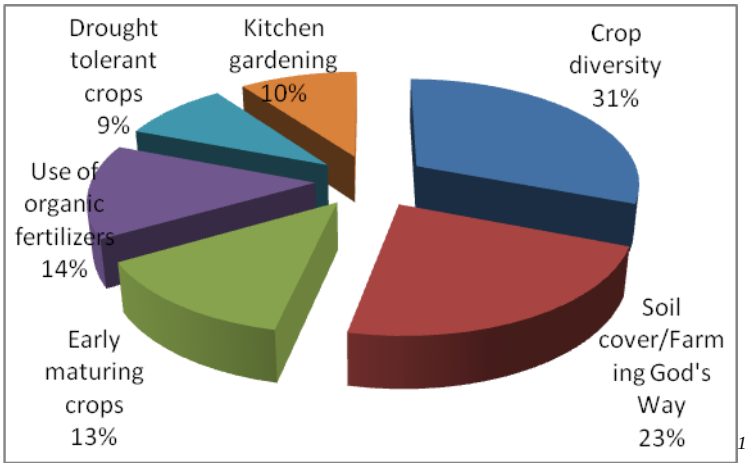
4.4 Adaptation strategies

The study sought to identify mechanisms that are used by the farmers to deal with the effects of drought due to climate change for both crops and animals. The study identified several strategies in use as outlined below:

4.4.1 Adaptation strategies for crop production

Variability in weather conditions affects crops normal growth and yields in equal measures. They may suffer from frost due to extreme cold and death due extreme heat. To shield themselves from these extremes the study found out that majority of the farmers 85% had adopted adaptation measures while 15% had not. The crop production adaptation measures adopted by the farmers were as indicated in Figure 4.9.

Figure 4.9: Crop production adaptation strategies



[1] *N=102*

[1] *Farming God's Way- A conservation agriculture technique, that incorporates biblical principles*

From the above findings, majority of the farmers, 31% adopted planting several crop varieties while planting of drought tolerant crops was the least practiced crop adaptation strategy by farmers at 9%.

The above results reveal that farmers had mainly adopted strategies for ensuring crop survival (crop diversity, planting early maturing and drought tolerant crops) and for ensuring soil fertility (use of organic fertilizers) and water management (soil cover/Farming God's Way and kitchen gardening) to cope with short and long rainfall regimes. It is therefore, deduced the extensive use of dissimilar crop varieties which is meant to adopt to the environment in a cost efficient manner, more trainings and extension on the same by government and non-government agencies, and ease of access of the strategy by farmers.

These findings contrast the strong believe that water harvesting strategies would be highly adopted strategy in this area since it has no flowing rivers.

However, this study identified the heavy capital outlay involved to construct a water pan or procure a water tank as big hindrance for adoption as they can hardly afford from their meager earnings mainly from casual labour.

Photo 2: A gunny garden in one of the household

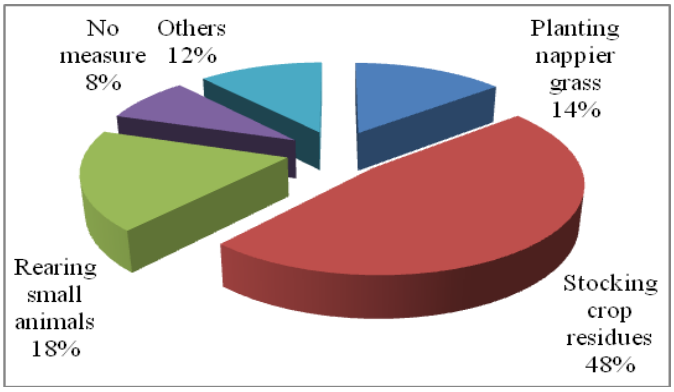
Photo 3: A drought resistant kale species in one of the households

4.4.2 Adaptation strategies for animal production

Livestock is one of the major assets that contribute to the livelihood of a household. Loss of livestock due to climate shock is great set back to the household. Based on their previous experiences farmers have adopted various strategies to cushion themselves from such losses.

This study found out that majority of the farmers 92% had adopted some adaptation measure to cushion their animals while 8% had no measures in place. The main adaptation measures adopted by farmers are as shown in Figure 4.10 below:

Figure 4.10: Animal production adaptation strategies



N=120

From the above results it is evident that only a minority 9% of the farmers that were most vulnerable to climate shocks since they had no adapation measure in place. Ninety two percent had some level of resilience having adopted atleast some adaptation measures.

From the findings above 62% had embraced measures to shield their ruminants by stocking crop residues and establishing napier grass to ensure continuous supply of fodder. Rearing of small animals is embraced by 18% of the farmers and it deduced that the small land sizes and previous experiences of loss of animals and ease of disposal may have contributed to the adoption of this measure.

