ASSESSING VULNERABILITY TO CLIMATE VARIABILITY AND CHANGE OF FOCUS CROPS SMALL SCALE FARMERS IN WOTE DIVISION-MAKUENI COUNTY, KENYA.

By

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JANUARY, 2016

Declaration

Declaration by candidate:

This thesis is my original work and has not been presented for a degree in any other University or other award

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Dedication

I dedicate this work to my parents Angelo Borona and Grace Borona for their invaluable and dedicated guidance and support throughout my graduate academic work.

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ABBREVIATIONS AND ACRONYMS

ASALs	Arid and Semi-Arid Lands
ASARECA	Association for Strengthening Agricultural Research in East and Central Africa
ATPS	Africa Technology and Policy Studies Network
CCAFS	Climate change agriculture and food security research project (under the CGIAR consortium)
CGIAR	Consultative Group for International Agricultural Research
CSTI	Center for Science Technology and Innovation
ENSO	Elnino southern oscillation
FAO	Food and Agricultural Organization
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GIS	Geographical Information System
IARSAF	International Association of Research Scholars and Fellows
IASC	International arctic science committee
ICPAC	IGAD Climate Prediction and Application Center
ICRISAT	International Crop Research Institute for Semi-Arid Tropics
IFC	International Finance Corporation
IGAD	Inter-Governmental Authority on Development
IISD	International Institute of Sustainable Development
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
IPCC	Intergovernmental Panel on Climate Change
KIRDI	Kenya Industrial Research and Development Institute

KNBS	Kenya National Bureau of Statistics
LVBC	Lake Victoria Basin Commission
MDGs	Millennium Development Goals
MoAL	Ministry Of State for Development of Northern Kenya and Other Arid Lands
MoE	Ministry of Environment
NIACS	National Institute of Applied Climate Science
NWCPC	National Water Conservation and Pipeline Corporation
PANESA	Pastures Network for Eastern and Southern Africa
PWC	Price Waterhouse Coopers
SFSU	San Francisco State University
SMEs	Small and Medium Enterprises
SSA	Sub Sahara Africa
SACCO	Savings and Credit Cooperative Society
UNCTAD	United Nations Conference for Trade and Development
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change

ABSTRACT

Climate variability and change are some of the most pressing environmental challenges of the globe and are associated with complexity and extreme events mainly drought and floods. Among small scale farming communities in Sub-Saharan Africa including Kenya, climate variability and change have been a more tasking challenge compared to the rest of the regions. There is little understanding of the vulnerability to climate change among such households in Wote based on their socio economic backgrounds. The main objective of the study was to determine the extent of vulnerability among small scale farmers in Wote division, Makueni County by specifically determining exposure, sensitivity and adaptation mechanisms as pertains climate extremes. The study was carried out between August and September 2013. The study targeted selected farmers cultivating drought tolerant sorghum, cow peas and pigeon peas which are some of the dominant multipurpose crops in the area and are also key means of food security. Random and purposive sampling methods were applied in identifying households cultivating all the three focus crops. Data collection methods and sources included the use of focused group discussions, semi structured questionnaires and secondary climate data from the meteorological department. The collected data was entered and cleaned using CSPro program and later exported to Ms Excel and SPSS for coding and analysis. Descriptive and inferential statistics approaches included correlation, chi square, non-parametric tests and regression. Household characteristics included main respondents and correspondents, 86% and 76% respectively, engaging in farming as the main occupation with 86% of household's main income obtained from on farm produce. Results showed that households have been exposed to calamities in form of; drought, 100%: crop pests, 93%: crop diseases, 83% and erratic rains, 59% with drought ranking highly ($\bar{x}=1.06$,σ=0.28).Crop diseases significantly related to occurrence of crop failure, χ^2=24.860,p=0.000 and Cohen's index=0.445 showing a medium relationship. Drought however did not show a significant relationship with crop failure, p=0.334.Temperature data indicated an annual trend of 0.2122^{0}C (R^2=0.4881) per year with annual means varying significantly, p=0.002. Annual rainfall indicated an annual trend of -0.0708mm (R^2=0.0016) with non-significant seasonal variation, p=0.166, p=0.189 for March-May and October-December rains. Average number of calamity adaptation means were 8, $\bar{x}=8.53$,$\sigma=2.230$,with key mechanisms being pesticide use, 32.5%:drought resistant crops,65%:crop diversification,13% and terracing, 28%. A multiple regression model F (9, 51) =2.655, p=0.013, R^2=0.319 indicated that age, gender and acreage influenced adaptation means significantly: $p<0.05$), p=0.027, 0.043, 0.011 respectively. Further vulnerability analysis indicated most of the households; 79% experienced more than 2 months of food insecure months ($\bar{x}=3.75$,σ=1.49) with such food insecurity correlating significantly with households income (p=0.001,ρ=-.316). Results demonstrate vulnerability due to high dependence on rain fed farming with minimal alternative income and instances of food shortage .The study mainly recommends adoption of alternative income activities, including on farm value addition to supplement farm based income and at the same time enhancement of indigenous and effective modern adaptation mechanisms to enhance adaptive capacity.

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

Climate change, as defined by the IPCC, refers to “statistically significant variation in either the mean state of the climate or its variability, persisting for an extended period typically decades or longer” (IPCC, 2001a). The UNFCCC distinguishes climate change and climate variability with the former being associated with anthropogenic activities such as land use change leading to alteration of the atmospheric composition: the latter is linked to natural processes (UNFCCC, 2014) including SST changes (Lyon & DeWitt, 2012) in the tropical Atlantic and Indian ocean (Johnson, 1996). In addition the WMO give a wider definition of climate variability as “variations in the mean state and other statistics of climate on temporal and spatial scales beyond individual weather events”(WMO, 2015).

Occurrence of climate variability in regions such as East Africa as exhibited by rainfall variations has been associated with natural process such as the ENSO with years experiencing this phenomena characterized by higher than average annual rainfall (Johnson, 1996). The variation of rainfall in the region is also influenced by the ITCZ (Johnson, 1996). Other studies for example Hulme et al.,(2001) add that indeed the ENSO is one of the important causes of climate variability in Africa at large. Smit, Burton, Klein, & Wandel (2000) in their analysis of adaptation explain their lies a strong relationship between climate change, climate variability and extremes such that adaptation to change necessarily includes adaptation to variability.

Climate variability and change have been identified as major challenges facing communities at local, regional and international levels in an array of ways such as prolonged drought and flooding (LVBC, 2011). Indeed data for the last 100 years indicates that the climate over the African continent has warmed up (Hulme, et al., 2001). Hulme et al., (2001) add that this warming has severe impacts on the available water resources an effect that is anticipated regardless of significant alteration of future rainfall. High confidence IPCC projections further indicate that climate change will amplify existing stress on available and already stressed water resource catchments in Africa (Niang et al., 2014).

In Africa climate variability is primarily exhibited by inter-annual, inter decadal and multi-decadal variations which present a great challenge in understanding and prediction (Hulme, et al., 2001). A sector that is highly vulnerable to climate variability and change is agriculture which in Africa is highly dependent on seasonal rainfall (Challinor et al., 2007; Rao et al., 2011). In Africa such rain fed agriculture covers 97% of the crop land and is mainly practiced by rural small scale farmers who are part of the 62% of Africa's rural population (Calzadilla et al., 2009). In Kenya for example agriculture contributes to 25% of the country's GDP (KNBS, 2014). Such numbers indicate Africa is indeed highly vulnerable to climate change impacts a situation that is worsened by high cost of inputs and high population growth rates (Tubiello & Fischer, 2007; Calzadilla, et al., 2009). Such vulnerability has been shown to directly lead to food insecurity and poverty a situation that has hampered achievement of MDGs (Haile, 2005) or even the recently drafted SDGs (Minang et al., 2015).

Effects of extreme events resulting from climate change are becoming a major area of concern and will affect the poor in developing countries in many ways (Desanker & Justice, 2001) including amplifying poverty levels (Speranza et al., 2010). High confidence projections by the IPCC in the fifth assessment outline that climate change will interact with non-climatic drivers to amplify vulnerability of agricultural systems especially in semi-arid areas (Niang, et al., 2014). Specifically, changes in rainfall and temperature are likely to lead to drop in cereal yields quantity and quality which will have severe effects on food security.

Climate change and variability are associated with a wide range of direct and indirect impacts. Drought as one of the key impacts, is a natural disaster brought about by precipitation failure such that there is inadequate water to support crops, livestock and human beings (Oliver, 2005) and such effects are severe in areas of extreme poverty (Sivakumar & Motha, 2008). As such drought as a result of climate extremes has an array of severe impacts on the livelihoods of farming communities in the study area since they are mostly farmers. Crop pests populations and diseases occurrence and/or virulence have also been linked to changes in temperature and humidity (Verchot et al., 2007). This phenomenon indicates that in farming communities variation in climate will indeed be one of the drivers of crop losses. Indeed the IPCC fifth assessment does raise concerns that effects associated with pests, diseases on livestock and crops are likely to be a concern as the climate changes (Niang, et al., 2014). Other studies for example Hendrix & Glaser, (2007) indicate an interesting relationship between interannual variability in rainfall and conflict and emphasize that such instability can be cushioned by breaking the overdependence on rain fed agriculture.

The IPCC assessment as detailed by Niang et al., (2014) indicates that climate change is likely to amplify existing health challenges in the Africa region for example highlands of East Africa could start experiencing instances of malaria including increased health risks as a consequence of insufficient safe water, poor sanitation and limited access to health care.

Vigna unguculata (Cowpeas), *Cajanus cajan* (Pigeon peas) and *Sorghum bicolor* (Sorghum) (referred to as, focus crops, hereafter) are examples of drought tolerant crops and their varieties widely cultivated by small scale farmers in Wote (RoK, 2013). There are renewed efforts, including cutting edge research, to enhance cultivation of the focus crops in SSA to enhance adaptive capacity among these farmers such that they benefit from their efforts (CGIAR, 2006; IITA, 2009; ICRISAT, 2014). The focus crops farmers were the entry point of this study since understanding multiple risks posed among these farmers is going to inform appropriate and transferable adaptive capacities.

1.2 Problem Statement

Climate variability and change, primarily associated with inter-annual and intra-seasonal rainfall variability, are affecting patterns of life and reducing productivity among small holder farmers. This variability is more prevalent in semi-arid environments. Since rainfall and agriculture are intimately linked, heavy reliance on rain fed agriculture as the main source of livelihood by small scale farmers, negates development by increasing poverty when climate extremes strike. Specifically, small holder farmers in Wote are becoming increasingly vulnerable as their adaptation efforts and key livelihoods such as drought resistant crops are eroded (Speranza, et al., 2010; RoK, 2013) by severe climate impacts.

There is evidently little understanding of the drivers and nature of vulnerability of such communities and households in this Semi-arid area. The need to identify indicators of vulnerability to inform on the best interventions to enhance existing adaptive capacity and even transfer and share adaptation mechanisms, informed this study.

1.3 Justification

Enhancement of adaptive capacity among Wote small scale farmers cultivating the drought tolerant focus crops is necessary to enhance resilience at the local level. This is primarily because the farmers in Wote, which is largely semi-arid, are heavily dependent on rain fed farming and are frequently exposed to instances of extreme climate events such as intermittent rainfall. Appropriate and informed crop based adaptation mechanisms and related response strategies indeed do assist small scale farmers achieve food, income and livelihood security in the face of climate variability and change. Accordingly, this research was critical in characterizing the nature and drivers of vulnerability among Wote small scale farmers, cultivating the drought tolerant focus crops, based on their socio economic profiles and acclimatization means. The study is equally essential to inform on appropriate interventions for buffering against inherent and new combinations of climate extremes.

1.4 Research Questions

1. Which are the socio-economic characteristics of the focus crops small scale farmers in the Wote area affecting their adaptation to climate change?
2. Which are the current prevailing climate variability and change indicators in Wote area?

3. How is climate variability and change affecting livelihoods of the focus crops small scale farmers in the study area?
4. Which similar or different means of adaptation have the focus crop small scale farmers in the study area applied with regard to climate variability and change?
5. How vulnerable are the focus crop small scale farmers in the study area?

1.5 Objectives

1.5.1 Main Objective

The main objective of the study was to assess the extent to which the small scale focus crops cultivating households in Wote are vulnerable to prevailing climate variability and change conditions.

1.5.2 Specific Objectives

1. To determine the socio-economic factors that influences the focus crops small scale farmers' adaptation to climate change and variability in Wote areas.
2. To identify local climate variability and change indicators that are affecting the focus crops small scale farmers in Wote area.
3. To examine the impacts of climate variability and change indicators on livelihoods of the focus crops small scale farmers in the study area.
4. To characterize the existing adaptation strategies among the focus crop small scale farmers in the study area.
5. To determine the extent of vulnerability among the focus crop small scale farmers in the study area.

1.6 Research Hypotheses

The study involved testing of three hypotheses involving the household's livelihoods, vulnerability and adaptation to climate change.

i) There is a significant relationship between extreme events and crop failure.

ii) Key occupation of the small scale farmers significantly influences their food security.

iii) There is a significant relationship between food insecurity (number of food short months) and the aggregated household income.

1.7 Significance

Firstly, the vulnerability assessment has identified avenues for informed response strategies such as upscaling of agricultural extension services. These results are additionally relevant in informing decision making at the county level especially in the development of strategic plans that anticipate climate risks. These results can further inform the national government in allocation of adequate funds to ensure small holder semi-arid areas are able to adjust to unexpected climate risks. Secondly, on identification of novel adaptation strategies in the study area, such adaptation strategies can be linked to the climate analogues tool and be applied in other areas of similar climate currently or in future to enhance proactive resilience or “farmers of the future” (CGIAR-CCAFS, 2011). This involves adoption of adaptation mechanisms in practice in other areas experiencing future climate events of the present study area (Adger et al., 2003). As such farmers will be in a position to institute/invest and pay attention adaptation mechanisms based on projected climate events already experienced in other areas. Lastly resulting findings form basis for further research in the topic of climate vulnerability using presented techniques or alternative methods.

1.8 Conceptual Framework

Climate change vulnerability is a relationship between exposure to climate variations, sensitivity to the stressors and adaptive capacity of the households (Schneider et al., 2001; Adger & Vincent, 2005). An example is as Sanchez (2000) state**,** agricultural vulnerability to climate change and variability effects can be detailed in terms of exposure to elevated temperatures, crop yield sensitivity and the ability of farmers to adapt to extremes. Figure 1.1 outlines the relationship between the discussed climate change vulnerability variables linked to specific objectives and data collection tools.

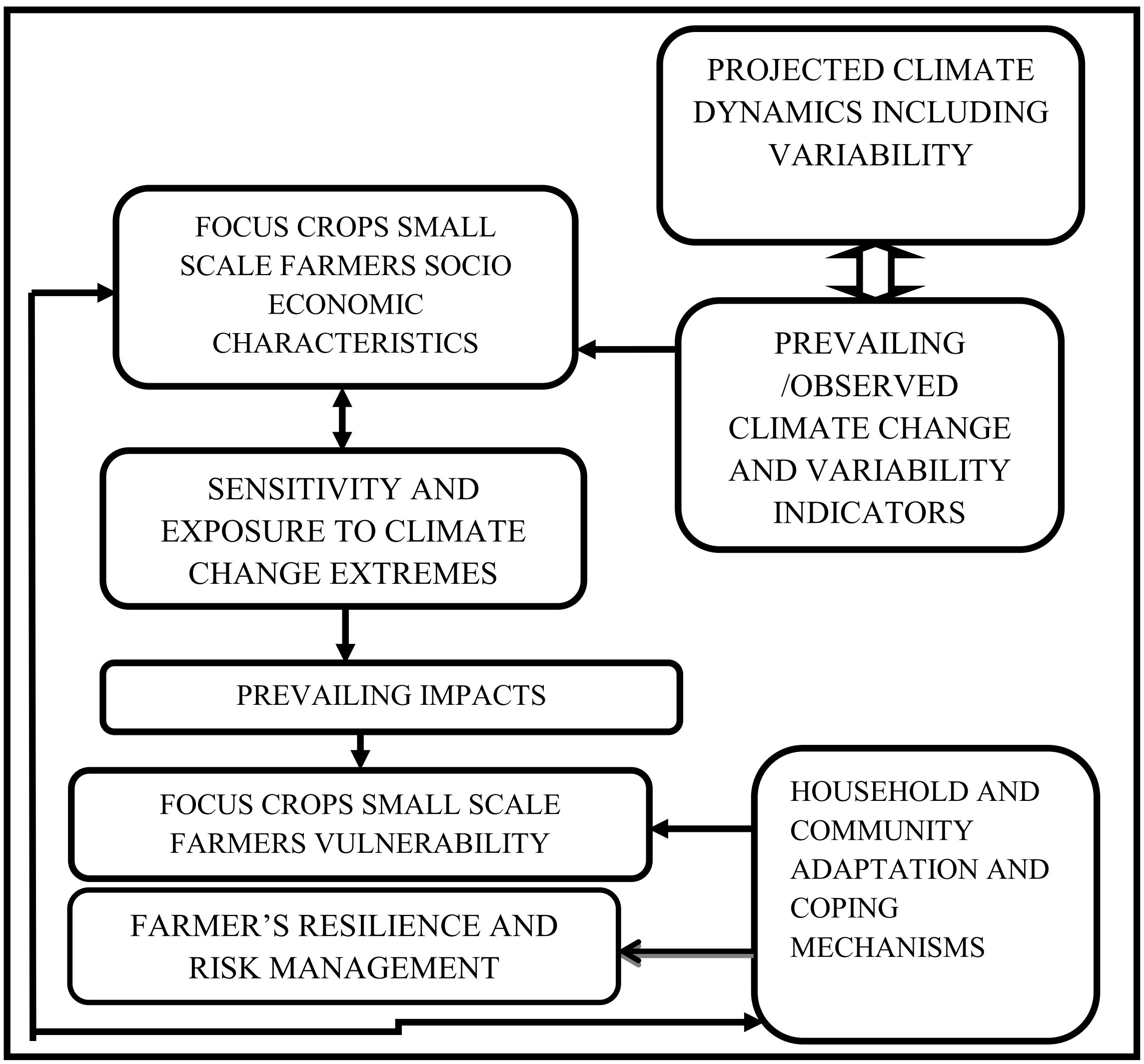

Figure 1.1Conceptual framework adapted from (Füssel & Klein, 2006; NIACS, 2012) showing the relationship between key variables explaining vulnerability.

The vulnerability assessment initially sought to capture selected socio economic characteristics of the focus crops small scale farmers at household levels in Wote that could influence sensitivity and adaptive capacity. Exposure sought to identify specific extreme events including droughts and strong winds that have been experienced by the small scale farmers cultivating the focus crops, including reference to available projections by the IPCC and meteorological data from the Kenya meteorological department.

Impacts include effects associated with exposure to extreme climate events that the households have experienced. Sensitivity to climate extremes is as a result of exposure to extremes and the extent is captured with reference to socio economic profiles (Heltberg et al., 2009). Adaptive capacity is captured as the various adaptation strategies that households have put in place and the availability of government and non-government agencies assistance to farmers when climate extremes strike. These adaptation mechanisms reduce the vulnerability of farmers or in other cases fail to absorb or manage experienced risks. These mechanisms are linked to the socio economic profile of the households including the level of income and the level of education.

With reference to socio economic profiles, the aspects of exposure to climate events and associated impacts, the nature and extent of vulnerability is detailed. As Figure 1.1 also indicates the nature of the relationship between socio economic factors and adaptation strategies is explored.

1.9 Definition of Key Terms

Exposure-defined as the direct stressor and the extent of climate impacts either short or long term on a particular system and includes changes in climate variability and magnitude or frequency of extreme events.

Sensitivity- extent to which a natural or social system will respond to a particular change or variability in climate whether beneficial or harmful. Sensitivity can also be defined as environmental and human conditions that increase, worsen or trigger impacts.

Adaptation-defined as adjustments in practices, processes or structures to offset or accrue from climate variability and change and can be planned or autonomous.

Risk- Probability of damage, liability or injury or equivalent negative occurrence that results from either external or internal vulnerabilities.

Livelihood-array of on-farm and off-farm activities that provide that involve an array of means for making a living

Food security-refers to a state of people's capacity to access safe, adequate and nutritious food.

Focus crops-A word used in this documentation to refer to crops of interest in this research; Sorghum, Cowpeas and Pigeon peas and hence associated households.

Respondent- In this analysis this refers to the household head involved in making of key household decisions and is the main provider of household income.

Correspondent- In this analysis this term refers to mainly the spouse or an elder son or daughter who assists the household head in decision making and obtaining of household income.

1.10 Assumptions and Limitations

It was expected that all respondents will cooperate during the data collection exercise and data collection tools would be well understood. The assumption was indeed met as an array of quality control measures were applied during the study. This included re visiting selected households, while in the field, where provided data had some inconsistencies.

The weather and transport network at the proposed study time was expected to be serene. Indeed the weather was friendly hence challenges of accessing farmer's locations/households were not experienced.

Available climate records were assumed to manifest equally among households in the respective study area hence analysis of climate data was such that all households experienced similar climate extremes. The study was to a certain extent limited by the available finances though efforts were made to efficiently use available resources. This was to ensure the quality of collected data was not compromised.

CHAPTER TWO LITERATURE REVIEW

2.1 Introduction

This chapter discusses the aspect of climate change and variability including global, regional and local climate change predictions as well as aspects of climate impacts and adaptation. Further, the chapter discusses the relationship between the focus crops of the study and climate change extremes. The chapter then presents related research on climate change vulnerability while outlining gaps in such research.

2.2 Causes of climate change and climate variability

Research indicates that key factors bringing about changes in the earth's energy balance and subsequent climate change include; changes in the abundance of greenhouse gases, cloudiness and aerosols, alteration of the earth's atmosphere and surface reflectivity (Forster et al., 2007; IPCC, 2007). The release of GHGs, has been shown since mid-18th century; tended to significantly bring about a warming effect on the earth as a result of alteration of the abundance and properties of GHGs in the atmosphere (Baede et al., 2001). Agriculture contributes about 13.5% of global GHGs emissions mainly methane and nitrous oxide, representing 47% and 58% of the total CH_4 and N_2O respectively: such emissions vary globally though with Africa's being lowest (Chidumayo et al., 2011). Climate variability on the other hand is largely driven by short term changes in average weather conditions including changes in the sea surface temperature (SST) in the Indian ocean (Ingram et al., 2002) as well as changes due to modification of land cover (Nicholson et al., 1998). To this end climate variability is as a result of natural causes but is exacerbated by human activities.

2.3 Global, regional and local Climate change projections

Climate change projections by computer models foresee a global average temperature increase of 0.1^0C per decade with global mean surface temperature increase of between 1.5^0C and 5.8^0C by the year 2100 (Folland et al., 2001; IPCC, 2007; Chidumayo, et al., 2011).

Generally with such temperature rises projections indicate occurrence of key extreme events such as; more frequent heat waves, decrease in (diurnal) temperature range, fewer frost days(in north and central Europe), decrease in frequency of cold air outbreaks, summer dryness/dry extremes and winter wetness-or both at the same place, intense precipitation (due to warmer atmosphere) (Folland, et al., 2001; FAO, 2012).

The most important elements of climate change in Africa include variations in precipitation, occurrence of extreme events as well as CO_2 enrichment (Downing et al., 1997). Projections for indicate that the continent is likely to experience higher than the global annual mean with the drier subtropical regions warming more than the moister tropics and equatorial areas may experience $+3^0$C warming (Christensen et al., 2007). Recent high confidence projections by the IPCC further indicate that the continent has indeed experienced warming over land which is consistent with anthropogenic climate change (Niang, et al., 2014). There are inter model variations hence need for more research in the downscaling of precipitation for Africa (Christensen, et al., 2007) -though generally annual precipitation is likely to decrease in much of Northern and southern Africa while an increase is likely in East and West Africa (Stern, 2006; Christensen, et al., 2007; Chidumayo, et al., 2011; Niang, et al., 2014).

Projections for Kenya to the 2030's indicate a temperature increase trend of a maximum of about 3^0C with regions extending from Lake Victoria to the east of Kenya's central highlands expecting increases in rainfall with maximums at 20% (MoE, 2002).

2.4 Impacts of Climate variability and change on Agriculture and livelihoods

Significant impacts of climate variability and change on agriculture include raising the water demand, limiting crop productivity and reducing water availability where irrigation is needed, increased pest attacks and reduced soil fertility (Chidumayo, et al., 2011; FAO, 2012). In the mid to higher latitudes, a rise in temperature of between 2-3^0C and higher CO_2 levels is likely to benefit- with adaptation-due to lengthening of the growing season (Stern, 2006; Easterling et al., 2007; FAO, 2012) . High confidence projections for Africa by the IPCC indeed indicate ecosystems including species shifts, amplification of water stress, reduced cereal production and increased diseases prevalence (Niang, et al., 2014). These impacts are expected to lead to other devastating effects including effects on fisheries, slowed economic development due to water scarcity and food insecurity and high infant mortality coupled with malnutrition. Niang et al., (2014) emphasize that semi-arid regions are likely to experience severer impacts due to additional influence by non-climatic drivers and stressors and these effects will largely alter agricultural ecosystems subsequently leading to food shortage. This shortage includes aspects of food security such as availability, access, utilization and price stability (Porter et al., 2014).

In SSA including Kenya, climate extremes such as droughts and floods are the main risks affecting agricultural productivity and hence rural food security (Haile, 2005).

These key impacts are largely associated with changes and variations in temperature and precipitation. An estimate of economic costs by Heinrich-Boll-Stiftung (2013) indicates annual losses of about $0.5billion annually from continued extreme climate events in Kenya. Wote area being classified as semi-arid is similarly vulnerable to more frequent severe droughts which are mainly characterized by long dry spells and water shortage (MoE, 2002; Rao, et al., 2011; RoK, 2013).

2.5 Specific impacts associated with climate change and variability in semi-arid agroecosystems and the importance of adaptations.

Climate change and variability are mainly associated with instances of dry spells and droughts which principally result from highly variable rainfall and high temperatures. Dry spells are lengthy instances of absence of rainfall during the growing period which grow into droughts when this length is about 40 days (Mkandawire, 2014) . As such dry spells play a role in shortening of the growing season by bring about a delayed or false onset of the season. Subsequently, there is a high likelihood of crop failure as well as inter-annual yield variability especially for moisture dependent cereals such as maize (Kambire et al., 2010). Instances of dry spells in arid environments indeed largely influence soil-moisture availability (Kisaka et al., 2015) and subsequently contribute to crop-water deficit during key crop growth stages (Igbadun et al., 2005).

Water scarcity is likely to negatively impact livestock in mixed farming systems. This could be by limiting the availability of pasture as well as the area for increasing livestock populations especially in sub Saharan Africa (Porter, et al., 2014). Instances of climate change will also lead to occurrence and distribution of certain diseases and pests such as ticks which carry zoonotic diseases (Porter, et al., 2014).

Vulnerability assessments in other areas have indeed noted the importance of livestock as a key income generating activity (IGA) where such livestock is traded in markets (LVBC, 2011; Recha, 2011). Being a key livelihood sources, including provision of nutrition, livestock loss due to extreme climate events could greatly increase the vulnerability of small holder households.

In the event of climate change and variability impacts as well as changes in socio economic conditions, farming communities at individual level employ adjustments or adaptations to manage associated impacts. These practices also aim at taking advantage of new opportunities. These adjustments can reduce the unforeseen damage resulting from extreme weather risks and are important in Africa where there is higher vulnerability coupled with lower adaptive capacity (Hassan & Nhemachena, 2008). These adaptations assist small holder households achieve their food, livelihood and income security in the face of climate risks and non-climatic drivers such as market fluctuations (Kandlikar & Risbey, 2000). Adger et al., (2003) in their review outline that many adaptation efforts in developing countries will be informed by past experiences and will be further autonomous and facilitated by their own social capital and resource base.

The relationship between climate change and food availability is largely dependent on the timing and nature of adaptation mechanisms (Porter, et al., 2014). This could be influenced by the effectiveness of employed adaptation mechanisms including the timing. Smit et al. (2000) and Kandlikar & Risbey, (2000) add that adaptations could vary with prevailing climate stimuli and economic and institutional arrangements in place at a particular locality.

This implies certain socio economic factors influence the nature and choice of adaptation mechanisms that a household employs (Deressa et al., 2009) with certain adaption mechanisms proving beneficial in addressing climate impacts while others fail (Porter, et al., 2014). Adger et al., (2009) in their detailed review emphasize that a wide range of factors including knowledge on future climate, ethics and their manifestation as well as the value given to places and cultures equally influence climate notwithstanding physical and ecological barriers. This aspect is further reiterated by Kandlikar & Risbey, (2000) who indicate that infrastructure, information systems as well as research for development equally play a role in enhancing adaptation. Absence of these mechanisms in developing countries amplifies their vulnerability.

As such while adaptation mechanisms remain the key drivers of addressing climate induced risks among many households in rural areas of SSA, there are combinations of forces that hinder these resilience efforts, subsequently increasing household's vulnerability. These forces range from those occurring at the household and community level to those manifested at the national and regional stage.

