ANALYSIS OF FARMERS' ADAPTATION STRATEGIES TO CLIMATE VARIABILITY IN KYAWANGO LOCATION, MACHAKOS COUNTY, KENYA

BY

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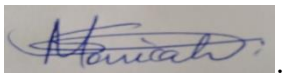
DECLARATION

This project report is my original work and has not been presented for an award at any other college, institution or university.

Signed  ……

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This project report has been submitted with our approval as the University supervisors.

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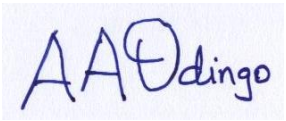
Signed…  ……

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DEDICATION

I dedicate this work to my spouse Dennis Nyahanga, my sons Keith and Nathaniel for being part of my education journey. Also, special dedication goes to my parents Mr. Raphael Mwanzia and Mrs. Jane Mwanzia for their encouragement and offering me good foundation which has enabled me reach this far.

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Thanks to the Almighty God for His sufficient grace, I owe it all to Him.

ABSTRACT

This research was conducted at Kyawango location in Machakos County which is located in the lower Eastern side of Kenya. The aim of the study was to analyse local farmers' adaptation strategies in the Kyawango region due to the effects of climate variability and change for at least 20 years, between the year 2000 and 2020 or beyond. The study objectives were to assess the rural farmers' knowledge of climate variability in the study area, determine the effects of climate variability on the livelihoods of local farmers in the study area, assess the various strategies used by farmers to adapt to effects of climate variability in the study area and examine the challenges faced by farmers in adapting to climate variability in the study area. The null hypotheses of the research were stated as follows: $1H_0$: There is no significant difference between farmers' knowledge on climate variability and adaptation to climate variability, $2H_0$: There is no significant difference between effects of climate variability on livelihoods and adaptation to climate variability, $3H_0$: There is no significant difference between the challenges faced by the rural farmers and adaptation to climate variability.

The primary data was collected using questionnaires, key informant interviews, focus groups, photography and observation while secondary data was obtained from various publications and existing materials. Qualitative and quantitative data analysis techniques were used, which included descriptive and inferential statistics, and were presented using pie charts, frequency tables and graphs. The hypotheses of the study were tested using chi-square to test the difference between variables. Climate Variability involves short-term variations in climate which last longer than an individual weather event while Climate Change is long term and may extend to several decades. The study findings indicate that CV, which is indicated by variations in rainfall and temperature, has affected the livelihoods with farmers registering low yields, increased crop and livestock pests and diseases, drying up of water sources and migration to other areas. The farmers adapt to these effects by planting drought resistant crops, building water harvesting schemes, soil conservation, irrigation, reduction of livestock numbers, diversification to non-farming activities and change of planting dates. The study concludes that farmers of Kyawango have been adapting to climate variability although the responses are not robust due to the challenges faced in the area. The study recommends that the government and NGOs should come up with programs to educate the locals on effective adaptation measures. Also, programs to provide more capital and other resources such as farm inputs and water resources should be constructed to help in adaptation.

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LIST OF ABREVIATIONS AND ACRONYMS

AEZ	Agro-ecological zones
ASAL	Arid and Semi-Arid Lands
CBO	Community Based Organization
CC	Climate Change
COVID-19	Coronavirus disease of 2019
CV	Climate Variability
GOK	Government of Kenya
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
KMD	Kenya Meteorological Department
KWG	Kithito Women Group
NACOSTI	National Commission for Science, Technology and Innovation
NGO	Non-Governmental Organization
NEMA	National Environment Management Association
SIDA	Swedish International Development Cooperation Agency
SPSS	Statistical Package of Social Sciences Software
UNFCCC	United Nations Framework Convention on Climate Change
UN	United Nations
USA	United States of America

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1. CHAPTER ONE: INTRODUCTION

1.1 Background of the study

Climate variability may have significant negative effect on natural resources and livelihoods of the affected population (Serdeczny et al., 2017). Such effects include low crop yields, increased evapotranspiration leading to water shortage, increased forest fires and decrease in soil fertility (Serdeczny et al., 2017). The production capacity of the tropical developing countries has been limited due to climate variability/change which has often led to food insecurity (Schlenker & Lobell, 2010).

Nations all over the world realized the significance of climate change effects and converged in France in 2015 to discuss and come up with a binding agreement for combating climate change and adapting to its effects (IPCC, 2015). The Paris Agreement seeks to improve the global community's response to climate variation risks by limiting the global temperature increase under 2 ºC below pre-industrial levels and making efforts to further limit the rise in temperature at under 1.5 ºC (IPCC, 2015). The agreement also aimed at enhancing the capacity of nations to deal with effects of climate change.

Via SDG 13, the United Nations Post 2015 Development Agenda (SDGs) seeks to fight climate change and its effect on the world - wide community and the environment. The aim is to empower developing nations for climate-variations adaptation and encourage investment in low-carbon development (Doni et al., 2020). In Africa, there has been increases in temperature and extreme events which has impacted many people in the continent.

Although those patterns have a tendency of being constant across the continent in Africa, the changes are usually not consistent. For example, temperatures have increased by 0.29°C in the African tropical forests (Malhi and Wright, 2004) and between 0.1 and 0.3°C in Southern Africa have been witnessed (Kruger and Shongwe, 2004). The quantity of warm periods increased in the African West and South (Botswana, Tanzania, Seychelles, Mozambique, Namimbia, Zambia, Zimbabwe, Lesotho, South Africa, Uganda, Nigeria, Gambia and Mauritius) with severe decrease in cold days from 1961 to 2000 (New et al, 2006). In the Eastern side of Africa, recessing temperature patterns from weather stations within major the major inland lakes or along the coast have also been reported (King'uyu et al., 2000).

In Africa, variability in precipitation has also been reported. For instance, in the tropical rainforest region, annual mean precipitation decreased to about 4 percent in West Africa, 3

percent in Northern Congo and 2 percent in South Congo between the year 1960 and 1998 (Malhi & Wright, 2004). However, there has also been a rise of 10% in annual quantities of rainfall in the Coast of Guinea over the last 30 years (Nicholson et al, 2000). A large rise in high rainfall occurrences was also witnessed in most sections of Southern Africa (Zambia,Angola, Mozambique,Namibia,Malawi) (Usman and Reason, 2004), including evidence of changes in seasonality changes and extremes of weather (New et al., 2006). In the past few decades, East Africa has witnessed an increasing trend of dipole rainfall over a period of ten years which comprises increasing rainfall especially on the areas on the northern side and reducing quantities in the sector to the south (Schreck & Semazzi, 2004).

In Africa, millions of people often suffer from floods and drought impacts which are frequently aggravated further by health problems (Few et al., 2004). Changes in Climate with its projected shifts in the long-term patterns of rainfall and changing temperature zones is likely to significantly impact water, agriculture and food (DFID 2004; Kinuthia, 1997).

Additionally, it is projected that climate change will continue increasing as the severe weather conditions in Africa rise in frequency and severity (Nhemachena and Hassan, 2007).

When communities experience food shortages due to climate change, they adopt several coping strategies. Diamond (2004) argues that the human race has always established the ability to respond to changes in the environment. However, since the magnitude of climatic changes may exceed the adaptation capacity of many farmers (CEC, 2009; Mekbib et al., 2011), adaptation measures are imperative. Climate variability responses can either aim to lower the level or rate of change (mitigation) or manage its consequences (adaptation) (Slater et al., 2007).

1.2 Statement of the problem

Changes and variations in climate have been observed as among the environmental, economic and social challenges that humanity grapples with currently. It is an occurrence which undermines the efforts for sustainable development, predominantly in Sub-Saharan Africa (Scholes and Biggs, 2004). Climate scientists are predicting increasingly dry conditions in most parts of sub-Saharan Africa due to climate variability. This is expected to further aggravate the situation by triggering more severe and heavy droughts and increasing temperatures. Variability of rainfall in eastern Africa is expected to increase further (IPCC, 2007).

Climate variability, especially in Africa, is postulated to intensify existing problems and generate new risk mixes. Factors such as prevalent poverty, reliance on agriculture that is mainly rainfed, inequitable distribution of land, limited access to technology and capital, insufficient public utilities like highways, long-term forecast of weather, and insufficient study / data, extension and research aggravate the situation (Akinagbe, O. M and Irohibe I. J, 2015).

Adaptation relates to the capability to adapt to the human or the natural systems in reaction to real or anticipated climate provocations or the effects that result from them, which regulates damage or makes use of the beneficial opportunities (UNFCCC, 2007).

In Kenya, variations in climate has become a reality and is becoming intense at a faster rate, as is can be witnessed from increases in country irregularity in temperature and intensification of rainfall. Those changes that are driven by climate have an impact on Kenya's economic development critical resources.

Although Kenya came up with the National Climate Change Response Strategy in 2010, the impacts of the implementation of the recommended action plans are yet to be felt, possibly because of lack of ecosystem specific modalities of implementation (Nasreen, 2012).

Machakos is an ASAL County with low rainfall and climate variability impacts are conspicuously felt (MCIDP, 2018). Kyawango is in Mwala Sub-County within Machakos County. The area has been rated as a semi-arid and arid land and has an ecologically diverse climate characterized by little and unpredictable bimodal rainfall with two separate rainfall seasons (long rains and the short rains). The mean annual rainfall is about 596.7 mm which is unreliable, erratic and occurs on a short duration with high intensity storms accompanied by partial or total crop failure in over 50% of the times (Mutuku et al., 2017). The mean annual temperatures range between 21.3°C to 22°C (MCIDP, 2018).

Several studies (discussed below) have been conducted on Climate Variability, but no research was found to have been conducted in Kyawango Location and specifically on the adaptation strategies of climate variability. Macharia, P.N., 2012 undertook a similar research but focused farmers (immigrant) and perceptions of CV in semiarid areas of Kenya. This research is closely related to the topic under investigation in this research it only focuses on immigrant farmers, it does not focus on the resident rural farmers. It also focuses on Narok whose geographical dynamics are different from Machakos County. Jelagat J. (2019) conducted a similar research but only focussed on effects of Climate-Smart Agricultural

knowledge and practices on food-security among smallholder farmers in Nandi County. Mburu (2013) also did a research on the effects of climate variations and changes on dry land Agriculture and small-scale farmers' adaptation strategies in Yatta district, Kenya but only focused on agriculture and farmers. In the topic under investigation, the study focused on adaptation strategies by Kyawango farmers, whether small scale or largescale. In summary, the study focused on livelihoods, not specific to Agriculture, but investigates Agriculture as part of the livelihood activities in Kyawango Location. This study therefore sought to establish the strategies or adjustments used by rural farmers, in the last twenty years, in Machakos County to adapt to effects of climate variations and CC, in order to come up with recommendations on the same.

1.3 Research questions

The research questions were;

i. What is the perception/knowledge of rural farmers in Kyawango location on climate variability?

ii. What are the effects of climate variability on the livelihoods of farmers in Kyawango location?

iii. What are the strategies being used by Kyawango farmers to adapt to effects of climate variability?

iv. What are the challenges to adaptation to climate variability and change in Kywango location?

1.4 Objectives

1.4.1 General objective

To assess the strategies used by Kyawango farmers to adapt to effects of climate variability.

1.4.2 Specific objectives

The specific objectives were to:

i. Assess the rural farmers' knowledge of climate change in the study area.

ii. Determine the effects of climate variability on the livelihoods of local farmers in the study area.

iii. Assess the various strategies used by farmers to adapt to effects of climate variability in the study area.

iv. Examine the challenges faced by farmers in adapting to climate variability in the study area.

1.5 Hypotheses

1. H_0: There is no significant difference between farmers' knowledge on climate variability and adaptation to climate variability.

   H_1: The alternative.

2. H_0: There is no significant difference between effects of climate variability on livelihoods and adaptation to climate variability.

   H_1: The alternative.

3. H_0: H_0: There is no significant difference between the challenges faced by the rural farmers and adaptation to climate variability.

   H_1: The alternative.

1.6 Significance of the study

Previous responses to climate variability have been interventions implemented and planned based on globalized scenarios (Kituyi & Eriksen, 2012). These have generally overlooked local conditions and complexities which comprise of the cultural, social, political and other financial real factors that drive structures (frameworks). Examples of these interventions can be seen in the list of technology prescriptions such as heat resistant crops, building gabions and dykes and others executed by various levels of government or even coming up with crops or trees that are tolerant to harsh weather, or seed sources as adaptive approaches to alleviate the projected impacts of climate variability on the structure and productivity of ecosystems. It is important that any strategies to address the negative results of climate variations in Africa address poverty.

Most of the work done so far on CV effects and adaptation strategies has been focused on relatively large spatial coverage, often on a global, regional or country scale (Thornton et al., 2009). More accurate data on the negative results of climate variations is required on area specific rural households, as well as the strategies adopted by the communities for adaptation so that proper adaptation policies can be suitably targeted. Much about climate variability and

change however, is a global phenomenon, its effects are experienced locally and adapting to its impacts must be a local process. People adapt to the changes that they experience in their day-to-day lives (Mburu, 2005).

To provide adaptation strategies that suit their needs, it is necessary to gain as much information as possible and study the condition of the rural communities and their methods of adapting to CV.

The study aimed to come up with new data that will enrich the adaptation initiatives for Kenya, and more specifically for Machakos County or lower Eastern region which may inform the process of crafting climate change policies for the region and to coordinate a wide range of objectives into one comprehensive document that may be used by the Counties to decrease the impacts of climate variations.

In addition, Climate variability and change affects livelihoods, sustainable livelihoods is the cornerstone of a progressive economy, therefore, this study lays ground for providing information to further improve adaptation to climate variability and change, and contributes significantly to improving living conditions in the area. The results of this study will also be important for all development partners interested in issues of climate variability and change adaptation in rural communities such as policy makers, extension officials, researchers, education institutions, NGOs, and planners of techniques for climate-change adjustments. Apart from enhancing and improving the researcher's knowledge base, the in-depth review of written works in this topic is believed to be a fundamental document in the field that could additionally empower various stakeholders at different levels to investigate dimensions of unused existing knowledge.