Photo 4: A farmer's barn for stocking animal feeds ***Photo5: A farmer's housing unit rabbits and chicken***

4.5 Socio-economic factors affecting choice of adaptation strategy

Socio-economic factors including; gender, age and group membership were cross tabulated with adaptation strategies for both crop and animal production and Chi Square Test of goodness fit was carried out to establish whether there is any relationship between these independent variables and dependent variables (crop diversity, soil cover/Farming God's Way, planting napier grass, rearing small animals and stocking of crop residues).

4.5.1 Gender

4.5.1.1 Gender and soil cover

A two by two cross tabulation of gender and use of soil cover gave the following results.

Table 4.4: Observed Frequencies of Gender * Soil cover

		Soil cover		Total
		Yes	**No**	
Sex	**Male**	6	20	**26**
	Female	29	65	**94**
Total		**35**	**85**	**120**

The expected frequencies were: $\frac{(\sum \text{row})\ (\sum \text{column})}{N}$

Table 4.5: Expected Frequencies of Gender*Soil cover

		Soil cover		Total
		Yes	No	
Sex	Male	8	18	**26**
	Female	27	67	**94**
Total		**35**	**85**	**120**

Table 4.6: Deviations of Observed and Expected Frequencies and Chi-Square

Observed	Expected	Deviations	Deviation squared	Chi-Square
6	8	-2	4	0.50
20	18	2	4	0.22
29	27	2	4	0.15
65	67	-2	4	0.06

The computed Chi Square is 0.93 at 1 degree of freedom.

Table Chi Square at 1 degree of freedom at .05 is equal to 3.841

The computed Chi Square is lower than the table Chi Square, therefore gender is has no relationship with the adoption of soil cover as an adaptation strategy for crop production and thus both genders have adopted and practiced soil cover/Farming God's Way.

4.5.1.2 Gender and Stocking crop residues

From a two by two cross tabulation of Gender and stocking of crop residues the following frequencies were observed:

*Table 4.7: Observed Frequencies of Gender * Stocking of crop residues*

		Stocking of crop residue		Total
		Yes	No	
Sex	Male	19	7	**26**
	Female	57	37	**94**
Total		**76**	**44**	**120**

*Table 4.8: Expected Frequencies Gender * Stocking of crop residues*

		Stocking of crop residue		Total
		Yes	No	
Sex	Male	16	10	**26**
	Female	60	34	**94**
Total		**76**	**44**	**120**

Table 4.9: Deviations of Observed and Expected Frequencies and Chi Square

Observed	Expected	Deviations	Deviation squared	Chi-Square
19	16	-3	9	1.78
7	10	3	9	1.11
57	60	3	9	0.15
37	34	-3	9	0.26

Computed Chi Square is 3.3 at 1 degree of freedom.

Table Chi Square at 1 degree of freedom at .05 is equal to 3.841

The computed Chi Square is lower than the Table Chi Square, therefore gender is not associated with the adoption of stocking of crop residues as an animal production adaptation strategy and hence not a factor to consider as any gender has equal chance of adopting the strategy.

4.5.2 Age

4.5.2.1 Age and Soil Cover

From a cross tabulation of Age and Use of soil cover the following frequencies were observed:

Table 4.10: Observed frequencies Age * Soil cover

		Soil cover		Total
		Yes	No	
Age	<20 Years	0	2	**2**
	21-30 Years	1	11	**12**
	31-40 Years	13	7	**20**
	41-50 Years	8	22	**30**
	51-60 Years	6	17	**23**
	>60 Years/Aged	7	26	**33**
Total		**35**	**85**	**120**

Table 4.11: Expected frequencies Age * Soil cover

		Soil cover		Total
		Yes	No	
Age	<20 Years	1	1	**2**
	21-30 Years	4	8	**12**
	31-40 Years	6	14	**20**
	41-50 Years	9	21	**30**
	51-60 Years	7	16	**23**
	>60 Years/Aged	10	23	**33**
Total		**35**	**85**	**120**

Table 4.12: Deviations of Observed and Expected Frequencies and Chi-Square

Observed	Expected	Deviations	Deviation squared	Chi-Square
0	1	1	1	1
2	1	-1	1	1
1	4	3	9	0.44
11	8	-3	9	0.88
13	6	-7	49	0.12
7	14	7	49	0.29
8	9	1	1	9
22	21	-1	1	21
6	7	1	1	7
17	16	-1	1	16
7	10	3	9	1.11
26	23	-3	9	2.56

Computed Chi Square is 60.4 at 5 degree of freedom.