2.6 Climate change tolerance and the focus crops

Various staples have withstood extreme climate events notably drought for thousands of years and these include sorghum and the multipurpose grain legumes; cow peas and pigeon peas (CGIAR, 2006). The grain legumes not only fix nitrogen but also are vital sources of low cost protein in semi-arid tropics and sale of excesses generates significant farm income (CGIAR, 2006; IITA, 2009).

Cowpeas is the most grown grain in the dry areas of Africa producing (5.2 million tons) since the legume tolerates drought and performs in a wide array of soils (IITA, 2009). The cereal is preferred because of its adaptation to marginal climate and suitability for intercropping systems and fast maturity (Infonet-Biovision, 2015a). Pigeon pea is an important crop in Kenya and is grown for home consumption and export and is also rain fed (ICRISAT, 2014). It is an important grain legume in the rain fed farming of semi-arid tropics and yields well in drier conditions with poor soil quality while offering high protein content (Cook et al., 2005; ICRISAT, 2014) . The legume is also used for other purposes such as livestock feed as well as firewood as well as wind control (Cook, et al., 2005).

Sorghum is the fifth most important multipurpose cereal grown in 105 African countries with sweet sorghum providing food, feed, fuel and fodder without significant tradeoffs in grain production (ICRISAT, 2014). Sorghum has a wide adaptability, has a high levels of iron and zinc and is drought hardy than maize but is affected by sustained flooding and numerous diseases (ICRISAT, 2014). Other than tolerating drought conditions the crop also tolerates a wide range of soil types including poor soils where other crops fail (Infonet-Biovision, 2015b).

Based on these hardy characteristics these legumes are important in ensuring of food security in semi-arid lands where rainfall is scarce and soil fertility is low. The increasing importance of the focus crops in achieving food security and adapting to climate change, has indeed been exemplified by their listing as mandate crops for research and development in the CGIAR consortium and funding of related research in Africa by some leading research supporting agencies (CGIAR, 2006; ASARECA, 2013).

2.7 Climate change vulnerability assessment

Recent research on effects of climate variability and change has led to development of the concept of vulnerability to climate change. This refers to the probability to which a natural, social system or wellbeing is susceptible to adapt to or recover from effects resulting from climate change (Kelly & Adger, 2000; Schneider, et al., 2001). Further, three important components are applied in understanding the concept of vulnerability in sectors such as agriculture including: sensitivity, exposure and adaptive capacity (Schneider, et al., 2001; Adger & Vincent, 2005; Easterling, et al., 2007; Heltberg, et al., 2009).

Assessing or rather assessment of vulnerability to climate variability and change seeks to understand which socioeconomic groups or regions are at risk, how and why they are susceptible (Ribot, 1996). Vulnerability assessments present a useful tool for comprehending and responding via appropriate adjustments at national and community levels though there exists challenges such as scarcity of data, crosscutting stressors (non-climate linked) and limited capacity especially in Africa (Adger & Vincent, 2005; Nzeh & Eboh, 2011).

2.8 Literature gaps on vulnerability to climate change

Reviewed of related work on vulnerability assessment does capture the focus crops as adaptation measures while presenting methods of vulnerability assessment. The study hence heavily borrowed from the methodologies particularly indicators applied in vulnerability assessment in sub Saharan Africa, to develop the data collection tools and enrich the literature review.

In addition this study emphasizes on the identified gaps in understanding vulnerability based on socio-economic dimensions at household level as several of reviewed studies on vulnerability emphasize. For example this study looks at vulnerability from a multidimensional point of view by use of socio-economic data and meteorological data. The study additionally involves research at local levels to capture specific social dimensions of climate change. Further the study addresses the gap in understanding vulnerability by emphasizing on socio-economic profiles unlike the use of secondary data. This brings out the local focus in understanding vulnerability.

This study is also informed by the fact that the use of household level primary data is not influenced by a wide range of limits of secondary data including consequences of combining data collected at different spatial-temporal scales and for different research purposes. Further the study ensures that uncertainties associated with vulnerability studied through climate scenarios are accommodated.

CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter includes a description of the study areas geography, population, climate and administrative location. The chapter also discusses the selection of the study area in relation to the continuing project linked to this study. In addition the details on the sampling strategy, research instruments and data analysis are discussed.

3.2 The study area

The study was part of an ongoing project (CCAFS) which cut across the CGIAR consortium, also reported by other studies within the project (Rufino et al., 2013a). The criterion for selection of the study area: heavily applied GIS and remote sensing (high resolution images) and ground truthing techniques to identify dominant production systems -while relying on secondary and primary data: has been detailed below (CGIAR-CCAFS, 2011; Rufino et al., 2013b).

The larger sites (regions), e.g. East Africa in this case, were selected referring to the factors; "There is poverty and high degree of vulnerability to climate; significant but contrasting climate related problems and opportunities for intervention; security, governance, institutional capacity that favour likelihood of generating transferable results; complementary climatic contexts and reflecting different temporal and spatial scales of climate variability and predictability".

The projects study areas in Kenya include Wote in Makueni which is one of the other 34 CGIAR-CCAFS study areas (also referred to as benchmark site's or blocks) measuring 10kms by 10kms found across Africa and Asia.

The blocks are within larger sites (regions) and are chosen where the site listed selection criteria are met which include exhibiting variation with blocks in other regions. Further, benchmark sites or blocks identified within the regions are areas experiencing drier and wetter areas or are at high risk of climate change effects; Wote is associated with severe drought (CGIAR-CCAFS, 2013). The benchmark sites are also focal locations that are expected to generate results that can be applied and adapted to other regions worldwide since these sites are also broad areas including several adjacent districts.

3.3 Description of Study Area

The Wote site (Plate 3.1) lies in Makueni constituency/sub county (RoK, 2013) which has a population of about 243,219 and about 50,203 households and lies within Makueni County in lower eastern Kenya (KNBS, 2011). The coordinates of the specific sampling block are: 37^0.378E, 1^0.657S; 37^0.298E, 1^0.702S; 37^0.244E, 1^0.624S; 37^0.326E, 1^0.581S as shown in the map (Figure 3.1) (Wiebke et al., 2011).

The area has been further described by (CSTI & MoAL, 2009; USAID, 2012). The constituency neighbours include Kaiti and Kilome constituencies to the West, Mbooni to the north, Kitui West to the North West, Kitui south to the east and Kibwezi west to the south, the constituency covers an area of 2,010km^2 with a population density of about 121 persons per km^2. The areas climate is generally semi-arid with the southern part being mainly low lying grassland which is suitable for ranching.

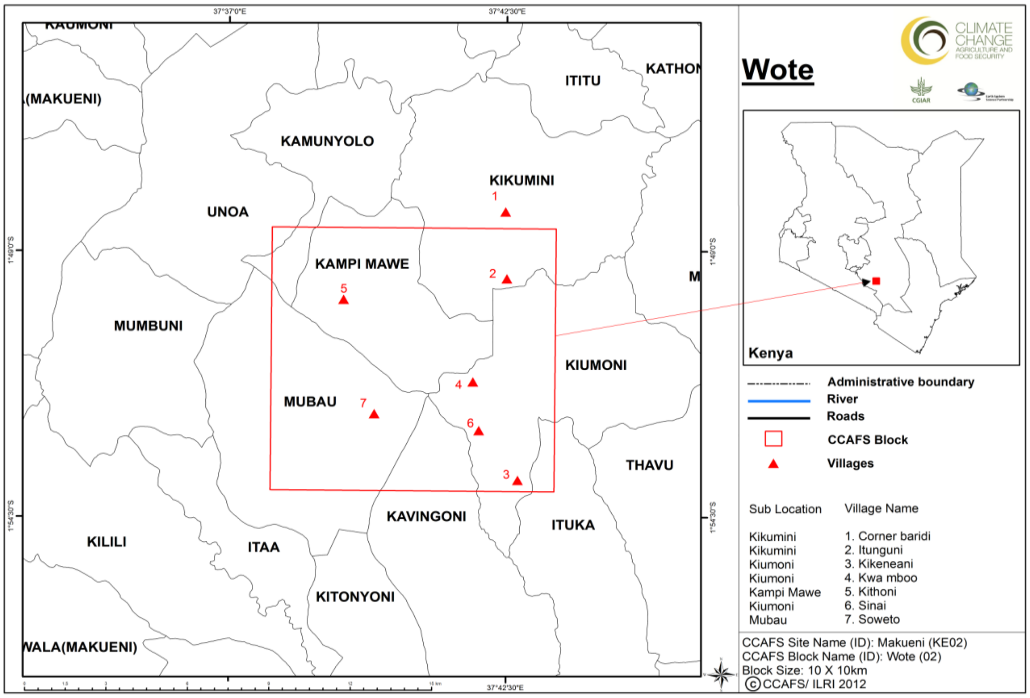

Figure 3.1 Map of the study area

The mean temperature range is between 20.2^{0}C and 24.6^{0}C and is characterized by extreme rainfall variability which affects farming. Hilly areas receive about 800-1200mm per annum while the rest of the areas receive about 500mm per annum. The existing community practices mainly small scale rain fed Agriculture and livestock rearing.

3.4 Sample Size and Sampling techniques

A households sample was generated from an ILRI-CCAFS study in the same area conducted in 2011-2012 (CGIAR-CCAFS, 2012). The ILRI-CCAFS study sample included twenty villages (including those shown in the map legend: Figure 3.1) and a total of 200 households. In the ILRI-CCAFS sample, identified dominant production systems in the area, as described in section 3.2 above, included crop-livestock mixed with local sheep and crop-livestock mixed with dairy (Rufino , et al., 2013b).

In the ILRI-CCAFS sample, 10 villages were randomly selected within each of the two systems and subsequent random selection of ten households in each of the sampled villages. In the listing of villages and households, local leaders notably elders and chiefs were involved mainly in identification of persons and boundaries.

Households cultivating all the three focus crops, were selected by purposive sampling., A total of 120 households cultivating all the three focus crops (sorghum,cowpeas and pigeonpeas) were purposively selected from the ILRI-CCAFS sample.

3.5 Research Instruments

3.5.1Data Collection

A one week pretesting of the research instruments was carried out in the month of July 2013. Both primary and secondary data were collected between the months of August and September 2013.

3.5.1.1Secondary data

Secondary data was collected from an array of sources including CGIAR-CCAFS, ILRI-CCAFS programme baseline studies, district development plans, Kenya Bureau of Statistics, Kenya Meteorological Department, peer reviewed journals, institutional websites and text books. Weather data was collected for the period 1983-2013 for Machakos station located at 1.35^0S and 37.14^0E at an altitude of 1600M.

3.5.1.2 Primary data

1. **Questionnaires**

This included use of pretested questionnaires (Appendix 9) which were semi structured and coded and targeted household respondents for quantitative and qualitative data.

The questionnaire also included measures such as Likert scales. The likert scale was chosen since it has an array of merits and is one of the most common attitude or level of agreement to statement scales (Monette et al., 2013). Merits of likert scales include; possibility of identifying differences among respondents and gives respondents an array of choices and further provides ordinal data that can be analyzed using powerful statistics than nominal data (Kothari, 2011; Monette, et al., 2013). The aim was to capture socio economic data, adaptation strategies, climate impacts and perceptions on climate change.

The study involved a main respondent and correspondent, as defined in section 1.9, with the aim of identifying and involving key members of the respective households involved in decision making. This was important because each contributes to the household's income, well-being and decision making. In addition having two respondents per household was aimed at ensuring all the necessary household information was captured with the two respondents assisting each other in recalling. During the survey it was a requirement that the involved main respondent and correspondent were involved in decision making just like a similar approach employed by Notenbaert et al. (2013) in their climate vulnerability studies in Mozambique. In this study responses from the main respondents and correspondents are only analysed separately for selected variables including age, gender and main occupation. Other variables represent the respective household responses.

2. **Focus group discussion(FGD)**

These targeted knowledgeable focus crops farmers in the study areas focusing on vulnerability to climate variability and change at the community level and sought quantitative data to supplement survey data.

These tool captured aspects such as perceptions on climate change and adaptation at community level. The Focus Group Discussions (Appendix 10) selected men and women from across the villages. The listed villages in the study area were randomly selected and knowledgeable and active farmers nominated from sampled villages with the assistance of local leaders.

3. **Observation**

Direct field observations and photography were applied to identify adaptation strategies and GPS readings of all households were recorded. This was to mainly capture photographic records of specific indicators of socio economic profile and adaptation strategies. An observation checklist (Appendix 7) was applied in this study.

3.5.2 Data management and analysis techniques

Data entry and cleaning was conducted by use of the CSPro version 5.0. This involved initially creating an electronic form replicating the hard copy of the questionnaire and subsequently entering the responses from farmers. The data was then converted into a comma separated value file (CSV) and exported to Microsoft excel version 12 for coding. Subsequently the data was imported into SPSS version 19 for analysis. Indicators of vulnerability and associated data as indicated by farmers were analyzed by among other methods; descriptive statistics, multiple regression and non-parametric correlation.

Air temperature and precipitation are principle elements of the weather systems and examining of their characteristics is vital in comprehending climate variability. As such the parameters monthly maximum and minimum temperatures as well as monthly precipitation totals were applied in computing of annual averages. The formulas applied in computing temperature averages are presented below as shown by in equation 3.1 and 3.2 (Ackerman & Knox, 2007).

$$\boldsymbol{Mean\ monthly\ temperature} = \frac{(\boldsymbol{Max\ monthly\ temperature} + \boldsymbol{Min\ \ monthly\ temperature})}{\boldsymbol{2}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{Equation 3. 1}$$

$$\boldsymbol{Annual\ temperature\ average} = \frac{\sum \boldsymbol{Mean\ monthly\ temperatures}}{\boldsymbol{12}\ (\boldsymbol{number\ of\ months})} \ldots\text{Equation 3. 2}$$

The mean annual rainfall, an average of the monthly rainfall totals for respective year dividend by the number of months as presented in equation 3.3 below (Fedstats, 2009).

$$\boldsymbol{Mean\ annual\ rainfall} = \frac{\sum \boldsymbol{monthly\ rainfall\ totals}}{\boldsymbol{12}(\boldsymbol{number\ of\ months})} \ldots\ldots\ldots\ldots\ldots\ldots\text{Equation 3. 3}$$

A linear regression approach was run to detect trends of annual average precipitation and temperature over the years. Using a linear regression model the rate of change is defined by the slope of the respective regression line (Karabulut et al., 2008).

Examples of non parametric tests include the Kendall’s coefficient of concordance (W) which is applied to determine whether the household’s level of agreement in terms of ranks on key calamities is statistically significant or rather “the degree of agreement or consensus in ranks” as Reid and Smith (2007) state.

The Kendall's coefficient of concordance (Kendall's W) which is used on ordinal data and is a non-parametric statistic similar to spearman correlation (Kraska-Miller, 2013) used on three or more sets of ranks (Asthana & Bhushan, 2007). The formula adopted from Kraska-Miller, (2013) is shown in the equation 3.4.

$$\boldsymbol{W = \frac{12S}{m^2\ n(n^2-1)}}$$ .... Equation 3. 4

Where W is Kendall's coefficient of concordance, S is the sum of squared deviations of the ranks from the mean rank, m is the number of measures and n is the number of objects.

The other non-parametric technique is the Mann-Kendall trend test. Annual average temperature values were subjected to non-parametric tests to identify significant variation. The Mann Kendall statistic was applied to test for monotonic and/or increasing and decreasing trends and change points as well as significance level of annual average temperature values (El-Shaarawi & Piegorsch, 2001; Karabulut, et al., 2008; Mustapha, 2013). The Sen's slope estimator was computed to indicate the magnitude of the significant trend found in the Man Kendall test(Mustapha, 2013).

The Man Kendall's statistic assumes a null hypothesis (Ho) that there is no trend in a series of data (XLStat, 2014).The non-parametric tests were chosen since they are not affected by outliers and do not rely on the traditional assumption that the data is normally distributed and are further easier to apply than their parametric alternatives (Weber & Stewart, 2004; Afzal et al., 2011; Hollander et al., 2013).

The Mann Kendall test value(S) was computed as presented in the equation 3.5 below as discussed by Mustapha (2013) and Karmeshu (2012).

$$\boldsymbol{S = \sum_{k=1}^{n-1} \quad \sum_{j=k+1}^{n} Sign(x_{j-} \, X_K} \,) \text{.. Equation 3.5}$$

Where S is the Mann-Kendall test value, x_j and x_k are the sequential values and *j*, *k* and *n* denote the length of the data.

Equation 3.6 shows an indicator function that takes the values 1, 0 or -1 as per the sign of $(x_{j-} \, x_k \,)$.

$$\boldsymbol{sgn(x_j - x_i)} = \begin{Bmatrix} \boldsymbol{+1\; if(x_j - x_i)} > 0 \\ \boldsymbol{0\; if\; (x_j - x_k) = 0} \\ \boldsymbol{-1\; if\; (x_j - x_i)} < 0 \end{Bmatrix} \quad \text{...................................Equation 3. 6}$$

The variance (σ^2) of the Mann Kendall statistic, VAR(S) as discussed by Mustapha (2013) and Karmeshu (2012) was computed using equation 3. 7.

$$\boldsymbol{VAR(S)} = \boldsymbol{\frac{1}{18}[n(n-1)(2n+5) - \sum_{p=1}^{g} tp(t_{p-}\; 1)(2_p^t + 5)]} \text{...........Equation 3. 7}$$

Where *n* denotes the number of points, *g* denotes the number of tied groups while t_p denotes the number of points in the p_{th} group. The summation term was only used since there were tied values in the data series or in the equation (Karmeshu, 2012).

As discussed by Mustapha (2013) where the length of the data exceeds 10 in this case years the standard normal variate is calculated to determine the trend in the set. The normalized test statistic noted as Z is computed as shown in equation 3.8 adapted from Douglas et al. (2000) in their floods trend analysis.

$$\boldsymbol{Z} = \begin{Bmatrix} \boldsymbol{\frac{S-1}{[\sqrt{VAR(S)}]} if\; S} > 0 \\ \boldsymbol{0\;\; if\; S = 0} \\ \boldsymbol{\frac{S+1}{[\sqrt{VAR(S)}]} if\; s} < 0 \end{Bmatrix} \text{.. Equation 3. 8}$$

Where *Z* is the normalized test statistic, S is Mann-Kendall's statistic and *VAR(S)* is the variance of the Mann-Kendall test.

The Sen's slope (Q) estimates for the annual temperature averages was computed using the method shown in equation 3.9 as discussed by (Gilbert, 1987).

$$\boldsymbol{Q = \frac{x_j}{j} - \frac{x_k}{k}} \text{..........Equation 3. 9}$$

Where Q is the Sen's slope estimator: x_j and x_k are data values at periods/time *j* and *k*.

When there are *n* values of the x_j in the time series or periods, the Sen's slope estimator is equal to the median of *n* (*n*-1)/2 pair wise ranked slopes, the Sen's slope can be hence computed using the equation 3.10 or 3.11 shown below (Gilbert, 1987) and as reported by (Mustapha, 2013);

$$\boldsymbol{Q = Q\left(\frac{N+1}{2}\right) if\ N\ is\ odd} \text{..........Equation 3. 10}$$

$$\boldsymbol{Q = \frac{1}{2}\left(Q\frac{N}{2}\right) + Q\left(\frac{N+1}{2}\right)\ if\ N\ is\ even} \text{..........Equation 3. 11}$$

Another applied method is the coefficient of variation. Initially in the seasonal rainfall trend computations years with several missing monthly values were excluded since they may influence the averages by acting as extreme values or outliers. The coefficient of variation (CV) for seasonal rainfall was computed which implies that seasons with a smaller value are homogenous in terms of rainfall variations unlike those with large CV values (Karabulut, et al., 2008; Recha, 2011).

The coefficient of variation was computed by division of the average annual rainfall by the standard deviation multiplied by 100 and is usually used to measure how points vary about a mean(Mustapha, 2013; SFSU, 2013). This is presented in equation 3.12.

$$\boldsymbol{COV = \frac{Mean\ Annual\ Rainfall}{\sigma} \times 100} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Equation 3. 12}$$

The higher the coefficient of variation the more variable the rainfall of a place is and more so the COV of yearly precipitation is an index of climatic risk noting the likelihood of drops in crop yield (Shulze, 2001).

In addition the standardized anomaly index, an approach of examining presence of climatic fluctuations was used on seasonal rainfall data .This is to study trends and enable identification of instances wet and dry periods or annual variability as discussed by (Lázaro et al., 2001; Tilahun, 2006; Karabulut, et al., 2008). The standardized anomaly index was applied in this study to indicate wetter and drier years as shown in equation 3.13. This approach was applied in this study for the years, running from 1983 to 2012.

$$\boldsymbol{Z = \frac{(x-\mu)}{\delta}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Equation 3. 13}$$

The equation is adopted from Hadgu et al.,(2013) where *Z* is the SAI, *x*, is the respective year annual precipitation, μ and δ represent the mean precipitation and standard deviation for the time series.

Another technique is applied to identify the direction of selected weather and related aspects, households indicated which of those aspects had to a large extent changed over the last decade, a similar approach applied in related vulnerability assessments (LVBC, 2011).

Such significance was noted by denoting a value of one (1) on the respective aspect in this study by the respective household.

To test hypothesis (i) using categorical dependent and independent variables, the Pearson Chi square, a non-parametric statistical technique (Pallant, 2013) was used . The Chi square tests an alternative hypothesis that there is a significant relationship between two categorical variables with a threshold value/significance level/p-value of 0.05 (Huizingh, 2007).

Since the chi square does not specify the nature of the relationship between two variables, additional statistics were computed and in this case Cramer's V which denotes the strength of the correlation between two nominal variables (David & Sutton, 2004; Huizingh, 2007) as has been applied in other studies to identify the strength of association (von Below et al., 2008). As discussed by Gray and Kinnear (2012) to further evaluate and interpret Cramer's V index the values were transformed into an equivalent Cohen's index of effect size, with the formula presented in equation 3.14 and 3.15.

$\boldsymbol{V} = \sqrt{\frac{\boldsymbol{x^2}}{\boldsymbol{N(a-1)}}}$.. Equation 3. 14

$\boldsymbol{w} = \boldsymbol{V}\sqrt{(\boldsymbol{a} - \boldsymbol{1})}$..Equation 3. 15

Where *w* is Cohen's Index, a and *V* represents the Cramer's V index computation formula. The formula shown in equation 12 is "applicable to a $a \times b$ contingency table, in which *a* is not larger than *b*". In this case $a \times b$ is represented by a 2×2 contingency table.

Other techniques used in hypothesis (ii) and (iii) testing included the Mann Whitney test and spearman correlation. The Mann-Whitney U test which is a non-parametric alternative to independent samples T-test (Pallant, 2013). The spearman correlation is a similar approach applied by Adebayo et al.(2011), in their climate change adaptation studies in Nigeria. Further, Pearson correlation was chosen due to the continuous nature of the variables (2007) and to accommodate for non-normal distribution of the variables (Pallant, 2013).

The wide range of inferential statistics were mainly computed with the aid of SPSS and XLStat, a powerful extension of Microsoft excel. This tool was used in trend analysis and runs independently but relies on Microsoft excel for input and output. Results are presented and discussed in detail in the next section. Tables and Figures were developed from SPSS output using Microsoft excel because of the software’s strength in presentation.

3.5.3 Validity and Reliability

To ensure the survey tools produce stable and consistent results as well as measuring the intended parameters, an array of techniques were applied. Initially the developed survey tools were subjected to content validity assessment by sharing with experts with knowledge in the subject of climate vulnerability. This was followed by adjustments as well as development of construct validity where wording was developed to ensure responses were consistent during a typical survey. In addition a pre-test was conducted before the survey to find out how the survey tool captured the topic at hand practically.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This section is the core of the research presenting results of analysed secondary and primary data and relying on related work to justify such results. Initially discussed are selected socio economic characteristics of the selected households in Wote which are at the end related to instances of food insecurity. Socio-economic characteristics are applied in reaching of objective 1 and 4 of the study. This is followed by the exposure context outlining the specific calamities that have affected them and associated impacts and a detailed discussion of the means of adaptation against impacts and relationship between adaptation and household characteristics.

4.2 Household socio economic characteristics

4.2.1 Respondents gender and Age

The tabulation in Table 4.1 presents the gender distribution of key respondents and correspondent's by gender which shows that demographic representativeness was achieved. The lesser number of correspondents was a result of cases where the spouse was unavailable or the household head was bereaved.

Table 4.1 Gender distribution of main respondent and correspondent in Wote

	Main respodent		Correspondent	
	No.	%	No	%
Male	69	58%	38	36%
Female	51	43%	68	64%
Total	**120**		**106**	

Involvement of both genders and/or respondents enabled comparative conclusions notably influence on adaptation as indicated in other studies such as Morlai et al.(2011).

From the tabulations it is apparent that more than half, 58%, of the main respondents were male while female constituted 43%. On the other hand in the correspondents group the female respondents were more at 64% while males were 36%. The age statistics of respondents as presented in Table 4.2 indicate that the average ages of the respondent were 49 years ($\bar{X}$=49.87, σ=18.069) and 42 years ($\bar{X}$=42.63, σ=16.099) for the main respondents and correspondents respectively.

Table 4. 2 Age distribution statistics of the respondents

	Main respondent age	Correspondent age
Mean	49.87	42.63
Mode	45	30
Std. Deviation	18.069	16.099
Minimum	21	17
Maximum	95	95
N	**120**	**106**

Further most common recorded ages were 45 and 30 years for main respondents and correspondents respectively. The highest recorded ages for both groups were 95 years while the lowest ages were 17 years and 21 years respectively for main respondents and correspondents. The age distribution pivot table indicates that most of the main respondents were aged between 31 and 60 years while most correspondents were aged between 27 and 66 years (Table 4.3).

Table 4.3 Age distribution of main respondents and main correspondents in categories in Wote

Respondent			**Correspondent**		
Age category	Count	%	Age category	Count	%
21-30	16	13%	17-26	14	13%
31-40	29	24%	27-36	27	25%
41-50	24	20%	37-46	29	27%
51-60	20	17%	47-56	13	12%
61-70	14	12%	57-66	15	14%
71-80	9	8%	67-76	3	3%
81-90	4	3%	77-86	4	4%
91-100	4	3%	87-96	1	1%
Total	120			106	

Since the study aimed at identifying exposure and adaptation to climate change the larger number of experienced farmers is better at" distinguishing climate change and inter-annual variation" Maddison (2007) as well as exhibiting farming experience (Deressa, et al., 2009). Other studies have reported that age and gender influences the capacity of an individual, household or community to cope with climate impacts as well as contributing to adaptive capacity to curb climate vulnerability (Gabrielsson et al., 2013). The age categories distribution for both main respondents and correspondents indicated that more than half of the respondents were experienced farmers who were in a position to adequately detail their experiences with climate dynamics at Wote (Table 4.3).

4.2.2 Household roles

To further characterize the households in the study area, the roles of the respective respondents were recorded as presented in Table 4.4. Most of the main respondents, 63%, were household heads while most of the correspondents, 44% were spouses.

Table 4.4 Roles of main and correspondents in Wote

	Household head		Spouse		Child		Parent		Sibling		House help		Other	
	No.	%	No.	%	No.	%	No.	%	No	%	No	%	No.	%
Main respondent	75	63%	36	30%	5	4%	1	1%	1	1%			2	2%
Correspondent	23	22%	53	50%	17	16%	3	3%			2	2%	10	9%

N=120

The findings represent a typical African rural farming household where the key decisions are made by the household head and in their absence the spouses are responsible, as noted by (Tabola & Amponsah, 2012).

In other cases, notably contemporary times, both the household head and spouse consult among themselves on farming and business decisions in the household notably where women are of powerful and wealthy backgrounds (Tabola and Amponsah, (2012). Additionally the 16% representing the children included elder sons and daughters who are old enough to make household decisions in the absence of their parents.

4.2.3 Education levels

Table 4.5 indicates that both the main respondents and co respondents were mostly educated to the primary level at 55 % and 62% respectively.

The numbers educated at secondary were almost the same for both the respondents and correspondents at 20.8% and 19% respectively (Table 4.5). There was low percentage of respondents who had pursued education past the secondary level with main respondents at 3% and co respondents at 1% while 19% and 16% of the same having no formal or informal education (Table 4.5).

Table 4.5 Education level of Respondents in Wote

	none		**Adult education**		Primary		Secondary		Above secondary		Total
	No	%	No	%	No	%	No	%	No	%	
Main respondent	23	19%	23	19.2%	66	55%	25	20.8%	3	3%	120
Correspondent	17	16%	2	2%	65	62%	20	19%	1	1%	100

Such minimal education level is likely to reduce the capacity of the respondents to adapt to extreme events and more so the capacity to improve their livelihoods. The low literacy levels involving large number of primary level educated respondents in rural small scale households has been similarly noted in other vulnerability studies in semi-arid areas in Kenya Recha (2011) and parts of Southern Africa (Notenbaert, et al., 2013). Education has been identified as a key avenue for gaining employment and subsequent alternative income for providing resources in rural households and hence a key endowment to enable households deal with poverty (Verma, 2001; Christensen, et al., 2007).

Notenbaert et al. (2013) in a similar vulnerability assessment in arid and semi-arid Mozambique did identify low education levels as a factor in reducing the ability to manage farms and access to public services resulting in vulnerability and reduced coping capacity.