1.7 Scope of the study

This study focuses on Kenya’s rural farmers, and how they manage to survive with the effects of climate variability. The study assessed the knowledge of rural farmers in Kyawango Location regarding climate variability and change, coping strategies (adjustments) used by the farmers and the challenges and barriers faced by local farmers when adapting to effects of climate variability. The study collected both qualitative and quantitative data using properly designed data collection instruments. The data was analyzed using SPSS and results presented in terms of graphs, charts, tables and percentages.

Geographically, the research was carried out in Kyawango Location in Machakos County. The study did not cover the wider Machakos County or Kenya as a whole and therefore the

findings in this study are specific to Kyawango location. Climate variability is a wide topic, therefore the study focused on adaptation strategies and not mitigation strategies or other climate components such as vulnerability. Further, the study focused on rural farmers in Kyawango location and not those living in urban centers within the location.

The choice of Machakos County is justified by several factors. First, Machakos is a rural socio-politically monolithic County largely dependent on peasant agriculture as the main economic activity. The Study area experiences erratic, unreliable and low rainfall with high temperatures (Mutuku et al., 2017). It was therefore interesting to discover how households manage to deal with the climate variability impacts. Secondly, Machakos County is increasingly becoming a cosmopolitan County, with many middle-class Kenyans working in Nairobi having built or bought homes in the county. This county also comprises small traders, the working class and the middle class. Demographically, the county has a total population of about 1,098,584 people. The county is located in Eastern province comprises 8 constituencies i.e. Machakos town, Masinga, Yatta, Kangundo, Matungulu, Mavoko, Kathiani and Mwala.

1.8 Operational Definition of terms

Adaptation: Refers to a procedure that empowers people to limit the unfriendly impacts of CV on their wellbeing and health. It also refers to the capacity of individuals or societies to take advantage of the changes that the climate might bring.

Climate Change: Long-term shift in global weather patterns, especially associated with temperature rise, precipitation, and storm activity.

Climate Variability: Fluctuations in the mean state of excesses or extremes of the climate on both the spatial and the temporal scales past those of specific weather events.

Climate Change Effects: are the environmental and social adjustments or changes (brought on directly or indirectly) which occur as a result of worldwide/global warming.

Strategies: plans for managing future climate risk, prioritizing and coordinating action, which aims at increasing society's resilience to CC and CV.

Households: is composed of one or more people occupying a housing unit, who are related by birth, marriage, adoption and may also include other unrelated people.

2. CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This section outlines the various literature that are relevant to this study. The section contains a review of available literature related to the history of variability and changes in climate, Climate variability and change projections, knowledge and perceptions of CV, adjustment to variations in the climate, coping mechanisms for the negative effects of climate variability and change, summary of literature and study gaps, the theoretical framework of the study and the conceptual framework.

2.2 History of Climate Variability and Change

The history of CV dates back to 1800's when the first industrial revolution (Coal, rail roads and land clearing) speeded up greenhouse gas emission (Mburu, 2005). In 1859, John Tyndal discovered that the principle of gases that occur in the atmosphere, oxygen gas and nitrogen gas, are nearly clear to heat that results from radiation, while water vapour, the ozone and carbon dioxide are good absorbers that they absorb heat radiation much more intensely compared to the rest of the environment, even in small amounts (Fleming, 1998). This discovery that some gases block infra-red radiation led to a suggestion by Tyndal that the changes in gases concentration could lead to climate change.

In mid 1950s, a few scientists were concerned that anthropogenic activities for example burning fuel were growing carbon dioxide concentration within the atmosphere. The suggestion that this would change the climate was abandoned by almost everyone. Scientists argued that the additional gas would not remain in the air much of the planet's surface carbon dioxide was not tenuous in the atmosphere but dissolved in the huge mass of water and Oceans. (Weart and AIP, 2011). However, solid proof of human effect on climate surfaced towards the end of 1950s when the concentration of carbon dioxide in the Ice cores was measures by Keeling and others at the Institute of Oceanography. In 1960, Keeling demonstrated an increasing carbon dioxide level in the air and connected the rise to an upsurge or rise in international temperatures (Henderson, 2006).

The World community began to get concerned over precipitation and global environmental change in 1970s which saw the first major climate science conference being held in Geneva in 1979. The conference called on governments to tame effects of climate change by early detection and prevention (GoUK, 2012).

The concerns became more conspicuous in the 1980s with the coming of Brundtland report (Our common futures). This report highlighted various environmental concerns including climate change and increasing concentration of atmospheric gases (Butlin, 1989). Greenhouse warming became prominent in global politics in the late 1980s and led to IPCC formation in 1988 by World Meteorological Organization and by UNEP (Mburu, 2005).

The Earth Summit, was held in Rio de Janeiro in 1992 (UN, 1999) to make a track on the Brundtland Commission report, formally known as the World Commission on Environment and Development (WCED). The Meeting intended to take stock of the paths to development and to set a foundation for development trajectory that would guide future developments-one that would create a balance for the environmental concerns and economic development (Mburu, 2005).

This was an important meeting that contributed to the emergence of UNFCCC among others. This conference was also the original combined effort to get to grips with global warming and it led to talks which resulted in the Kyoto Protocol in 1997 that set targets to decrease greenhouse gas emissions. In 1995 the second IPCC report was produced and suggested a distinct human contribution to global climate (IPCC, 1995).

In the following years, climate change issues took a deeper plunge into the global politics with the election of George W. Bush as the new President of the United States, renouncing the Kyoto Protocol in 2001 (White, 2012). This was despite the fact that the third IPCC report declared that the evidence of global warming in the last 50 years resulted from anthropogenic activities had become stronger than ever (IPCC, 2001). In the same year, a meeting held in Bonn developed approaches to guide the work towards Kyoto targets. In 2003, a fatal heat wave in the summer in Europe accelerated divergence between European and United States public opinion after claiming the lives of nearly 27,000 people, surpassing all the world records for heat-induced human fatalities (Wang and Chameides, 2005).

In 2005, the Kyoto protocol became a legally recognized global document following its ratification by Russia. America and Australia however refused to sign the protocol citing fear of interference with their economies.

A series of Conferences of the Parties (COPs) to the UNFCCC have developed Agreements a nd frameworks to tackle CC. The world nations agreed to negotiate and address CC at the 2007 UN climate change conference in Bali. The climate change talks in Bangkok signaled the beginning of a brand fresh talks phase, formulating a work plan that would help in

building future International pacts on in an effort to effectively halt the boom in global emissions over the coming 10-15 years and substantially limit the Greenhouse gas emissions by mid-century (Boyle, 2011). In Copenhagen climate talks, there was an immediate need to come up with a new climate protocol since the Kyoto Protocol to stop incidents of greenhouse effect and CC since the initial one was to expire in 2012. However, what was produced was an interim accord barely worth the name (UNFCCC, 2010).

In the Cancún meeting of 2010 that followed Copenhagen, for an initial time, the developing countries came to a consensus to work towards cutting emissions in the future (King et al., 2011). Nevertheless, they did not make specific pledges. The parties agreed to set up a new green fund at Cancun whereby developed countries would wire funds to developing countries to counter effects of CC (King et al, 2011). The Durban conference concluded that the following phase of the Kyoto Protocol would set a specific goal of decreases of 25-40% below 1990 levels of GHGs by 2020 for the group of countries that are collectively known as Annex 1 parties. The Green Climate Fund was also agreed upon (UNFCCC, 2012).

In Kenya, there has been marked variability in climate with minor droughts experienced after every three or four years and major droughts after every ten years (Herrero et al., 2010). Heavy rainfall incidents follow these droughts which result into floods. The variability in rainfall total is greatly manifested in Kenya with the lowest being 150 mm and high of 800 mm in some areas (Herrero et al., 2010).

2.3 Climate Variability and Change projections

Global climate simulations between 1900 and 2100 depict various behaviours with regards to temperature and precipitation. The global projection about climate variability depicts an increase in water vapour, increases in precipitation and a general increase in water vapour means. In the high-altitude areas, there will be an increase in precipitation (Cubasch et al., 2001).

Tropical areas as in the situation in Africa will mostly have an increase in precipitation, while the sub-tropical areas will experience a decrease in precipitation (Cubasch et al., 2001). Theses variations in climate are likely to increase in severity and frequency

Records from the Kenya Meteorological Department (KMD) display proof and climate variability effects in Kenya for a period of more than 50 years (GoK, 2010). During this century, the climate in Kenya is predicted to heat up during all seasons. In a scenario whereby there will be medium emissions, it is anticipated that mean annual surface air temperatures

will rise by 2099 between three degrees Celsius and four degrees Celsius, meaning that it will increase by 1.5 times that of the worldwide average (Boko M. Et al., CC 2007). This will trigger an increase of roughly 7% in the annual rainfall, and the variation will not occur uniformly throughout the year or across the area. It is expected that rainfall variability will rise, and hotter temperatures are probable to increase the severity and occurrence of intense climate activities in the region, leading to a rise in the danger of heavier storms and longer dry spells facing many areas in East Africa (Ochieng et al., 2015).

The climate forecasts for Kenya reflect largely those regional patterns. Mean annual temperatures for the country are anticipated to rise by 1-2.8°C in the 2060s and by 2090s rise by 1.3 to 4.5 degree Celsius (IPCC, 2007); followed by a rise by forty eight percent in the average rainfall per annum, with the rise in the overall rainfall of October through December being the greatest while the highest relative change will be in January February.

The Lake Victoria and the central highlands regions are projected to have increases in rainfall. For the purpose of this study, the northern and eastern arid & semi-arid lands (ASAL) are projected to experience an overall decline in rainfall because of climate inconsistency (IPCC, 2007). Furthermore, increasing temperature degrees will eventually result in a rise in evapotranspiration rates, minimizing further the effect of rainfall on crop developing soil water.

There is strong scientific consensus that CC would lead to a rise in climate variability, with growing changes in climate patterns, primarily between years and seasons (Ochieng et al., 2016). Increasing volatility suggests that food production will progressively become less stable and this will adversely affect food safety or security (GoK, 2007). The findings by Ochieng et al.,(2016) and GOK (2007) agree with the current study which has established that there is variability of climate which has affected food security in Kyawango location. Agricultural climate alteration impacts are likely to be distinct regionally and spatially heterogeneous, demanding detailed knowledge of underlying causes and consequences, and appropriate implementation of effective responses. Kenya's ASAL climate forecast may involve prolonged and more consisted dry spells intermixed with extreme yet lesser or shorter and varying periods of rainfall.

2.4 Knowledge and Perceptions of Climate Variability

Perception and knowledge of climate variability influence how groups manage climate associated dangers and possibilities and the character of how they behave and respond to belief will decide adaptation alternatives (Debela et al, 2015). Misperceptions regarding CV and its inherent risks could result into maladaptation or into no adaptation, thereby resulting in an increase in the undesirable CC impacts (Grothmann and Patt, 2005).

The infamous instability in conditions of climate and the fundamental long-term trends of rising temperatures make discerning climate change challenging for local population. Climate change opinions, attitudes and beliefs depend on a number of contextual factors, which include knowledge of climate or exposure to climate information, and learning through experience (Debela et al, 2015). For example, many scientists working on disciplines that relate to the information on climate variability agree that climate variability is likely caused by human activities. Native people that have inadequate or no access to information related to climate seem to have more possibility to attribute changing climate to changes in the cultural and ritual practices, particularly extreme weather events (Debela et al, 2015).

Leiserowitz (2006) claimed in a report, using case studies and the Dillman customized design process, that multiple public opinion surveys have shown that 92 percent (majority) of Americans have been aware of global warming since 2000. In addition, 74 percent of them said that CV / CC was real and already in development. In the meantime, 76% of the total population has already found climate change to be a very serious issue. But at the same time, despite being the biggest contributors (25 percent) to global carbon emissions, Americans continued to view both the atmosphere and climate variability as fairly low national priorities. For example , climate change ranked 16th on America's list of most important problems facing the country in a 2000 Gallup poll (PIPA, 2005). In addition, Namafe (2009) highlights that even Barrack Obama, the former US president, didn't regard CC as a main urgent environmental problem compared to terrorist activities and others by the time this study was carried out.

In another research by Lorenzoni et al., (2003), most interviewed people in UK believed that CC was there and would be existent future. In the survey by Globescan (2009), 64 per cent of people interviewed considered climate change and global warming as very serious problems and this showed an increase of up to 20 per cent from a 1998 poll. This issue was tabled at the Copenhagen Summit, yet the efforts to enhance a better perception were still marred by

cyclopean futility especially following the failure of the Conference of Parties 15(COP15) (Globescan, 2009). Similar to the earlier mentioned cases from USA, the surveys in the UK also concentrated more on simplistic themes such as how serious was climate change and people's awareness. Moreover, perception studies cannot be understood using one method of data collection as was the case in the UK.

Salequzzaman (2009) argued that the majority of people in Bangladesh, which is one of the CV/CC sensitive areas, did not view it from a wider perspective and some of them did not know what it was in certain areas. Using reconnaissance survey, Salequzzaman (2009) discovered that 59 per cent in the southwest region of coastal Bangladesh did not know what climate change was. Using the focused group discussion, he came to a conclusion that the people of Bangladesh juxtaposed climate change with heavy rainfall and floods only. Scarcely did they associate other aspects such as cyclones, irregular temperatures and others with climate change. It is for such instances that Groenewald (2004) argues that people's views on CC/CV vary depending on various parts of the world and experiences.

Two Vietnamese provinces, Ben Tre and Quang Tri, were surveyed by Oxfam (2008) in May 2008 to find out how poor families faced CC/CV and how they could deal with it in the future. In these provinces, several local people and leaders recognized that the climate was already unpredictable and in many cases were ill-equipped to minimize or adapt to the consequences. It was believed in many villages that women were hardest hit by natural disasters as they were often unable to swim in severe flood waters, when crops were ruined and had less work options away from home, there were less assets to look to for alternative livelihoods. The other outcry was lack of proper source of climate variability information among others. However, if the educational implications of such perceived challenges faced by women due to climate change were investigated, a more complete spectrum would have been secured in planning for adaptation and mitigation learning.