Table Chi Square at 5 degree of freedom at .05 is equal to 11.070.

The computed Chi Square is higher than the Table Chi Square therefore; age is associated with the adoption of soil cover. Thus, a factor to consider when promoting the adoption of soil cover as an adaptation strategy since an as people advance in age the probability of adopting soil cover decreases.

4.5.2.2 Age and Rearing of small animals

From a cross tabulation of age and rearing of small animals as an animal production adaptation strategy the following frequencies were observed:

*Table 4.13: Observed Frequencies Age * Rearing of small animals*

		Rearing of small animals		Total
		Yes	No	
Age	<20 Years	0	2	**2**
	21-30 Years	3	9	**12**
	31-40 Years	5	15	**20**
	41-50 Years	5	25	**30**
	51-60 Years	1	22	**23**
	>60 Years/Aged	2	31	**33**
Total		**16**	**104**	**120**

*Table 4.14: Expected Frequencies Age * Rearing of small animals*

		Rearing of small animals		Total
		Yes	No	
Age	<20 Years	0	2	**2**
	21-30 Years	2	10	**12**
	31-40 Years	3	17	**20**
	41-50 Years	4	26	**30**
	51-60 Years	3	20	**23**
	>60 Years/Aged	4	29	**33**
Total		**16**	**104**	**120**

Table 4.15: Deviations of Observed and Expected Frequencies and Chi Square

Observed	Expected	Deviations	Deviation squared	Chi-Square
0	0	0	0	0
2	2	0	0	0
3	2	-1	1	2
9	10	1	1	10
5	3	-2	4	0.75
15	17	-2	4	4.25
5	4	-1	1	4
25	26	1	1	26
1	3	2	4	0.75
22	20	-2	4	5
2	4	2	4	1
31	29	-2	4	7.25

Computed Chi Square is 61 at 5 degree of freedom.

The table Chi Square at 5 degree of freedom at 0.05 is 11.070.

The computed Chi Square is higher than the Table Chi Square. Therefore, age is a factor in the adoption of rearing of small animals as an adaptation strategy.

4.5.3 Group Membership

4.5.3.1Group membership and crop diversity

From a two by two cross tabulation of group membership and planting crop varieties/diversity, the following frequencies were observed:

*Table 4.16: Observed Frequencies of Group Membership * Crop diversity*

		Crop diversity		Total
		Yes	No	
Group Membership	Yes	33	73	**106**
	No	5	9	**14**
Total		**38**	**82**	**120**

*Table 4.17: Expected Frequencies of Group Membership * Crop diversity*

		Crop diversity		Total
		Yes	No	
Group Membership	Yes	34	72	**106**
	No	4	10	**14**
Total		**38**	**82**	**120**

Table 4.18: Deviations of Observed and Expected Frequencies and Chi-Square

Observed	Expected	Deviations	Deviation squared	Chi-Square
33	34	-1	1	34
73	72	1	1	72
5	4	-1	1	4
9	10	1	1	10

Computed Chi Square is 120 at 1 degree of freedom.

The table Chi Square at 1 degree of freedom at 0.05 is 3.841

The computed Chi Square is higher than the Table Chi Square. Therefore, group membership is associated with adoption of crop diversity hence a factor to consider when offering farmers training since more farmers in groups have an opportunity to be learn from peers as an adaptation strategy.

4.5.3.2 Group membership and planting of napier grass

*Table 4.19: Observed Frequencies of Group Membership * Planting napier grass*

		Planting napier grass		Total
		Yes	No	
Group Membership	Yes	8	98	**106**
	No	0	14	**14**
Total		**8**	**112**	**120**

Table 4.20: Expected Group Membership * Planting napier grass

		Planting napier grass		Total
		Yes	No	
Group Membership	Yes	7	99	**106**
	No	1	13	**14**
Total		**8**	**112**	**120**

Table 4.21: Deviations of Observed and Expected Frequencies and Chi-Square

Observed	Expected	Deviations	Deviation squared	Chi-Square
8	7	-1	1	7
98	99	1	1	99
0	1	1	1	1
14	13	-1	1	13

The computed Chi Square is 120 at 1 degree of freedom.

Table Chi Square at 1 degree of freedom at .05 is equal to 3.841. The computed Chi Square is higher than the Table Chi Square therefore; group membership is key factor in the adoption of planting of napier as an adaptation strategy for animal production.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter presents the summary of key findings and conclusion of the study. It also gives recommendations drawn from the study findings and finally suggestions for future research related to this study.