The study further found that education informs on proactive adaptation means such as sleeping under nets to avert mosquitoes as an impact associated with climate extremes. In other studies better health and improved physical well-being, both that reduce climate vulnerability, have indeed been linked to better education levels (Striessnig et al., 2013).

Other studies have identified access to education as a means of enhancing access to early warnings such as drought predictions, which contributes in reduced vulnerability to climate risks (Patt et al., 2005; Thornton et al., 2006; Striessnig, et al., 2013).

4.2.4 Household size

The average household size in the area was six members ($\overline{X}$=6.08, σ=2.38) (Appendix 1) with most households consisting of five members (*Mo*=5) which does not differ from the county average of 6 (RoK, 2013) and national average of 5 as noted by (UNFPA, 2009).

Table 4.6 Household size categories

Household number range	No.	%
2-6	78	66%
7-11	38	32%
12-17	3	2%
Total	**119**	

A shown in Table 4.6 the larger proportion of households consisted of up to 6 members. Further investigation of the results as shown in appendix 1 indicated that both the kurtosis and skewness values are more than 2.5 times larger than their standard errors violating the rule of normality or normal distribution.

This implied that such variable should be analysed using non parametric tests (Morgan & Griego,(1998). Larger households with more than six members which is the county average are likely to face challenges in achieving food security during extreme weather events while they could also benefit from the households adequate labour.

From the results in Table 4.6 these households were about 34%. This relationship between household size and household vulnerability has indeed been noted in related studies. Recha (2011) in his vulnerability assessment in semi-arid Kenya indicates that large households with as many as 8 or 9 members and above are likely to have problems during climate related events such as famine notably resource limited ones.

Recha (2011) however adds that large households will benefit from distribution of on farm labour. This number can however be influenced by the age of the household members. Higher number of dependants has additionally been shown to contribute to shifting of a household from low to high vulnerability to climate change effects in other related studies since there are more mouths to feed than pair of hands to work (Leary, 2008; Nkondze et al., 2013). A related vulnerability study in rural Ghana found a trend where household size tended to increase vulnerability to climate change extremes (Leal Filho, 2013).

4.2.5 Main occupation and Income sources

Most of the respondents were engaged in farming as their major occupation represented by 86% and 91% of the main respondents and correspondents respectively (Table 4.7).

Table 4.7 Main occupation of respondents in Wote

	Small Business		Casual labour		Farming		Formal employment		Informal Employment		Total
	No	%	No	%	No	%	No	%	No	%	
Main respondent	4	3%	2	2%	103	86%	1	1%	6	5%	116
Correspondent	1	1%	3	3%	91	91%	3	3%	2	2%	100

A small number of main respondents (5%) indicated that they were engaged in informal employment while a slightly lower percentage, 2%, of correspondents engaged in the same (Table 4.7). The results indicated that majority of the households in the area were indeed engaged in farming as a major occupation as reported by 86% and 76% of respondents and correspondents respectively (Table 4.7).

This concurs with government reports on Makueni county (RoK, 2013). This has also been noted in related studies in semi-arid parts of Kenya (Recha, 2011) as well as future projections for other parts of sub Saharan Africa (Cooper et al., 2008) and more so the drier parts (Mertz et al., 2009). Alternative off farm activities such as small businesses, 3% for main respondents and 1% for correspondents, account for alternative sources of income. Examples of small businesses included kiosks established adjacent to the household mainly at the gate and involved selling of household goods such as cooking fat, bar soap and sugar.

To further understand the household’s livelihoods, the main income sources were recorded (Table 4.8).

Table 4.8 Main Household income sources among Wote Households

Income source	%*	No
On farm produce	86%	103
Small business	61%	73
Animal products	50%	60
Remittances	32%	38
Casual labour	28%	33
On farm products	25%	30
Selling natural products	15%	18
CBO loan	9%	11
Renting out land	8%	9
Renting out machinery	8%	9
Selling natural resources	8%	10
Salary	7%	8
Pension or aid	6%	7
Gifts	5%	6

N=120 *Percentages sum exceed 100% because these are multiple responses.

Farm based sources of income included on farm produce (86%), on farm products, (25%), natural products (15%), and animal products, (50%), which represented a big proportion of the sources of income (Table 4.8). In the study, on farm produce were categorized as crops, fruits, vegetables and fodder. On farm products on the other hand included timber, fuel wood, charcoal, compost, honey and carvings. The results gave evidence that since the major occupation was farming, by 86% and 91% of main and correspondents, the households highly relied on farm output. However, such dependence on agricultural based income is at risk when climate extremes strike.

This is because effects associated with extreme climate events on farming indeed bring about severe impacts on agricultural based income notably in least developed countries due to over dependence on rain fed farming (Dixon et al., 2003; UNCTAD, 2009).

It is notable that more than half of the households, 61%, were engaged in small business to supplement their income sources. In addition other households, 28%, engaged in casual labour as a means of obtaining additional income (Table 4.8). Another income source was remittances as indicated by 32% of the households who received income from household members working in other parts (Table 4.8).

The sale of natural resources and natural products ,as noted by 8% and 15%, of the households included resources outside their own farms, for example resources obtained from community land (Table 4.8). In this category natural resources included cutting of trees as well as rock and or sand harvesting. Further, natural products included honey, charcoal and handicrafts. Households further indicated obtaining income from renting out of resources such as land, 8% as well as farm machinery, 8%. Households with membership in CBOs, 9%, indicated obtaining income from CBO loans (Table 4.8).

To further understand income sources the respondents were asked to rank the three main income sources by labeling them rank1, rank 2 or rank 3 with rank1 indicating the main sources of income. In selected cases households did give up to four main income sources, hence the appearance of rank 4 in Table 4.9. As such Table 4.9 puts income sources into further perspective by indicating a summary of ranks of the various major income sources. The ranks were aggregated into median and mean values for the respective sources of income as indicated by the respondents. The ranks means and median in Table 4.9 indicate indeed on farm produce is considered as the main source of income among the interviewed households ($\tilde{x}$ =1).

Table 4.9 Main Income sources among households in Wote ranked

Income Source	Number of responses	Mean	Median($\tilde{x}$)	St Dev
On farm produce	114	1.27	1	.599
Animal products	89	2.40	2	.686
Casual labor	45	2.02	2	.812
Pension or aid	4	3.25	3	.500
Small business	33	2.30	2	.770
Salary	9	2.22	2	.833
Remittances	22	3.32	3	.945
CBO loan	6	4.17	4	1.169

N=120

Several other sources of income follow including animal products ($\tilde{x}$=2), casual labor ($\tilde{x}$=2), small business ($\tilde{x}$=2).The ranks mean further demonstrate that the households rely heavily on agricultural based income with sources such as on farm produce and animal products ranking highly. Alternative sources of income still appear to have importance in a large number of the households income bracket with small business ($\tilde{x}$=2) and casual labor ($\tilde{x}$=2) ranking highly.

These ranks indicate that the households rely heavily on agriculture as a source of livelihood and value such sources highly compared to other sources of income hence effects on such sources of income could affect their livelihoods negatively. The median was chosen to average the ranks due to the ordinal nature of the rank data (Ho, 2006; Huizingh, 2007).

Alternative income among farming households enhances access to alternative endowment that curbs the effects of poverty and by extension reduce climate change vulnerability (Adger, 1999).

This is because it has been noted that heavy dependence on land based activities such as farming increases the risk associated with climate variability and change (IPCC, 1998). Other than farming other engagements such as formal employment and informal employment are applied to ensure the households have a fallback position when climate extremes affect their main income sources (Ndulo, 2011).

Ndulo (2011) add that while such alternatives help adapt to low agricultural prices they may increase vulnerability when influenced by prevailing economic conditions. In addition, sources of alternative income such as casual labor could be linked to farming given that farming is the most prevalent casual employer in the area.

Households further indicated the aggregate cash income from an array of sources including remittances, employment, savings and small business. The amounts were denoted by households as whether such income was monthly and annual basis. Such amounts were then computed to monthly level and then grouped as shown in Table 4.10.

Table 4.10 Cash Income categories among Wote Households

Monthly Income categories(Kes)	**No.**	**%**	**Statistics**
350-5349	60	50%	Mean=8371.5960
5350-10349	26	22%	St dev=8545.89062
10350-15349	16	13%	Skewness=1.961
15350-20349	7	6%	
20350-25349	5	4%	
25350-30349	1	1%	
30350-35349	1	1%	
35350-40349	3	3%	
40350-45349	1	1%	
Total	120		

Results showed that most household's cash income ranged between KeS 350 and about 5350. Table 4.10 indicates indeed the household's income varied greatly with the average monthly income recorded as KeS 6,385($\bar{X}$=8371.5960,σ=8545.89062). The statistics in appendix 2 further indicated the income is positively skewed (γ_1=1.961). Such highly skewed data does further require transformation using appropriate methods before additional analysis as applied in section 4.6 (Tabachnick & Fidell, 2001).

4.2.6 Livestock assets

Most of the respondents reported owning poultry; chicken and chicks at 97% and 83% respectively (Table 4.11). Other livestock widely owned included goats 83%, cattle 33% and donkeys 29% (Table 4.11).

Table 4.11 Respondent ownership of specific livestock

Livestock	No.	%*
Chicken	116	97%
Goats	100	83%
Chicks	99	83%
Cattle	39	33%
Donkey	35	29%
Sheep	20	17%
Rabbit	7	6%
Duck	3	3%
Household Number 120		

*Percentages sum exceed 100% because these are multiple responses.

The composition corresponds to national distribution reported by Gerber et al.,(2010) where cattle, sheep and goats are dominant in Kenya. Plate 4.1 presents a typical representation of livestock, notably large number of goats.

Plate 4.1 Typical livestock reared by households in Wote

Livestock play a crucial role in income as indicated by their role in being a key source through sale of animal products among Wote households. At the same time livestock products were key to enhancement of nutrition among the households notably among growing children. In other instances livestock were used by Wote Households in improved farming activities such as ox plough and traction as well as collection of water.

In cases of extreme climate events households reported to selling of livestock as a means of obtaining income to provide off farm income. In other cases livestock were sold to obtain cash income that was directed to education of children. The lower number of larger livestock such as cattle could signal the lower income among households in the study area. Livestock also produced valuable manure that was applied by the households in the study area to improve crop performance through amelioration of soil fertility. Sale of livestock and livestock products increases the purchasing power of households (Ehui, 2002) since they are liquid, more so in the face of food insecurity.

Recha (2011) in his vulnerability study however adds that sale of livestock is seen as a last resort in semi-arid agro pastoral communities since livestock is seen as a wealth symbol in a household.

Livestock are also seen as a significant contributor to reduction of climate related risks since they are a form of on farm diversification in mixed farming systems (Swanepoel et al., 2010). Livestock are also a source of nutrition notably milk and are a key coping strategy since they are quickly disposed of as an asset to purchase food and/or pay for other needs (Mwang`ombe et al., 2011). Livestock products are particularly a good source of absorbable nutrients such as iron, zinc, vitamin B_{12} and retinal which are necessary for child development (Ehui, 2002).

Such benefit has been emphasized by Phillips (2010) where he states that “livestock convert fibrous grasses into food in areas where crops for direct human consumption cannot be grown well”. The importance of livestock has also been discussed in relation to climate change projections of the future. Thornton et al., (2009b) have projected need to shift from crop to livestock keeping as a change in agricultural systems among widely spread remote households in areas such as East Africa to enhance food security in the face of climate change.

While certain livestock kept by households provide an array of benefits, they contribute to quick land degradation due to their feeding habits. Smaller ruminants such as sheep as kept by most of the Wote households, 83%, are more likely to cause more vegetation destruction since they are non-selective and feed close to the ground as reported by Phillips, (2010).

4.2.7 Land ownership

The average number of plots owned in the study area was approximately 1($\bar{X}$=1.19, σ=0.43) by 83% of the households, with the largest number of plots owned being 3, by a few of the households 2%, Figure 4.1).

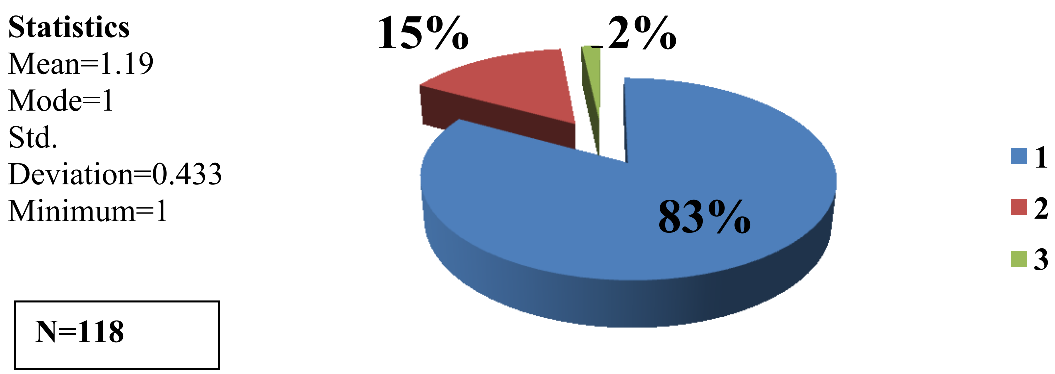

Figure 4.1 Number of owned plots among households in Wote

From the number of plots owned it was further noted that the nature of ownership varied from each household and plot. As such Table 4.12 indicates most households owned one plot (plot1), 95%, (where the household lives) with 5% indicating that such plot was borrowed from relatives. Households with a second plot (plot 2) most indicated that such plot was rented in, 8%, or owned, 7% (Table 4.12).

Table 4.12 Plot ownership/tenure among households in Wote

	plot 1		plot 2		plot 3	
Ownership	No	%	No	%	No	%
Owned	113	95%	8	7%		
Borrowed	6	5%	1	1%		
Rented in			9	8%	1	1%
Rented out			1	1%		
N=120						

Still a small number 1% indicated such plot was borrowed or rented out. One household indicated owning a third plot, 1%, which was rented in. Such ownership by 95% of the respondents could be customary or inherited a tenure system which is most common in SSA though such ownership nowadays needs a certificate of ownership (Nkonya et al., 2008).

This is because land tenure has indeed been quickly evolving in countries such as Kenya as a result of demographic growth which has led to increased value of land and transition from communal to individual land ownership (Chauveau & Cotula, 2007).The type or nature of land tenure does influence the improvement of land or even the cultivation of perennials which play a role in climate effects management (IITA, 2008).

(IITA, 2008) reports that climate related effects such as desertification influences land availability in combination with other factors such as population pressure. Related studies on climate change adaptation such as Akon-Yamga et al.,(2011) have indeed included land ownership as one of the key household characteristics. To further understand land ownership the respondents were asked about the acreage of all their farms and as Table 4.13 shows , the average acreage was approximately seven acres ($\overline{X}$=7.0988,σ=6.97365). As Table 4.13 indicates the positive skewed and the largest acreage recorded was 40 acres with the smallest plot recorded measuring one acre.

Table 4.13 Acreage statistics of Wote Households

	Statistic	Standard error
Mean	7.0988	
5% Trimmed Mean	6.0852	
Std. Deviation	6.97365	
Minimum	1.00	
Maximum	40.00	
Skewness	2.667	.225
Kurtosis	8.147	.446

The 5% trimmed mean ($\overline{X}$=6.0852) shown in Table 4.13 excludes outliers and is necessary to identify the influence of extreme values on the variable acreage mean and in this case there are extreme values slightly influencing the mean ($\overline{X}$=7.0998) (Huizingh, 2007).

To further understand the acreage the data was tested for normality and distribution using the koglomorov smirrnov test ($p<0.05$) (Table 4.14) and also Figure 4.2, a quantile-quantile plot (deviation from normal) showing violation of normality (Landau & Everitt, 2004).

Table 4.14 Test for acreage Normality of Wote households land acarage

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Mean acarage	.221	116	.000	.694	116	.000

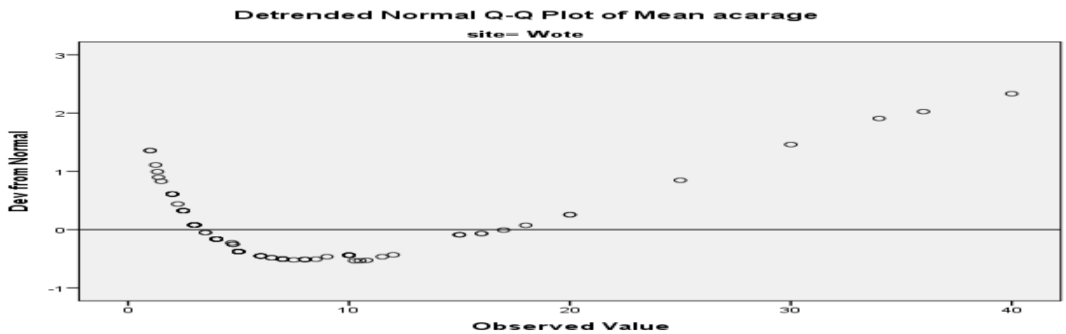

Figure 4.2 Quartile (Q-Q) Plot for testing acreage distribution in Wote

It is recommended that continuous data and/or variables that are non-normally distributed, be analyzed by non-parametric statistical methods such as Mann Whitney test (Corder & Foreman, 2009) as has been applied in this research to test certain hypothesis in section 4.8. Such non normality further indicates acreage varies in the study area.

Studies concerning land use in the region have noted several factors that influence expansion of cultivated land among SSA small scale farmers. These include insecure land tenure, limited access to animal and mechanical inputs, reduced labor as well as competition from off farm activities (IITA, 2008). In this study insecure land tenure was likely to influence farm use and management decisions made by households indicating they borrowed, rented in or rented out land for example minimal long term adaptations.

Land size measured in acres, as has been applied in this study, has been applied in related climate vulnerability studies to identify influence on selected household aspects including adaptation. IITA (2008) for example found that land size was related to adjacency of markets and water points with land far from such amenities having larger land sizes.

The landscape orientation of a plot to a certain extent influences impacts of climate extremes and more so the nature of interventions that households employ to curb such effects. Households were hence asked to identify the type of their plot in terms of orientation or landscape as Table 4.15 indicates. This involved noting whether their land was flat, slope, and located on a hill or a combination of the two or three allowing multiple responses.

Table 4. 15 Plot orientation of households land, Wote

		No.	Percent*
Plot type	Hilltop	106	77.9%
	Slope	30	22.1%
	Total plots	**136**	

*Percentages sum exceed 100% because these are multiple responses.

From Table 4.15 it is apparent cumulatively most of the plots, 78%, were situated on a hilltop or elevated land with 22% situated on the slope. The study area was mainly characterized by elevations with hilltops and slopes hence the nature of responses.

Slopy land as noted by 22% of the households was likely to experience instances of surface run off during instances of rainfall -notably where there were no barriers or soil controls in place. Such barriers could include terraces or improved farming practices such as cultivation across the slope. This phenomenon has also been noted in other studies including IITA, (2008) and Merrington et al.,(2002).

Such run off could however be influenced by rainfall and evaporation as experienced in semi-arid areas such as Wote and could in cases of extreme rainfall lead to flooding and soil erosion which is a common occurrence in arid and semi-arid lands (RoK, 2004). These events could be a concern among the many households residing in hilltops as such locations are similarly prone to influences of flooding and soil erosion especially where land is pitched.

On the other hand cultivation including livestock rearing on hilly areas, as indicated by most of the farmers, 78%, could encourage soil erosion due to associated treading and removal of vegetative cover. Phillips (2010) adds that climate change may increase the problem, since higher transpiration and elevated temperatures as well as low rainfall, all characteristics of the study area, play a role in reducing pastures in areas affected by overstocking.

4.3 Exposure context-Indicators of climate events affecting households.

4.3.1 Key Climate Indicators

Climate indicators include certain weather related events that households experiences and more so in extremes and are additionally some of the key indicators of exposure to climate change and variability against which we associate impacts (IPCC, 2001b). Apart from climate related extremes other effects such as crop pests and diseases were noted to play a significant role in affecting farming households in Wote (Table 4.16).

Table 4. 16 Key calamities experienced by households in Wote

Calamity	No	%*
Drought	120	100%
Crop pests	111	93%
Crop diseases	100	83%
Erratic rain and erosion	71	59%
Strong wind	23	19%
Floods	5	4%
Frost	2	2%

N=120 *Percentages sum exceed 100% because these are multiple responses.

Extremity is identified by the nature of impacts both negative and positive that the households experience, these are discussed in the next section. In this regard households identified key climate extremes and other key issues that they had been exposed to. From Table 4.16 it is apparent that all the households, 100%, had experienced drought at some point.

This large percentage indicated that households were highly affected by instances of drought which was associated with minimal rainfall and subsequent water shortage and food insufficiency. A similar observation has been made by Mwang`ombe et al., (2011) in a similar study on rural poor in Kenyan dry lands implying drought events are indeed a key concern in arid and semi-arid lands.

An almost equal number of households had experienced crop pests, 93% and crop diseases following at 83%. In addition to drought events such calamities will contribute to severe food insecurity among the Wote households notably when both or all events strike simultaneously or within a year. This could involve destruction of crops in the field as well as harvests in store. In more serious instances these calamities strike concurrently and bring about severe losses.

This phenomenon is exhibited by cross tabulation presented in Table 4.17 where 71.9% of the households reporting calamities had experienced all the main calamities including; erratic rains, drought, crop pests and diseases.

Table 4.17 Cross tabulation demonstrating multiple calamities experienced by households in Wote

				Crop diseases experienced	
Erratic rain experienced		Crop pests experienced		No	Yes
Yes	Drought experienced	Yes	Count	18	46
			Percentage within drought experienced	28.1%	71.9%

This implied a large number of households were indeed experiencing multiple calamities subsequently worsening their vulnerability. Climate related effects such as erratic rains experienced in more than half of the households, 59%, are also to a certain extent a concern as more than half of the households were affected. This could negatively affect timing for key farm activities such as land preparation such that farmers suffer losses when rains fail at the onset of the season.

A non-universal description of drought as discussed by Oliver (2005) and Paron et al., (2013) states the event as a ,natural reduction in the volume of precipitation or available freshwater for an ecosystem, over an extended length of time specifically a season or longer and such droughts differ in intensity, duration and spatial coverage. Drought is associated with certain weather timings such as season of occurrence, delays in start of the rainy season, rain versus crop growth stage as well as rainfall effectiveness (Oliver, 2005). Drought cases in Wote area can be associated with the fact that the area is classified as an arid area (RoK, 2013) in the category of 85-100% arid and semi-arid with total arid and semi-arid land at 25 % (RoK, 2004).

Indeed the Government of Kenya in a policy document reports that major droughts in ASALS such as Wote are now experienced every 5-7 years as a result of factors such as climate change (RoK, 2004). While these drought events are not getting severe over time, there is evidence of increasing trend of drought events in Kenya (Paron, et al., 2013) the most recent being the much publicized 2010/2011 drought. In the earlier years the range of drought occurrence was every 10 years.

Reynolds (2010) states that the relationship between pests, diseases and the environment form a ‘diseases triangle’ that determines the outcome of a particular crop disease. Such crop diseases and pests are likely to reduce crop yields and performance and as Reynolds (2010) notes; they are to a great extent affected by environmental factors, new cropping practices, international trade as well as globalization. There indeed exists a relationship between crop pests and diseases and climate change and/or weather parameters.

This is because factors such as rising temperatures, variation in humidity as well as rainfall patterns are likely to increase or decrease the spectrum and distribution of crop pests and diseases (Letcher, 2009; Reynolds, 2010). Such relationship is however complex but can be demonstrated via simulations and experiments (Letcher, 2009). Specific examples of effects of climatic change on occurrence of pests is termites during due to dry planting as mentioned during the focus group discussion.

Erratic rains are associated with unpredictable rainfall spells in some instances late onset of rainfall and insufficiency in the amount of rainfall and do contribute to intermittent dry spells (Vanlauwe, 2002; Shahid et al., 2013). Strong winds experienced in 19% of the households as Table 4.16 shows are not a key concern and can to a certain extent be associated with high temperatures experienced during agricultural drought (Oliver, 2005; Paron, et al., 2013). It is also notable that events such as floods affecting a few of the households, 4.2%, and frost at, 2%, indicate that the study area does indeed not experience heavy rainfall related impacts. This gives more evidence of the area being arid though there are some instances such as the *el-Niño* rains of 1997 reported in Table 4.18 during the focus group discussion.

Table 4. 18 Major calamities in the last fifty years at the community level ,Wote

Period	Description of event
In 1961 and 1997	There was torrential rainfall known as el-Niño .The 1997 el nino floods forced migration of people living along Kaiti river
In 1964 – 1965	The drought period during this period was known as "*Atta*" implying the brown flour they received then
In the years 1974-1975	A drought during this period was called "*Longosa*" signifying the minimal movement of Livestock as there was scarce pasture
In the years 1980-1984	The drought event during this period was known as "*Nikuvaa ngurete*" -"don't depend on me".
2009-2010.	Most recent drought

Since farming is a key economic activity and a source of livelihood in the area and more so a source of income, calamities such as drought, crop pests and diseases are likely to lead to severe effects on the livelihoods of the households. As earlier mentioned the issue of climate related calamities was also discussed at the community level through a focus group discussion involving 16 experienced farmers; equal number of selected men and women from around the study area.

The focus group discussion was held to populate general community level information on complex issues around climate change and was mainly to supplement information gathered at household level. The results tended to align with the household survey results as Table 4.18 shows, that most of the community has mainly experienced drought conditions over the last five decades; 1964, 1965, 1974, 1975, 1980-1984, 2009 and 2010. Table 4.18 from the focus group discussion further indicates floods have been experienced only during the *El Nino* rains in the years 1961 and 1997 where they lead to forced migration of inhabitants in the latter year. This demonstrates the absence of rainfall events in the area. Records indicate the *El Nino* phenomenon hit most of Kenya and the east Africa region in the year 1997 to 1998 and was associated with oceanic disturbances and did cause flooding in several areas of the country and caused damage to crops (Rosenzweig & Hillel, 2008).

The results of the focus group discussion tally with selected records of drought incidences in Kenya as noted by Paron et al., (2013) in Table 4.19 notably in the years 1980, 1984, 1983 and 2010.

Table 4.19 Recent occurrences of drought events in Kenya from 1980 to 2011

Year	Region	Remark
1980	Widespread	40,000 people affected
1983/1984	Central, Rift valley, eastern and North eastern	Severe food shortages in eastern province and less in central
1987	Eastern and central provinces	4.7 million Provided with relief. Power outages and water shortage
1991/1992	North eastern, rift valley, eastern and coast provinces	1.5 million affected
1993/1994	Northern, eastern and central	
1995/1996	Widespread	1.41 affected
1997	Northern parts of Kenya	2 million affected
1999/2000	Widespread except coast and western	4.4 million affected(severest in 37 years)
2004	Widespread	2.3 million affected
2005	Northern Kenya	2.5 million affected
2010/2011	Widespread	3.5 million affected

Source: Paron, et al., (2013)

To further bring calamities to perspective households were asked to rank the three key calamities they had experienced with the value of one representing the calamity that had affected them most. The ranking in Table 4.20 still indicates drought is the major climate related event affecting the households where ($\tilde{x}$ =1).

Table 4.20 Ranking of Key calamities experienced by households in Wote

	Household number	Mean($\overline{X}$)	Median($\tilde{x}$)	Std. Deviation
Drought ranking	110	1.06	1	0.28
Floods ranking	4	2	2	0
Erratic rain ranking	51	2.49	2	0.703
Frost ranking	2	1.5	1.5	0.707
Wind ranking	16	3.13	3	0.619
Crop disease rank	82	2.48	2	0.757
Crop pest rank	85	2.99	3	0.809

N=120

Due to the ordinal nature of the data the median ($\tilde{x}$) is the more useful measure of central tendency indicating the most occurring calamity (Huizingh, 2007; Harvey et al., 2014). Other events scoring highly in the ranking order include erratic rains ($\tilde{x}$ =2), floods ($\tilde{x}$ =2) and crop diseases ($\tilde{x}$ =2) (Table 4.20).

The results shown in Table 4.21 indicate the ranking of key calamities; Drought, erratic rains, pests and diseases are statistically significant (p= 0.000) at 95% C.I with (χ=32.788, DF=3).

The results from Table 4.21 further indicate the Kendall's coefficient (W=0.643) which is close to 1 showing strong agreement or similar standards in ranking (Kraska-Miller, 2013; Martella et al., 2013). This can be interpreted that the households are in agreement or consensus of their rankings of key climate and related risks affecting them.

The Kendall's coefficient of correlation has for example been applied in risk related studies such as Reid and Smith (2007) study on investors ranking of investments by degree of risk.

Table 4.21 Kendall's coefficient of concordance for key calamities ranking

Kendall's Coefficient of Concordance	0.643
Chi-Square	32.788
Df	3
Asymp. Sig.	0.000
Mean Ranks	
Drought ranking	1.06
Erratic rain ranking	2.53
Crop disease ranking	2.94
Crop pest ranking	3.47

4.3.2 Perceptions on patterns and direction of change of weather and related parameters

Farmers put forward their perceptions of changes in weather parameters against a four point likert scale shown on the legend in Table 4.22 and further noted the direction of selected parameters as Table 4.23 shows.