Madison (2007) surveyed ten countries in Africa and found that a large number claimed that average temperatures had risen due to climate change. The results from the precipitation exhibited a consistent uniformity of opinion across the 10 nations. The majority of individuals in six out of ten countries believed that rainfall levels had declined, and rainfall timing had changed. However, if not critically considered, such outcomes seem to suggest that Africans were brilliant at detecting climate change, which is a basic precondition for adaptation. Using focused group interviews and a household survey, Mertz et al. (2007) also

studied CC attitudes and sedentary farmers' coping and adapting techniques in some parts of the Sahel, such as Senegal. They came to the conclusion that households were knowledgeable of climate variability and described the most destructive climate factors as increased rainfall and wind. In addition, poor livestock health, lower crop yields and a range of other issues were attributed by communities to climate factors, particularly wind. Mertz et.al.(2007) generally concluded that, based on their ecological history, the groups surveyed had a strong knowledge of climate issues.

In Kenya, farmers have extensive knowledge of climate variability as ascertained by the study by Ogalleh et al (2012) who found out that local communities assert that climate characteristics including rainfall variability, increases in temperature, frost increases is increasingly changing and hunger. The extensive knowledge by the farmers make them find ways of coping and adapting to climate variability (Ogalleh et al., 2012). Kichamu et al (2018) established that the perception of farmers in Eastern Kenya is influenced by the experiences they have had in the past regarding climate variability such as droughts and extreme floods which have affected their incomes and levels of production. The farmers have in turn made strategic responses to climate variability. Kichamu et al (2018) further emphasized that inadequate technical knowledge is among the major issues affecting adaptation by farmers. Other issues to adaptation are inadequate financial resources and land sizes (Kichamu et al., 2018). The findings of Kichamu et al. (2018) are in agreement with the findings of this study that farmer experiences and knowledge influence their perception and choice of adaptation practice.

2.5 Adaptation to climate variability and change

The term adaptation has become synonymous with measures taken before or after climate variability/change to allow people to better cope with the effects. Adaptation is often empowered through governance reforms that concentrate on capacity building (UNDP, 2008). In general, it refers to capacity improvement (resilience), thereby reducing individual or state vulnerability to respond to climate change impacts (UNDP, 2008).

There is currently an increasing variability in the world climate which makes it incumbent upon nations to adapt to the changes and the risks that are associated with these changes are practical although uncertain. Societies that depend on resources that are susceptible to climate change will highly be affected and will therefore need to adapt to climate uncertainties (Adger et al., 2003). Developing countries will mostly be affected by climate variability

although in some way, there have been situations where they have been able to adapt to climate variability in the past (Adger et al., 2003).

Despite past efforts towards adaptation in developing countries, there still needs a lot of work to help understand drivers of past adaptation efforts, the significance and need for future adaptation and climate mainstreaming in the countries' development policies (Mertz et al., 2009).

There are three main objectives of adaptation: to decrease the risk of injury, to boost the ability to deal with unavoidable harm and to take advantage of new alternatives (Akinagbe, O., and Irohibe, I., 2015).

According to a study commissioned by DRSRS (2010), some of the ongoing and suggested strategies for adapting to climate change in Kenya include, promotion of drought resistant/tolerant crops, introduction of measures to control flood in some of the heavily inundated areas, introduction of trees that break wind, promotion of agro forestry and application of mulching materials, promotion of public awareness among communities and undertaking research to enhance capacity among small holder farmers. The study by DSSR agrees with the findings of this study which established that adaptation strategies practiced in Kyawango are growing of drought tolerant crops, flood control, awareness creation among other measures.

The National climate change response strategy (NCCRS, 2010) outlines Kenya's climate variation and change adaptation measures in various sectors of the economy as shown below;

2.5.1 Agriculture:

Provision of downscaled environment and agricultural inputs; water storage, e.g. construction of sand dams for irrigation; preservation of the natural resource base (soil and water management and conservation techniques); and study and distribution of superior crops (drought tolerant, salt tolerant, pest and disease resistant).

2.5.2 Water:

Preservation of water reservoirs, riverbanks and water bodies; desilting of riverbeds and dams; urban water recycling facilities; capacity building to improve water quality; and awareness campaigns to encourage water conservation programs or steps. Water sector

programs will need to adapt the integrated approach to water resource management and utilization.

According to IFAD, the most practical adaptation to climate change in rural families include diversification of livelihoods to reduce risks, improving farm technologies and methods, boosting the governance of community-based natural resources, risk preparedness and disaster management.

Adaptation is now widely acknowledged as a crucial part of any climate change policy response. This refers to changes made in natural or anthropogenic systems in order to control damage or make use of the opportunities that are beneficial as a reaction to actual or anticipated climate stimuli or their consequences (Bryan et al., 2011). It is asserted that efforts must be made to grow the potential for tolerance in order to increase resilience by enabling the changes caused by climate variability to have positive or limited impacts. Building resilience of human society to deal with impacts such as water scarcity will very likely depend on sound knowledge on rainwater harvesting systems. This is because it is asserted that where there is water on earth, virtually no matter what the physical conditions, there is life (Pandey et al., 2003).

2.6 Strategies for adaptation to effects of climate variability

There are many methods and techniques that are employed to accommodate variations in climate as diversification where communities plant crops or involve in activities that are climate resilient, communal pooling where local communities come together to share risks that result from climate variability, storage of produce for use during extreme climatic conditions and mobility where people move to areas that are not affected by climate extremes (Bryan and Berhman, 2013). Heltberg et al. (2009) further categorizes these adaptation strategies according to their timing and effect using a social risk management framework whereby they are categorized as those strategies that prevent risks, those that mitigate risks and those that compensate for the risks.

Adaptation strategies are further categorized based on their development objectives as those that enhance pure development and those that enhance pure adaptation. On the pure development side, measures that reduce poverty and vulnerability which further help households absorb climate changes and shocks. The adaptation side incorporate measures that provide information for adaptation which helps reduce climate risks and result into development benefits (Bryan and Berhman, 2013).

In rural Kenya, farmers adopt changes in crop varieties since most training and extension services offered to farmers stress the importance of diversification of crops and growing of drought resistant crops (Ochieng et al., 2016). The findings by Ochieng are in agreement with that of the current study which found out that farmers practice crop diversification and growing of drought resistant crops as strategies for climate variability adaptation strategies.

2.7 Summary of Literature/research gaps

Literature review has established that CV and CC has been researched widely. Most of the research undertaken has been on a wider geographical scale, covering the globe, a continent, a region or Nation, thus failing to focus on specific area. In Kenya, several academic research documents and articles were reviewed but no research was found to have been conducted in Kyawango Location regarding changes in climate and specifically on the adaptation strategies to climate variability. Macharia, P.N., 2012 undertook a research on the perception and adaptation to CV by farmers (immigrant) in semi-arid regions of Kenya. This study is closely related to the topic under investigation in this research it only focuses on immigrant farmers, it does not focus on the resident farmers, neither does it investigate livelihoods. It also focuses on Narok whose geographical dynamics are different from Machakos County. Macharia's study focuses on perception while the current study focuses on rural farmers knowledge. The current study determines the effects of climate variability on the livelihoods of local farmers in Kyawango location, a topic that has not been studied by the above literature. Jelagat J. (2019) conducted a similar research but only focussed on effects of Climate-Smart Agricultural knowledge and practices on food security among smallholder farmers in Nandi County. Mburu (2013) also researched on the impact of climate variability and change on dry land Agriculture and small-scale farmers' adaptation strategies in Yatta district, Kenya. This research is related to the topic under investigation although it only focuses on Agriculture and farmers. This study by Mburu (2013) is in agreement with the objective of this study which seeks to assess strategies by various farmers to adapt to climate variability in Kyawango location. In the topic under investigation, the study focused on adaptation strategies by Kyawango farmers, whether small scale or largescale. In summary, the study focused on livelihoods, not specific to Agriculture, but investigates Agriculture as part of the livelihood activities in Kyawango Location. The current study further seeks to examine challenges faced by farmers in adapting to climate variability in Kyawango location, an area that has not been studied by many researchers as shown in the literature.

After reviewing all the available literature, it was evident that this topic has not been researched and therefore the need to investigate and come out with findings and give recommendations accordingly.

2.8 Theoretical Framework

Gender – Climate Change Framework: The theory of Bryan and Berhman (2013) on Community-Based CC Adaptation informed the study and helped in understanding several key factors which include user characteristics, information and technology, biophysical characteristics and institutional arrangements which influence the ability to adapt to the effects of CV.

Local community or user characteristics (e.g., poverty level resulting in lack of financial resources, dependability on natural resources resulting in higher sensitivity to climate variability). Cognitive factors also influence the adaptive capacity of the affected population. This includes the ability of an individual or social group to perceive the risks posed by CV, which is very important in coping with its effects. This is of relevance to the research conducted in Kyawango as there is a big influence on the farmers characteristics and their ability to adapt to the effects of CV.

This theory also informed the study by focusing on information and technology, whereby an individual's response to CV effects highly relates to the source of information and if it will allow for effective response. The source of information, level of knowledge is key in helping farmers to understand what affects them, the effects of CV and the effective strategies that should be adopted in order to be able to overcome the challenges. This was very relevant and informed the research on the objective of perceptions/knowledge of CV by the farmers.

Another factor that the theory informed the study is understanding the biophysical characteristics and institutional arrangements which enable actors to adapt to climate variability and shocks thereby enhancing human well-being. Any change in biophysical systems tend to have an effect on the local farmers and have an impact on the type of adjustments or strategies which are possible in the area.

Institutions such as organizations, policies, laws and social groups play a major role in influencing how a community or individual member will adapt to the CV effects. Institutional arrangements or networks make it easier to get information from higher government institutions and to access donor aid in order to help them in adapting to CV. Community

Based Approach focuses on communities' ability to work together to reduce the effects of CV across social networks.

2.9 The Conceptual Framework

Climate variability, a phenomenon which is manifested through changes in temperature and rainfall trends, droughts or even flooding is hypothesized to be brought by human induced activities such as land degradation, industrial pollution, tree cutting among others; and natural factors such as heat waves within the inner Earth which leads to drying of land (Kazoka, 2013). Persistent occurrence of these human induced activities and natural causes lead to the depletion of the Ozone layer thus exposing the Earth to extreme insolation. This leads to global warming, increased evaporation of water bodies hence excess rainfall and flooding in some areas, while in other areas, it leads to dry conditions which causes extreme drought conditions which lead to desertification if the situation persists. This is indicated on the conceptual framework below in the first two left blocks.

In this research, the independent variables illustrated in the conceptual framework were, knowledge of CV, strategies/adjustments made and challenges experienced in trying to adjust. The dependent variable was adaptation to CV. The intervening variable was the farmers characteristics which is explained further below. The variables are drawn from both the literature review objectives and the Gender-CC framework.

In the conceptual framework, socio-economic characteristics are the influencing factors which include education level of the respondents, gender, age, information availability and access to it, and poverty levels also influence how an individual farmer understands and responds to climate variability. If the individual farmer or household has limited knowledge and information, their response to climate variability will be hampered thereby leading to high impacts as shown in the Gender – CC Framework of Bryan and Berhman (2013). As Mertz et al (2011) observed, a small change in climate is likely to put pressure on socio-economic systems of the rural communities such as agriculture thereby affecting their livelihoods. The results are crop failure, low yields, water shortage, insufficient pasture and reduced living standards.

The level of awareness and source of information by Kyawango farmers were examined. Household knowledge and perception of climate variability enables the farmers to come up with measures that can enable them to live with effects of climate variability. These measures are referred to as adaptation strategies. These strategies are different from one farmer to the

next due to many factors. The strategies that were examined include soil conservation, irrigation of crops, change of varieties and planting dates, reduce number of livestock, change to non-farming activities and use manure or fertilizer.

The adaptation strategies also face several challenges that may limit the household's ability to adapt. These challenges may include lack of or insufficient information, shortage of capital, inadequate labour, insufficient water and size of land and poor health. Those who make adjustments can adopt and cope with the effects of CV which enhances their wellbeing. However, those who do not adjust end up being more vulnerable to the effects of CV.

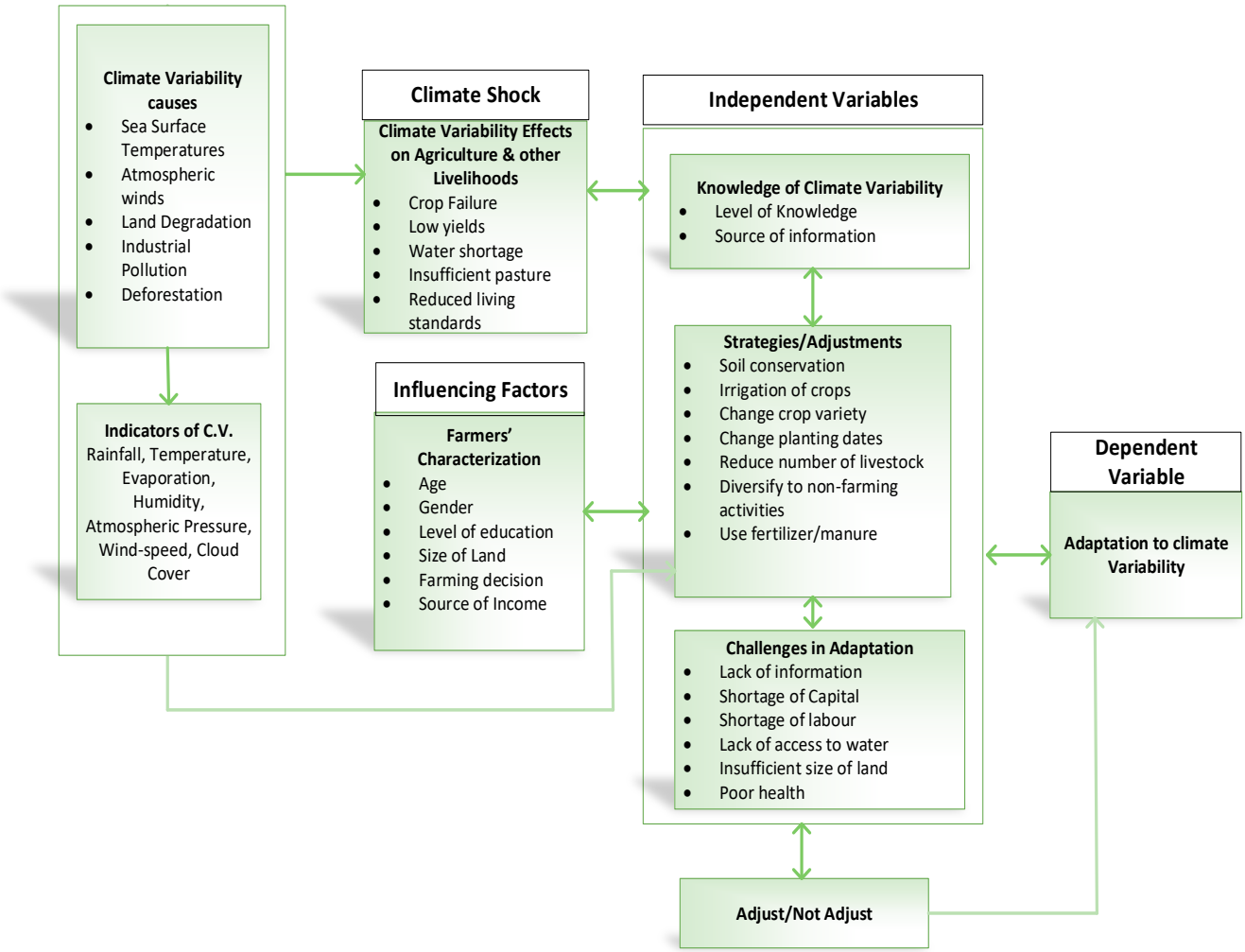

Figure 2.1: Conceptual Framework for studying adaptation strategies in Kyawango Location

Source: Researcher, 2020

3. CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the area of study and its physical components such as location, climate and topography and the socio-economic characteristics. The chapter also discusses the study design, study population, sources of data, data collection methods, sampling techniques and sample size and data analysis methods.