5.1 Summary of Key Findings

The study investigated the adaptation to climate change in Kenya by small holder farmers in the semi-arid area of Ndeiya Division, Kiambu County. It assessed farmers' perceptions of climate change; the impacts of climate change in the study area, identified adaptation strategies adopted by farmers to enhance crop and animal production and finally, assessed the socio-economic factors that influence adoption of climate adaptation strategies. The summary of the findings is presented below based on the research objectives.

5.1.1 Farmers' perception of climate change

The study found out that majority of the farmers 94% were aware of climate change and received information on climate change mainly from the media (radio and TV) and through their social networks. The study further revealed that 99% of the farmers have experienced change in weather conditions, 98% change in temperature as either too cold or hot. Ninety three percent of the farmers had noted a reduction in rainfall and 91% had identified an increase in drought frequency. This perception was confirmed by the drying up of boreholes and unpredictability of rainfall pattern. Data from department of Meteorology validated these perceptions.

5.1.2 Impacts of climate change

The study revealed several impacts of climate change. They include: crop failure which was identified by 97.5% of the farmers. Loss of livestock as also identified as an impact to climate change by 66% of the respondents due to loss of pasture and slow rate of regeneration especially during dry spell. Social networks were identified by 80% as very supportive during drought where family and community members assisted each other. Finally, water shortage was

identified by 90% of the farmers as impact since during drought boreholes dry up and families are forced to travel longer distances to access water for domestic consumption.

5.1.3 Adaptation strategies

The study identified several adaptation strategies adopted by farmers to deal with climate change for both crop and animal production. Majority of the farmers 31% were practicing crop diversity (planting of several crop varieties), followed by soil cover/Farming God's Way 23% and use of organic fertilizers 14%. Kitchen gardening and planting of drought tolerant crops were the least practiced at 10% and 9% respectively. Inadequate water and pests were identified as the main reasons behind the low uptake of these strategies. Stocking of crop residues 48%, rearing of small animals 18% and planting of napier grass 14% were the main adaptation measures for animal production.

5.1.4 Socio-economic factors influencing farmers' uptake of adaptation strategies.

Several socio-economic characteristics of farmers were identified by this study to have association with climate adaptation strategies for both crop and animal production.

5.1.4.1 Gender

The study found out that gender did not have any association with the adoption of soil cover/Farming God's Way or stocking of crop residues as adaptation strategies for both crop and animal production and there was therefore no gender limitation to adoption of these climate adaptation strategies.

5.1.4.2 Age

The study found out that age was associated with soil cover and rearing of small animals as adaptation strategies. In regard to soil cover, this can be attributed to the labour needed to get the soil cover/mulch and thus as one progresses in age the level of energy decreases. The rearing of small animals is partly associated with experience of loss of crops and animals in the previous droughts and partly to decreasing energy as one ages.

5.1.4.3 Group membership

From the study findings, group membership was found out to have association with the adoption of crop diversity and planting of napier grass as adaptation strategies for both crop and animal production. This can be attributed to farmer extension training and sharing of experiences among the farmers as they undertake their group activities.

5.2 Conclusion

The study findings demonstrate that climate change is a real challenge that is being experienced by smallholder farmers in Kenya. Media and social networks had played a major role in dissemination of information on climate change among the respondents and this is evident from the high level of awareness of climate change. Farmers agree that climate had changed and this was confirmed by occurrences such as; increased frequency of drought, drying of boreholes, and change in temperature. As result of the negative effects of climate change farmers had suffered losses of crops and animals. Consequently their experience on climate change and exposure to climate and agricultural information had enabled them to adopt adaptation measures to shield themselves from these negative impacts.

5.3 Recommendations

From this study several recommendations were made:

1. To increase adoption of adaptation strategies, the county governments and non-governmental agencies should intensify farmers' capacity building on climate adaptation at the farm level.
2. The media is a strong tool to disseminate information. The county governments and NGOs should utilize vernacular radio and TV stations in order to reach farmers with climate adaptation information since majority of the farmers have access either radio, mobile phone or TV.
3. The government at both national and county level should increase the level of investment on water harvesting technologies particularly in the arid and semi-arid areas that have no flowing rivers in order to promote dryland farming/irrigation as an adaptation measure and way of fighting food insecurity.

5.4 Suggestions for further research

1. This study was based on a peri-urban setting where dynamics of the urban areas come into play. A study focusing on a rural semi-arid area is recommended so as to compare the adaptation measures.
2. This study was undertaken in area where several non-governmental agencies had been involving in agricultural projects. A study on climate adaptation in an area where no interventions by non-governmental agencies had been implemented is recommended so as to fully understand the farmers' motivation for climate adaptation.

REFERENCES

Adger, W.N. and P.M. Kelly (1999). *Social vulnerability to climate change and the architecture of entitlements.* Mitigation and Adaptation Strategies for Global Change, 4(3–4), 253–266.