Table 4.22 Perception on selected weather parameters comparing with 10 years ago

	Neutral		Slightly agree		Strongly agree		Strongly disagree	
	No	%	No	%	No	%	No	%*
Severer dry season	1	1%	4	3%	112	93%	3	3%
Rain prediction difficult			8	7%	106	88%	6	5%
Temperature increased	10	9%	10	9%	90	85%	8	8%
Frequent floods	5	4%	27	23%	6	5%	80	67%
Higher yields with c.change	3	3%	16	13%	42	35%	59	49%
Climate change not big issue	4	3%	25	21%	74	62%	16	13%
Get adapted varieties			1	1%	117	98%	2	2%
Dry season shorter			14	12%	10	8%	94	78%
Temperatures decreased	9	8%	23	19%	9	8%	76	63%

N=120

*Percentages sum exceed 100% because these are multiple responses.

The results of the farmer's perceptions shown in Tables 4.22 and 4.23 indicate that one of the key issues noted by Wote households is severe dry seasons with a large number of households, 93%, indicating that they strongly agree that there indeed has been a severer dry season over the past ten years.

Table 4.23 Households perception on Changes in selected weather parameters over the last 10 years in Wote

Parameter	Decrease		Increase		Not different	
	No	%	No	%	No	%*
Total amount of rainfall	115	96%	5	4%		
Short rain onset	98	82%	22	18%		
Long rain onset	91	76%	15	13%	1	1%
Long rain duration	112	93%	2	2%		
Temperature Intensity	20	17%	91	76%	7	6%
Number of hot days	25	21%	91	76%	4	3%
Dry months in a year	14	12%	105	88%		
Incidence of floods	99	83%	5	4%	14	12%
Ground water table	115	96%	3	3%		
Land fertility	109	91%	8	7%	1	1%
Length of growing period	84	70%	35	29%		

N=120 *Percentages sum exceed 100% because these are multiple responses.

Further, most of the households, 85%, strongly agreed that over the last ten years temperatures have increased. Table 4.22 further indicates, 76% of the respondents stated that they had noted an increase in the number of hot days and an even a larger number, 88%, indicating increase in dry months.

Similar trends have been noted by related studies on perceptions on climate change in ASALs such as Mary and Majule (2009) and Macharia et al.(2012). A key effect of temperature increase as a result of climate variability and change has been effect on crop growth and subsequent yields as well as livestock productivity which may contribute to food insecurity. Temperature changes do negatively affect crop growth and production by altering processes such as soil water balance Blanco-Canqui and Lal (2008) .

Studies also show that temperature variation and intensity influence crop yields in several ways especially when such parameter is on an upward trajectory or is experienced for prolonged periods (World-Bank, 2013) by for example altering organic matter content of soils (Letcher, 2009). Temperature changes also affect crop growth and yield by influencing evapotranspiration Datta et al. (2008) and more so by coinciding with sensitive stages of crop growth (Lin et al., 2008). Datta et al.(2008) also argue that spatial-temporal changes in temperature among other weather parameters can also influence farmers on farm decisions on input use as well as crop management which eventually affect the yield.

The responses in Table 4.22 indicated that most of the households interviewed, 88%, strongly agreed that they had difficulties in predicting occurrence of rainfall over the last decade.

This has been further noted by 82% of the respondents as shown in Table 4.23, stating the onset of short rains had delayed with, 76%, indicating that there has been a similar delay in the start of the long rains in the study area. Further, in terms of precipitation volume, as Table 4.23 indicates, there has been a decrease in the amount of rainfall as indicated by almost all of the households, 96%, with an almost equal number, 93%, indicating that there was a notable decrease in the long rain period duration.

To further bring out the issue of rainfall failure, 67% of the households strongly disagreed that over the last decade there has been frequent floods and most 83%, stating indeed there was a decrease in flood events over the last 10 years as shown in Table 4.23. Rainfall distribution/regularity has been associated with occurrence of drought conditions and severely affects farming activities notably causing crop failure (Zeleza, 1997).

Related perception studies in arid and semi-arid areas of East Africa have similarly noted a similar trend in reduction of rainfall amount and distribution (Mary & Majule, 2009; Mongi et al., 2010) including instances of erratic rainfall in several African countries (Simelton et al., 2011). Macharia et al. (2012), in a similar perception to climate change study among farmers in arid and semi-arid areas of Kenya, also found out that there were changes in rainfall patterns and increased drought instances. It has also been shown that one characteristic of change in climate is variations or erratic rainfall -such that farming households relying on rain fed farming are unable to adequately prepare their land and start planting (Cooper, et al., 2008).

Table 4.22, further notes that while more than half of the households, 62%, do not view climate change as a great challenge but almost all, 98%, strongly agreed they need to obtain varieties that could enable them adapt indicating that climate change features as a concern in farming decisions. In a related aspect almost half of the households, 49%, further strongly disagreed they had more yields in their farms with the climate change phenomenon in place ,with a slightly lower number, 35%, tending to experience positive benefits from climate change.

Some projected studies have outlined some positive benefits of climate change in farming notably higher yields among certain crops, C4, with higher CO_2 levels in higher latitudes unlike C3 crops e.g. Maize cultivated widely in Africa (Ringius et al., 1996; Reynolds, 2010; World-Bank, 2013). Such yields may however be negated by high and/or rising temperatures (Letcher, 2009). Studies have also point out that yields can be sustained or even increased in severe climate events when appropriate adaptation measures are employed (Dinar & Mendelsohn, 2011). This could explain why some households in the study area are reporting better yields while identifying climate change not being a key concern. Nevertheless climate change is a risk to reckon with as households are compelled to institute adaptation mechanisms.

Several related studies in the region have similarly studied and shown the importance of perceptions to climate variability and change among farming households to bring out communities exposure to climate extremes and other significant changes including Mertz et al. (2009); Morlai et al. (2011) ; Nizam (2013); Simelton et al. (2011); Apata et al.(2009) ; Hassan and Nhemachena (2008) and Deressa et al. (2009).

This is because farmers are some of the hardest hit by climate extremes and their knowledge , perceptions and choice of adaptation can further inform on future action and solutions (Maddison, 2007; Gbetibouo, 2009; Morlai, et al., 2011).

4.3.3 Patterns of selected ecosystem based variables in the last 10 years

Apart from weather related events respondents further noted changes in the natural environment and crop performance Table 4.24. This was to further understand the direction of weather and related parameter changes respondents were asked to identify the direction and timing of key changes over the past decade.

Table 4.24 Responses on changes in selected parameters over the last decades in Wote

	Decrease		Increase		Not different/change	
	No.	%	No.	%	No.	%*
Forest and vegetation cover	112	93%	7	6%	1	1%
Wild animal species	112	93%	7	6%		
Incidences of crop failure	10	8%	109	91%		
Incidence of weeds	58	48%	56	47%	4	3%
Outbreak of pests and diseases	6	5%	110	92%	1	1%
Resistance to pests	76	63%	40	33%	1	1%
New crop pests	3	3%	113	94%	1	1%
New crop disease	5	4%	110	92%	2	2%
Ground water table	115	96%	3	3%		
Land fertility	109	91%	8	7%	1	1%
Length of growing period	84	70%	35	29%		

N=120 *Percentages sum exceed 100% because these are multiple responses.

Notably almost all respondents, 91%, had experienced an increase in the incidences of crop failure while 70% expressed concern that the length of the growing period had decreased in the last decade (Table 4.24).

Another key observation is decrease in land fertility as noted by 91% of the households. In addition increased incidences related to pests and diseases such as new crop pests and diseases have been experienced by most of the households; 94% and 92% respectively (Table 4.24). The direction of incidence of weeds was almost equal with 47% of the respondents reporting increase and 48% indicating decrease. These incidences pose a great risk to crop yield quantity and quality and only add to harvest drops which magnify impacts from climatic factors. Pest and disease density and prevalence increase as mentioned by households could result from the array of factors including the nature of modern and indigenous control and management approaches employed by farmers as Allara et al., (2012) states in his work. In addition climate variability related effects such as changing moisture regimes and increasing temperature have been identified as key contributors to pest and disease prevalence (Holmberg, 2008; Reynolds, 2010).

Increased crop failure and decrease in the length of the growing period, as other studies have mentioned, could be associated with an array of parameters ranging from those related to extreme climate (Haile, 2005). Severe crop failure could have far reaching implications on the households in the study area notably because they heavily rely on farming as a primary source of livelihood. Other studies in the region indicate indeed crop failure is a concern and more so effects of climate change play a crucial role in occurrence of the same (Leary, 2008).

The experienced decrease in land fertility could be partly attributed to repeated cultivation of land over the years by the households due to land scarcity; this was mentioned by the focus group discussion participants. Other related studies mention factors influencing loss of soil fertility in sub Saharan Africa which could play a role in the study area. These could include; variable and inadequate rainfall and rapid evaporation that induce soil erosion and insecure land ownership rights that curb soil fertility investments as noted by Gruhn et al. (2000). In addition increase in population, also mentioned in the focus group discussion, leads to reduced land sizes and reduced fallow intervals where land is not taken out of production for nutrient replenishment (Bekunda et al., 1997; Gruhn, et al., 2000).

Only a small number of households, 6%, had noted an increase in forested area and wild vegetation with almost all 93% indicating over the last ten years the vegetated area had decreased as shown in Table 4.24. A related observation is that of decrease in the number of wild animal species as noted by 93% of the households. Such decreases could be associated with population increase which necessitates clearance of forested area for farmland expansion as noted during the focus group discussion. Participants noted that in the 1960's there was minimal deforestation but today charcoal making has contributed to wanton tree felling.

The concern has also been raised by authorities in the areas strategic development plan (RoK, 2013). This has also been observed by other studies such Scholes et al.,(2011) who further establish that charcoal burning, prevalent in rural SSA, plays a role in emission of GHGs, decrease in forested and vegetated area and subsequent land degradation and desertification in farming communities.

Ground water, accessed by sinking wells, plays a crucial role in sustainability of farming especially in areas experiencing frequent dry spells and/or unpredictable rainfall such as Wote. Most households rely on such water with most, 96%, indicating there was a decrease in groundwater levels a similar observation noted by Macharia et al.(2012) , in their related climate adaptation study in semi-arid Kenya. Groundwater volumes, whose demand is expected to rise in future UNEP (2008), are influenced by the amount of rainfall which recharges such water as well as vegetation changes which are in turn affected by changes in climate (Parry, 2007) though there is still less uncertainty as on how such climate change-groundwater relationship manifests (Thornton et al., 2009a) .

4.3.4 Significant climatic and non-climatic changes over the last ten years in Wote

The responses are presented in Table 4.25 showing that most households, 71%, had experienced changes in land fertility over the last decade (Table 4.25). Changes in the total amount of rainfall were also experienced in most 72 % of the households. Another key change noted is incidences and/or outbreak of pests and diseases as noted by 47% of the respondents (Table 4.25). Other noted changes included incidences of crop failure by 26% of the respondents and forest and vegetation cover by 23% of the households (Table 4.25). A few of the households, 18% had experienced changes in resistance to pests , 6%, had noted changes in incidences of new crop diseases with 5% noting changes in new crop pests (Table 4.25).

Table 4.25 Most significant weather and related changes by count experienced by households in Wote

Environmental change	No.	%*
Total rain amount	86	72%
Land fertility	85	71%
Outbreak pests & diseases	56	47%
Incidence crop failure	31	26%
Forest & vegetation cover	28	23%
Resistance to pests	21	18%
New crop diseases	7	6%
New crop pests	6	5%
Length of growing period	5	4%
Weeds	5	4%
Short rain onset	4	3%
Dry months in a year	3	3%
ground water table	3	3%
Long rain duration	3	3%
Short rain duration	3	3%
Wild plants species	3	3%
Floods	2	2%
Long rain onset	2	2%
No of hot days	2	2%
Temperature intensity	2	2%
Wild animal species	2	2%

N=120 *Percentages sum exceed 100% because these are multiple responses.

Relating results in Table 4.24 and Table 4.25, it is apparent the direction of the change has been mainly decreasing of the noted key changes such as total amount of rainfall, forest cover and land fertility. On the other hand the direction of pest and disease outbreak, crop failure and has been on an upward trend.

From the respondent's observations it is apparent rainfall is indeed a key concern in the study area since as Table 4.25 shows, households reported the parameter has been decreasing, while at the same time it is a high ranking issue among most households as Table 4.25 shows.

Rainfall indeed is a key source of water, a precious commodity in farming households used in crop cultivation, household chores as well as watering of livestock. Inadequacy of such water resulting from rainfall variation and by extension climate change Wallace (2000), has been linked to crop failure, livestock death or disposal and food insecurity around SSA (Haile, 2005). In addition Kurukulasuriya et al. (2006) in their marginal climate impacts study, note eventual effects on household revenues on affected households more so in the drier areas of Africa. Noting of rainfall failure as a key change is evidence that households in Wote are at risk of effects resulting from such key determinant of food security and more so livelihood security.

Land fertility has been identified as a key issue affecting households in the study area with most of the households, 71% indicating it was a significant change in the area. Loss of land fertility as a key concern in other studies in the region has been linked to soil erosion and over cultivation among farming communities (Clay & Lewis, 1996).

Forests and vegetative cover play a crucial role in enhancement of ecological stability and are also a key source of valuable ecosystem services and goods such as enhancement of climate regulation, soil erosion control, wild fruits and firewood provision (Ash & Jenkins, 2007).

Some of the households, 23%, identified loss of natural forests and vegetative cover as a key concern and referring to Table 4.24 the trend has been a decrease in the same. As such loss of vegetative and forest cover will lead to households in Wote not benefiting from the natural products and services bestowed by the vegetation and forested areas.

4.3.5 Trend analysis of climate data from 1983 to 2013, for Wote

This analysis explains exposure based on climate descriptors computed from meteorological data. This exposure is defined by significant changes in rainfall and temperature over the study period.

4.3.5.1 Annual temperature and precipitation trends

As Figure 4.4 indicates, the rate of change in annual temperature is 0.2122^0C (with a coefficient of determination of (R^2 =0.4881) showing medium change/dispersion in temperature per year which is not consistent with the global average of 0.7^0C.

There is a noticeable increase from the year 2007 through to 2011 as Figure 4.3 indicates, with 2009 and 2011 recording highest means, 25^0C. It has however been noted that warming of the climate system varies, for example the 100 year (1906-2005) global warming average of 0.74^0C is larger than the corresponding trend of 0.6^0C of the period 1901-2000 (IPCC, 2012).

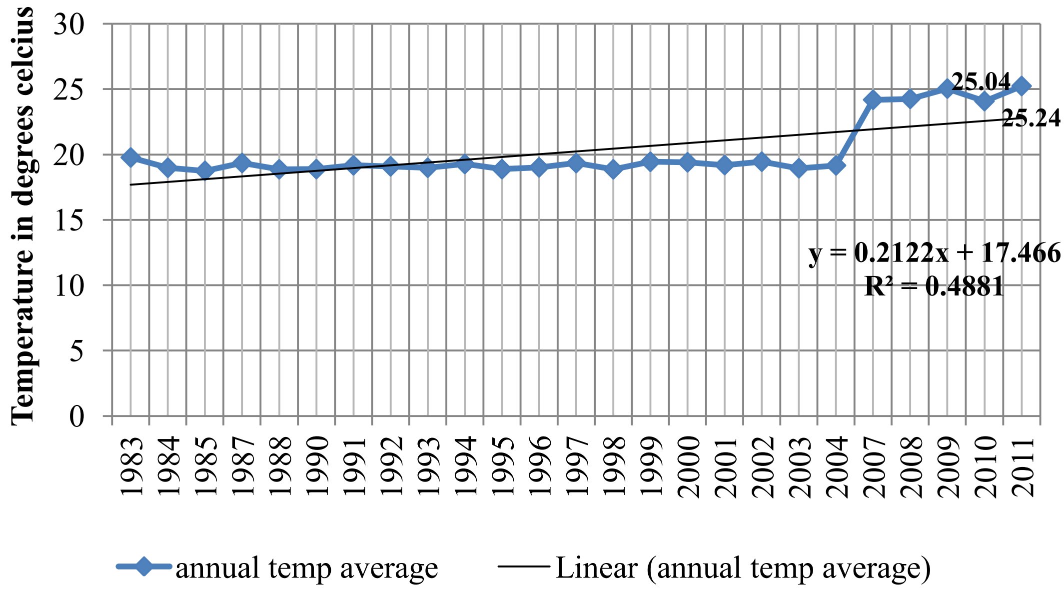

Figure 4. 3.Annual temperature trends-1983 to 2011 for Wote

Table 4.26 Annual average temperature trend statistics for Wote

Variable	Observations	Min	Max	Mean	Std. deviation
Annual average temperature	25	18.746	25.237	20.224	2.235
Mann-Kendall(MK)trend test / Two-tailed test (Annual average temperatures):					
Kendall's tau					0.448
S					134.000
Sen's slope(Q)					0.05
Var(S)					1831.333
p-value (Two-tailed)					0.002
Alpha					0.05
Z value					0.072625
Skewness					1.594024
Coefficient of variation(COV)					66%

The results of the annual average temperature statistics are presented in Table 4.26 showing the mean and standard deviation ($\overline{X}$=20.224^{0}C, σ=2.235) and positive skewness. From Table 4.26 the average annual temperature values show a positive trend over the years (Z=0.072625, Q=0.05) which is statistically significant (*p*=0.002).The coefficient of variation (COV) value of 66% indicates the annual mean temperatures vary about or scatter about the average. Further, the annual precipitation regression model was run for the thirty years to identify the trend as Figure 4.4 shows a slope value of -0.0708 with R^2=0.0016 showing a negative but minimally varying/dispersing trend in annual precipitation over the years.

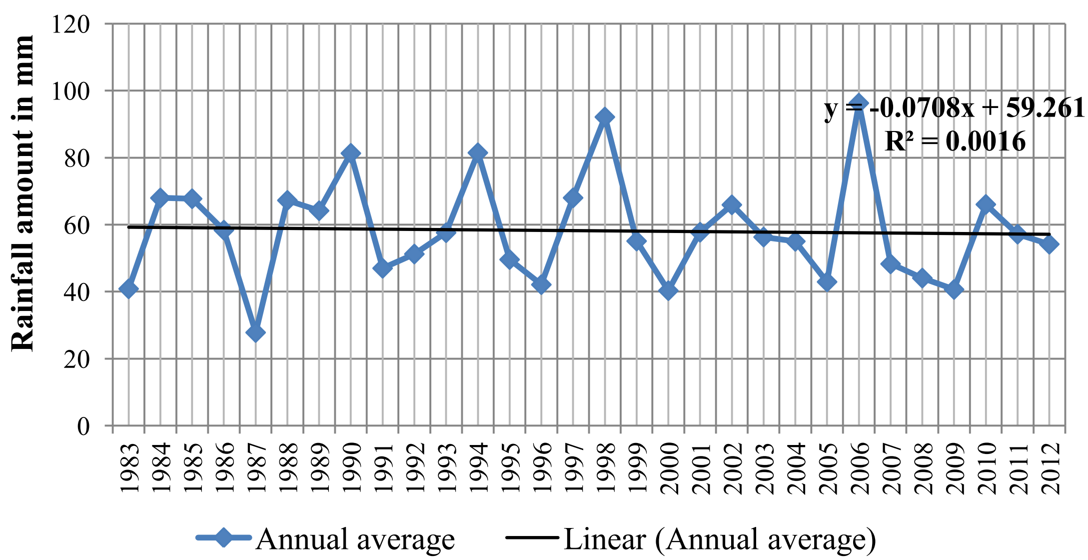

Figure 4.4 Annual precipitation trends-1983 to 2012 for Wote

4.3.5.2 Seasonal trend analysis

The COV for the 30 years seasonal rainfall data for the long rain (MAM) and short rain (OND) were computed as indicated in Table 4.27 denoting that the OND is more variable and less dependable than the MAM rains.

Table 4.27 Coefficients of variation for short and long rains for Wote

MAM Average	90.12
OND Average	102.11
Standard deviation(σ) MAM	39.33
Standard deviation(σ) OND	51.82
Coefficient of variation(COV)MAM(March-April-May)	0.43
Coefficient of variation(COV)OND(October-November-December)	0.50
COV MAM %	44%
COV OND %	51%

Figure 4.5 presents seasonal variations in rainfall for the periods 1983 to 2012 and shows a cyclic pattern of variance characterized by wetter and drier years.

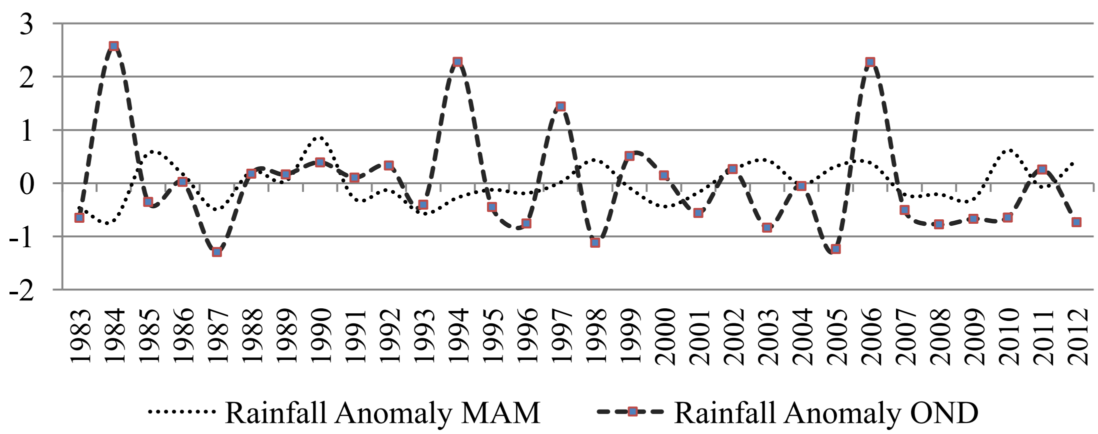

Figure 4. 5 Standardized anomaly indices for seasonal rainfall 1977 to 2013 in Wote

Figure 4.5 indicates that the years 1984, 1997, 1997 and 2006 recorded the highest positive deviations from the average for OND while 1985,1990,1998,2006 and 2010 recording highest positive deviations from the average for MAM.

These indicate instances of wetter years for both the short and long rain seasons, periods that experienced enhanced rainfall. Conversely Figure 4.5 shows years 1984, 1987, 1993 and 1994 recorded the lowest negative deviations from the average for MAM with 1987, 1998, 2000 and 2005 recording the lowest deviations from the average for OND. The changes from the mean however vary indicating indeed the study area has been experiencing inter-annual and inter-seasonal variability in rainfall volumes over the 29 years depicting variability in precipitation. This deviation from the mean is more evident in the OND time series where the oscillations from the time series mean are more pronounced.

The results shown in Table 4.28 show non-significant variation rainfall in the MAM season over the 30 years (p=0.166) at 95% C.I, though the trend is positive (Q=1.3870). The same observation was made on the OND season data where p=0.189 at 95% C.I though in this case there is a negative trend (Q=-0.871) as shown in Table 4.29.

Table 4.28 MMM season statistics for Wote for the period 1977 to 2013

Variable	Observations	Min	Max	Mean	Std. deviation
MMM rainfall	30	18.467	177.900	90.129	39.334
Mann-Kendall trend test / Two-tailed test (MAM season):					
Kendall's tau					0.182
S					79.000
Var(S)					0.000
Skewness					0.3054
Sen’s slope(Q)					1.3870
p-value (Two-tailed)					0.166
Alpha					0.05

Table 4.29 Statistics for OND season in Wote for the period 1977 to 2013

Variable	Observations	Min	Max	Mean	Std. deviation
OND rainfall	30	35.267	235.667	102.118	51.829
Mann-Kendall trend test / Two-tailed test (OND season):					
Kendall's tau					-0.172
S					-75.000
Var(S)					0.000
Skewness					1.3109
Sen’s slope(Q)					-0.871
p-value (Two-tailed)					0.189
Alpha					0.05

In addition a high positive value of Man Kendall’s statistic (*S*=79) as indicated in the case of MAM season denotes an increasing trend while a negative(*S*=-75) indicates a dropping trend in the OND season. These results demonstrate that the long rain season has experienced a generally increasing and relatively positive trend over the study period. This trend is however not significant. On the other hand the short rain season by a decreasing and non significant trend over the study period. These observation show the reliability of the long rain season when it comes to agricultural activities implying households should pay attention to farming activities during the May to April period.

4.3.6 Relating farmer perceptions with climate data trends

In this study, relating the variations in the climate data with the farmer’s perceptions indicates similar changes with farmer’s perceptions on changes in temperature and precipitation.

Most farmers indicated, in section 4.3.2, Tables 4.22 and 4.23, they have observed increase in temperatures and further the number of hot days and months. This observation shares similarity with the observed increases in temperature over the years as noted by the standardized Mann-Kendall's coefficient (Z) and Sen's slope(Q) (Z=0.072625, Q=0.05) shown in Table 4.26. In addition Tables 4.22 and 4.23 indicate concerns such as reduced rainfall amounts as well as reduced long rain duration. Such observations can be likened to the variability exhibited by standardized anomaly index, Figure 4.5, and more so the decreasing trend observed for OND season (Q=-0.871).

In other studies for example Meze-Hausken (2004), Thomas et al.,(2007), Gbetibouo (2009) and Mongi et al.,(2010) the accuracy of farmer's perception to climate change and variability is indeed assessed through comparison of individual and community perceptions with climate records of adjacent meteorological stations.

4.4 Climate Change and variability Impacts in Wote

4.4.1 Impacts associated with drought in Wote

Most of the households, 46%, reported that they have experienced crop failure as a result of occurrence of drought in the study area as indicated in Table 4.30.

Table 4.30 Key impacts experienced as a result of drought in Wote among households

Drought Impact	No.	%*
Crop failure	53	44%
Water shortage	53	44%
Famine	48	40%
Livestock death	37	31%
Drying up of vegetation	26	22%
Loss of fodder	24	20%
Livestock diseases	17	14%
Food shortage	15	13%
Human diseases	13	11%
Human death	6	5%
Poverty increases	5	4%
Malnutrition	4	3%
Soil erosion	2	2%
Deforestation	1	1%
Increase in theft	1	1%
Increases pests and diseases	1	1%
Reduced investments	1	1%
Reduced plant diversity	1	1%

N=120 *Percentages sum exceed 100% because these are multiple responses.

An almost equal number, 44%, Table 4.30, indicated that they had experienced famine in the area as a result of drought. A slightly lower number, 43%, noted that they had experienced water shortage with a small number, 3% reporting malnutrition. Other than malnutrition, in some households there were more serious impacts reported; occurrence of human diseases, 11% and death, 5% (Table 4.30) .

Such cases were associated with food shortage and were mainly noted by, 4% of the households with cases of poverty increase, indicating that loss of human life and health is an issue among households with minimal resilience and heavily dependent on rain fed agriculture as other studies such as Mirza (2003), Mary & Majule (2009) and Shemdoe (2011) have highlighted.

Further, water quality determines water availability which in turn depends on precipitation and evapo-transpiration and such water quality affects human health (Müller, 2009). Such water quality health impacts and malnutrition are likely to affect children more severely Holmberg (2008) since they are more vulnerable when extreme events strike (Mirza, 2003). There indeed does exist a strong relationship between occurrence of famine, crop failure, malnutrition and water shortage. This is because each of the effects, as some authors have noted, leads to another: famine or severe food shortage results from crop failure Haile (2005) while water scarcity due to rainfall failure is a key contributor in occurrence of crop failure Dilley (2005) and low yields in sub Saharan Africa (Blanc, 2012).

In addition to rainfall failure (water stress) as mentioned, high temperatures and/or occurrence of drought are a major limit to crop growth, yield and yield quality and an array of other plant development processes (Rosenzweig et al., 2001; Prasad et al., 2008). Indeed water availability is a concern in the larger Makueni county with average distance from water points at 8kms RoK (2013). Plate 4.2 shows dry water pan, a typical evidence of water shortage in the study area.

Plate 4.2 Dry water pan depicting typical water shortage in Wote.

Further, 30% of the households indicated that they had experienced death of livestock with 15% indicating cases of livestock diseases occurrence. There has been related research such as Thornton et al., (2007), Mwang`ombe et al., (2011) and Shemdoe, (2011) indicating confluence of climate events and livestock health and production with an existing relationship being identified in farming communities in sub Saharan Africa.

Such negative effects have been associated with heat stress, water scarcity and livestock vectors (Thornton, et al., 2009a). Loss of livestock as an asset due to extreme events is a key concern among farming households in Wote. This is because such livestock play a key role in enhancing resilience since they can be sold at a fair price to buy food and do provide household nourishment (Thornton, et al., 2007).

In a related impact, 20%, of the households indicated having experienced loss of fodder and an almost equal number, 22%, experiencing drying of vegetation**.** Loss of or reduced quality of fodder due to climate extremes, as reported in related studies ,has a direct impact on the livestock by bringing about malnutrition, low productivity and even mortality (Thornton, et al., 2007; Mwang`ombe , et al., 2011). Such loss of fodder could specifically result from water scarcity affecting cultivation of fodder as Thornton et al. (2009a) mention in their review.