3.2 Area of Study

The research was carried out in Machakos County, Mwala Sub-County and more specifically in Kyawango Location. This location was chosen because it lies in an ASAL County and the area has experienced CV and its effects have been felt by farmers.

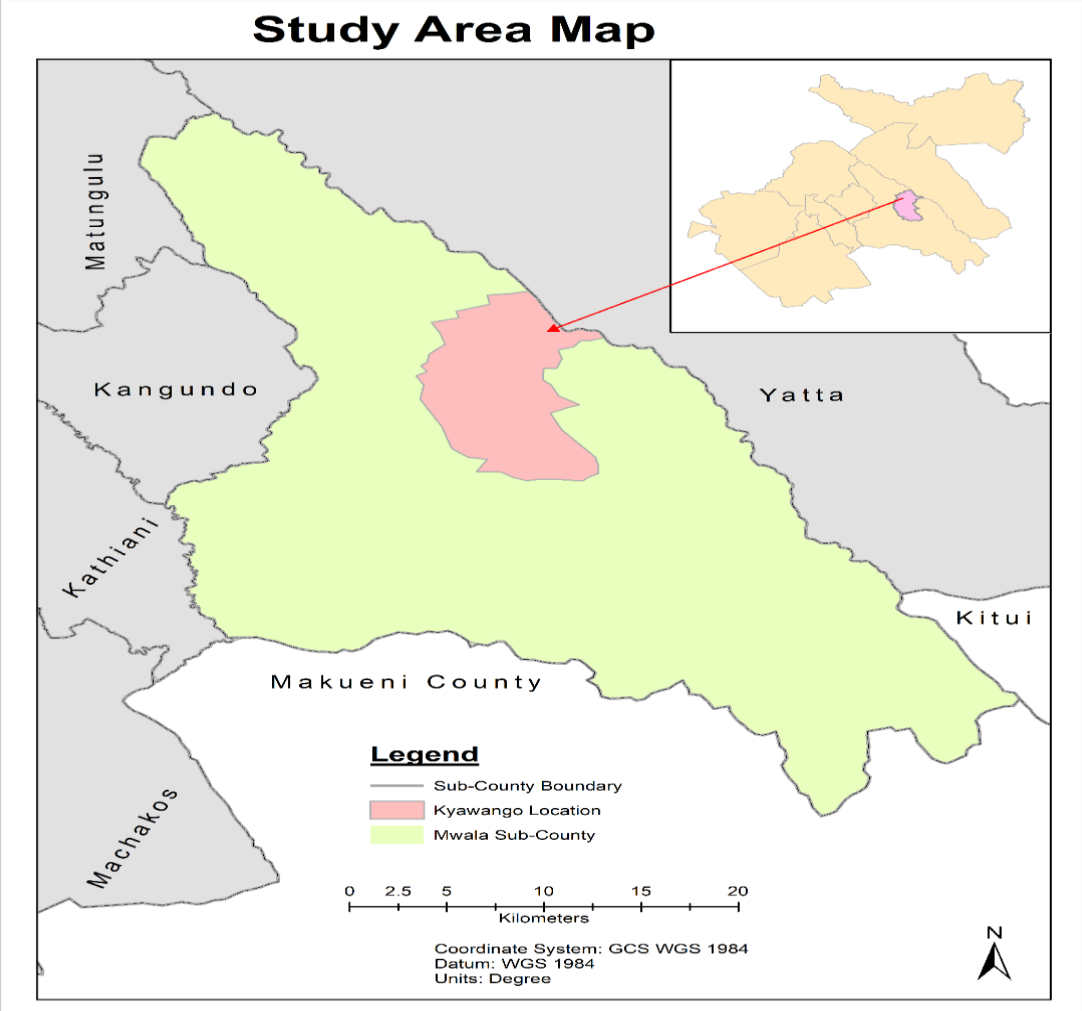

Figure 3.1: Map showing the Study Area
Source: Researcher, 2020

3.2.1 Size and Location

The County of Machakos lies from latitudes 0º45′S to 1º31′S from North to South and between longitudes 36º45′E and 37º45′E from East to West. The average altitude is 1714 meters above sea level (Muhammed et al., 2010) and long rains fall between March and May while between October to December, short rains are experienced.

The County is located in Eastern region of Kenya and comprises 8 constituencies i.e. Machakos town, Masinga, Yatta, Mavoko, Kangundo, Matungulu, Kathiani and Mwala. The County has 1,421,932 people as per 2019 census and covers 6,208 square kms.

3.2.2 Climate and Topography

Although Kyawango Location is mostly flat, the prevailing landscape rises from an altitude of 1,000 to 1,600 meters above sea level, and there is a semi-arid climate. Variable rains are experienced in this county of less than 1000mm annually, long rains occur between late March and May and short rains between October and December as stated by (Huho, 2017).

Kyawango location is highly affected by climate variability like water shortage, drought, vegetation loss, floods and heat. These effects are evident in the area and it would be important to find how the community adapts to these effects and risks. Machakos County is increasingly becoming a cosmopolitan County, with many middle-class Kenyans working in Nairobi having built or bought homes in the county. This county also comprises small traders, the working class and the middle class. Demographically, the county has a total population of about 1,098,584 people.

3.2.3 Agro-ecological Zone

Agro-ecological zone of an area is defined by its agro-climatic factors and soil patterns. Agro-ecological zone were introduced by FAO in 1978 with an aim of informing agricultural policies. The study area falls under arid and semi-arid agro-ecological zone. It receives an average rainfall of around 500 mm annually and this varies depending on the altitude, with temperatures ranging from 18 to 29 °C. The county is categorized into five different Agro-ecological zones (AEZs) for their crop production potential suitability as shown below:

1. UM 2-3: maize, beans, dairy and coffee.
2. UM 5-6: this zone is suitable for ranching- Matungulu and Mavoko.
3. LM3: Kyawango Location fall under this zone and is potential for indigenous poultry, maize, mangoes, cow peas, and pigeon peas.

4. **LM4**: good in production of maize, indigenous chicken, mangoes, cow peas, beans, and pigeon peas. The study area also falls under this AEZ.
5. **LM5:** favourable for dairy, pigeon peas, beans, maize, cow peas, mangoes, and indigenous chicken. Also covered in the study area.

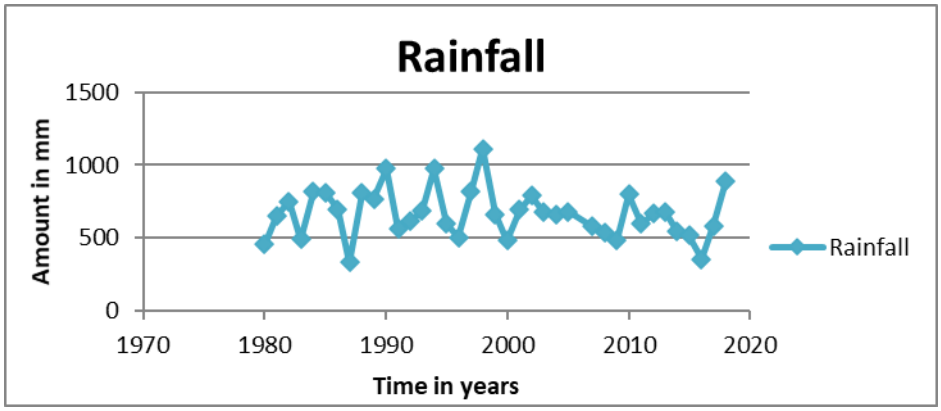

Figure 3.2: Machakos annual rainfall from 1980 to 2018

Source: Kenya Meteorological Department (2019)

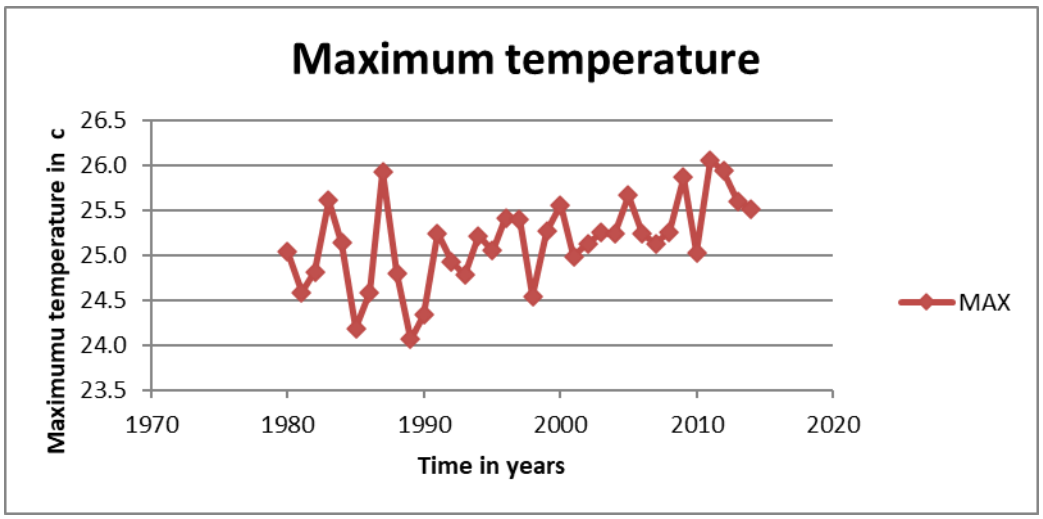

Figure 3.3: Maximum temperature from Machakos station 1980 to 2014

Source: Kenya Meteorological Department (2019)

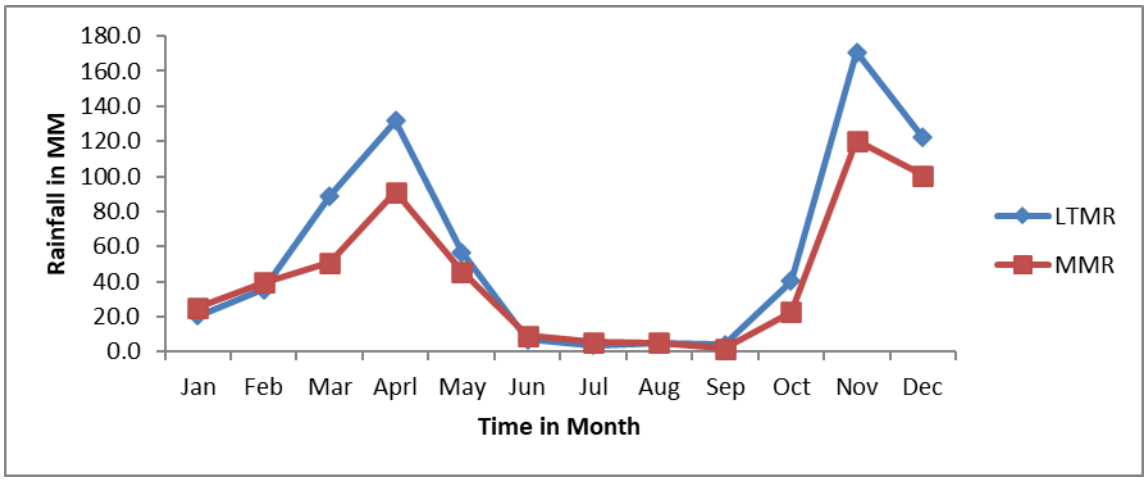

Figure 3.4: Long term monthly mean and monthly mean rainfall 1980 to 2018

Source: Kenya Meteorological Department (2019)

3.2.4 Socioeconomics

Socio-economic characteristics such as education levels, gender, poverty levels and access to information also influence how an individual farmer understands and responds to climate variability. If the individual farmer or household has limited knowledge and information, their response to climate variability will be hampered thereby leading to high impacts (Bryan and Berhman 2013).

According to KIHBS (2009), the poverty level in the county was at 59.6% against the national average of 47.2%, thus this places the county at 33 out of the 47 counties in the country that is above the national average of 29.9%. An increase in unemployment led by an increase in labor force has led to rise of crimes due to non-absorption of the active population in services of beneficial employment.

Therefore, the county is in need of investments in order to increase growth and reduce the poverty level. This may hinder the farmers in Kyawango from adjusting their farming appropriately to overcome the harsh climatic variations that they are experiencing due to lack of enough capital.

3.3 Research Design

The study adopted a mixed methods research design, an approach which combines both quantitative and qualitative forms. It entails the use of qualitative and quantitative methods, philosophical assumptions and the mixing of both techniques in study. Therefore it is more than collecting and analyzing data of both kinds and also entails the use of both techniques in tandem so as to ensure the overall strength of is greater than quantitative or qualitative research (Creswell and Plano-Clark, 2007). Specific methods for data collection included the administration of questionnaires, interview schedules, Focus Group Discussions (FGDs), desk research, and observations from the field.