Ajayi. O.C. etal (2006). *Local solutions to global problems: the potential of agroforestry for climate*

change adaptation and mitigation in southern Africa. ICRAF. Lilongwe. Malawi.

Bryant, C etal (2000). *Adaptation in Canadian agriculture to climate variability and change.* Climatic Change 45: 181–201

Collier P. etal (2008). *"Climate change in Africa,"* Oxford Review of Economic Policy. Vol. 24, No. 2.

Conway, G. (2009). *The Science of Climate Change in Africa: Impacts and Adaptation*; Department for International Development (DFID): London, UK

County Government of Kiambu (2013). *County Integrated Development Plan 2013-2017.* Unpublished

Deressa T, etal (2011). *Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia.* Journal of Agric Sci. S0021859610000687.

Droogers, P. (2004) *Adaptation to climate change to enhance food security and preserve environmental quality: Example for Southern Sri Lanka.* Agricultural Water Management 66(1)

Easterling, W.E. (1996). *Adapting North American agriculture to climate change in review.* Agricultural and Forest Meteorology, 80.

Easterling, W.E. etal (2004). *Coping with global climate change: the role of adaptation in the United States*. Pew Center on Global Climate Change. Arlington, Virginia

FAO (2008). *Climate Change and Food Security: A Framework Document*; Food and Agriculture, Rome. Italy.

Gbetibouo, G.A. (2009)**.** *Understanding Farmers' Perceptions and Adaptations to Climate Chan ge andVariability:The Case of the Limpopo Basin, South Africa*. IFPRI Discussion Paper No. 00849

GoK (2013). *National Climate Change Action Plan 2013-2017*. Government Printer. Nairobi.

Hayami, Y. and Ruttan V. W. (1985). *Agricultural development: An international perspective*. The John Hopkins University Press, Baltimore.

Intergovernmental Panel on Climate Change (IPCC), (2001). *Climate Change 2001: Impact, adaptation and vulnerability. (McCarthy J.J. et al (eds). Contribution of working Group II to the third assessment report of the Intergovernmental Panel on Climate Change.* Cambridge: University press Cambridge.

IPCC (2007). *Climate Change 2007: Synthesis Report, Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*; IPCC: Geneva, Switzerland Accessed 10th February, 2016

Jones, P and Thornton, P. (2003). *The potential impacts of climate change on maize production in Africa and Latin America in 2055*. Global Environmental Change 13 (2003) 51–59

Kandlinkar, M and Risbey, J, 2000. *Agricultural impacts of climate change: If adaptation is the answer, what is the question?* Climatic Change 45

Kang'ethe, G. (2004). *Improving information and communication for the smallholder farmers in Kenya.* (Unpublished M.A Project), Nairobi-Kenya.

Kidane, T (2006). *Responding to food security challenges through an integrated watershed approach: Tigray experiences*. Tigray, Ethiopia

Kiteme B. P. (2009). *Agricultural Extension Services and Adaptation to Climate Change in Kenya.* Draft Report. June 2009. German Development Institute Bonn, Germany.

Kitinya, T. K etal (2012). *Climate Change and Variability: Farmers' Perception, Experience and Adaptation Strategies in Makueni County, Kenya*, Asian Journal of Agriculture and Rural Development, Vol.2, No. 3.

Kombo, D. K. & Tromp, D. L. (2006). *Proposal and thesis writing: An introduction*. Nairobi: Paulines Publications Africa

Kurukulasuriya, P. and Rosenthal, S. (2003). *Climate change and Agriculture: A review of impacts and adaptations.* Paper 91 in climate change series, Agriculture and Rural Development, World Bank, Washington DC.

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

Mertz O, etal. (2009). *Farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel*. Environ Manage. 00267-008-9197-0.

Ndambiri K, etal. (2012). *Analysis of farmers' perceptions of the effects of climate change in Kenya: the case of Kyuso district*. Journal of Environment and Earth Science.

Ngigi, S.N. etal (2000). *Technical evaluation of low-head drip irrigation technologies in Kenya. Research report,* University of Nairobi and the International Water Management Institute (IWMI), Nairobi.

Nhemachena, C.; Hassan, R.M (2008). *Micro-Level Analysis of Farmers' Adaptation to Climate Change in Southern Africa*; International Food Policy Research Institute (IFPRI), Center for Environmental Economics and Policy in Africa (CEEPA): IFPRI, Washington, DC, USA.

Nyanga P, etal. (2011). *Smallholder farmers' perceptions of climate change and conservation agriculture: evidence from Zambia.* Journal of Sustainable Development. jsd. v4n4p73.