In the same regard loss of fodder may bring about the need to or anticipation to purchase fodder from other sources in some cases from other farmers which leads to strain on limited household resources (Mimi & Jamous, 2010). A few of the households, 1%, reported reduced investments in the event of occurrence of drought as a result of diverted household resources. This is not a major impact in the study area but is nevertheless of importance. Related studies have similarly linked climate extremes to reduced investments in households due to factors such as medical expenditure and reduced productive labor LVBC (2011) though this depends on factors such as the level of the farming household's market integration (Hertel & Rosch, 2010).

4.4.2 Impacts associated with erratic rains in Wote

The results indicate that crop failure, food shortage and malnutrition are some of the impacts associated with occurrence of erratic rains as reported by 39%, 7% and 1% of the households respectively (Table 4.31).

Table 4.31 Key impacts associated with erratic rains in Wote

Erratic rain impacts	No.	%*
Crop failure	47	39%
Soil erosion	47	39%
Destroys vegetation	8	7%
Food shortage	6	5%
Water shortage	3	3%
Livestock death	2	2%
Loss of fodder	2	2%
Seed scarcity	2	2%
Destruction of assets	1	1%
Famine	1	1%
High cost of seeds	1	1%
Human death	1	1%
Loss of pasture	1	1%
Malnutrition	1	1%
Seed wastage	1	1%

N=120 *Percentages sum exceed 100% because these are multiple responses.

Such occurrence of crop failure and subsequent food shortage due to insufficient and/or erratic rainfall has a major effect on farming communities since most of them depend on agriculture as a key source of livelihood as FAO (1993) reports. Mary and Majule (2009) in their climate variability study in ASAL Tanzania similarly show that unpredictable rainfall was the major contributor to low crop production and further led to occurrence of crop failure.

As mentioned by 39% of the households erratic rains lead to soil erosion when rainfall occurs abruptly in significant amounts eroding top soils and eventually leading to land degradation especially when there is minimal vegetative cover (Sivakumar & Ndiang'Ui, 2007) as is the case in ASAls such as Wote.

Erratic rains have also been associated with destruction of vegetation as noted by 7% of the respondents. Such occurrence could similarly be as a result of sudden heavy downpours that bring about effects such as mud slides and erosion of top loose soil and vegetation growing within. Natural vegetation plays a big role in holding of soil particles and destruction of the same exacerbates occurrence of soil erosion. In addition as Sivakumar & Ndiang'ui (2007) argue, rainfall and temperature are the key factors in determining climate and as such play a key role in defining the nature and type of vegetation in an area.

A few of the households, 3%, did experience water shortage, an impact that can be directly linked to unpredictable or unreliable erratic rains. At community level farmers mentioned that delayed onset of rains also leads to water shortage affecting livestock and other household uses and in some instances leading to severe food shortage. Availability of water is key in crop cultivation notably planting as well as livestock survival during extreme events. Other minor impacts include livestock death as reported by 2% of the households could also be associated with loss of pasture and fodder as indicated by 2% and1% of the households respectively.

A few of the households, 2%, indicated experiencing seed scarcity with an almost equal proportion, 1%, noting seed wastage. In related studies cases of seed shortage and rising costs have been noted as negative challenges resulting from occurrence of climate change and associated events (Mertz, et al., 2009). Among the Wote Households such effects are likely to influence availability and access to seeds for planting and eventually contribute to food scarcity.

On the same vein seed wastage as a result of failed germination due to insufficient or erratic moisture (Chrispeels & Sadava, 2003; Calzadilla, et al., 2009) can lead to eventual occurrence of effects such as low yields. At the community level, delayed onset of rainfall leads to some farmers feeding their families with seeds for the planting season which could result in food scarcity. In addition it was noted during the community FGD that, delayed onset leads to consumption of seeds by termites where dry planting is practiced, which may negatively affect anticipated yields.

4.4.3 Impacts associated strong winds in Wote

From Table 4.32 23% of the households, indicated they had mainly experienced loss of assets as a result of strong winds with occurrence of soil erosion affecting an almost equal number, 22%. Responses for strong winds however indicate this is not a key calamity when compared with drought and erratic rains; nevertheless the main impacts are highlighted.

Table 4.32 Impacts associated with strong winds in Wote

Wind impacts	No.	%*
Destruction of assets	28	23%
Soil erosion	26	22%
Destroys vegetation	21	18%
Crop failure	13	11%

N=120 *Percentages sum exceed 100% because these are multiple responses.

These numbers indicate a concern since assets such as houses are vital for household's enjoyment of basic needs such as housing. Strong winds are associated with occurrence of high temperature cells in an area and play a role in affecting aspects such as evapotranspiration (Rosenzweig, et al., 2001) as well as promoting land degradation and desertification(Jama & Zeila, 2005).

Soil erosion resulting from strong winds also poses a threat to farmers since this translates to loss of soil fertility which influences crop yields. Strong winds with high speeds in deed do affect assets mainly houses an issue that has been noted in semi-arid areas such as Wote and in a related study by Mertz et al.(2009) on adaptations in rural Sahel. Destruction of living areas has effects on the households living conditions and could divert their minimal resources to reconstruction. Strong winds associated with extreme weather events such as dry conditions (Blanco-Canqui & Lal, 2008) can even contribute to physical damage of crops and vegetation and further increase water requirements (Datta, et al., 2008) by enhancing evapotranspiration (Sivakumar & Motha, 2008).

Occurrence of soil erosion as a result of strong winds as reported in Table 4.32, has been linked to loosening and propulsion of top soil particles in existence during dry conditions mainly in arid areas and is also propelled by poor cultivation practices (Merrington, et al., 2002). Wind as an erosion agent has the ability to contribute to effects on soil structure leading to lowering of soil fertility which may subsequently affect yields notably in arid areas like Wote (Merrington, et al., 2002; Blanco-Canqui & Lal, 2008).

4.4.4 Impacts associated with crop pests and diseases in Wote

Occurrences of diseases are a key concern among households in Wote as shown in Table 4.33, with most households, 78%, experiencing crop failure, 28% experiencing famine, 3% experiencing food shortage and 1% experiencing malnutrition.

Table 4. 33 Impacts associated with crop diseases in Wote

Crop disease impacts	No.	%*
Crop failure	93	78%
Famine	33	28%
Cost of production	5	4%
Affects pollination	3	3%
Food shortage	4	3%
Livestock death	1	1%
Malnutrition	1	1%

N=120 *Percentages sum exceed 100% because these are multiple responses.

Effects such as food shortage have indeed been shown to occur in relation to instances crop failure Haile (2005) and could directly and indirectly affect human health (Pinstrup-Andersen, 2012).

Households further mentioned impacts such as livestock death, 1%, and increased costs of production, 4%. Loss of livestock due to crop diseases can be linked to loss of crops among households that rely on crops as fodder which is common among farming households in the area where livestock are fed on crops residues from crops such as pigeon peas.

Occurrence of malnutrition mainly affects poor households and involves unbalanced dietary intake with inadequacy in certain key nutrients such as vitamins and minerals McMichael et al.(2007) and is a common issue in sub Saharan Africa notably among children (Garcia et al., 2008). Occurrence of malnutrition has additionally been used by some studies as a way of understanding vulnerability to climate change (Gabrielsson, et al., 2013; Notenbaert, et al., 2013). From these results however malnutrition is not a key impact.

Increased cost of production as a result of crop diseases is linked to the fact that households incur losses or income is reduced due to low crop quantity and quality regardless of investments in farm preparation, planting and application of relevant inputs as (Pinstrup-Andersen, 2012) and (Lenné, 2000) mention in their reviews.

Table 4.34 indicates that households in Wote have also been affected by crop pests. The table further indicates that crop pests have affected most of the households, 79%, by causing crop failure.

Table 4.34 Impacts associated with crop pests in Wote

Crop pests impacts	No.	%*
Crop failure	95	79%
Famine	22	18%
Crop diseases	14	12%
Seed wastage	9	8%
High cost of production	7	6%
Food shortage	5	4%
Malnutrition	2	2%
Loss of soil fertility	1	1%
Seed scarcity	1	1%
Soil cracking	1	1%

N=120 *Percentages sum exceed 100% because these are multiple responses.

Further, 18% of the households mentioned occurrence of famine with 5% and 2% experiencing food shortage and malnutrition respectively. Indeed crop pests epidemics do contribute to food insecurity among farming households in developing nations(Infonet-biovision,2012) with rice, sorghum and maize pests for example affecting 10-35% of yield loss annually (Lenné, 2000).

Table 4.34 denotes an existing relationship between impacts associated with crop pests and diseases. This is because 12% of the households indicated that crop diseases are an effect associated with crop pests as Reynolds (2010) mentions in a related study on climate change and crop production.

Availability of seeds is affected by pests with 8% of the households experiencing seed wastage while 1% experienced seed shortage as indicated in the table. Such wastage of seeds or lowering of their quality possibly occurs in instances where seeds whether in storage or in the farms are attacked by certain pests affecting their germination and viability as Infonet-Biovision,(2012) and DOAF,(2014) also explain in their technical reviews. At the community level impacts associated with crop pests and diseases were mentioned during the focus group discussion as a key concern. It was noted that farmers were concerned that pests and diseases were lowering the quantity and quality of produce since they have increased today in the study area.

4.4.5 Hypotheses test results

From the discussed impacts an hypothesis (i) was formulated and sought to identify the relationship between selected nominal variables representing the households exposure to mentioned extreme events specifically drought and crop diseases as well as crop failure.

This hypothesis relates to Objective 3 on impacts associated with climate variability and change. The results of the test are presented in Table 4.35.

Table 4.35 Hypothesis summary for the relationship for the relationship between key extreme events and crop failure (Chi square test)

		Crops failing drought	Crops failing crop diseases
Drought	Pearson Chi-square	2.132	
	Asymp. Sig. (2-sided)	0.344	
	Cramer's V	0.139	
	Df	1	
	Cohen's Index(*w*)	0.139	
Crop diseases experienced	Pearson Chi-square		24.860
	Asymp. Sig. (2-sided)		0.000
	Cramer's V		0.455
	Df		1
	Cohen's Index(*w*)		0.455

The Chi square results indicated that there is a significant relationship between occurrence of crop diseases and crop failure, $\chi^2(1)$ =24.860, p=0.000. While drought was mentioned as the key climate related calamity experienced by farmers in the study area exposure to such event did not significantly relate with crop failure ,$\chi^2(1)$ =2.132, p=0.334.

Table 4.36 Reference values for interpreting Cohen's Index (Adapted from Cohen, 1988)

w (Cohen's Index)	
0.00 to 0.30	Small
0.30 to 0.50	Medium
0.5 and above	Large

With reference to Table 4.36, adopted from Cohen (2013) and as discussed by Gray and Kinnear (2012) it is concluded that the relationship between crop diseases and occurrence of crop failure in the study area is medium, w=0.455.

4.5 Adaptation strategies

4.5.1 Adaptations to major calamities

4.5.1.1 Adaptations to drought in Wote

Most of the households, 65%, have engaged in cultivation of drought resistant crops and varieties, 13% practicing crop diversification and 28% setting up terraces (Table 4.37). This large number of households engaging in cultivation of drought resistant crops is evidence of the importance of crop based adaptation mechanisms among households in the study area.

Table 4.37 Drought adaptation mechanisms among households in Wote

Adaptation means	No.	%*
Drought resistant crops	78	65%
Terracing	34	28%
Crop diversification	16	13%
Early planting	9	8%
Building wells	7	6%
Early land preparation	6	5%
Early land preparation	6	5%
Fast maturing crops	5	4%
Off farm income	5	4%
Agroforestry	3	3%
Irrigation	3	3%
Food storage	2	2%
Increasing farms	2	2%
Cover crops	1	1%
Allocating labour	1	1%
Cash crops	1	1%
Manure	1	1%
Fertilizers	1	1%
Harrowing	1	1%
Destocking	1	1%

N=120 *Percentages sum exceed 100% because these are multiple responses.

Similar mechanisms have also been noted in adaptation studies around Africa. These include growing of drought tolerant crops and varieties (Mahu et al., 2011; Mwang`ombe , et al., 2011; Rufino , et al., 2013b) crop diversification (Woodfine, 2009) and terracing to conserve elusive soil moisture (Mwang`ombe , et al., 2011). Drought and heat tolerance crops have indeed been noted as a practical option for adaptation with appropriate implementation (Ngigi & Denning, 2009). As farmers in Wote indicated, related studies similarly show that crop diversification is a means adopted against climate extremes among farmers in other areas of sub Saharan Africa (Deressa, et al., 2009; Mertz, et al., 2009; Bizuneh, 2013) .

It is likely that few of the households in Wote involved in crop diversification aim at reducing the risk of extreme events where all crops fail. This could be seen as a means of spreading climate risks. Woodfine (2009) also indicates that one of the key reasons for crop diversification other than monoculture is avoiding the risk of extremes such as droughts such that some crops are likely to survive. Other studies show crop diversification is one of the most applied adaptation strategies to counter climate extremes in Africa (Below et al., 2010). Related mechanisms employed by a few of the households, 4%, included cultivation of fast maturing crops and 3% practicing agro forestry. Cultivation of fast maturing crops aims at cultivating crops that reach maturity while utilizing minimal precipitation, experienced in semi-arid areas (Orindi & Murray, 2005) such as Wote. The mechanism has been mentioned in related studies on climate change adaptation such as Mahu et al.,(2011).

Agro forestry as mentioned, involves growing of certain multipurpose trees and shrubs on farm to provide an array of products and services including shade, fruits, fodder, wood, carbon sequestration, wind control (Jama & Zeila, 2005) and increased water infiltration (Verchot, et al., 2007).

Such products and services ensure a blend of food and income security with ecosystem services (Jama & Zeila, 2005) in the face of climate variability (Verchot, et al., 2007). The practice has been further mentioned and identified as a suitable and sustainable mechanism, in related studies on adaptation to climate variability among small holder farmers in drier areas of sub Saharan Africa (Shemdoe, 2011).

Still there were related adaptation mechanisms including early land preparation, 5% and early planting by 8% of the households as Table 4.37 shows. Early land preparation as applied by Wote households is a commonly employed means among farming communities in the face of drought and is immediately followed by early planting all aiming at ensuring crops utilize minimal rainfall amounts ,characteristic of semi-arid rural areas as (Rao & Okwach, 2005) mention in their climate variability study in Machakos.

A few of the households 4% sought alternative income through off farm activities. The approach ensures the household has alternative income when extreme events such as drought affect their main activity i.e. farming. The mechanism was additionally mentioned during the community focus group discussion with examples such as charcoal burning and brick making shown in Plate 4.3.

Plate 4.3 Brick making an alternative income source

To manage water resources a few of the households 6% sank wells to supply water. Practicing irrigation in the study area involved supplying water to farms during dry spells. Sinking of wells in the study area involved mainly non drill methods where farmers communally dug holes in areas where aquifers are adjacent to the surface to reach underground water.

Sinking of wells is usually a costly exercise and has been the work of government agencies and aims at providing the elusive water resource in ASAL areas prone to drought in Kenya (NWCPC, 2014). Provision and availability of water is important in livestock keeping whether in small scale or large herds in areas such as Wote where drought and associated rainlessness is a key calamity.

4.5.1.2 Adaptation to erratic rains in Wote

Households in Wote division have made efforts to adjust to erratic rains through several adaptation mechanisms. From Table 4.38 most of the households, 39%, established terraces with 18% cultivating cover crops to manage instances of erratic rains.

Table 4.38 Adaptations to erratic rains among households in Wote

Adaptation mechanism	No.	%*
Terracing	47	39%
Cover crops	22	18%
Agroforestry	9	8%
Water catchment	7	6%
Contour ploughing	5	4%
Drought resistant crops	5	4%
Fast maturing crops	5	4%
Manure	3	3%
Conservation tillage	2	2%
Crop diversification	1	1%
Early planting	1	1%
Allocating labor	1	1%
Seeking information	1	1%
Food storage	1	1%
Increasing farms	1	1%
Pesticides	1	1%

N=120 *Percentages sum exceed 100% because these are multiple responses.

Cultivation of cover crops as applied by 18% of the Wote households is a widely applied in farming communities and involves cultivation of certain multipurpose legumes to manage changes in water availability. A few households employed related mechanisms such as contour ploughing, 4%, agro forestry, 8% and water catchment, 6% as presented in Table 4.38. Contour ploughing aims at controlling soil erosion as a result of runoff by increasing soil water infiltration (Blanco-Canqui & Lal, 2008). As such the aim of the mechanism, as applied by farmers, is to mainly avoid effects of runoff which leads to soil erosion while at the same time enhancing water conservation.

Water catchments, also applied by a few of the Wote households, have a high adaptation potential in semi-arid areas and include certain water harvesting techniques aiming at capturing precipitation as Critchley, (1991) explains in his technical review. The approach aims at utilizing of the minimal rainfall in dry areas where it ensures soil and water conservation. In Kenya there in deed have been efforts by agricultural institutions to build capacity on establishment of water pans, *zai* pits and furrows in arid and semi-arid lands to enhance utilization of the scarce resource during extremes such as drought (Ketiem et al., 2010).

Crop based mechanisms of adaptation also feature, though in smaller numbers, in adaptation to erratic rains as shown in Table 4.38 just as they feature prominently in drought adaptation. These include drought resistant crops, 4% and fast maturing crops 4%. These adjustments largely aim at ensuring cultivated crops have the necessary traits to survive instances of water scarcity resulting from poor rainfall distribution. Indeed as Lin (2011) notes , crop diversification in the event of erratic rains aims at reducing the risk of losing all crops in the event of occurrence of climate variability and associated extreme events.

4.5.1.3 Adaptations to Strong winds in Wote

As shown in Table 4.39 households in the study area employed one key mechanism to control winds namely agro forestry, by 33% of the households with a few, 3%, planting cover crops.

Table 4.39 Adaptation to strong winds among households in Wote

Adaptation mechanism	No.	%*
Agroforestry	40	33%
Cover crops	4	3%

N=120 *Multiple responses

The practice of agro forestry as practiced in the study area involves planting of multipurpose shrubs and trees on or along the farm. These trees not only assist in controlling wind but also provide food, fodder and firewood. In other cases woodlots are established around the farm. Trees are planted to form a physical barrier that protects the land and crops from destruction associated with blowing winds (Sinclair, 1995). The beneficial effects of agroforestry in farming systems as other studies have found include control of soil erosion where wind is the agent (Nair, 1993).

Cultivation of cover crops is a not a key measure in the study area but principally aims at stabilizing and covering the top soil from the effects of strong winds since strong winds are an aggressive erosion agent as Blanco-Canqui and Lal (2008) indicate. Occurrence of strong winds in arid and semi-arid is a key concern since most of the land is dry due to high temperatures and wind as an erosion agent degrades soils when there is minimal soil cover.

4.5.1.4 Adaptations to crop pests and diseases in Wote

To adjust to the effects of pests households in the study area employed an array of mechanisms notably application of pesticides by most of the households, 88% as shown in Table 4.40.

Table 4.40 Adaptation to crop pests among households in Wote

Adaptation mechanism	No.	%*
Pesticides	105	88%
Early planting	5	4%
Crop rotation	6	4%
Resistant crops	8	2%
Weeding	2	2%
Indigenous mechanisms	1	1%

N=120 *Percentages sum exceed 100% because these are multiple responses.

The large number of households utilizing pesticides indicates access to such chemicals and more so knowledge on modern farming techniques in the study area. The farmers however did mention, during the focus group discussion, that they would welcome support in form of information on the best chemicals to use in pest control through farm demonstrations and exchanges with support from research institutions. This indicates that while small holder farmers are able to access pesticides sold at local agro veterinary centers they may not have the necessary knowledge on dosage and appropriate application times and products. In other cases they may violate the restricted entry interval or appropriate time to visit crops once agro chemicals are applied (WSDA, 2009).

This could increase their vulnerability since uninformed utilization of such pesticides may impact on their health and safety. Further, unintended abuse of agro chemicals can result in resistance by pests as well as destruction of parasites and predators (Lenné, 2000). Nevertheless, pesticides play a big role in alleviating hunger if used appropriately and their use has been reported in related studies on adaptation to pests attack.

For example Akon-Yamga et al. (2011) in their adaptation studies found most households in their study controlled pests via agro-chemicals compared to other methods. In addition Shemdoe (2011) noted that households in his study in Tanzania considered pesticides as an important measure against pests as a way of ensuring food security.

An almost equal, but a very small number of households adapted to crop pests effects by practicing early planting, 4% and crop rotation 5%. The idea behind early or timely planting as a means of avoiding pests is to ensure crops are past an appropriate growth stage before pests strike. Crop rotation on the other hand controls pests by ensuring crops are not cultivated in a specific plot of land over long periods of time, a state that encourages attack by pests and possible crop failure. The mechanism has been applied by farming households as related research on adaptation in Ghana by Mahu et al.,(2011) has shown.

Adaptation mechanisms aimed at adjusting to crop disease attacks are presented in Table 4.41. Most of the affected households, 63%, indicated that they apply chemicals to control crop diseases.

Table 4.41 Adaptations to crop diseases among households in Wote

Adaptation mechanism	No.	%*
Chemicals spraying	76	63%
Resistant crops	16	13%
Crop diversification	1	1%
Fast maturing crops	1	1%
Increasing acreage	1	1%

N=120 *Multiple responses

This shows some similarity since a larger number similarly applied pesticides to fight against pests as Table 4.40 indicates. In deed other studies have linked attack by pests to occurrence of crop diseases indicating a relationship between the two calamities (Reynolds, 2010). Further, the table does additionally indicate accessibility of the biocides among households in the study area. Other households, 13%, (Table 4.41), indicated that they cultivated disease resistant crops in their farms as a means of curbing crop diseases. This number indicates that crop based mechanisms still play a role alongside chemical based responses in the face of crop diseases.

4.5.2 Adaptations to major changes in land and natural environment

4.5.2.1 Adaptations to changes in land fertility in Wote

Households in Wote employ two main adaptation mechanisms to manage soil fertility including application of manure, 66% and fertilizer, 16%, as shown in Table 4.42. Application of manure is commonly practiced because of the availability of the product within households and is mostly obtained from own livestock.

Table 4.42 Adaptations to land fertility loss among households in Wote

Adaptation means	No.	%*
Manure	79	68%
Fertilizer	19	16%
Terracing	8	7%
Adaptable crops	5	4%
Crop rotation	4	3%
Agroforestry	1	1%
Intercropping	1	1%

N=120 *Percentages sum exceed 100% because these are multiple responses.

Manure has been identified in other studies as indeed contributing to the improvement of soil fertility by addition of key nutrients such soil organic matter, Nitrogen and available Phosphorus to soils when applied in an integrated fashion (Zingore et al., 2008). In most instances manure is applied just before planting is done or continuously as crops grow with the aim of maximizing plant yields.

Application of inorganic fertilizers has been adopted by faming households with adequate resources because of the associated costs. In deed most small holder farming communities are unable to access the inorganic fertilizers because of their high costs though there are proposed solutions such as integrated soil fertility management (ISFM) (Vanlauwe, 2002). Further as, Muyanga & Jayne (2006) mention less endowed farmers are risk-averse and are less likely to spend on new technologies rather they exhibit the 'wait and see' mentality. Recent policy developments (e.g. soil fertility policy draft) and public interests in Kenya have been recognition of the role of organic farming in agriculture, environment as well as food security (Kledal et al., 2009).

A few households, 7%, managed land fertility loss by setting up terraces. Terraces are classified as structural interventions or modifications of original land topography in sloppy landscapes aiming at soil erosion control and soil moisture retention (Blanco-Canqui & Lal, 2008). Blanco-Canqui and Lal (2008) give an example of the *fanya juu* terrace which is common in semi-arid Kenya. Since terracing is labour intensive, households have to hire additional labor while others have to join groups where they aid each other.

It has been shown by studies that soil fertility degenerates over time due to continuous cultivation and when such fertility isn't replenished by use of fertilizers such land can easily become derelict or unproductive (Dejene, 1997). Loss of fertility could specifically result in on-farm effects such as less fodder, less firewood and less crop residues as well as an array of environmental externalities (Sanchez et al., 1997; Sanchez, 2000).

As such this phenomenon does have food security implications on small scale farming households with small acreages and inability to acquire new pieces of land. There also exists a link between climate extremes, population increase and land fertility and by extension land degradation, notably extremes such as runoff and wind erosion contributing to a drop in soil fertility by facilitating soil erosion (Blanco-Canqui & Lal, 2008; Pittock, 2013). Such effects are exacerbated by unwise farming practices such as clearing of land in marginal areas where vegetation plays a big role in prevention of soil erosion (Pittock, 2013).

4.5.2.2 Adaptations to vegetative cover changes in Wote

To adapt to such changes in vegetative cover households engaged in an array of mechanisms aimed at adjusting to the effects including 11% of the households engaging in cultivation of cover crops and a few, 8% practicing agro forestry as shown in Table 4.43. Other mechanisms include purchasing fodder by 2% of the households.

Table 4.43 Adaptation to vegetative cover change among households in Wote

Adaptation mechanism	No.	%*
Cover crops	13	11%
Agroforestry	10	8%
Destocking	3	3%
Buying fodder	2	2%
Reduced deforestation	1	1%

N=120 *Multiple responses

Cultivation of cover crops as pertains to adaptation to vegetative cover change aims at reducing open soil surface which encourages soil erosion. The mechanism has been mentioned in other studies related to adaptation such as land degradation studies in Ghana by Mahu et al.,(2011). Agro forestry is aimed at ensuring farming communities restore vegetative cover through planting of trees and shrubs on farm to ensure households benefit from an array of environmental products and services including raising the value of land.

Establishment of agro forestry systems are an important shelter from effects of wind and water erosion; plants roots anchor the soil and subsequently reduce runoff and erodability (Nair, 1993; Blanco-Canqui & Lal, 2008). Since several of the households in Wote practice livestock keeping, availability of fodder is critical for survival and productivity of such livestock. As such a few households engaged in purchase of fodder when they experienced vegetation scarcity. A related mechanism noted through observation is where some households store fodder from crop harvests in specially made storage shelters for use during dry spells as shown in Plate 4.4.

Plate 4.4 Storage of fodder for use during dry spells among some households in Wote

Destocking as mentioned by a few of the households ,3% ,is a closely related mechanism which involves reduction of livestock numbers to reduce the risk of negative effects on fragile vegetative cover characteristic of ASALs. In deed livestock play a role in reduction of above ground cover and by extension reduction of diversity via removal of rare species (LUCID, 2006). The approach of destocking has been noted mainly in pastoral communities (Hein et al., 2009). Woodfine (2009) describes a related high adaptation potential mechanism, sustainable grazing management, which improves vegetative cover through maximizing capture, infiltration and storage of rainwater.

4.5.3 Access to weather and calamities information as an adaptation mechanism in Wote

Most of the farmers, 81%, in Wote noted that weather information is important to enable informed farming (Table 4.44).

Table 4.44 Households indication of weather information importance in Wote

Response on weather information importance	No.	%*
Strongly agree	97	81%
Slightly agree	7	6%
Strongly disagree	1	1%

N=120 *Multiple responses

Another number, 6%, indicated that they slightly agreed that weather information is important. This observation indicates that the farmers are aware of informed farming such that they are in a position to employ appropriate farming decisions in the face of climate extremes. Households with access to weather information were further asked to indicate the three most important weather information to their households using a ranking system ranging from value's 1 to 3 showing decreasing level of information importance. The median was applied due to the ordinal nature of the data Huizingh (2007) where households noted each of the key weather information with values 1 to 3.

As Table 4.45 indicates information on the start of rains was highly ranked by the households (Median=1.5) indicating such information was equally important to many of the households.

Table 4.45 Most important weather information ranking in Wote

	No.*	Mean	Median ($\tilde{x}$)	Std. Deviation
Drought weather information ranking	84	1.95	2	0.82
Pest and disease information ranking	68	2.24	2	0.601
Rain information ranking	96	1.79	1.5	0.87
Weather information for next 2 to 3 months	42	1.98	2	0.811
Weather for 24hrs and next 3 days	45	2.16	2	0.903

N=120 *Multiple responses

Weather information on key climate events ranks highly as the most important weather information with households ranking drought information with the value 2 (Median=2). Ranking of extreme weather information such as drought indicates the exposure and sensitivity of the households to drought which has been noted as the key calamity by households in Wote. Information on the start of rains is key since rainfall greatly influences land preparation dates as well as start of planting and subsequent performance of crops notably in arid and semi-arid areas. Rainfall also influences several other household aspects such as pasture availability and subsequent livestock productivity.

Weather for the next two to three months was ranked second by most of the households ($\tilde{x}$ =2). Such ranking indicates that prior knowledge on the nature of weather events for following months is viewed as important as a way of ensuring farmers are aware of the dates to prepare their farms and more so planting dates to avoid crop failure. Access to such information, which informs farm activity dates , influences adaptation mechanisms aimed at adjusting to extreme weather events notably rainfall failure which could affect key plant growth stages Hassan and Nhemachena (2008) more so in a semi-arid area like Wote.

Information on occurrence of pests and diseases was equally ranked second by most households ($\tilde{x}$ =2).Pests and diseases are some of the calamities that households reported to be affecting their farming activities. When such crop pests and diseases are linked or coincide with occurrence of certain extreme climate events, households are likely to experience more adverse impacts notably crop failure and/or low yields. Weather information for the next twenty four hours to three days was similarly ranked second by most of the households ($\tilde{x}$ =2).