In order to determine the adaptation strategies adopted by the target community, the study adopted the Participatory Vulnerability Profiles (PVP) method that was used by Haan, et al. (2001). The PVP approach focuses on present vulnerability, the risk of current and future changes in climate, and the responses to them or actions to bring current vulnerability down and advance the future risk resilience. It places stakeholders at the center of the study, which is relevant because the residents of the area have built traditional systems of knowledge that have allowed them to respond and adjust to the climate variability and change so far. The methodology includes data collection through the administration of questionnaires; FGDs, stakeholder analyses, and field observations.

3.4 Study population

The sampling frame included farmers who live in Kyawango Location. This included Youth, men and women who practice farming in the target area. The target population includes all the farmers who live in Kyawango location. This population is distributed in three sub locations namely; Maweli, Kangii and Kyawango, and is a total of 6,982 people and 1,802 households (KNBS, 2019).

3.5 Sources of data

During fieldwork, primary sources and secondary sources were used to acquire data as discussed below;

3.5.1 Primary sources

The primary data was obtained from various households, community groups, government offices and NGOs working in Kyawango. The collection of this type of data occurred through a participatory approach by the use of questionnaires, oral and formal interviews.

3.5.2 Secondary Sources

The sources included desktop readings from various past studies related to the issue. The information collected helped build the literature review and identify the research gaps. These sources include relevant books, past publications of government and the local and international non-governmental organizations, unpublished reports prepared by various scholars, universities, journals, newspapers and magazines.

3.6 Sample size and sampling techniques

In the study, the researcher used the following methods to attain the study objectives;

3.6.1 Sample size

The sample size was established based on the total population in Kyawango Location which is 6,982 people and a total of 1,802 households (KNBS, 2019). Only one farmer was to be interviewed per household. The sample was determined by the **Solvin's Formula**

$$n=N\div(1+Ne^2)$$

Where;

- **n** = sample population
- **N** = total no of households in Kyawango Location (1,802)
- **e** = margin of error which will be calculated at 95% confidence level.

$$n = 1{,}802 \div (1+1{,}802 \times 0.95^2)$$

$$n = 110$$

Based on the calculation, 110 people were to be interviewed in Kyawango Location although the researcher managed to interview 101 people. This is explained further in the study limitations.

3.6.2 Sampling techniques

The researcher used simple random sampling method because of the nature of the target population. Farmers were selected using simple random sampling which followed several steps: Defining the population, deciding on the sample size, listing the population, randomly selecting and then collecting data. Samples collected using simple random sampling were

dependent on the population of people within the study area. A total of 110 farmers were sampled.

3.7 Methods of data collection

Different reliable instruments were used to collect data in the field. These data collection instruments included structured questionnaires, which were administered in the households and commercial structures to help obtain information from the study area. Photography was also used, as a reliable instrument as it helped show the actual situation on the ground.

3.7.1 Questionnaires

One set of questionnaires was prepared and administered by research assistants (using ArcGIS Survey123 software) to the farmers living in the study area. The survey collected data related to household characteristics, knowledge of each household on climate change, strategies that are used by households to cope with CV and the challenges/ barriers faced during adaptation to climate variability and change. 101 resident farmers of Kyawango Location were interviewed randomly whereby every farmer had an equal chance of being interviewed. The unit of analysis is the individual respondents (farming households) in Kyawango Location.

3.7.2 Oral Interview guides

These are schedules designed to help direct the interview through an oral engagement with the stakeholders. These targeted those with technical knowledge on climate change adaptation such as NGOs, government officials and key informants with technical understanding on climate variability. The schedules are intended to extract information from small number of people and it enhances the generation of information from knowledgeable people on the issue. A total of five key informants were interviewed which included, a county official from Ministry of Agriculture, an official from Machakos County Ministry of Environment, a village Elder, Kithito Women Group leader and the local chief. The data collected were qualitative and quantitative and was related to CV knowledge, strategies that are suitable for coping and barriers or challenges in adapting to climate change.

3.7.3 Observation schedule

This was important to help obtain information about physically observable attributes of the area of study; these include observable adaptation activities currently being undertaken by the

communities. This was used to obtain information about the nature of adaptation in the study area.

3.7.4 Photography

Photography was used to show certain aspects of the development in the study area. It therefore gave a clear view as it is in the area of study. Several striking images were taken which showed the actual situation on the ground during the time of study.

3.8 Methods of data analysis

The study adopted inferential and descriptive statistics. The quantitative data were presented using percentages, pie charts, bar charts and frequency tables. Non-parametric tests i.e. chi-square was used to test the hypothesis of the study, using the following formula:

$$\chi^2 = \Sigma \frac{(O-E)^2}{E}$$

Where:

- χ^2 refers to the chi square test
- = Observed frequency from the sample
- E= Expected frequency in each of the response categories

This was used to test the difference between variables as follows:

3.8.1 H_0: There is no significant difference between farmers' knowledge on climate variability and adaptation to climate variability.

3.8.2 H_0: There is no significant difference between effects of climate variability on livelihoods and adaptation to climate variability.

3.8.3 H_0: There is no significant difference between the challenges faced by the rural farmers and adaptation to climate variability

Statistical Package for Social Sciences (SPSS) in analysis of data, and specifically chi-square used to test hypotheses. Percentages were computed for all quantitative data, and results presented using frequency tables, bar graphs and pie charts.

The data collected for analysis can be found in the appendix, indicated as Data Matrix.

3.9 Study limitations

Field data collection was done during the COVID 19 pandemic period and the researcher faced several challenges in reaching the target groups and key informants because of the restrictions and measures set by the Ministry of Health. Most of the respondents were not very comfortable being interviewed (because of fear of contacting the disease). This was realized during the reconnaissance study and the researcher managed to engage research assistants from the area who were more accepted and received by the respondents. Also, the researcher used a soft copy questionnaire which was accessed through a mobile phone, through ArcGIS Survey 123 (an application) to reduce the fear and chances of spreading the virus. The challenges faced were unwillingness by some farmers to participate during the COVID era, failure to get the farmers even on going back to their homes severally, and finally financial constraints to keep the research assistants in the field longer. This resulted in only 101 respondents out of a sample of 110 farmers to be successfully interviewed. However, 9 out of 110 was a small percentage (8%) of the sample population and did not affect the result or findings much.

3.10 Ethical issues

The researcher observed all ethical standards such as observing the traditions and norms of the target population to ensure good response during the study. Research permit was obtained from NACOSTI, and approval from Machakos County Government was requested. The respondents were given the will to participate or not throughout the study. Other ethical standards were maintained.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This section presents a detailed presentation of findings of the socio-economic characteristics, household knowledge of climate variability, effects of CV on livelihoods, adaptation strategies and challenges faced in adapting to CV/change.

4.2 Socio-Economic Characteristics of the farmers

The table below summarizes the socio-economic background of the farmers in Kyawango location. Further discussions on socio-economic condition of the respondents are discussed in subsequent sub-sections. The respondents are farmers and the farming decision at married household level is majorly done by husband 78.2%. About 51.5% of the respondents have attained secondary level of education. The female participation was 50.5% whilst male participation in the study was 49.5%.

Table 4.1: The socioeconomic background of the respondents in Kyawango

Variable	Respondents (%)
Gender	
Male	49.5
Female	50.5
Marital status	
Married	67.0
Single	11.0
Divorced	2.0
Widowed	20.0
Level of Education	
No formal education	11.8
Primary	23.8
Secondary	51.5
College and above	12.9
Source of income	
Business	7.9
Crop farming	62.4
Pastoralism	7.9
Remittance	8.9
Salary and wages	11.9
None	1.0
Farming decision	
Husband	78.2
Wife	16.8
Others	5.0

Source: field data 2020

4.2.1 Population and Age Category

The findings show that most respondents were of age 41-50 years bracket, followed by those between 31-40 years as shown in the figure below. The population of the old people is also high as shown in the figure below for those with 51 years and above. The Machakos County Integrated Development Plan (CIDP) 2018-2022 considers the age of 15-65 as the working population. It therefore means that majority of the population in Kyawango location are within the working age. These are also people who are the key decision makers on farming strategies and adjustment that was key in the study.

There is almost equal distribution in the population gender that was interviewed in Kyawango with women accounting for 51% while men accounted for 49% of the respondents. The findings match the contents of the CIDP 2018-2022 which observes that the sex ratio of Machakos County is 1:1.02 for male and female sex respectively.

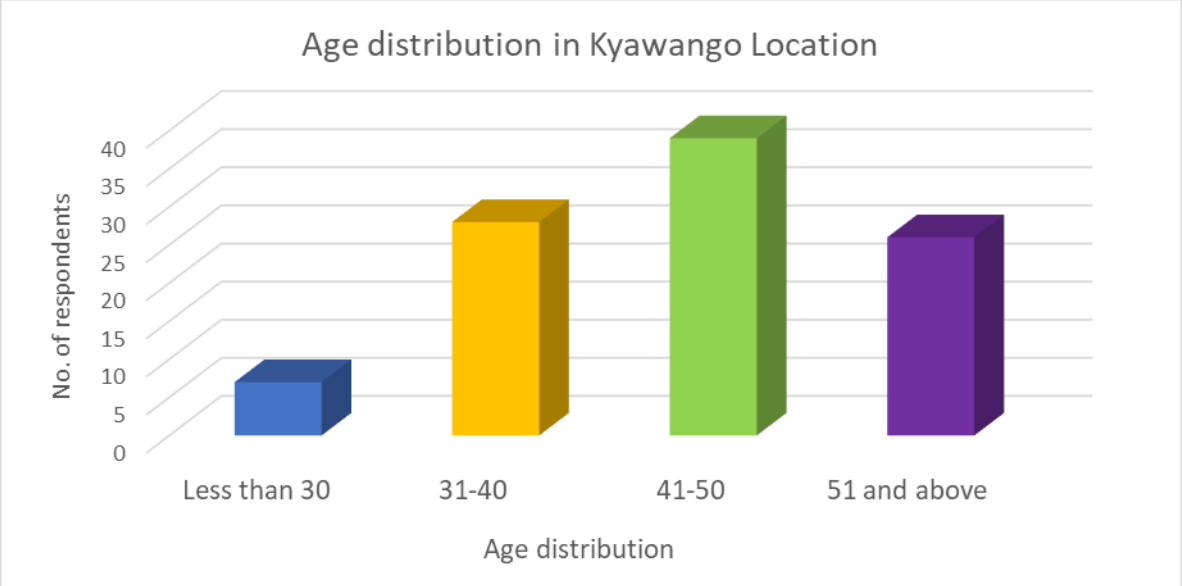

Figure 4.1: Age distribution in Kyawango location

Source: Field data

4.2.2 Marital status

Majority of the respondents in Kyawango location are married (67%) as shown in the figure below. There are also widowed (20%) and divorced (2%) people within the area which accounts for 22% of the total respondents. In total, the section of the population that have been married in their lives is 89% and this is the population that is actively involved in farming activities in Kyawango location, and was very key in finding out what adjustments they had made. 11% of the respondents indicated that they are single. This population is not actively involved in farming activities.

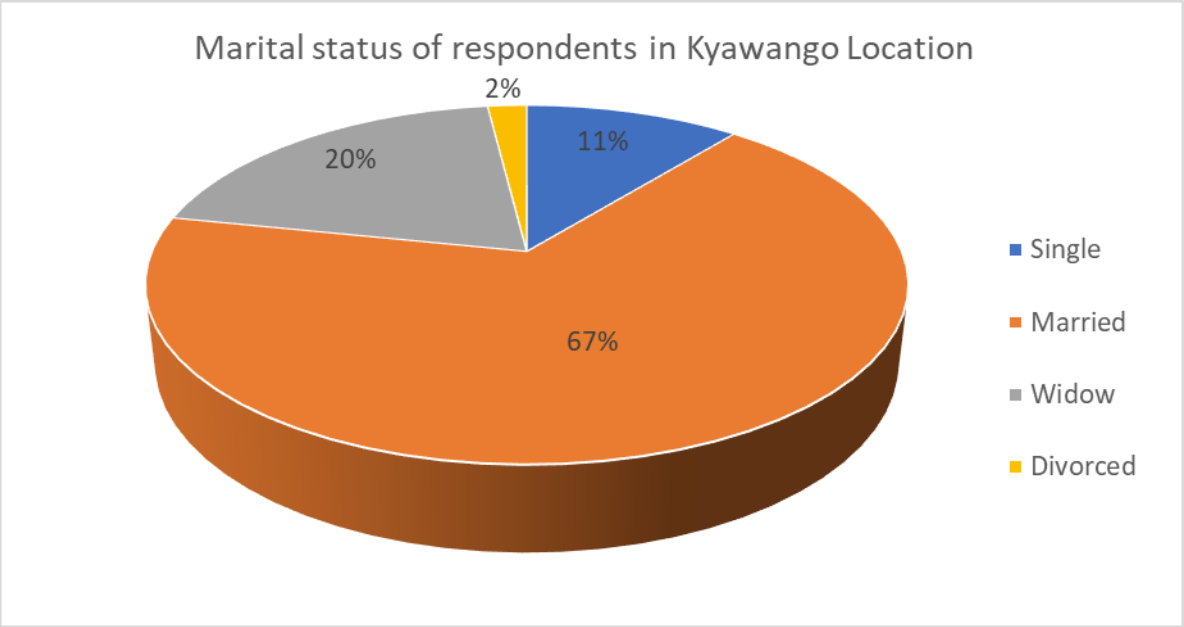

Figure 4.2: Marital status of respondents in Kyawango location

Source: Field data

4.2.3 Household Composition

Majority (61%) of the households in Kyawango location have 4 to 6 people per household, 29% of the households have 1 to 3 people per household while only 10% of the households have 7 or more people per household as shown in the figure below. This helps in understanding the family size in terms of household labour, which is a key determinant in the adaptation process.