Odingo, R.S. 1990. *Implications for African agriculture of the greenhouse effect. In: Soils on a Warmer Earth: Proceedings of an International Workshop on Effects of Expected Climate Change on Soil Processes in the Tropics and Subtropics,* Nairobi, Kenya [Scharpenseel, H.W., M. Schomaker, and A. Ayoub (eds.)]. Elsevier Press.

Oloo G, I (2013). *Evaluation of Climate Change Adaptation Strategies and their Effect on Food Production among Smallholder Farmers in Bungoma County, Kenya*. (Unpublished MA Project)

Orotho, A.J. (2004). *Techniques of writing proposal and reports in education and science*: (1st edition). Reater Printers. Nairobi. Kenya

Pandey et al (2007). *Economic cost of drought and rice farmers coping mechanisms: A comparative analysis from Asia*. IRRR. Los Banos. Philippines.

Reilly, J., and D. Schimmelpfennig (1999). *Agricultural impact assessment, vulnerability and the scope for adaptation*. Climatic change 43: 745–788 Resources

ROK, (2007) *Kenya Vision 2030—The Popular Version*; Republic of Kenya (ROK): Nairobi, Kenya

Rutaisire et al. (2010). *Indicators of citizen participation: lesson from learning teams in rural EZ/EC Community*. Community Development Journal Vol 35 No. 1

Sarah, A.O. etal (2012). *Local Perceptions and Responses to Climate Change and Variability: The Case of Laikipia District, Kenya*. MPDI Volume 4 Issue 12

Short, C. and Gitu, K.W. (1990) *Land use and agricultural potential in Kenya. Technical Paper 92-08*. Ministry of Planning and National Development, Nairobi (unpubl.)

Smit, B. etal,(1999): *The science of adaptation: a framework for assessment. Mitigation and Adaptation Strategies for Global Change*, 4, 199–213.

Stringer, L. C. etal (2006). *Unpacking "participation" in the adaptive management of social-ecological systems: a critical review*. *Ecology and Society* 11

Thorlakson, T. (2011). *Reducing subsistence farmers' vulnerability to climate change: The potential contributions of agro forestry in western Kenya.* ICRAF Occasional paper 16.

UNDP (2007). *Human Development Report 2007/2008. Fighting Climate Change: Human Solidarity in a Divided World*; Palgrave Macmillan: New York, NY, USA.

Verchot, L. etal. (2007). *Climate change: linking adaptation and mitigation through agroforestry* Mitigation Adaptation Strategies and Global Change 12: 901-9

World Bank (2008). *Development and Climate Change. A Strategic Framework for the World Bank Group; Technical Report*; World Bank: Washington, DC, USA.

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

Zendera, W. 2011. *Access and utilization of agro meteorological information by smallholder farmers in Perkerra and Lari-Wendani irrigation schemes, Kenya*. (Unpublished MA Project)

APPENDICES

Appendix 1: HOUSEHOLD SURVEY QUESTIONNAIRE

Interview introduction:

Hello,

My name is Kennedy Gichira a Master of Arts student at the University of Nairobi, Department of Sociology. Am conducting a study for my academic qualification to understand how farmers are adapting to the changes in climate here in Ndeiya. Information from this study will help in my studies and development organizations working on Food Security Programs.

Your participation in this study is voluntary and will be immensely appreciated, and your answers will remain confidential. If you feel at whatever point you do not want to continue, kindly let me know. This interview will take approximately 45 minutes.

Thank you for your assistance.

I. GENERAL INFORMATION

ID. 01	Interview guide serial #	(Allocated during data entry)
ID. 02	Date of interview	_____ / 07/ 2016
ID. 03	Name interviewer	

II. DEMOGRAPHIC AND SOCIO-ECONOMIC CHARACTERISTICS

DS. 01 Sex	**DS. 02 Age (years)**	**DS. 03 Marital Status**	**DS. 04 Education Level**	**DS. 05 Family Size (Number)_____**	**DS. 06 Main Occupation**	**DS. 07 Member of a group** If **No** go
1=M 2=F	**1=≤20** **2=21-30** **3=31-40** **4=41-50** **5=51-59** **6=Above 60**	1= Single 2=Married 3=Divorced 4= Other (specify)	1=Illiterate 2=Read and write 3=Primary 4=Secondary 5=College 6=University	1=17 years and below (Children) ---------- 2=18-35 (Youth) 3=36-59 (Adults)---------- 4=Above 60 (Aged)--	1=Crop cultivation 2=Animal rearing 3=Mixed farming 4=Other (specify)	1=YES 2=NO

DS. 08 What is the **Main** activity of your group?