Such ranking indicates that households prefer weather information into the near future. Weather information for one to three days plays a key role in averting sudden climate extremes notably flash floods which could severely affect households assets.

Further households indicated which specific weather information they had actually received over the last two years which denoted the actual access to weather and calamities information as a mechanism of adaptation in the study areas. As Table 4.44 indicates, a larger number of the households, 81% had received weather information on extreme events forecast as well as forecast for the start of the rains. An equally larger number of the households, 73% had received information on occurrence of pests and diseases in the study area. A few households, 38%, and 48%, indicated they had received weather information for the next two to three months and forecast for the next one to three days respectively (Table 4.46).

Table 4.46 Weather and calamities information received over the last two years in Wote

Information received	**No.**	**%***
Drought forecast	97	81%
Start of rain forecast	97	81%
Pests and disease forecast	88	73%
Forecast for 24hrs or next 3 days	58	48%
Weather for next 2 to 3 Months forecast	46	38%

N=120 *Percentages sum exceed 100% because these are multiple responses.

Access to information on extreme events such as, drought, pest and diseases, indicates indeed the households have made an effort to adapt to extreme calamities experienced in the study area through informed practices.

In addition access to daily and seasonal weather information, for the next one to three days indicates almost half of the households with access to such information are in a better position to adjust to potential extreme events. However, the limited number of households with access to seasonal information compared to other sources indicates households do not get information necessary for agricultural decisions, which could affect their adaptive capacity as Recha,(2011) indicates in a related study. Access to such seasonal information enables the households to make the necessary arrangements regarding farming activities including when to start land preparation, start of planting and harvest to avert crop failure due to extreme events. Indeed Maddison (2007) in his study in Africa shows that access to information about weather and climate change as some of the barriers to adaptation to extreme events associated with climate change.

Households further indicated the key sources of weather and calamities information for each of the mentioned weather data, with most households, 32%, indicating they received information through radio (Table 4.47).

Table 4.47 Main weather and calamity information sources in Wote

Information source	No.	%*
Radio	207	32%
Indigenous knowledge	96	15%
Local meetings	97	15%
Extension	93	14%
Friends, relatives and Neighbours	66	10%
NGOs	19	3%
Television	22	3%
Cell phones	13	2%
Newspaper	12	2%
Religious faith	7	1%
Teachers	6	1%
Internet	3	0%
Total	**641**	

*Percentages sum exceed 100% because these are multiple responses.

Other households, 15% indicated receiving weather and calamities information from local meetings and indigenous knowledge. An almost equal number, 14%, indicated receiving information from extension with 10% indicating friends, relatives and neighbors as the information source. Other studies have noted related sources of weather and calamity information sources with radio as the key source (Akon-Yamga, et al., 2011; Recha, 2011) indicating the penetration and popularity of the gadgets in rural areas of SSA as noted in Wote. Indeed the current availability of local language broadcasts has enhanced the dissemination of weather and calamities information in rural areas. In deed studies have shown the effectiveness and importance of radio broadcasts as early warning systems promoting adaptation to climate change extremes as well as informing farmers on agricultural messages (Munyua 2000).

Indigenous mechanisms as applied by Wote Households, has been mentioned as a vital means of adapting to constantly changing climate among farmers and can even be built upon by modern agricultural advisors to enhance resilience (Nyong et al., 2007; Woodfine, 2009). Further, similar studies have been conducted to identify indigenous mechanisms of identifying and adapting to extreme climate events in the region among farming communities, showing the importance of such practices (Nyong, et al., 2007; Enete et al., 2011). Examples of indigenous mechanisms applied by farmers in Wote include observing the movement of birds as well as observing appearance, such as flowering, of certain species on farm.

Extension services (also mentioned in section 4.5.4) play a role in updating and informing farmers in the study area. Typical information disseminated during such extension services is weather related and also ways of adjusting to and enhancing resilience in the face of extreme climate events. While farming households have access to weather information, studies have determined the reasons leading to non-use of such information including language barrier, poor user friendliness as well as unavailable timelines (Leary, 2008). As such it is important to communicate climate forecasts in a format and manner that is relevant to their needs.

4.5.4 Selected adaptation mechanisms

These mechanisms presented in Table 4.48 include selected initiatives and key individual household efforts to adapt to climate extremes as well as institutional backing to enhance adaptive capacity against climate change and variability. Most of the households, 68%, as Table 4.48 indicates, involved in selling of household assets such as livestock.

Table 4.48 Selected adaptation mechanisms among Households in Wote

Selected adaptation mechanism	**No.**	**%***
Sale of household assets	81	68%
Extension services	55	46%
CBOs and farmer associations	43	36%
Post-harvest processing and value addition	19	16%
Credit and loans for farming	1	1%

N=120 *Percentages sum exceed 100% because these are multiple responses.

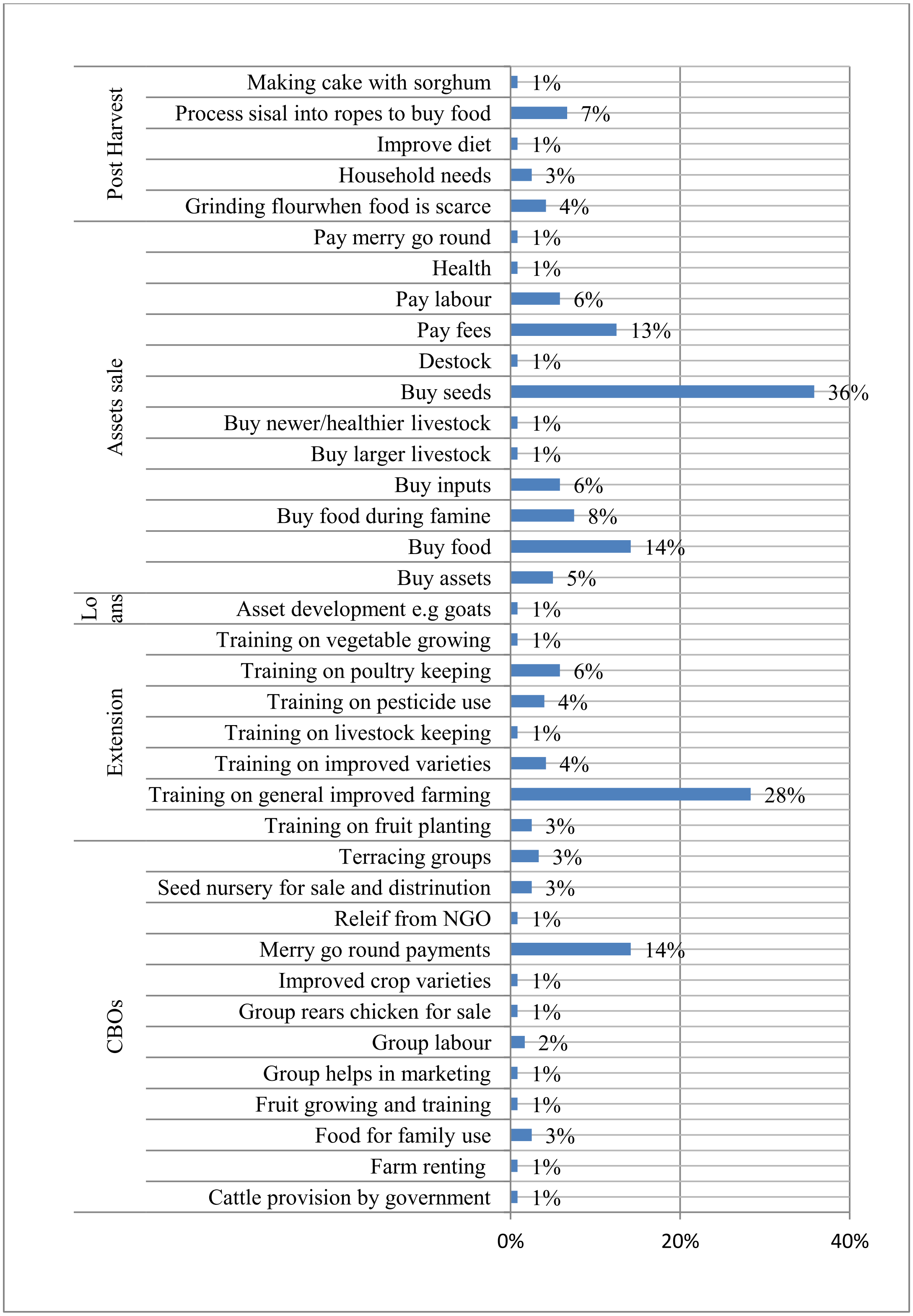

Figure 4. 6 Reasons and benefits for adoption of selected adaptation strategies among Households in Wote

Assets include means of production available at household level and are applied in their livelihood activities (Cooper, et al., 2008). Households had an array of reasons for disposal of such livestock as Figure 4.6 summarizes. Such assets disposal reduces the variety of assets or assets base available in a household which eventually affects their adaptive capacity and future livelihoods (Cooper, et al., 2008). A key reason noted is sale of assets to purchase food during famine by 8% of the households while 14% indicated that they sold assets to buy food in less severe instances of food insecurity. Some of the farming households, 13%, involve in sale of assets to obtain funds to pay for the education of their children.

In other instances 36% of the households in the study area indicated selling assets to purchase seeds while a lesser number 6% did sold assets to purchase farm inputs such as fertilizer and biocides as well as spray equipment and water tanks. In addition households involved in sale of livestock assets to purchase healthier as well as larger livestock and in other instances to destock. As noted key assets sold are mainly livestock (chicken, goats and cows) a situation that reduces the asset base of households which could make them unable to adapt to future extreme events. Research has indeed identified additional reasons that force households in extreme circumstances to opt to, sell key assets such as land and even livestock. These include paying off debts a decision that reduces their chance of survival in future (Orindi & Murray, 2005).

Table 4.48 indicates that 46% of the households have accessed extension services which aids in decisions around adaptive capacity and more so improved and new farming practices such as grafting and improved crop varieties.

In addition a few of the households received training on appropriate pesticide use, poultry rearing as well as goats rearing as Figure 4.6 indicates. Households in Wote mainly obtain such extension services from local Ministry of Agriculture (KARI) extension officers as well as nongovernmental organizations (NGO's) and private companies on the ground. These are indeed the common actors in provision of agricultural extension provided to farmers in Kenya as Muyanga and Jayne (2006) note in their study on extension services in Kenya. Extension services include supply of information concerning improved farming practices in the face of extreme climate events and related calamities and have changed or evolved over time due to new farming needs and threats.

Leeuwis (2013) indeed argues that there is need to rethink the definition and conception of extension to modern times. In this regard extension can be viewed as "communicative interventions meant to develop novel patterns of coordination and adjustment between people, technical devices or natural phenomena, so as to resolve problematic situations". Related studies have further indicated and demonstrated the critical role and need of extension services in; improved farming knowledge and more so their continued contribution in improving adaptive capacity in the face of climate change and variability among small scale farming households in SSA (Kabubo-Mariara & Karanja, 2007; Mustapha et al., 2012) as well as improvement in yields Muyanga and Jayne (2006).

Further, 36%, of the households in Wote indicated being members of Community based organizations (CBOs) and farmer associations. The reasons behind involvement in such organizations include mainly obtaining of payments through merry go rounds as noted by 14% of the households.

In addition households are involved in group farming practices, mainly group based labor which is suitable for labor intensive activities such as terrace building. Other households participated in CBOs rearing chicken, fruits or seeds for sale and additionally benefit from training. Such income enabled the households to have alternative income and food sources in the event of crop failure in their individual farms.

Studies have indeed indicated additional benefits of households having membership in such CBO's. These include ease of access to loans (Muyanga & Jayne, 2006; Hammill et al., 2008) and related microfinance services provided by: governments, credit unions and SACCOs (Hammill, et al., 2008). Hammill et al.,(2008) add that such microfinance institutions aim to fill the gap left by traditional banks, which are unable to effectively offer such services due to barriers such as lack of collateral. They also state that some micro finance institutions do offer non-financial services such as education, training and healthcare among their members which directly and indirectly contribute to improved household assets base and improved farming practices. In addition community based organizations improve individual farming practices in the face of climate variability notably from implementing shared knowledge from other farmers and more so benefiting from group capacity building by NGOs and government agencies (Ngigi & Denning, 2009).

A few of the households, 16%, indicated involving in post-harvest processing and value addition. This involves applying technologies that aim at improving harvests or developing multiple products from harvests or on farm produce.

Examples mentioned include grain grinding when there is food shortage (as shown in Plate 4.5) and processing sisal into ropes for sale to purchase food by 7% of the households as Figure 4.6 indicates. Equipment used in sisal processing is presented in Plate 4. 6.

Plate 4.5: Grinding equipment used in post-harvest processing of Maize into smaller grains (*Nzenga*) among some households in Wote

Additional approaches for such post-harvest processing includes making of sorghum cake. Other households, 3%, mentioned that they are involved in post-harvest processing to meet their general household needs. Value addition aims at improving the shelf life, marketability and profitability of farm products or rather raise the value tremendously which improves on the income of households.

Plate 4.6 Equipment utilized in sisal processing among some households in Wote

Muyanga & Jayne (2006) in their work on extension in Kenya outline other examples of value addition or as they mention “farm level processing” including; yoghurt from milk, cakes from sweet potatoes, jam from tomatoes and preserving vegetables by drying. Ability to add value to products among farming households could be hampered by inadequate energy and water which raise costs (Nyamulinda et al., 2011). Nyamulinda et al., (2011) add that value addition coupled with reduced post-harvest losses is much cost effective than improving farm yields through an array of interventions. Further, enterprise diversification including value addition (or processing) has been mentioned in other studies as a practical option to adaptation against climate change extremes (Ngigi & Denning, 2009). In Kenya provision of value addition technology has been at an industrial level where technology transfer is provided to individuals, SMEs and groups with substantial financial muscle and includes food processing technologies targeting perishables (KIRDI, 2014).

4.6 Socioeconomic factors influencing adaptation in Wote

A multiple regression model allows prediction of a continuous dependent variable (Y) based on several continuous or categorical independent variables(X_1 to X_p) (Afifi et al., 2003; Landau & Everitt, 2004; Lund-research, 2013). Lund research (2013) further states that other names given to the dependent variables include the outcome or target variable while independent variables are also called predictors or explanatory variables.

Multiple regressions explain the overall fit of the model or rather prediction of the value of one variable from others and also the relative unique contribution of each explanatory variable to the model (Lund-research, 2013). Freund et al.(2006) and similarly Tabachnick and Fidell (2001) state that a multiple regression model is denoted as an extension of the linear or bivariate regression as shown in equation 4.1;

$y=\beta_0+ \beta_1x_1+\beta_2x_2+ \ldots\ldots\ldots\ldots + \beta_m x_{m+} E,$ ....Equation 4. 1

Where y is the dependent, target or response variable

$X_j, j =1,2 \ldots\ldots, m,$ represent m different independent, explanatory or control variables

β_0 is the intercept value when all predictors are 0, also denoted as α in other cases

β_j, j =1,2 ,................,m, denote the respective m regression coefficients

E is the random error or disturbance term, usually assumed to be normally distributed with mean zero and variance. Also denoted as μ in other cases

In multiple regression the regression coefficient linked to each independent variable measures the average change in the response variable associated with changes in that predictor while all other predictors are held constant (Freund, et al., 2006).

Multiple regression models require an array of assumption or validity tests which include tests for independence of errors (residuals), linear relationship, multicollinearity, outliers and normal distribution of errors (Lund-research, 2013; Pallant, 2013).

4.6.1 The relationship between adaptations and socio economic factors in Wote

The Wote household's adaptation strategies were aggregated such that the total numbers of adaptations for each calamity per household were identified as shown in Table 4.49 to form a dependent variable to facilitate regression.

Table 4.49 Total number of adaptations to calamities experienced in Wote

Number of adaptation means	No.	%
0	1	1%
2	4	3%
3	25	21%
4	28	23%
5	22	18%
6	25	21%
7	12	10%
8	3	3%

N=120

The results indicate most households have between 3 and 6 adaptation mechanisms against a wide range of calamities associated with climate change.

One of the key assumptions for multiple regressions is independence of observations which is highlighted by the model summary output of the regression as shown in Table 4.50. Independence of observations is such that the predicted value is not related to any of the other predictions or rather each of the predicted values is independent (Ho, 2006).

Table 4.50 Regression model summary

Model Summary[b]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	**.568**[a]	**.323**	**.203**	**1.406**	**1.684**
a. Predictors: (Constant), Household number_sqrt, correspondent education, Number of income sources, Respondent gender, Acarage_sqrt, Respondent education, correspondent age_sqrt, respondent age_sqrt, correspondent gender					
b. Dependent Variable: Number of calamity adaptations _sqrt: implies the variable was transformed by computing the variables square root					

An important statistic as reported by Lund research (2013) and Ho (2006) is the Durbin Watson statistic that ranges from 0 to 4 with a value close to zero showing strong positive correlation.

The statistic is a test of the serial correlation of error values and is used to indicate non independence of error values when significant (Tabachnick & Fidell, 2001; Ho, 2006; Pallant, 2013). Ideally the statistic should be approximately equal to 2 to warrant the non-assumption of the requirement (Lund-research, 2013). From Table 4.50 there was independence of residuals, as noted by the Durbin Watson statistic of 1.684 hence the assumption was not violated. The table further indicates the array of predictors and response variable employed in the model including number of income sources, respondent age, correspondent age, household number, acreage, respondent gender, correspondent gender and respondent education level.

The next assumption is linearity where predictors are collectively tested for linearity with the dependent variable and also each predictor is linearly linked to the dependent variable (Tabachnick & Fidell, 2001; Lund-research, 2013; Pallant, 2013). Ho (2006) and Lund-research (2013) indicates that linearity can be assessed using residual plots where studentized residuals are run against unstandardized predicted values. In cases where linearity tests fails or shows partial linearity, transformation or corrective action of values is needed to improve model validity (Ho, 2006; Lund-research, 2013; Pallant, 2013). As shown in Figure 4.7, the residuals tend to form a non curvilinear pattern in the scatter plot noting to a certain extent a linear relationship between non transformed predictors and the response variable qualifying for the linearity assumption.

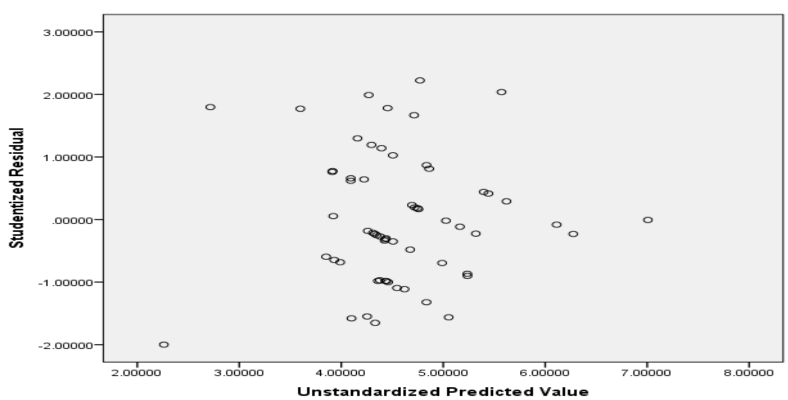

Figure 4.7 Scatter plot of the Linear relationship between studentized residuals and unstandardized predicted value

The scatter plot (Figure 4.7) can be improved further by transforming the predictors as discussed below. Lund-research (2013) provides a criterion for choosing the transformation approach depending on the level of skewness of the continuous variables as shown in Table 4.49 : For moderately positively skewed data, transformation via the square root of the values is run and for strongly positively skewed data the logarithm to the base of 10 is computed for each of the values.

In this case, as shown in Table 4.51 the continuous variables; household number, mean acreage, respondent's age and correspondent's age were all transformed through the square root function with the skewness values decreasing.

Table 4.51 Statistics for continuous variables included in the linear regression model

	No.	Mean	Median	Mode	Std. Dev	Skewness	**Skewness(transformed)**	Transformation approach
Household number	119	6.08	6	5	2.38	1.144	0.327	Sqrt
Main respondent age	120	49.87	45	45	18.069	0.63	0.294	Sqrt
Mean acreage	116	7.0988	5	3	6.97365	2.667	1.537	Sqrt
Correspondent age	106	42.63	40	30	16.099	0.81	0.4	Sqrt

As shown in Figure 4.4 the scatter plot with transformed predictors shows some improvement: the graph shows non-curvilinear relationship qualifying for linearity (Ho, 2006). Further, partial regression plots for each of the non-transformed and transformed continuous dependent variables, in Table 4.49, and the response variable were generated. This is an additional measure of assessing linearity between the individual predictors and the response variable.

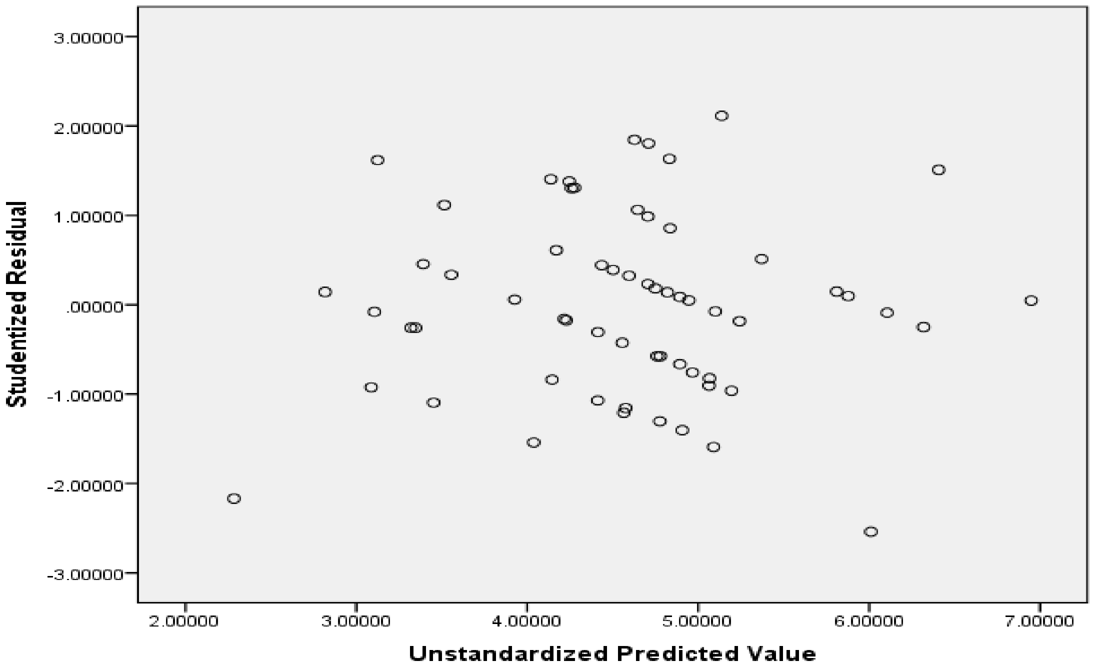

Figure 4. 8 Linear relationship between transformed studentized residuals and unstandardized predicted value

As presented above in Figure 4.8 the main respondent's age was transformed through computation of the square root for each case. After transformation the values show some level of improved linearity compared to non-transformed values.

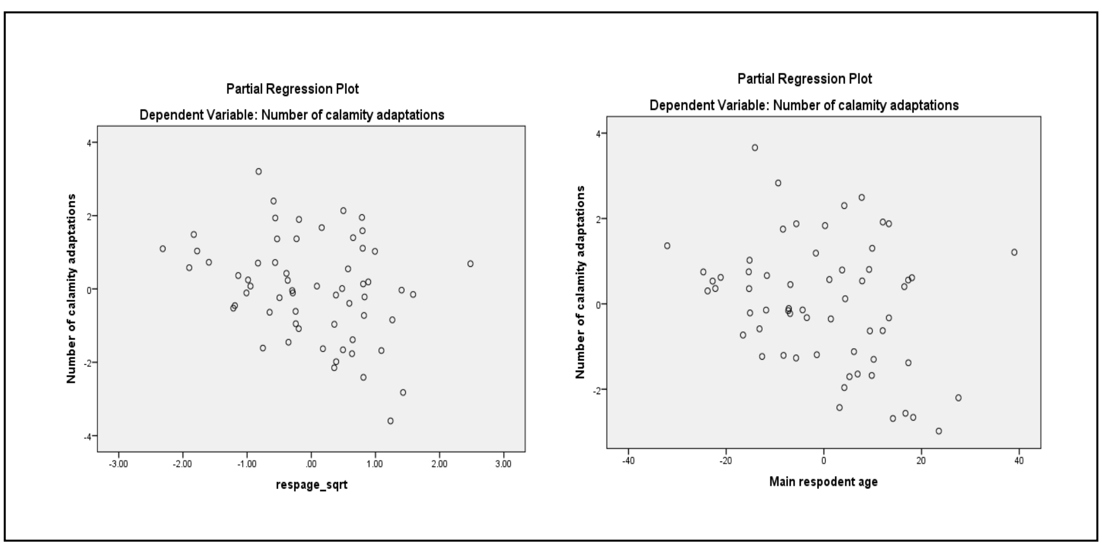

Figure 4. 9 Partial regression plots for main respondent's age.

The same applies to transformation of household number, Figure 4.10, mean acreage, Figure 4.11 as well as correspondent's age shown in Figure 4.12.

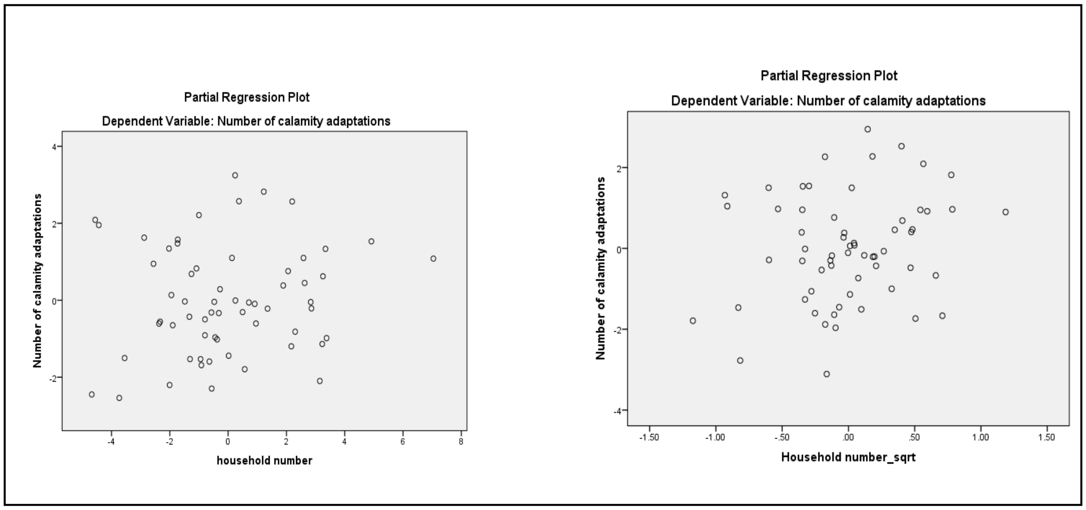

Figure 4.10 Partial regression plots for household number

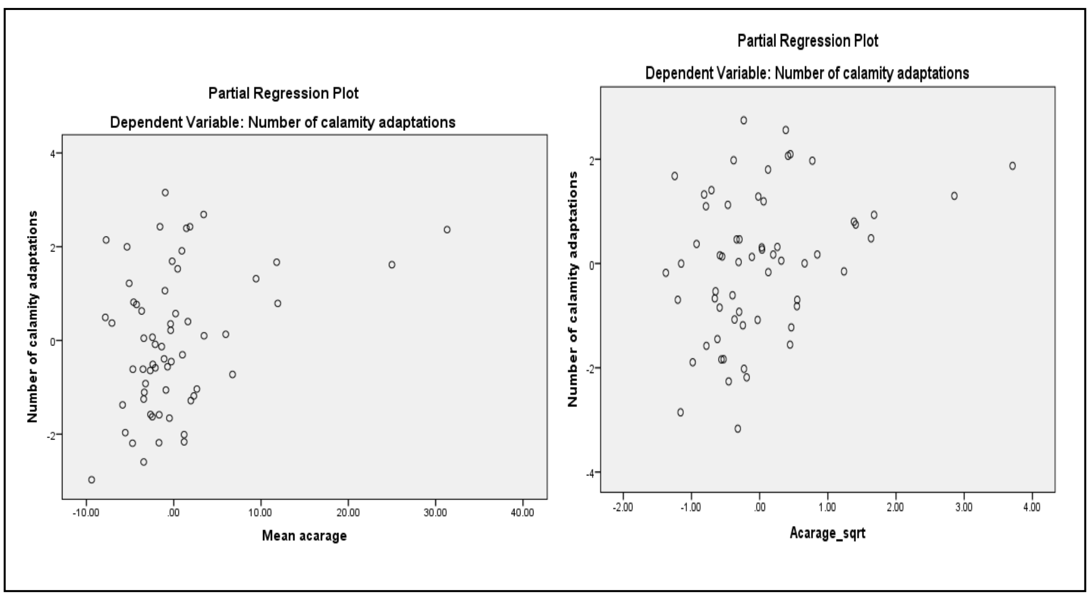

Figure4. 11 Partial regression plots for mean acreage

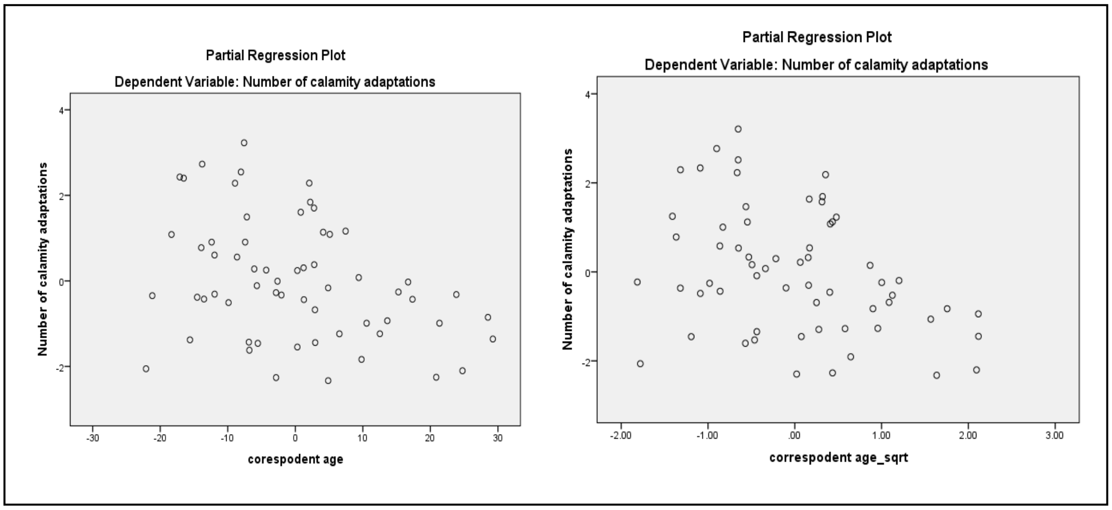

Figure 4.12 Partial regression plots for correspondent's age

The transformations represented in the charts above and as noted by Ho (2006) are ideally meant to increase "the predictive accuracy of the model and the validity of the estimated coefficients".