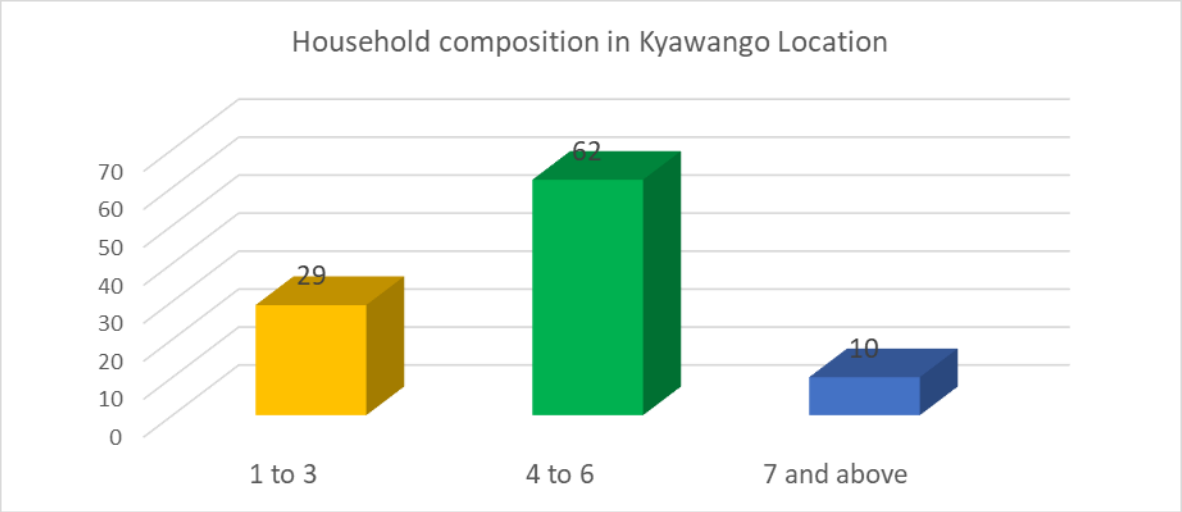

Figure 4.3: Household composition in Kyawango location

Source: Field data 2020

4.2.4 Level of education

Kyawango location has high literacy levels according to the results of the study which show that 51% of the farmerss have secondary education, 10% college education, 2% university level education,1% post graduate education, 27% of the respondents have primary level education and 9% have non-formal education. Cumulatively, about 64% of the respondents have attained secondary education and above.

The findings of this study on education therefore reflects the general picture in the County where literacy levels are high as shown in the CIDP. The Machakos County Integrated Development Plan for 2018-2022 rate the literacy level in the larger Machakos County at 92.4% where the male are more literate than their female counterparts at 95.4% and 89.4% respectively.

Literacy level also determines the level of knowledge and the understanding of the challenges resulting from CV. Farmers who have attained secondary level of education and above are likely to be more informed than the illiterate ones and hence end up choosing the right or the effective strategies in effort to adapt to CV.

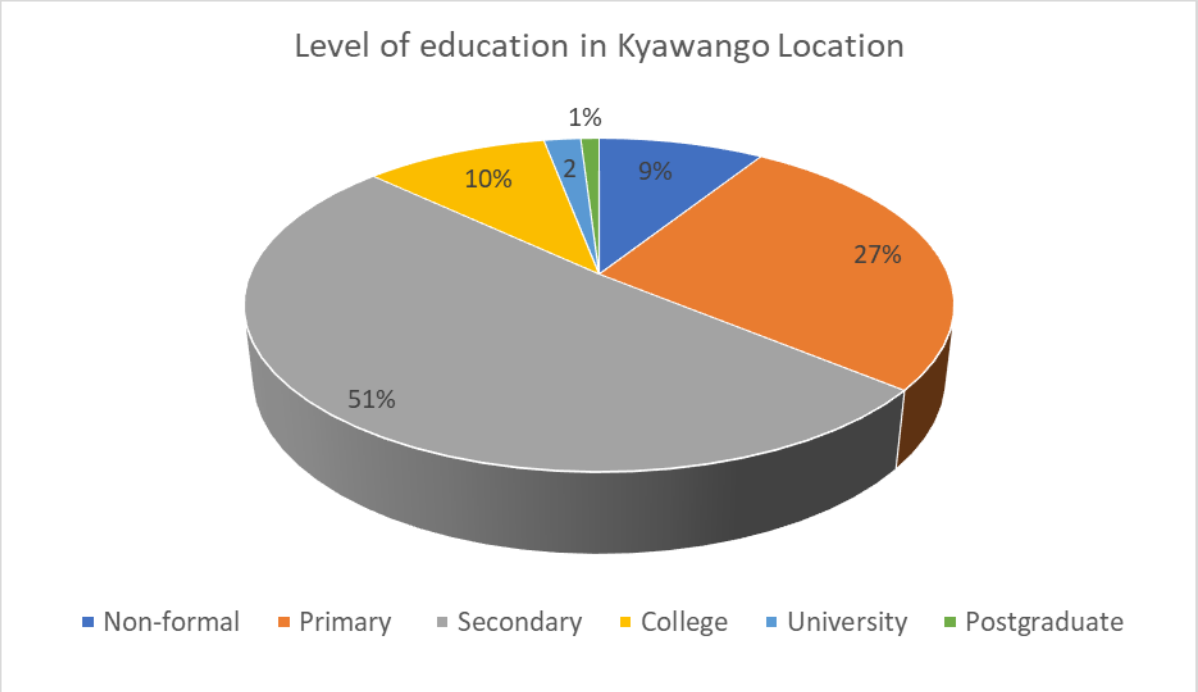

Figure 4.4: Level of education of the respondents in Kyawango location

Source: Field data 2020

4.2.5 Employment and Sources of income

Most of the residents of Kyawango are self-employed with most people engaging in agricultural activities. The study shows that the major source of income in Kyawango location is crop farming and farmers get between ksh.5000 and 80,000 from their farming activities. Pastoralism, businesses, salaried employment and remittances are also sources of income for the respondents as shown I the figure below. These findings corroborate the CIDP which indicates that Agriculture is the dominant land use in Machakos County with over 75% of the land used for agricultural purposes.

Farming is practiced in small scale with majority of farmers having between 1 to 3 Acres of land as shown in the figure below. Farmers with 4 to 6 Acres account for 27% while those with 7 Acres and above account for only 10%. These findings are in line with the situation in the whole of Machakos as indicated in the CIDP 2018-2022 where the mean agricultural land parcel stands at 2.4 Acres.

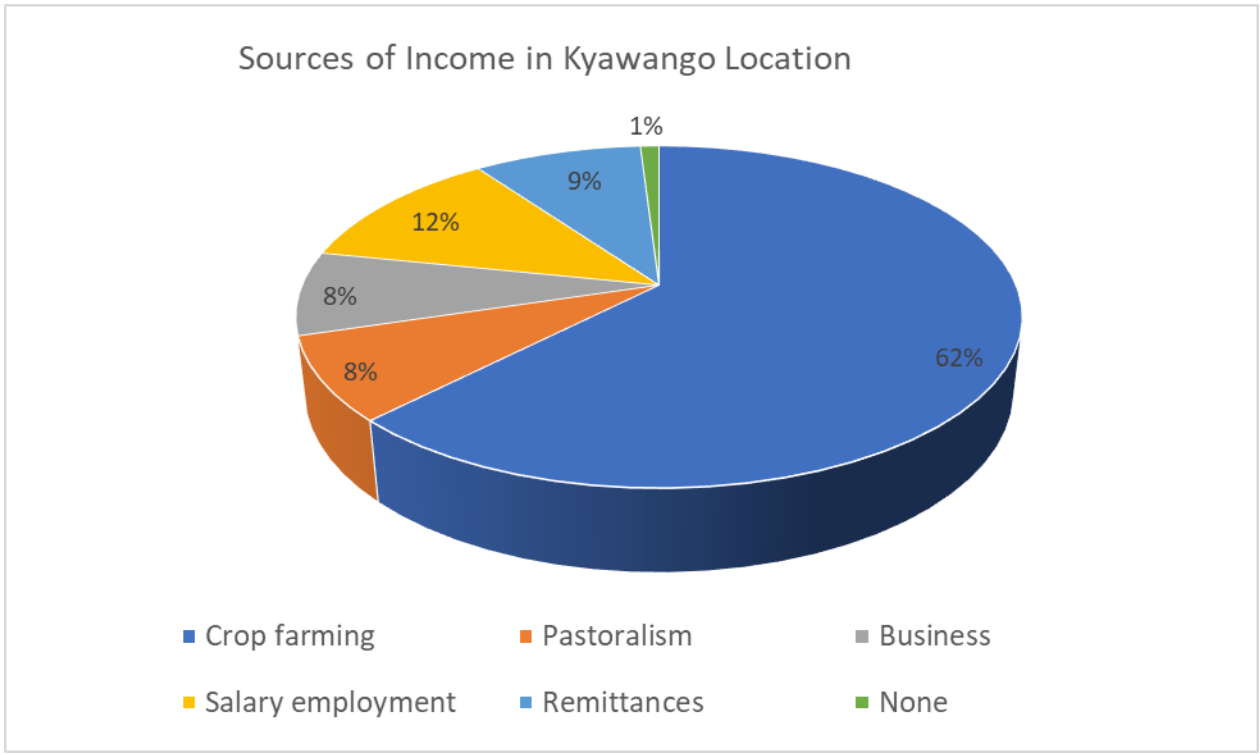

Figure 4.5: sources of income in Kyawango location

Source: Field data 2020

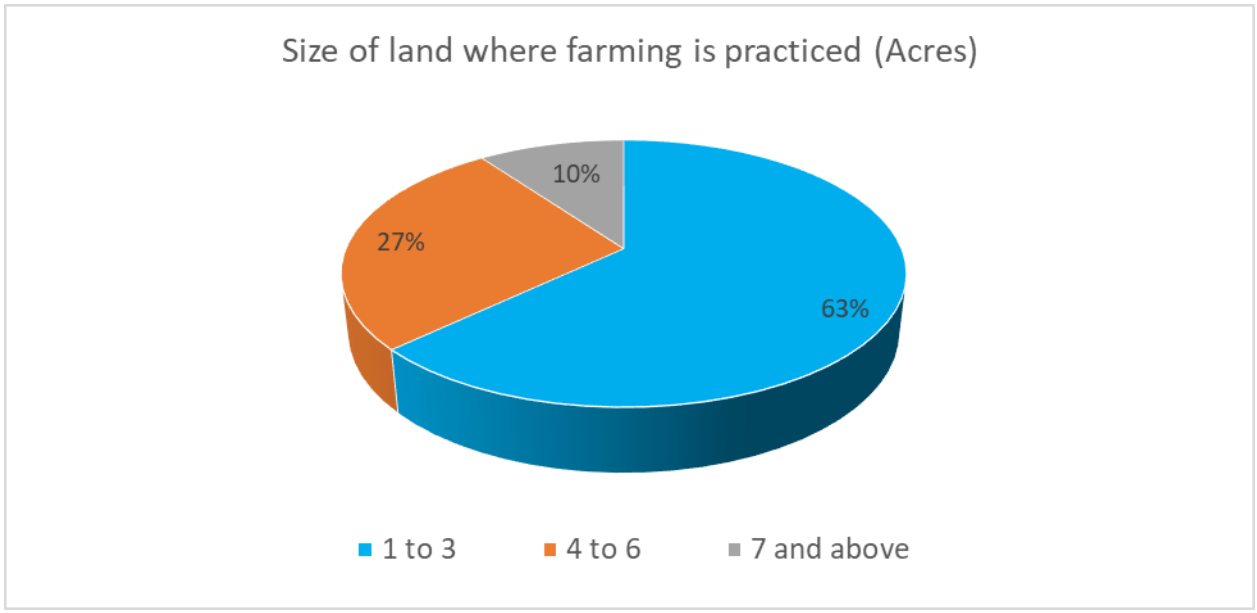

Figure 4.6: Size of farming land in Kyawango location

Source: Field data 2020

The farming activities are mainly done by family members within the households. Most of the households do not hire laborers in their farms as shown below

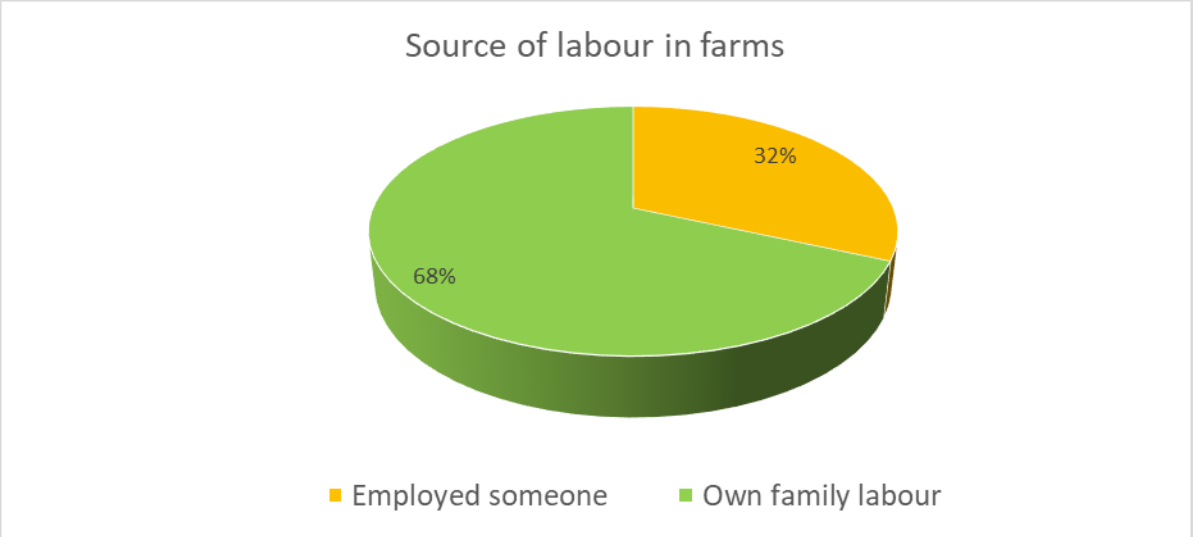

Figure 4.7: Source of labour in farms in Kyawango location

Source: Field data 2020

4.3 Household's knowledge on climate variability – Objective 1

From all the interviews and FGD concluded, agreement was reached that there were substantial changes in the Kyawango's climate. The majority (98%) of the households interviewed mentioned that they knew about climate variability and change in Kyawango location (Table 4.2). However, 2% mentioned that they do not know about climate variability. 51.5% had average knowledge whereas 2% had no idea on climate variability. Disaggregation of perception by level of education – college and above, secondary level, primary level and none-formal level showed that those with none formal education (10.9%)

are less likely to appreciate the existence of climate change and variability than those who have attained secondary level of education (50.5%).