□1=Savings and credit (Self Help) □2=Farming (crops) □3=Farming (animals) □4=Others (Specify)----

DS. 09 Who owns the land that your HH farms on? (i.e. under whose name is the land registered?)

□**1** =Self □**2**= Spouse □**3=**Parents □**4=** Other relative (Free rent) □**5=**Landlord (Paid rent)

DS. 10 (a) What is your total land holding in acres?----------

(b) How much land (in acres) is under:

1 = Crops cultivation----------

2 = Rearing of animals ----------

3 = Homestead----------

4 = Other (specify)----------

DS.11 Please indicate the manner in which you would classify fertility of your soil? □**1=**Infertile □**2=**Less fertile □**3=**Fertile □**4=**Highly fertile

DS.12 What level of productivity is exhibited by your land without use of inorganic fertilizer? □ **1=**High □**2**=Medium □**3=**Low

DS. 13 What form of cultivation do you practice? □**1=**Rain-fed □**2=** Irrigated□ **3=**Mixed

DS. 14 What is the main reason that drives you to farming? □**1=** Subsistence □**2=** For profit (business)

DS. 15 How long have you been involved in farming? □**1**=Short term period (0-10 yrs) □**2**=Medium term period (11-29yrs) □**3**=Long term period (30 years+)

DS. 16 Do you have any source of income outside farming (off-farm)? □ **1**=YES □ **2**=NO If **NO** go to **DS.18**

DS. 17 What is the source? □ **1**=Petty Trading (a kiosk) □ **2**=Casual labour □**3**=Remittance□ **4**=Salary □**5**=Pension □**6**=Other (Specify) ----------

DS. 18 What form of power do you apply when in farming? □**1**=Human □**2**=Non human (If Non human go to **DS 20**)

DS. 19 If Human above, from what source? □**1**=Family labor □**2**=Hired labor □**3**=Other (Specify) -------

DS. 20 From what source? □**1=**Animal traction □**2=**Tractor □**3**= Other (specify) ----------

III INSTITUTIONAL FACTORS (FARMERS PARTICIPATION IN DEVELOPMENT PROJECTS)

IF. 01 Are you aware about agricultural extension services? □**1=**YES □ **2=**NO

IF. 02 In any case, do you have any access to information regarding farming? □ 1=YES □ 2=NO

IF. 03 If YES above, what is your **MAIN** source?

1 = Radio □

2 = TV □

3 = Newspaper □

4 = Poster □

5 = Friends □

6 = Relatives □

7 = Other farmers □

8 = Self Help Group □

9 = GoK Extension Agents □

10 = NGOs Extension Agents □

11 = Others (specify)----------

IF. 04 What information do you get from the source (s) above? *(Check all that apply)*

1 = Making organic fertilizers □

2 = Use of organic fertilizers □

3 = Use of inorganic fertilizers □

4 = Soil conservation practices (Digging of terraces, trash traps among others) □

5 = Water conservation practices (Rainwater harvesting, drip irrigation, among others) □

6 = Tree planting □

7 = Early planting □

8 = Dry planting □

9 = Planting dates □

10 = Seasonal forecast (Expected rainfall, rainfall onset and cessation) □

11 = Suitable crop varieties (certified seeds, drought tolerant varieties) □

12 = Other (specify)----------

IF. 05 What have you implemented in your farm, from your main source of information**?**----------

---

IF. 06 What hinders you from implementing what you learn from the various sources?----------

---

IF. 07 Do you have access to credit for farming? □ 1=YES □2=NO **(If NO go to CP. 01)**

IF. 08 Which is your **Main** source of farming credit?

1 = Savings group □

2 = Bank □

3 = Relative □

4 = Friend □

5 = Other (specify)----------

IF.09 In what form is the credit?

1 = Money □

2 = Seeds□

3 = Fertilizers □

4 = Spraying chemicals □

5 = Others (Specify)----------

IV. FARMERS' PERCEPTION OF CLIMATE CHANGE (CP)

CP.01 Have you come across the word climatic change previously? **1**=YES **2**=NO. If NO go to **CP. 03**

CP. 02 From which source did you hear about climate change? (*Check all that apply)* **1=**Television (TV) □ **2=**Radio □**3=**Newspapers □**4=** Poster □**5=**Friends□ **6=** Chief's *baraza* □**7**= GoK extension agents □**8=**Other (specify)----------

CP. 03 In your opinion, what do you think causes climate change? (*Check all that apply)*

1=Human beings actions □

2=Natural procedures □

3= Human action and natural procedures□

4=I do not know □

Tick appropriately the statements below

CP.04 In the last two decades I have experienced change in weather conditions in Ndeiya

Strongly Agree	Agree	Neither Agrees nor Disagrees	Disagree	Strongly Disagree	Not Applicable