The next assumption checked on the variables is multicolinearity which is attributed to predictors or explanatory variables exhibiting high correlation and is considered a serious problem with regression (Crown, 1998; Lund-research, 2013). Lund research (2013) further adds that multicolinearity leads to problems of comprehending which variable uniquely contributes to the explained variance and even technicalities in computing the multiple regression model. Swanson and Holton (2005) also add that multicolinearity "can limit the size of the coefficient of determination (R^2)" which indicates the predictive capacity of the model. Multicolinearity is examined through inspection of correlation coefficients and the tolerance or variance inflation factors (VIF) among predictors (Crown, 1998).

Tabachnick and Fidell (2001) add that multicolinearity can also be detected by presence of very large standard errors for regression coefficients with reference to the scale of the variables. As such appendix 5 shows the correlation matrix of the variables included in the model, showing that none of the coefficients among the predictors is greater than 0.7 as noted by (Lund-research, 2013). The VIF is the inverse of the tolerance indicated in the Table 4.52 of coefficients.

Table 4.52 Collinearity statistics for the multiple regression model

	t	Sig.	Collinearity Statistics	
			Tolerance	VIF
(Constant)	4.895	.000		
Respondent education	-1.448	.154	.584	1.712
Respondent gender	-2.108	**.040**	.367	2.723
Correspondent education	-1.835	.072	.445	2.245
Correspondent gender	-1.631	.109	.339	2.950
Number of income sources	.684	.497	.894	1.119
Acreage(SQRT)	2.532	**.014**	.716	1.398
Respondent age(SQRT)	-2.345	**.023**	.514	1.947
Correspondent age(SQRT)	-2.850	**.006**	.554	1.803
Household number(SQRT)	1.529	.132	.904	1.106

The tolerance as discussed by Pallant (2013) indicates how much of the variability of the predictors is not explained by others included in the model and is equal to ($1-R^2$) for each of the variables. A tolerance value less than .10 indicates high correlation with other predictors and similarly a VIF above 10 (Reciprocal of 0.1) indicates collinearity in the model (Lund-research, 2013; Pallant, 2013).

From Table 4.52, the highest tolerance value is 0.339 (VIF=2.950) indicating the data does not exhibit multicollinearity. The next assumption is detection of outliers which involves inspection of the mahalanobis distance value output compared with the number of predictors as degrees of freedom against a critical chi square value (Pallant, 2013). The number of predictors in the model is 9 hence the degrees of freedom are 9 implying the critical chi square value is 27.88 at a critical alpha value(α=0.001) (Tabachnick & Fidell, 2001; Ossietzky 2013). This value falls below the maximum recorded mahalanobis distance value of 25.343 in Table 4. 53 indicating the dataset does not contain outliers.

Table 4.53 Residual statistics for the multiple regression model

	Minimum	Maximum	Mean	Std. Deviation
Predicted Value	2.28	6.95	4.57	.895
Std. Predicted Value	-2.557	2.654	.000	1.000
Standard Error of Predicted Value	.322	.932	.549	.153
Adjusted Predicted Value	2.24	7.24	4.58	.917
Residual	-3.011	2.862	.000	1.297
Std. Residual	-2.141	2.035	.000	.922
Stud. Residual	-2.540	2.114	-.003	1.023
Deleted Residual	-4.237	3.087	-.010	1.616
Stud. Deleted Residual	-2.691	2.191	-.003	1.042
Mahal. Distance	2.159	25.343	8.852	5.670
Cook's Distance	.000	.368	.027	.062

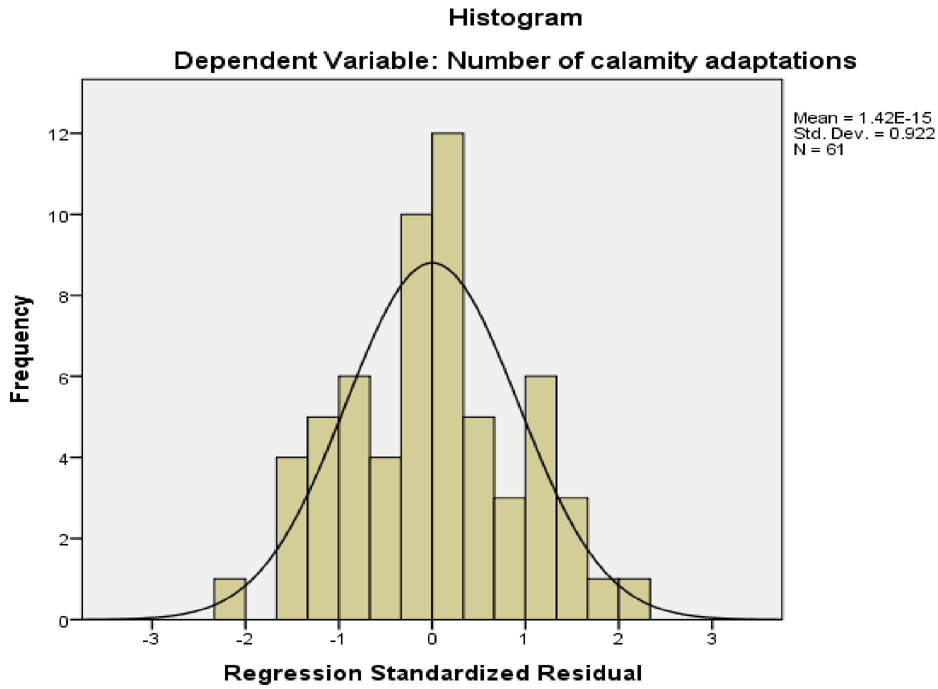

Figure 4.13 Superimposed curve for detecting normality among transformed predictors.

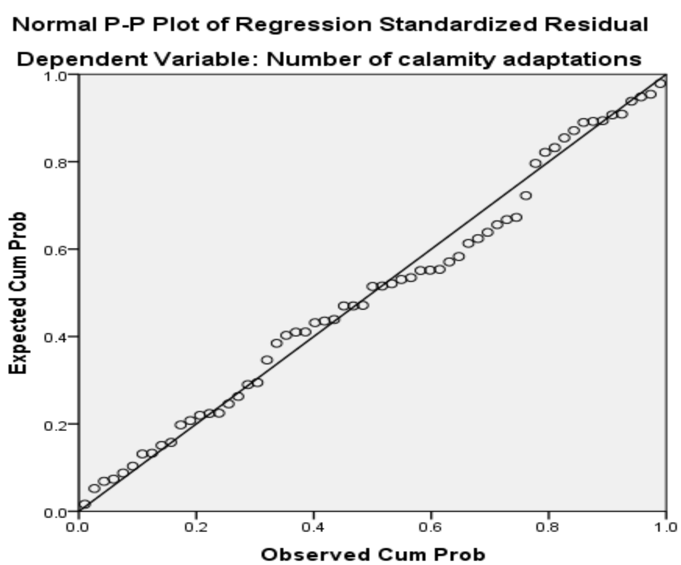

Figure 4.14 Detecting normality after transformation of predictors

The data was additionally evaluated for the assumption of influence on results using the Cook's distance and leverage points. As indicated in other studies, the critical values for Cook's distance and leverage points are 1 and 0.5 respectively (Lund-research, 2013). From Table 4.53, the largest values for the Cook's distance and leverage points are 0.368 and 0.422 respectively indicating absence of influential points in the model.

The data was also evaluated for violation of normality which happens when residuals (errors in prediction) are not normally distributed (Lund-research, 2013). An additional test run is the test for assumption of equal variances between pairs of variables also termed as homoscedasticity Ho (2006) or as Tabachnick and Fidell (2001) put it," the standard deviations of errors of prediction are approximately equal for all predicted dependent variable scores". Normality was assessed using a histogram with a superimposed normal curve and a P-P plot shown in Figure 4.13 and 4.14.

The histogram, Figure 4.9,indicates standardized residuals seem to be approximately normally distributed and further the mean and standard deviation have values close to zero and 1 respectively :all indicators of some level of normality (Lund-research, 2013). The P-P plot in Figure 4.14 shows residuals are aligned along the diagonal line running from bottom left to the top right suggesting no major deviation from normality (Pallant, 2013).The residuals scatter plot shown in Figure 4.15 is referred to check for homosdedasticity or homogeneity of variance as Ho, (2006) explains. Pallant (2013) states that the residuals should be such that they are roughly rectangular with most scores in the centre along point 0 as confirmed by Figure 4.15.

In instances where such rule is violated due to variable skewness, predictors can be transformed to reduce or eliminate heteroscedasticity (Tabachnick & Fidell, 2001).

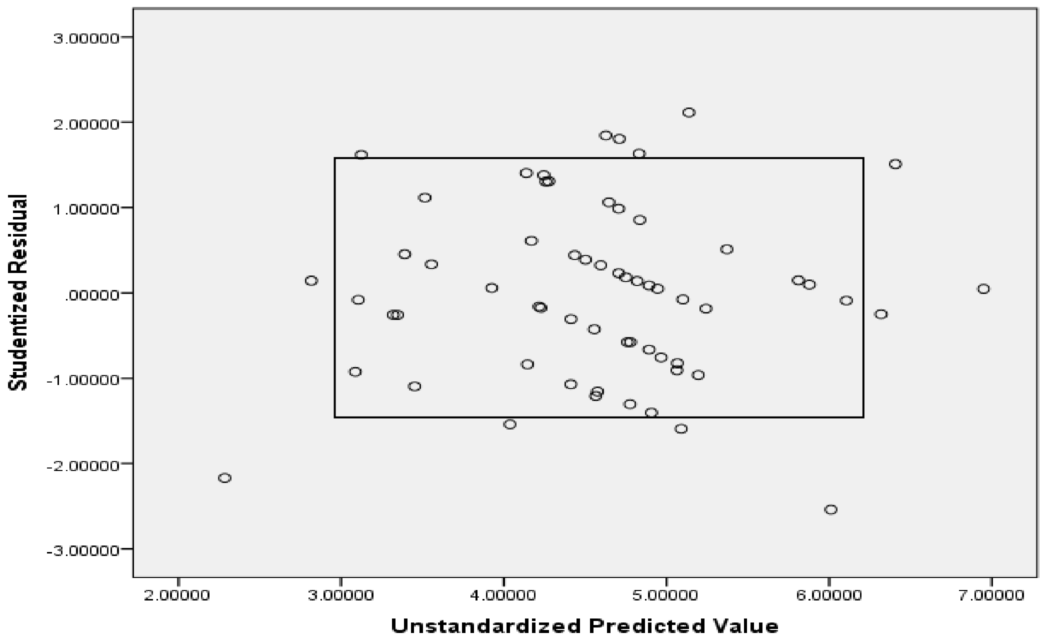

Figure 4.15 Plot for checking non-violation of homogeneity of variances

Once the model variables indicated non-violation of the multiple regressions assumptions the model was run to determine which socioeconomic factors play a role in influencing adaptation strategies. The first output (also indicated in Table 4.50) includes determination of the model fitting to the data entered as provided in the model summary in Table 4.54.

Table 4.54 Model fitting statistics summary

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	**.568[a]**	**.323**	**.203**	**1.406**	**1.684**

a. Predictors: (Constant), Household number_sqrt, correspondent education, Number of income sources, Respondent gender, Acarage_sqrt, Respondent education, correspondent age_sqrt, respodent age_sqrt, correspondent gender

b. Dependent Variable: Number of calamity adaptations

The value R known as the coefficient of multiple regression, ranging from 0 to 1, is a generalization of the correlation coefficient, *r* and can be looked at as one of the measures of the prediction capability of the dependent variables (Lund-research, 2013; Martella, et al., 2013). Lund-research (2013) adds that a higher value indicates that predicted values are closely correlated to the predictors showing better prediction by the dependent. From Table 4.54, R=0.568 shows a moderate level of prediction of adaptation strategies number by the selected socioeconomic factors after Martella, et al.(2013).

From Table 4.54 the value R^2=32.3, shows that the socioeconomic indicators explain 32.3% of the variability of the dependent variable (number of adaptation strategies). The adjusted R^2=0.203 includes correction for bias and hence provides a smaller value though it is useful for reporting for small samples (Lund-research, 2013; Pallant, 2013).

The Analysis of variance (ANOVA) Table 4.55, as noted by (Lund-research, 2013), “indicates the ratio of the mean sum of squares for the residuals” or as noted by (2013) assesses or tests the statistical significance of the results.

Pallant (2013) adds that the test is the null hypothesis, H_0=multiple regression coefficient of correlation in the population equals 0. In other words the test denotes whether the model reaches statistical significance when p<0.0005.From Table 4.55 it is concluded, household number, correspondent education, number of income sources, respondents age, acreage, respondent education, correspondent age, respondent age and correspondent gender do not significantly predict the number of adaptation strategies, $F(9,51)=2.700, p=0.012$.

Table 4.55 ANOVA table showing model significance

ANOVA[a]

	Sum of Squares	Df	Mean Square	F	Sig (*p* value).
Regression	48.063	9	5.340	2.700	.012[b]
Residual	100.855	51	1.978		
Total	148.918	60			

a. Dependent Variable: Number of calamity adaptations
b. Predictors: (Constant), Household number_sqrt, correspondent education, Number of income sources, Respodent gender, Acarage_sqrt, Respodent education, correspondent age_sqrt, respodent age_sqrt, corespodent gender

Table 4.56, indicates estimated coefficients and of notable importance in this study is the standardized coefficients and statistical significance of the independent variables. The Beta value(β) for each of the predictors denotes the relative contribution of each to the prediction of the dependent variable when variance explained by other variables is held constant regardless of the sign (Pallant, 2013). Martella et al.(2013) adds that Beta weights/values provide the “relative strength of the relationship between independent variables and the dependent variable”.

Table 4.56 Summary of the multiple regression model coefficients table

		Standardized Coefficients	t	Sig.	Correlations		
		Beta(β)			Zero-order	Partial	Part
1	(Constant)		4.895	.000			
	Respondent gender	-.401	-2.108	**.040**	-.111	-.283	-.243
	Correspondent gender	-.323	-1.631	.109	-.025	-.223	-.188
	Respondent education	-.218	-1.448	.154	-.074	-.199	-.167
	correspondent education	-.317	-1.835	.072	-.058	-.249	-.211
	Number of income sources	.083	.684	.497	.070	.095	.079
	Household number_sqrt	.185	1.529	.132	.133	.209	.176
	Respondent age_sqrt	-.377	-2.345	**.023**	-.085	-.312	-.270
	Correspondent age_sqrt	-.441	-2.850	**.006**	-.221	-.371	-.328
	Acarage_sqrt	.345	2.532	**.014**	.219	.334	.292

As such from Table 4.56 it is apparent that correspondent's age (β=-.441), acreage (β=.345) and respondent gender (β=-.401) made the strongest contribution in explaining the dependent variable, number of adaptation strategies. The independent variable number of income sources (β=.083) and respondent education (β=.154) made the least contribution in explaining the dependent variable number of adaptation strategies. Most importantly the column on statistical significance of the predictors tests whether the standardized coefficients are equal to zero in the population (Lund-research, 2013).

If the value is less than .05 or $p<0.5$ then the variable is making significant contribution to the prediction and such significance can be affected by overlap between variables (Pallant, 2013).

To report on the whole model in conclusion: a multiple regression model was run to identify the contribution of respondents and correspondent's gender, education and age as well as the acreage, household number and number of income sources contribution to the number of climate change calamity adaptation strategies in the respective household. Some of the variables added significantly to the prediction, where $p<.05$. These included respondent gender, $p=0.040$, respondent age, $p=0.023$, correspondent age, $p=0.006$ and land acreage $p=0.014$. The results suggest that gender of the main respondent, in most cases the household head, influenced adaptation to climate change and variability. Similarly the age of the key household members, the respondent and correspondent, affected the level of adaptation strategies significantly but negatively.

In these results it is likely that old aged household heads may be more experienced but have less diversity of adaptation mechanisms. Land size as a key resource affects adaptation level significantly and more so positively, implying owning a larger land resource would increase the ability of the household to adapt probably by instituting multiple adjustments. Other studies have identified similar and differing relationships between the selected socioeconomic characteristics and adaptation strategies. Adebisi-Adelani and Oyesola (2013) in their work in Osun state of Nigeria among selected horticultural farmers identified similar socioeconomic factors affecting adaptation. This include age which indicates the experience of the farmer plays a key role in determining the adaptation.

A related study by Apata et al.(2009) in arable crop farmers in south west Nigeria notes that age and land size are important factors influencing coping with climate change calamities. Deressa et al.(2009) in their work in Ethiopia similarly notes a significant relationship between selected adaptations with age and gender of the household head.

Income has been identified as a key factor influencing adaptation in other studies for example Apata et al.,(2009) and Adebisi-Adelani & Oyesola (2013) though in this study the influence was positive (β=.083) but not significant (p=0.497). In their work in Ethiopia Deressa et al.(2009) note that both on farm and non-farm income did influence certain adaptation strategies. In deed as Notenbaert et al.(2013) report in their related work in Mozambique, availability of adequate income facilitates the households' acquisition of new varieties, irrigation technologies and other inputs as well as ability to use available information which improves their adaptive capacity.

The results indicate household size does not influence adaptation significantly (p=.132) but indicated a positive relationship (β=.185) a similar observation made by Adebisi-Adelani & Oyesola (2013). Other studies such as Apata et al.,(2009) show that household size significantly influences adaptation while in their case the relationship was negative. Large household sizes have been associated with take up of labor intensive adaptation mechanisms such as irrigation in related studies such as Notenbaert et al.,(2013). Education did not show significance relationship with adaptation and additionally depicted a negative correlation with adaptation. Other studies such as Clay et al. (1998) and Anley et al. (2007) however show that education and access to farmer training contribute to better adaptation.

4.7 Vulnerability context of Wote Households

4.7.1 Vulnerability context among Wote households

This study found out that most of the households, 72%, experienced food shortage for 3 to 5 months within a normal year with 11% experiencing more than 5 months of food insufficiency as shown in Table 4.57.

Table 4.57 Distribution of monthly food insecurity among the Wote households

Number of food insecure months	No.	%
Less than 3	20	18%
3 to 5	82	72%
More than 5 months	12	11%

N=120

As Table 4.57 indicates, most households experienced food shortage in the months running from August to November which falls within the short rain season and further November indicated as the month with the highest cases of food insufficiency.

Table 4.58 Distribution of monthly food shortage within a year in Wote

Month	Number of food insecure households	%
January	56	47%
February	4	3%
March	None	
April	None	
May	1	1%
June	1	1%
July	4	3%
August	24	20%
September	56	47%
October	88	73%
November	102	85%
December	97	81%

N=120

From Figure 4.16 it is apparent that indeed food shortage as experienced in the months of August through November is characterized by most households obtaining food from off farm sources.

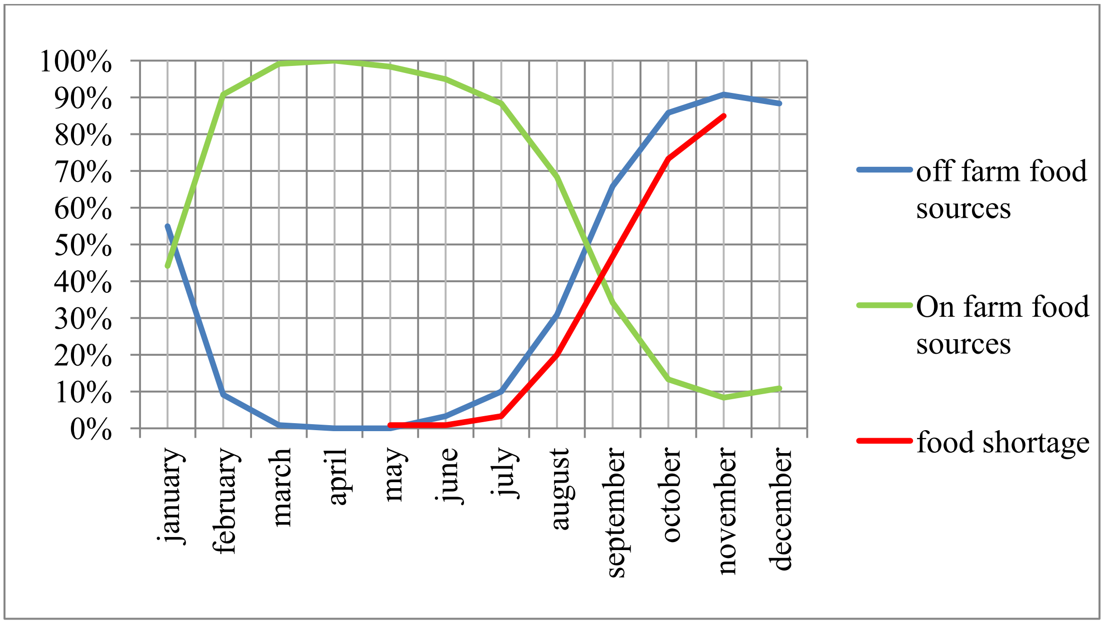

Figure 4.16 Relationship between food shortage and on/off farm food sources in Wote

Such observation indicates that indeed the households experience severe food insufficiency and resulted into alternative mechanisms and/or options to accrue food including sale of assets to purchase food, since on farm sources were insufficient or had been affected by instances of extreme climate events. This phenomenon was further evidenced and/or exacerbated by the fact that very few of the households are engaged in storage of food to cushion themselves during extreme events.

Most of the households, as indicated by 86% and 76%, of the main and correspondents rely on rain fed farming as the major activity. Farming as a key source of livelihood among the households in the study area is a function of exposure and sensitivity to climate extremes as well as crop pests and diseases as key calamities.

As such calamities such as drought, as experienced by 100% of the households, and further 93% and 83% experiencing crop pests and diseases respectively, denoted that the households in the study area were sensitive and have been exposed to such effects. On the same vein a cross tabulation of extreme events experienced, indicated that of 71.9% the households mentioning exposure to extreme events, had experienced all the major calamities i.e. drought, erratic rains, pests and diseases at the same time. Such high number of households experiencing climate extremes and associated impacts indicates a high level of awareness on exposure and vulnerability among the households in the study area.

Further, households noted changes such as increase in severe dry season, 93%, with increases in temperature reported by 85% of the households and reduced precipitation reported by 96% of the households; with 72% indicating such precipitation change was significant. In addition households noted an increase in the number of hot days, 76%, and months, 88%. Such observations tallied with statistical changes in climate data records; annual temperature change was significant p=0.002 while October-November-December (OND) rainy season showed higher variability with a high coefficient of variation (51%) and also indicating a negative trend (Q=-0.871,S=-75).

To this end, there is a high chance of vulnerability as such effects and changes in weather parameters negatively impact on crops by causing crop failure as noted by, 46% of the households and subsequently lead to the 3 to 5 month food insufficiency experienced by 72% of the households.

Crop failure did in fact show a significant relationship with occurrence of crop diseases (p=0.000). This is regardless of the households efforts to apply agro chemicals. In addition other extreme drought impacts such as famine, water shortage and drying of vegetation as experienced by 44%, 43% and 22% of the households further indicate the households' vulnerability to extreme events. Impacts associated with drought such as human diseases and malnutrition as noted by11% and 3% of the households influence availability of the much needed farm labor and by extension muscle power negatively, further adding to food shortage due to reduced farm output and even influencing obtaining of non-farm incomes.

Further, livestock as a key asset and source of animal products are similarly vulnerable due to effects of drought on pasture and water availability as mentioned by 20% and 43% of the households respectively. On the same vein other households indicated selling off livestock in event of extreme events. Such sale is necessitated by among other reasons the need to accrue quick income to sustain households. Disposal of such asset as noted by 68% of the households (Table 4.48) could further increase their vulnerability through reduction of adaptive capacity and/or resilience in the near future.

Household income is a key component as it influences the households' capacity to cushion against extreme events and further build on the assets base as well as facilitation of access to social amenities. Households in the study area highly ranked agricultural based income since most; 86% rely on off farm produce with 50% relying on animal products as a key source of income (Table 4.8). This distribution of income sources ,notably reliance on rain fed farming, further demonstrates the households high risk and vulnerability from extreme events notably occurrence of drought, pests and diseases.

Heavy reliance on farming is further affected by significant changes in land fertility as noted by 71% (Table 4.25) of the households and minimal access to credit and loans as only a few of the households, 1%, reported such access as reported in Table 4.48. Soil fertility directly influences on farm yields and when coupled with crop failure due to extreme events it is likely households in the study area will be food insecure. In addition the households are likely to experience poor yields even in a good year with sufficient rainfall since crops require appropriate nutrient balance to yield.

In an attempt to cope with extreme events farmers in the study area have instituted an array of adaptation mechanisms targeting specific calamities and land resource changes. In this regard mechanisms employed against drought as Table 4.37 shows include drought resistant crops, 65%, terracing, 28%, crop diversification, 13%, and early planting, 8%. In addition terracing was the key mechanism employed to adjust against effects associated with unpredictable/erratic rains by 39% of the households. To curb effects of crop diseases and pests, as shown in Table 4.40 and Table 4.41, 88% and 63%, of the households applied agrochemicals as the key adaptation mechanism respectively.

Further, 66% of the households indicated applying farm yard manure to improve soil fertility while 33% employed agro forestry to control strong winds. With regards to access to weather information (as presented in Table 4.46) 81%, 73% and 81% of the households noted receiving drought, pest and diseases and start of the rain forecast respectively.

While such array of adjustments has been instituted by households in the study area there are underlying factors that are contributing to sensitivity and subsequent impacts associated with the key calamities experienced notably drought. To put this argument into perspective, there is an array of factors leading to a cycle of food insecurity in the study area while households have employed adaptation mechanisms. As Gabrielsson et al.(2013) argues "when exposure, sensitivity and limited adaptive capacity reach a vantage point there is a likelihood of greater vulnerability due to destructive feedback on the human-environment system". Such limited adaptive capacity could be associated with reliance on autonomous and reactive means with reference to past experiences despite the poor performance of such means.

In this regard mechanisms such as drought resistant crops practiced repeatedly could be failed by the case of poor land fertility reported by the households. It is additionally likely that crops fail due to multiple impacts, notably as reported that drought, erratic rains, pests and diseases are key calamities that in other instances occur concurrently.

Availability of manure could be hampered by the fact that the households own minimal livestock capable of providing adequate manure and further most of the households have inadequate resources to engage in purchase of such manure or inputs such as inorganic fertilizer. This is evidenced by only 16% of the households having access to inorganic fertilizer as a mechanism aimed at managing low soil fertility. Even so, application of organic fertilizer on a piece of land requires adequate time before fertility of such land is sufficiently restored.

In addition most of the households, 83%, own one piece of land (*Mo*=1,$\bar{X}$=1.19, σ=0.433) indicating that they have minimal alternatives, specifically alternative nutrient rich plots. Such land tenure and acreage further hampers practices such as crop rotation which could play a key role in improvement of the land fertility and pest and diseases control. Further, crops may fail from impacts associated with pests and diseases since agrochemicals are costly and as such unaffordable to most households. Low education levels, as noted by most households reaching the primary level of education, also plays a role in utilization of weather information especially when such information has not been packaged such that it is easily understood by the respective households.