Knowledge of climate variability influences how groups manage climate associated dangers and possibilities and the character of their behavioral responses to this belief will decide adaptation alternatives (Debela et al, 2015). It is therefore important to know the level of awareness perceptions of the respondents regarding climate variability.

Table 4.1: Source of knowledge on Climate Variability

Source of knowledge on climate variability				
	Yes	%	No	%
Radio/Television	69	68	32	31
Observation/Experience	89	88	12	11
NGOs	2	1.9%	99	98
County ministry	5	4.9	96	95
Private sector	1	0.9	100	99
An individual	1	0.9	100	99
Social group	35	34	66	65
Others	8	7.9	93	92
Don't know	2	1.9	99	95

Source: field data 2020

88% of the respondents in Kyawango location get climate variability knowledge through their daily experiences as shown in the figure above. Radio/television also plays important part in informing the respondents on climate change and variability, accounting for 68% of respondents' source of information. These findings vary from the findings of Mburu (2013) who established that farmers in dryland areas have limited knowledge of climate variability and change.

Knowledge of climate variability is important because it determines how the population adjusts to the effects of the variability in climate (Debela et al, 2015). For example, many scientists working on disciplines that relate to the information on climate variability agree

that climate variability is likely caused by human activities. Native people with insufficient or lack of access to climatic information seem to be more likely to associate changing climate conditions to a change in their traditional practices such as rituals and cultural practices, particularly extreme weather events (Debela et al, 2015).

The respondents explained that they have experienced various shifts in the weather conditions in the past two decades as shown in the figure below. The changes range from unpredictable rains which in the most common change observed by respondents at 71%. Other changes are prolonged dry season (60%), very hot seasons (56%) and high wind speed at 2%. The area has not experienced increased rainfall as observed by the respondents. The findings corroborate study by IPCC (2007) which indicated that the northern and eastern arid & semi-arid lands (ASAL) are projected to experience an overall decline in rainfall because of climate inconsistency.

These results are also in conjunction with Macharia's (2013) findings, which centered on semi-arid immigrant farmers in Kenya. The study identified erratic and low rainfall, dust, frequent incidents of drought, low crop outputs and increased temperatures during the day as indicators of climate variability.

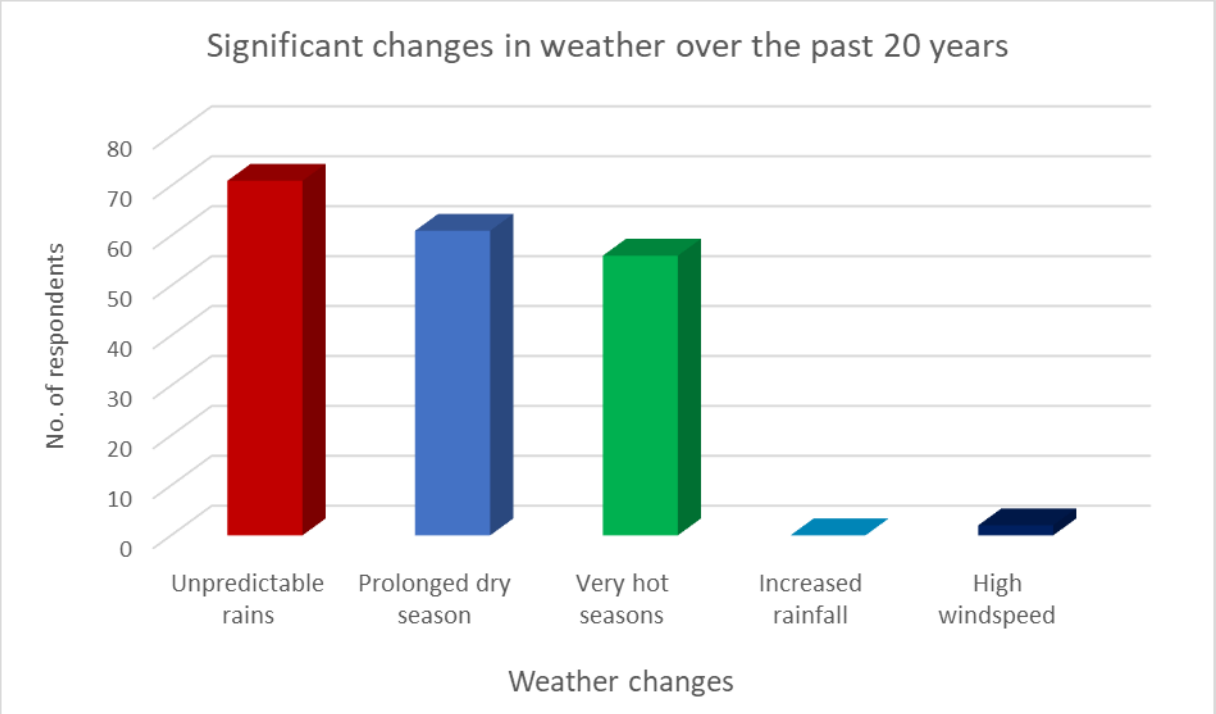

Figure 4.8: Significant changes in weather observed by respondents over the past 20 years

Source: Field data

Significant changes in Weather over the past 20 years				
	Yes	%	No	%
Unpredictable rains	71	70	30	30
Prolonged dry season	61	60	40	40
Very hot seasons	56	55	45	45
Increased rainfall	0	0	101	100
High wind speed	2	1.9	99	98.1

Table 4.3: Significant changes in weather

Source: field data 2020

Hypothesis Testing

The researcher began by testing the first null hypothesis using SPPS chi square test of association.

1. H_0: There is no significant difference between households' knowledge on climate variability and adaptation to climate variability.

   H_1: The alternative.

Results of the SPSS test

Table 2.4: Knowledge of climate variability / Adaptation to climate Variability Cross tabulation

			Adaptation to climate Variability		
			No	Yes	Total
Knowledge of climate variability	Average knowledge	Count	8	44	52
		Expected Count	12.9	39.1	52.0
	Extensive knowledge	Count	1	3	4
		Expected Count	1.0	3.0	4.0
	Minimal knowledge	Count	14	29	43
		Expected Count	10.6	32.4	43.0
	None	Count	2	0	2
		Expected Count	.5	1.5	2.0
Total		Count	25	76	101
		Expected Count	25.0	76.0	101.0

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	9.937a	3	.019
Likelihood Ratio	9.624	3	.022
N of Valid Cases	101		

For this analysis only the Pearson Chi–Square is required. The value of the chi square statistic is **9.937**. Considering that the hypothesis was tested at 5% level of significance, then our predetermined alpha level of significance is 0.05. From the table above, the corresponding P-value to our chi-square statistic is **0.019.** The result or statistic is therefore significant since this value is less than the designated alpha value (0.05). So, there is enough evidence to reject the null hypothesis that states that "there is no significant difference between households' knowledge on climate variability and adaptation to climate variability". In simple terms, the data suggests that significant differences do exist between households' knowledge on climate variability in Kyawango Location, Machakos County and measures adopted by farmers to climate variability. We therefore fail to reject the alternative hypothesis, and thus adopt it. This means that evidence from the sample shows that, there is a significant difference between the farmers' knowledge and adaptation to CV. Therefore the level of knowledge does affect how a farmer will adapt to the effects of CV.

The first crosstabs table also shows consistent data with this chi-square result. For example, there are more (44) people with average knowledge on climate variability than was expected (39) if the null hypothesis was to be true.

4.4 Effects of climate Variability on livelihoods – Objective 2

Resident farmers of Kyawango Location indicated that they practice crop farming (91%), livestock rearing (92%), fruit farming (43%), and basket weaving (4%) as their key livelihood activities. The major livelihood practices and activities of the residents of Kyawango location are Livestock rearing and crop farming as shown in figure below.

Table 4.3: Livelihood activities practiced by respondents

Livelihood activities practiced by respondents				
	Yes	%	No	%
Crop farming	92	91	9	9
Livestock rearing	93	92	8	8
Fruit farming	43	42.5	58	58
Basket weaving	4	3.9	97	96
Others	4	3.9		

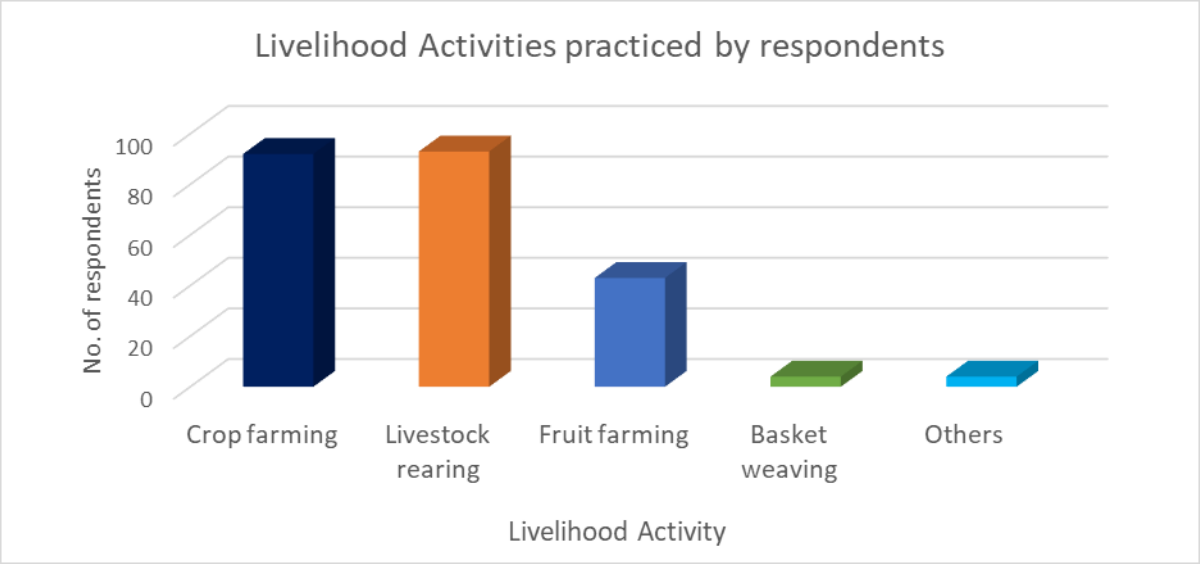

Figure 4.9: Livelihood activities practiced by respondents

Source: Field data 2020

However, the respondents intimated that their major livelihoods activities (Crop farming and livestock rearing) have been affected over the years and therefore is not perfect as shown in the figure below. Most respondents indicated that the performance ranged from fair to very poor. No respondent observed that the agricultural performance is perfect.

These results corroborate the findings by Ochieng et al (2016) who established that increased temperatures will continue to have significant negative effects on maize and other crops in Kenya.

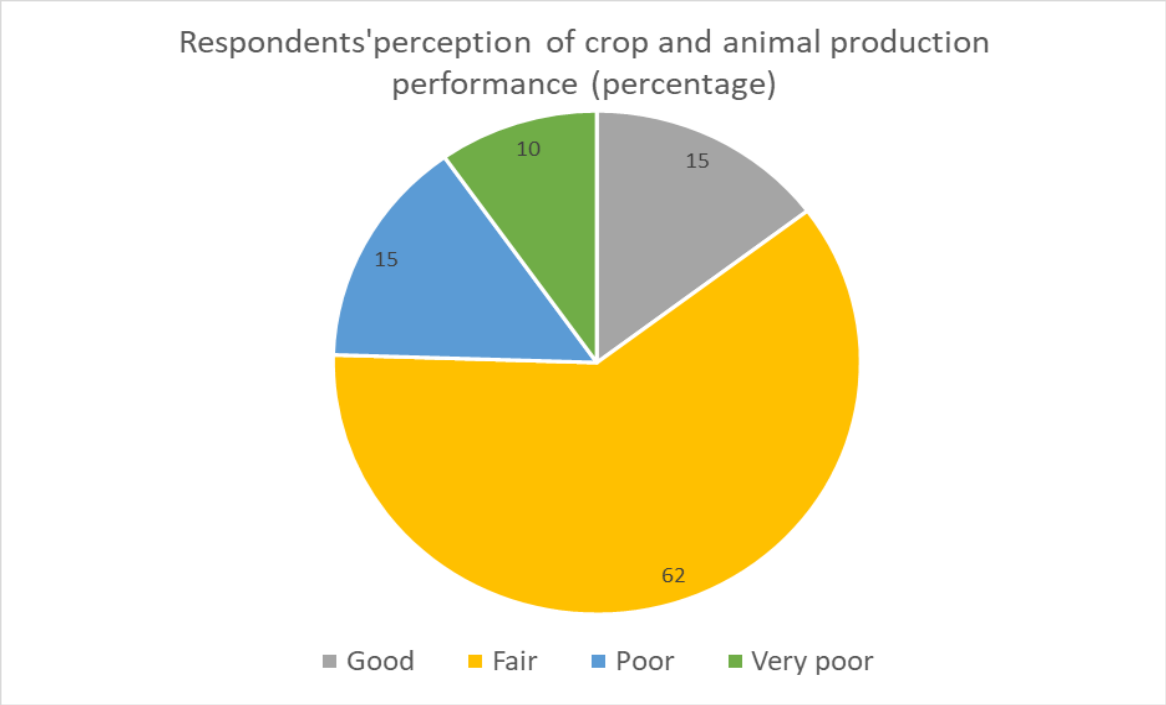

Figure 4.10: Perception of crop and animal production performance

Source: Field data 2020

The farmers of Kyawango grow various types of crops which is majorly influenced by the climate of the area. They grow maize (97%), Beans (93.1%), peas (88.2%), cow peas (77.7%), Mangoes, pumpkins among other crops. The main crop grown in the area is maize, which corroborates the study by Ochieng et al. (2016) which established that maize is the staple food grown in most of Kenyan households.