CP.05 In the last two decades I have experienced change in temperature range; either being too hot or too cold

Strongly Agree	Agree	Neither Agrees nor Disagrees	Disagree	Strongly Disagree	Not Applicable

CP.06 In the last two decades I have experienced a reduction in the amount of rainfall received here in Ndeiya

Strongly Agree	Agree	Neither Agrees nor Disagrees	Disagree	Strongly Disagree	Not Applicable

CP.07 In the last 20 years the frequency of droughts here in Ndeiya has increased

Strongly Agree	Agree	Neither Agrees nor Disagrees	Disagree	Strongly Disagree	Not Applicable

CP. 08 In your view, how has been the trend of precipitation over the last 20 years?

□ **1=**Rainfall has certainly increased □ **2=**Rainfall has decreased □ **3=**Raining times have changed

□**4=**The Frequency of Drought has Increased □ **5=** Other (specify)----------

V. CLIMATE CHANGE IMPACTS (CI)

CI. 01 What local parameter are you intending to apply to assess climatic patterns

□**1=** Plant loss and specifies of some animals

□**2=** Increase in famine

□**3=**Shorter crop growing season

□**4=**Rainfall falls earlier or much later

□**5=** Rainfall stops earlier for a shorter duration

□**6=**Decrease in soil productivity

□**7=** Decreased agricultural productivity

□**8=** Decrease in access water/drying up of boreholes

□**9=** Increased flood frequency

□**10=**Other (specify)----------

CI. 02 What local sign(s) have you noted due to variation in temperature in this area? (Please give an example to support your choice) (*Check all that apply)*

□**1.** Increased occurrence of animal and crop diseases which are unfamiliar to this area (i.e. Malaria, East Coat Fever among others)----------

□**2.** Introducing animal and plant species which were unpopular in this place (fast maturing crop varieties, drought tolerant crops)----------

□**3.** Observing physically designed structures and societal clothe styles (Increase in frost, rapid drying up of water pans/dams, dressing heavy clothes in months that were hotter etc) ----------

□**4.** Emergence of new invasive weeds----------

□**5.** Other (specify)----------

CI. 03 Have you observed the following in your neighbourhood during intense drought periods?

a) Family separation (father/husband seeking employment in urban centers) □1=YES □ 2=NO

b) Increased prevalence of malnutrition among children under five years □1=YES □ 2=NO

c) Increased school dropout □ 1=YES □ 2=NO

d) Crop failure □ 1=YES □ 2=NO

e) Loss of livestock □ 1=YES □ 2=NO

f) Elderly people left on their own by their children □1=YES □ 2=NO

g) Relatives supporting those affected □1=Yes □ 2=NO

h) Drying of boreholes, water pans etc □ 1=YES □ 2=NO

i) Others (Specify)----------

CI. 04 What has your family experienced as a result of these changes in precipitation and temperatures?--

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VI. ADAPTATION MEASURES (AM)

AM.01 What are the **MAIN** adaptation measures that you have taken or taking to deal with these extreme changes of weather to ensure continued crop and animal production?

Measures for crop production

Measures for animal production

AM.02 What motivates you to undertake a certain adaptation measure?----------

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AM.03 What factors limit/discourage you from undertaking certain adaptations measures?----------

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Exit

Thank you so much for your time.

Appendix II: INTERVIEW SCHEDULE FOR KEY INFORMANTS

Interview introduction:

Hello,

My name is Kennedy Gichira a Master of Arts student at the University of Nairobi, Department of Sociology. Am conducting a study for my academic qualification to understand how farmers are adapting to the changes in climate here in Ndeiya. Information from this study will help in my studies and also ADS-Mt. Kenya who are implementing the "Ndeiya Integrated Food Security Project". Your participation in this study is voluntary and will be immensely appreciated, and your answers will remain confidential. If you feel at whatever point you do not want to continue, kindly let me know. This interview will take approximately 30 minutes.

Thank you for your assistance.

1. For how long have you been assigned to work with farmers here in Ndeiya?---------years.
2. Kindly share what you do with the smallholder farmers? *Probe* on where and how they reach the smallholder farmers.
3. What are the **Main** challenges facing smallholder farmers in Ndeiya today?
4. What are you doing to help the smallholder farmers overcome these challenges?
5. What are smallholder farmers doing to respond to the negative impacts of climate change?
6. What have you identified as the main hindering factors to small holder farmers adoption of climate resilient technologies?
7. In your view what motivates smallholder farmers to adopt adaptation techniques?
8. Kindly describe the characteristics of a smallholder farmer household that adopts climate resilient technologies.

Exit

Thanks for your time. Do you have any question for me?