The study area experiences instances of water shortage occasioned by the high temperatures and erratic rains as reported by the households. On the contrary the households seemed not have instituted appropriate water storage mechanisms in the face of drought as indicated by absence of aspects such as water storage tanks or efforts to develop water pans or irrigation systems.

This further limits their efforts aimed at reduction of community vulnerability. Indeed harvesting of rainwater through an array of structures as Ketiem et al., (2010) indicate, plays a crucial role in enhancement of agricultural production.

4.7.2 Hypotheses test results

In testing hypothesis (ii) key variables included a categorical variable identifying the main respondents, as the household head, occupation against an ordinal (binned) variable noting the number of food short months which is also a measure of vulnerability to climate change. This hypothesis related to objective 1 and 5 to identify how vulnerability relates to main household activities.

The hypothesis test as shown in Table 4.59 revealed an interesting observation that the main respondent's occupation in the study area does not influence food security (*p*=0.570) at 95% C.I.

Table 4.59 Hypothesis summary for occupation of main respondent against food security

Hypothesis Test Summary

	Test	**Exact Sig.**	**Decision**
The distribution of Number of food short months (Binned) is the same across categories of Main respondent occupation.	Independent-Samples Mann-Whitney U Test	0.570	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Mann-Whitney U=7.000;Wilcoxon W=13.000;Test Statistic=7.000;Standardized Test Statistic(z)=-.569;Asymptonic Sig.(2-sided)=.570

From the results the hypothesis (ii) is rejected and it is concluded that, food security was not statistically different among different levels of main respondents occupation, (U=7.000,z=.569,*p*=0.570). As such whether the main respondent (household head) was involved in formal or informal activity still the household did experience food insecurity.

Hypothesis (iii) relates to objective 1 on household income and objective 5 on vulnerability. Food security has been used in other studies to identify vulnerability Gabrielsson et al.(2013) and was selected because almost households are engaged in farming. The third hypothesis is accepted as indeed the household's aggregate cash income (transformed using logarithm base 10 to adjust for variability) showed a significant relationship with food insufficiency (number of food insufficient months) as Table 4.60 shows.

Table 4.60 Hypothesis summary for the relationship between income sources and food insufficiency.

			Aggregate Income_Log	Number of food short months
Spearman's rho	Aggregate Income log	Correlation Coefficient	1.000	-.316**
		Sig. (2-tailed)	.	.001
		N	118	118

It is hence concluded that the there exists a significant relationship between household income and food insecurity (*p*=0.001). The relationship between income and food shortage was negative (ρ=-.316) indicating the higher the households income the less the instances of food insufficiency. Precisely, households with minimal alternative income sources are vulnerable to impacts such as food insecurity.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The research results are referred to in coming up with the listed summary and conclusions.

1) The study findings revealed that the households were mainly agriculturalists and heavily dependent on rain fed agriculture and more specifically engaged in crop farming and livestock keeping as indicated by 86% and 91% of the respondents. Further; most of the households' income was directly and/or indirectly obtained from crop produce (86%) and animal based products (50%). A few households have however made efforts to engage in alternative sources of income notably engagement in small businesses (61%) and participating in casual labor (28%). The study further established that majority of the households (63%) in the study area were male headed while it was found out that the levels of education in the area were minimal since most of the main and correspondents (55% and 62% respectively) had reached the primary level of education.
2) As pertains exposure to extreme events the study revealed that drought was the main climate related calamity affecting 100% of households in the study area. The households further indicated that pests and diseases were additionally a key concern adding to the effects of such drought as indicated by 83% and 93% of the households. It was established that both calamities were highly ranked as key concerns by the households. Household perceptions emphasized observations of increased temperatures (76%), reduced rainfall volumes (96%) and reduced length of the long rain season (70%).

These observations seemed to correspond with statistical changes from computations of climate records which revealed that there were significant changes in temperatures over the 29 years (1983 to 2012) while the short rain season was depicting high variability(CV=51%). These climatic shifts and associated effects are accompanied and perhaps amplified by instances of reduced soil fertility experienced in most of the households, 91%.

3) The study revealed that exposure to such climate related events, has resulted into several direct and indirect impacts that have implications on the livelihoods of the small scale farmers. The study reveals that each of the specific indicators notably drought and erratic rains have been mainly associated with crop failure (44%), food shortage (13%), water shortage (44%) as well as effects on livestock and human health. This does not leave out pests and diseases which have also been linked to occurrence of crop failure (79% and 78% respectively) and subsequent low yields and even food shortage. In other instances climatic impacts occur concurrently with crop pests and diseases leading to amplification of impacts.

4) In the face of climate change and variability extremes the study established that households in the study area have devised an array of indigenous and modern adaptation mechanisms. These are aimed at acclimatizing to climate variability and change impacts. More specifically crop based strategies including drought resistant crops and varieties (65%) as well as crop diversification (13%) are employed as key means aimed at reducing impacts associated with such extreme events.

Adjustments are short term and long term with notable long term examples being sinking of wells (6%) as well as establishment of agro forestry farming systems (3%). This indicates the absence of long term adjustment action in the area. The study also establishes that crop based adaptation mechanisms are primary in the study area probably due to ease of access and lower expense on the same.

Results also revealed that modern strategies including application of pesticides against crop pests (88%) and diseases (63%) were primarily employed to curb crop pests and diseases indicating relatively high access to these modern interventions. In addition, it was established that farmers not only considered weather information relevant but have also made efforts to obtain such information through available channels notably radio broadcasts.

5) The study further revealed that there exists a relationship between certain socio economic characteristics and the number of adaptation strategies. To this end, respondent age (β=-.377, p=0.023), correspondent age, (β=-.441, p=0.006) respondent gender (β=-.401, p=0.040) and acreage (β=.345, p=0.014) significantly influenced adaptation mechanisms.

6) The study further established evident sensitivity and vulnerability of the households with reference to the key occupations and income source as well as experienced extreme events and associated impacts more specifically the observed occurrence of food shortage in an average of 3 months ($\bar{x}=3.75, \sigma=1.49$) within a normal year in most of the households.

It is revealed that indeed households in Wote are vulnerable to climate change and variability due to high dependence on farm based income (86% and 91%) by key household members as well as heavy reliance on crop based adaptation mechanisms with low investments in alternative off farm income.

This vulnerability is further revealed by observed changes in weather patterns such as reduced length of the growing period (70%) as well as evident variability of rainfall in the growing season. In addition other concerns such as loss of soil fertility in combination with unfavorable climatic events ultimately lead to crop failure instances reported.

While this study attempts to denote the contributors of the households' vulnerability, it is apparent there is a challenge in understanding of the specific determinants of vulnerability and coping capacity. More specifically the selection of indicators is based partly on expert opinion but more so extensive literature review but such choices remain subjective.

5.2 Conclusions

Based on the research objective and summary the study makes the following conclusions.

1. The study concluded that households in Wote largely rely on farming as a key source of income. It is also concluded that majority of the household heads are male and are educated to the primary level of education and are further widely involved in informal employment.

2. The study concluded that the major climate related risk affecting households in Wote is drought accompanied by widespread occurrence of erratic or unpredictable rains.
3. Further crop pests and diseases are key non climatic calamities affecting households farming activities. These calamities do occur concurrently in some instances.
4. Occurrence of these climate calamities has resulted in a wide range of negative impacts notably crop failure and water shortage that have affected the principal livelihoods sources.
5. Households have employed crop based responses as the key adaptation against climate risks including cultivation of drought resistant and fast maturing crop variaties.
6. It is concluded that respondent age, gender and acreage are the principal drivers of the number or diversity of adaptation mechanisms among the various households.
7. The study ultimately concludes that indeed small scale farmers in Wote are vulnerable since they have experienced a wide range of climate linked calamities e.g. drought leading to instances of crop failure and subsequent food shortage. On the same vein the study deduced that the higher dependence on crop farming as a key income source, with minimal formal employment or alternative livelihood sources, intensifies the risks associated with climate events.

5.3 Recommendations

Based on the research findings that climate risks pose a threat to the households livelihoods on Wote, the study makes the following policy and research recommendations:

5.3.1 Policy recommendations

1. There is need to enhance adoption of alternative ecologically friendly income sources such as non-on farm income generating activities or post-harvest processing through approaches such as extension.
2. A key solution to climate risks would be enhancement of investment in water harvesting at the household and community levels through investment in approaches such as enhanced water storage, large scale irrigation or sustainable land management practices that enhance soil moisture retention.
3. A primary impact reported by farmers is occurrence of crop failure in the face of climate extremes. Provision of timely weather information could avert heavier losses associated with uninformed planting. This involves enhanced collection and dissemination of user defined climate related data up to the daily level to farmers.
4. It is recommended that action has to be taken to scale up locally made and or home grown technologies and innovations employed by the households to reduce their sensitivity to extreme climate events. Notably efforts should be directed towards effective crop based adaptation means which are widely employed by households in the study area as a means of cushioning against climate extremes.

5.3.2 Suggestions for further research

1. The study identifies areas for further research including alternative approaches to vulnerability assessment such as utilization of household composite vulnerability indexes as well as the use of land use climate scenarios to project future effects on crops and landscapes.
2. In addition studies revolving around effective adaptation strategies could be conducted to identify the usefulness of such adjustments in the face of extreme events and how such strategies can be effectively improved and linked with modern technology. This could for example include a study on the economic potential of certain adaptation mechanisms in a particular setting.

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7.0 APPENDICES

Appendix 1 Household size statistics

N	119
Mean	6.08
Mode	5
Std. Deviation	2.380
Skewness	1.144
Std. Error of Skewness	.222
Kurtosis	3.142
Std. Error of Kurtosis	.440
Minimum	2
Maximum	17

Appendix 2 Additional monthly income statistics

Median	5520.8333
Mode	1500.00
Kurtosis	3.952
Range	40089.58
Minimum	387.50
Maximum	40477.08

Appendix 3 Adaptation to calamities statistics

Mean	4.69
Median	5.00
Mode	4
Std. Deviation	1.527
Skewness	.003
Minimum	0
Maximum	8

Appendix 4 Food insecurity statistics

Statistic	Value
Mean	3.75
Mode	3
Std. Deviation	1.491
Skewness	.105
Range	7
Minimum	1
Maximum	8

Appendix 5 Correlation Matrix for testing multicollinearity in the multiple linear regression model.

Coefficient Correlations[a]											
Model			Household number (SQRT)	Correspondent education	**Number of income sources**	**Respodent gender**	Acarage_sqrt	Respodent education	Correspondent age(SQRT)	Respodent age(SQRT)	Corespodent gender(SQRT)
1	Correlations	Household number (SQRT)	1.000	-.156	.098	.055	-.123	.072	-.233	.000	.107
		correspondent education	-.156	1.000	-.040	-.034	.136	-.338	.586	-.065	.184
		Number of income sources	.098	-.040	1.000	.114	-.035	-.096	.035	-.222	.170
		Respondent gender	.055	-.034	.114	1.000	-.102	.189	-.029	.081	.755
		Acarage(SQRT)	-.123	.136	-.035	-.102	1.000	-.135	.082	-.445	-.091
		Respondent Education new values	.072	-.338	-.096	.189	-.135	1.000	-.086	.490	.006
		Corespodent age(SQRT)	-.233	.586	.035	-.029	.082	-.086	1.000	-.117	-.003
		Respondent age(SQRT)	.000	-.065	-.222	.081	-.445	.490	-.117	1.000	-.047
		Correspondent gender	.107	.184	.170	.755	-.091	.006	-.003	-.047	1.000

	Covariances	Household number (SQRT)	.153	-.038	.006	.014	-.009	.016	-.017	1.004E-005	.028
		Correspondents education	-.038	.392	-.004	-.013	.017	-.119	.069	-.008	.077
		Number of income sources	.006	-.004	.023	.011	-.001	-.008	.001	-.006	.017
		Respondent gender	.014	-.013	.011	.391	-.012	.066	-.003	.010	.315
		Acreage (SQRT)	-.009	.017	-.001	-.012	.038	-.015	.003	-.016	-.012
		Respondent education	.016	-.119	-.008	.066	-.015	.314	-.009	.051	.002
		Correspondent age (SQRT)	-.017	.069	.001	-.003	.003	-.009	.035	-.004	.000
		Respondent age (SQRT)	1.004E-005	-.008	-.006	.010	-.016	.051	-.004	.035	-.006
		Corespodent gender	.028	.077	.017	.315	-.012	.002	.000	-.006	.446

a. Dependent Variable: Number of calamity adaptations

Appendix 6 Multiple regression model coefficients complete table

Coefficients[a]													
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	10.819	2.210		4.895	.000	6.382	15.257					
	Respondent gender	-1.318	.625	-.401	-2.108	.040	-2.574	-.063	-.111	-.283	-.243	.367	2.723
	Correspondent gender	-1.089	.668	-.323	-1.631	.109	-2.429	.252	-.025	-.223	-.188	.339	2.950
	Respondent education	-.811	.560	-.218	-1.448	.154	-1.936	.314	-.074	-.199	-.167	.584	1.712
	correspondent education	-1.150	.626	-.317	-1.835	.072	-2.408	.108	-.058	-.249	-.211	.445	2.245
	Number of income sources	.105	.153	.083	.684	.497	-.203	.412	.070	.095	.079	.894	1.119
	Household number sqrt	.599	.392	.185	1.529	.132	-.187	1.385	.133	.209	.176	.904	1.106
	Respondent age_sqrt	-.438	.187	-.377	-2.345	.023	-.812	-.063	-.085	-.312	-.270	.514	1.947
	Correspondent age_sqrt	-.533	.187	-.441	-2.850	.006	-.908	-.157	-.221	-.371	-.328	.554	1.803
	Acreage _sqrt	.491	.194	.345	2.532	.014	.102	.881	.219	.334	.292	.716	1.398

a. Dependent Variable: Number of calamity adaptations

Appendix 7 Observation checklist

Observation Checklist		
Country: Kenya		
County		
Sub county		
Location		
Sub location		
Village		
Household ID		
GPS Co ordinates		
Date of photography		
Time of photography		
Query	**Yes**	**No**
1. Does the household exhibit evidence of water scarcity?		
2. Does the household farm exhibit crop failure evidence?		
3. Does the household exhibit evidence of crop pests/diseases?		
4. Is there evidence of on farm post-harvest technology in the household?		
5. Any observed livestock presence-consider larger numbers in enclosures?		

Appendix 8 List of equations and symbols

$\overline{X}$................................Mean

χ................................Chi square

σ................................Standard deviation

β.................................Beta

γ_1.................................Skewness

Mo..............................Mode

p.................................alpha or p-value denoting significance level

df................................Degrees of freedom

$\sum$................................Sum of (Summation)

$\tilde{x}$ ....Median

ρ...................................Spearman rho

Appendix 9 Household Survey tool

‘Climate variability and change vulnerability assessment in Wote-Makueni County

Introduction and consent by main respondent

Before the beginning of the interview read out the following paragraph and ensure that the respondent understands before asking for consent.

“Good morning/afternoon. I am a Kenyatta University Student with permission from the local government. I am conducting a survey on Sorghum, Cowpea and Pigeon pea and looking at farming practices. I would like to ask you some questions that should take no more than three hours of your time. I would like to share some of this information widely in order that more people understand how you use ***cultural knowledge and traditional farming practices to recover, mitigate and manage agricultural risks and climate change related calamities.***

Your name will not appear in any data that is made publicly available. The information you provide will be used purely for research purposes; your answers will not affect any benefits or subsidies you may receive now or in the future. Do you consent to be part of this study? You may withdraw from the study at any time and if there are questions that you would prefer not to answer then we respect your right not to answer them.

1	Interview date	
2	Household ID(Adopted from ILRI-CCAFS study)	
3	County/ village	
4	Enumerator name	
5	Latitude: S Longitude: E Altitude meters ASL	[_____________S] [_____________E] [_____________M]

A. Identification

Total number of family members who shares the same kitchen. Include visitors who stay more than 1 month.
Exclude family members who stay outside more than 1 month period.

1 Total household number [________________]

2. Indicate main respondent with* co-respondent with **	Indicate only family members who finished education. Full name (indicate full three names).	Age	Sex F/M	Major Occupation, Agriculture Other business, specify	Relation with HHH 1. HHH 2.Wife, Husband 3.Son, Daughter 4.Mother, Father 5.Sister, Brother 6.House worker 7.Others	Education level. 1 None 2.Primary 3.Secondary 4.Above sec. 5.Adult edu.	Monthly or Annual Income estimate(Tick) 1. Business 2. Remmitances 3. Savings 4. Employment 5. Farming
[ ]	[________________________________]	[_____]	[___]	[________________________]	[___]	[___]	[___________________]
[ ]	[________________________________]	[_____]	[___]	[________________________]	[___]	[___]	[___________________]
[ ]	[________________________________]	[_____]	[___]	[________________________]	[___]	[___]	[___________________]
[ ]	[________________________________]	[_____]	[___]	[________________________]	[___]	[___]	[___________________]
[ ]	[________________________________]	[_____]	[___]	[________________________]	[___]	[___]	[___________________]
[ ]	[________________________________]	[_____]	[___]	[________________________]	[___]	[___]	[___________________]

B. Socio-economic and animal asset information

3 Main source of income. Tick where applicable and dash if not applicable. Rank from the highest option.

Tick	**.**	**Rank**
O	On-farm produce (crops, fruits, vegetables, fodder)	[____]
O	Other farm products (timber, fuel wood, charcoal, compost, honey, wood carving, handicrafts).	[____]
O	Animal products (livestock and products, including manure, eggs, others specify [____]	[____]
O	Renting out your own land or houses	[____]
O	Renting out your farm machinery or animals e.g. donkey transport, cow ploughing etc).	[____]
O	Casual work (labour; temporary works),	[____]
O	Other payment from projects including pension, aid and subsidies	[____]
O	Small business	[____]
O	Food for work	[____]
O	Selling natural resources e.g. cutting tress, and/soil/rock harvesting, etc.	[____]
O	Selling natural products e.g. honey, charcoal, bricks, handicrafts, gravel, etc.	[____]
O	Monthly salary	[____]
O	Gift from friends	[____]
O	Remittances or gift from family member	[____]
O	food assistance (mwolyo)	[____]
O	Community-based financial loan	[____]

2 Animal Assets

Animal assest	**Number Including small ones**
Cattle	[____]
Goats	[____]
Chicken	[____]
Chicks	[____]
Sheep	[____]
Donkey	[____]
Duck (Bata)	[____]
Pigs	[____]
Rabbit	[____]
Others	[____]
Specify [__________________________________]	

4 Have you applied, benefited or were you involved in the following mechanisms in the last 12 months as a way of adaptation or coping with challenges faced? Tick when applicable or dash if not applicable.

MECHANISM	Tick	Comment
Involved in CBOs and farmer associations	[___]	________________
Extension services and farming training (incl. farm inputs)	[___]	________________
Obtained credit or loans for agricultural activities (incl. seed loans)	[___]	________________
Obtained weather based animal and crop insurance	[___]	________________
Conflict over scarce natural resources	[___]	________________
Sale of household assets	[___]	________________
Post harvest processing and/or value addition	[___]	________________
Traditional prayers	[___]	________________

B Landscape, crop diversity and food security

1	How many farming fields do you currently have for crops, animals, forest, house, etc.,	[________]					
		PLOT 1	**PLOT 2**	**PLOT 3**	**PLOT 4**	**PLOT 5**	**PLOT 6**
2	Ownership of land						
	1. Owned	[________]	[________]	[________]	[________]	[________]	[________]
	2. Borrowed (from O relatives, O friends and neighbours O goverment land, O others, specify, [______________________________]	[________] [________]	[________] [________]	[________] [________]	[________] [________]	[________] [________]	[________] [________]
	3. Rented in(cost per cropping season per unit area: [____________])	[________]	[________]	[________]	[________]	[________]	[________]
	4. Rented out (cost per cropping season per unit area: [__________])	[________]	[________]	[________]	[________]	[________]	[________]
3	Type of land.						
	1. Slope	[_____]	[_____]	[_____]	[_____]	[_____]	[_____]
	2. Hill top	[_____]	[_____]	[_____]	[_____]	[_____]	[_____]
	3. Flat	[_____]	[_____]	[_____]	[_____]	[_____]	[_____]
	4. Hollow	[_____]	[_____]	[_____]	[_____]	[_____]	[_____]
	5. River bed.	[_____]	[_____]	[_____]	[_____]	[_____]	[_____]
4	Size of the plot (acre)	[_____]	[_____]	[_____]	[_____]	[_____]	[_____]

5 For each month say whether the food you consume is mainly from your own farm or from other sources. In addition, which months if any you tend to find you do not have enough food to eat for your family.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Source of food	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]
	1=Mainly from own farm *2=Mainly from off farm (purchase/aid/other)*											
Shortage / struggle to feed the family	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]	[__]
	1=Shortage											

6	Do you grow newly introduced crop species that were distributed in your community in the last 5-10 years?	[______________________________] [______________________________] [______________________________]
	What were the reasons for introduction and distribution of the crops mentioned in the previous question?	[______________________________] [______________________________]

C. Perceptions on Climate Change and adaptation strategies

1	Statements (compare with 10 years ago)	Strongly agree	Slightly agree	Neutral	Slightly disagree	Strongly disagree
1.	Do you believe that there is now a more severe dry season?	[_ _]	[_ _]	[_ _]	[_ _]	[_ _]
2.	It has become more difficult to predict when the rains will start.	[_ _]	[_ _]	[_ _]	[_ _]	[_ _]
3.	Temperatures have increased	[_ _]	[_ _]	[_ _]	[_ _]	[_ _]
4.	Floods have become more frequent	[_ _]	[_ _]	[_ _]	[_ _]	[_ _]
5.	Yields are higher now because of changes in climate.	[_ _]	[_ _]	[_ _]	[_ _]	[_ _]
6.	Modern varieties are more susceptible to changes in climate.	[_ _]	[_ _]	[_ _]	[_ _]	[_ _]
7.	I will have to change my land management practices to protect my crop from heavy rainfall.	[_ _]	[_ _]	[_ _]	[_ _]	[_ _]
8.	Climate change is not a big issue because I will be able to adapt my practices to new conditions	[_ _]	[_ _]	[_ _]	[_ _]	[_ _]
9.	If you plant only one variety you will have more pests than if you grow more varieties	[_ _]	[_ _]	[_ _]	[_ _]	[_ _]
10.	I need to get varieties more adapted to drought conditions	[_ _]	[_ _]	[_ _]	[_ _]	[_ _]
11.	I need to get more climate and weather information	[_ _]	[_ _]	[_ _]	[_ _]	[_ _]
12.	The dry season has become shorter	[_ _]	[_ _]	[_ _]	[_ _]	[_ _]
13.	Temperatures have decreased	[_ _]	[_ _]	[_ _]	[_ _]	[_ _]
14.	People having more seed sources do better in coping with the calamities (droughts, floods, heat, frost, soil erosion/ landslides, ..)	[_ _]	[_ _]	[_ _]	[_ _]	[_ _]

2	Which effects have you observed in the past 10 years?	Increase	Decrease	Not different	Most significant effects (state 3)	Adaptation strategies for the most significant effects
	Total Amount of rainfall	[_ _]	[_ _]	[_ _]	[_ _]	______
	Onset of short rainy season* (early=increase, late=decrease)	[_ _]	[_ _]	[_ _]	[_ _]	______
	Duration of short rainy season	[_ _]	[_ _]	[_ _]	[_ _]	______
	Onset of long rainy season* (early=increase, late=decrease)	[_ _]	[_ _]	[_ _]	[_ _]	______
	Duration of long rainy season	[_ _]	[_ _]	[_ _]	[_ _]	______
	Temperature Intensity	[_ _]	[_ _]	[_ _]	[_ _]	______
	Nr. of hot days	[_ _]	[_ _]	[_ _]	[_ _]	______
	Forest and vegetation cover	[_ _]	[_ _]	[_ _]	[_ _]	
	Nr. of (wild) plant species and their habitats	[_ _]	[_ _]	[_ _]	[_ _]	______
		[_ _]	[_ _]	[_ _]	[_ _]	

Nr. of (wild) animal species and their habitats					
Nr. of dry months a year	[_ _]	[_ _]	[_ _]	[_ _]	______
Incidence of crop failure/famine	[_ _]	[_ _]	[_ _]	[_ _]	______
Incidence of floods	[_ _]	[_ _]	[_ _]	[_ _]	______
Incidence of weeds	[_ _]	[_ _]	[_ _]	[_ _]	______
Outbreaks of pests or diseases	[_ _]	[_ _]	[_ _]	[_ _]	______
Resistance to pest /disease	[_ _]	[_ _]	[_ _]	[_ _]	______
New crop pests have come	[_ _]	[_ _]	[_ _]	[_ _]	______
New crop diseases have come	[_ _]	[_ _]	[_ _]	[_ _]	______
Groundwater table	[_ _]	[_ _]	[_ _]	[_ _]	______
Land fertility/ productivity	[_ _]	[_ _]	[_ _]	[_ _]	______
Length of growing period	[_ _]	[_ _]	[_ _]	[_ _]	______

		tick	**Rank**	**Criteria**
3	What is the major calamity in your community and rank them? Rank the top 3 with the value 1,2,3 with 1 noting the key calamity.	O	[_ _]	Drought
		O	[_ _]	Floods
		O	[_ _]	Erratic rain/soil erosion, hailstones
		O	[_ _]	Frost
		O	[_ _]	Strong Wind
		O	[_ _]	Crop diseases, specifiy: [______________________]
		O	[_ _]	Crop pests, specifiy: [______________________]

5

Which calamities have you mainly experienced in your household?

Calamity

O Drought
O Floods
O Erratic rain/soil erosion, hailstones
O Frost
O Wind
O Crops diseases,
O Crop pests

6		For key experienced calamities indicated, describe the practices that help to adapt to it. O Drought HOW: [____] O Erratic rain/soil erosion ,hailstones HOW: [____] O Frost HOW: [____] O Strong Wind HOW: [____] O Crop diseases, specify: [______ _____ ___] HOW: [____] O Crop pests, specify: [_______ ___ ___] HOW: [____]
7	Describe the calamities and the type of impact affecting the enviroment	O Drought [IMPACT____] O Floods [IMPACT____] O Erratic rain/soil erosion, hailstones [IMPACT____] O Frost [IMPACT____] O Strong Wind [IMPACT____] O Crop diseases, specify: [__________][IMPACT____] Crop pest, specify: [___________][IMPACT____]

		Score 1. Strongly agree 2. Slightly agree 3. Neutral 4. Slightly disagree 5. Strongly disagree 99. Don't know/No idea	**Rank** (Three most important 1=most important)	**Information regularly received over the last 2 years (tick)**	**Type of weather information**	**Information source** (codes: see further down the page) More than one source is possible
8	Weather infomation is important to farming	**Score [_ _]**	**[_ _]**	O	Forecast of drought, flood, frost or other extreme event.	**[_______]**
			[_ _]	O	Forecast of pest or disease outbreak	**[_______]**
			[_ _]	O	Forecast of the start of the rain	**[_______]**
			[_ _]	O	Forecast of the weather for the following 2-3 months	**[_______]**
			[_ _]	O	Forecast of the weather for today, 24 hours and/or next 3 days.	**[_______]**

Codes for question 8
Weather information sources

01 Radio
02 Television
03 Government agricultural extension or veterinary officers
04 NGO project officers
05 Friends, relatives or neighbours
06 Teachers in local schools
07 Newspaper
08 Traditional forecaster/indigenous knowledge
09 Local group/gatherings/meetings
10 Religious faith
11 Cell phones
12 Internet
13 Other

Appendix 10 focus group discussion guideline

Introduction

The focus group objective is:

1. Examine climate change issues and adaptation strategies

Selection of participants and sites

The focus group discussion targets about 8 to 10 participants (per gender) from the study.

Focus Group Discussion Guidelines employed

This guide outlines the structure of the session, data set and methods that were guiding the focus group discussion.

a) Purpose

The focus group aimed at identifying farmers' perceptions to climate change; their experience based farming knowledge and practices for adaptation to climate change.

b) Design

- A team of at least two members agree on various task assignments including a facilitator/interpreter, 1-2 rapporteurs and a person responsible for logistics.
- The focus group discussion will consist of exercises to identify farmer's experience based farming knowledge and practices.
- Mobilize village elders/key-informants to select and identify the knowledgeable and reliable community representatives for both women and men groups.

c) Logistics

- Choose a venue where the atmosphere is less formal and which is close to the field. Minimize distractions, such as noise from passing vehicles or mobile phones.
- Each team member has its own copy of the FGD Guide with the discussion issues.
- Write a list of themes / outline of the meeting on a board so that each participant can see the scope and progress of the discussion.
- Prepare supplies and materials (pens, paper, writing board, etc) in advance.
- Invite the participants to the focus group meeting and inform them about the purpose of the time it will take.
- In the FGD obtain a list of participants and some basic information: full name, age, gender, village and sub-location, mobile number.

d) Facilitating the session

- Begin by introducing participants and facilitators, and then provide an overview of the session. We start by asking farmers their names and we put them in a board. If we think farmers are not able to write, to avoid embarrassment, the facilitator and rapporteur should write the names on their behalf.