Plate 1: Pawpaw crop grown in Kyawango
Source: Researcher 2020

Plate 2: Cowpeas grown in Kyawango location (being sun dried)

Source: Researcher (2020)

Table 4.4: Some of the crops grown in the study area

Types of crops grown by respondents				
	Yes	%	No	%
Maize	98	97	3	2.9
Beans	94	93.1	7	6.9
Peas	89	88.2	12	11.8
Cow peas	78	77.7	23	22.7
Mangoes	24	23.8	77	76.2
Green gram	21	20.8	80	79.2
Oranges	20	19.9	81	80.1
Pumpkins	15	14.9	86	85.1
Kales	16	15.8	85	84.1
Millet	6	5.9	95	94.1
Sweet potatoes	6	5.9	95	94.1
Bananas	6	5.9	95	94.1
Millet	6	5.9	95	94.1
Sorghum	7	6.9	94	93.1

Source: field data 2020

Cattle, goats and sheep are the major livestock reared in the study area as shown in the figure below.

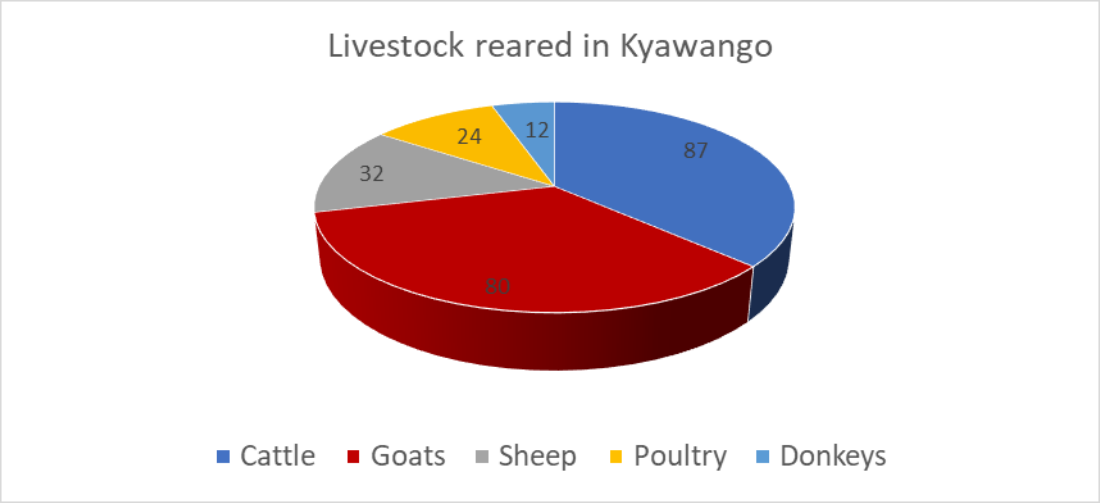

Figure 4.11: Livestock kept by residents of Kyawango location

Source: Field data 2020

The residents, however, observed that their crops and animal produce has widely been affected by climate variability which has affected their livelihoods. According to the respondents, crop and animal yields have reduced, water sources have dried up, and there is increase in crop and animal pests and diseases, inadequate pasture for livestock and stunted growth of crops.

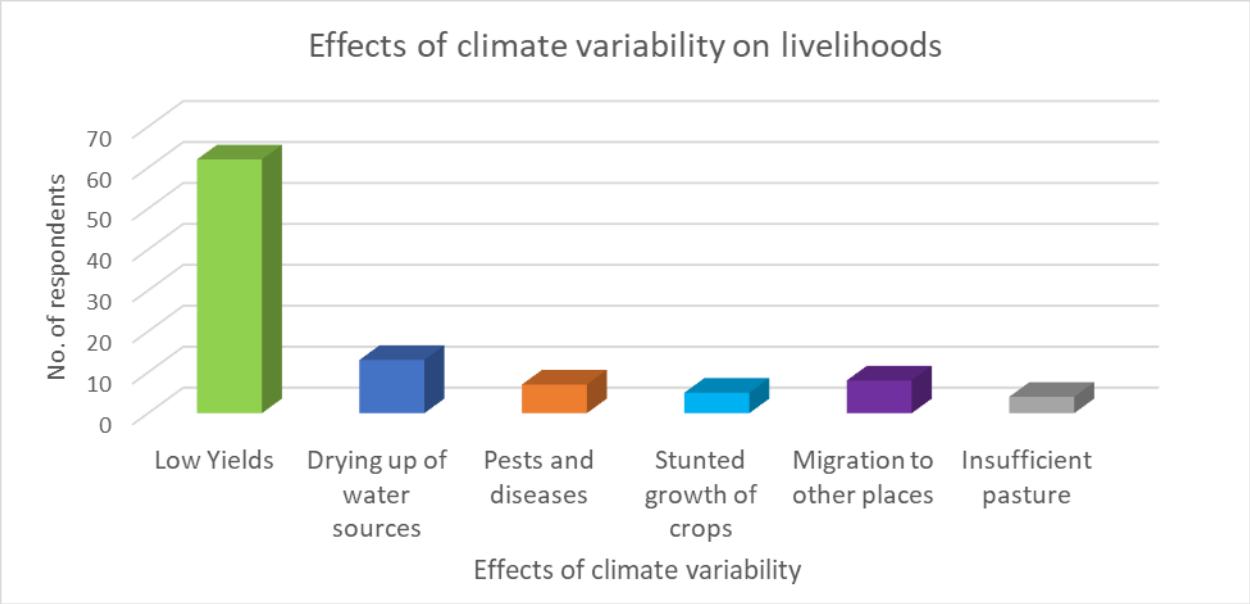

Figure 4.12: Effects of climate variability on livelihoods

Source: Field data

These effects have resulted into shortage of water in the area, unpredictable income since farmers are not certain of their seasonal harvests, high cost of production, reduced living

standards and in some cases, migration to other places in search of pasture. Macharia (2013) also found out that climate variability and change led to food insecurity, high levels of poverty, water scarcity and increased pest and disease infections.

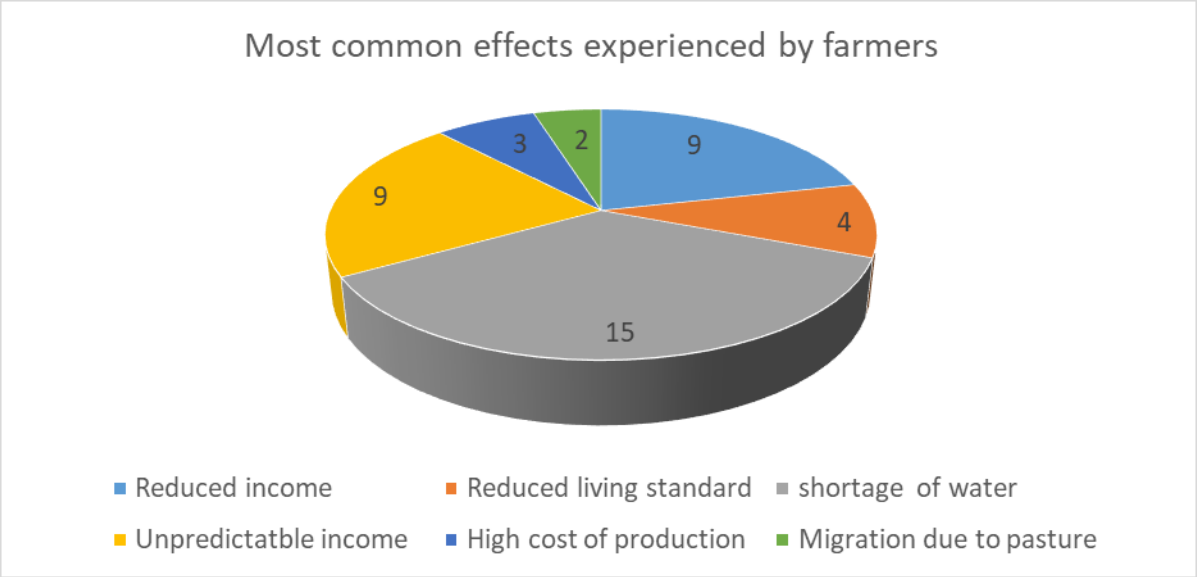

Figure 4.13: Most common climate variability effects experienced by Kyawango residents

Source: Field data 2020

Hypothesis testing

2. H_0: There is no significant difference between effects of climate variability on livelihoods and adaptation to climate variability.

   H_1: The alternative.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	8.940[a]	7	0.257
Likelihood Ratio	11.053	7	0.136
N of Valid Cases	101		

The result of the Chi Square statistic test is 8.940 and the corresponding p-value is **0.257**. Since this p-value is more than the normal alpha value, this means that we do not have enough evidence to reject the null hypothesis which states that "there is no significant differences between effects of CV and adaptation to climate variability". Therefore, we fail

to reject the null hypothesis and adopt it. Evidence from the sample shows that there is insignificant difference between the effects of CV and adaptation to the same, this means that the effects oof CV does not affect the adaptation or the adjustment process.

4.5 Adaptation strategies to climate variability – Objective 3

Resident farmers of Kyawango Location recognize the significance of the effects of climate variability and majority have changed their farming activities due to climate change as shown in the figure below. 76 (75.2%) farmers adjusted while 25 (24.8%) did not adjust their farming operations.

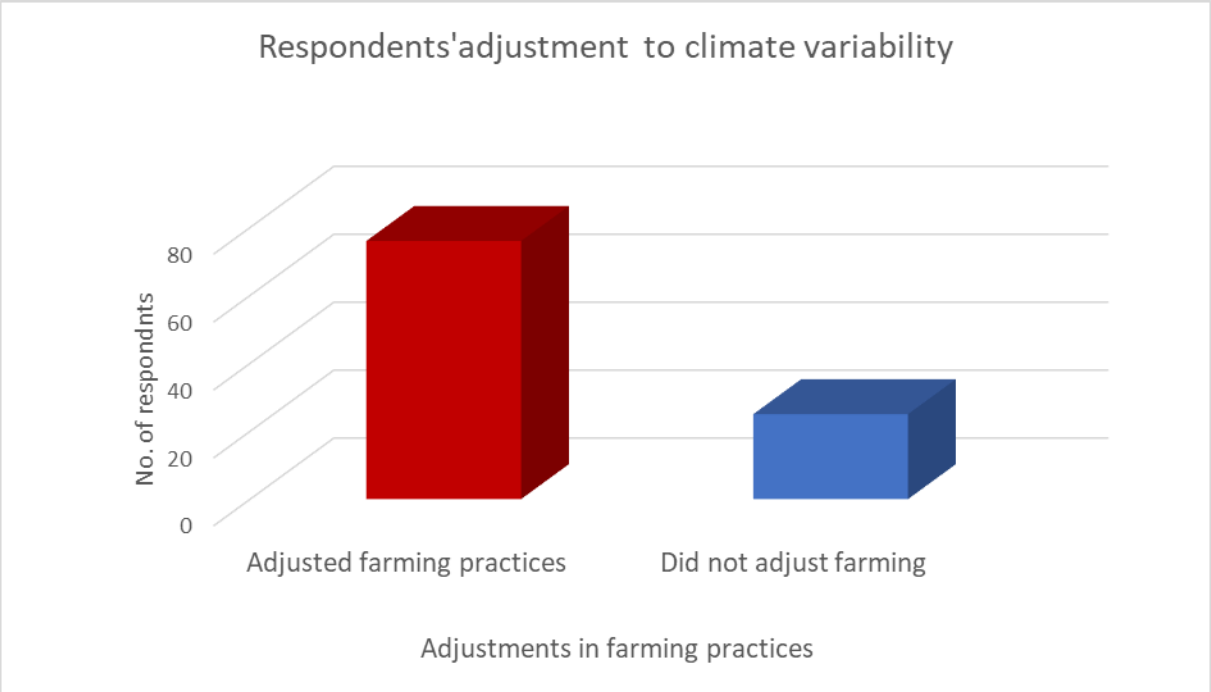

Figure 4.14: Residents' adjustment of their farming practices

Source: Field data 2020

Respondents mentioned that they undertake various practices as a way of adjusting to climate variability and its effects as shown in the table below. Soil conservation is the major practice by the residents at 62%. They also change crop varieties, build water harvesting schemes, irrigate crops, reduce the numbers of livestock they keep in their farms, diversify to non-farming activities (e.g fishing, bee keeping), change planting dates and use fertilizers and manure to improve their produce.

Table 4.7: Adjustment by households to climate variability

Adjustments by households to climate variability				
	Yes	%	No	%
Change crop varieties	25	24.7	76	75.3
Build water harvesting schemes	25	24.7	76	75.3
Soil conservation	62	61.4	39	38.6
Change planting dates	4	3.9	97	96.1
Increase land size	1	0.9	100	99.1
Irrigate crops	12	11.8	89	88.2
Reduce livestock numbers	9	8.9	92	91.1
Diversify to non-farming activity	7	6.9	94	93.1
Use fertilizer or manure	1	0.9	100	99.1

Source: field data 2020

These findings corroborate the research by Schlenker and Lobell (2010) who established that Sub-Saharan Africa needs to plant drought tolerant crop varieties, improve and expand crop irrigation, improve on rainwater harvesting and invest in rainwater harvesting technologies and increase on fertilizer inputs to maximize of crop yield. Mekbib et al. (2011) also suggest that to avert the effects that result from the impacts of climate variability, proper soil conservation measures such as terracing, building gabions, crop rotation, intercropping and crop diversification, use of improved seeds, change in the timing of the growing period to help improve productivity.

Plate 3: An adjustment done by a farmer – Irrigation

Plate 4: Terracing for soil and water conservation

Plate 5: Alternative livelihood adjustments - Bee hives for bee keeping and fish rod for fishing

Source: Field data 2020

4.6 The Role of Institutions

During the study, residents indicated that changes have occurred over time and various organizations and government agencies have been working with local communities to help them overcome or live with the CV challenges. Some respondents, however, observed that there are no organizations that have been working with them to help adapt to CV effects.

23% of the farmers had experience the intervention of institutions, while 78% said that no institutions had worked with them in the effort of overcoming CV.

Non-Governmental Organizations have had more impact compared to other organizations. County government ministries were also mentioned by some respondents as being actively involved in helping the respondents adapt to climate variability.

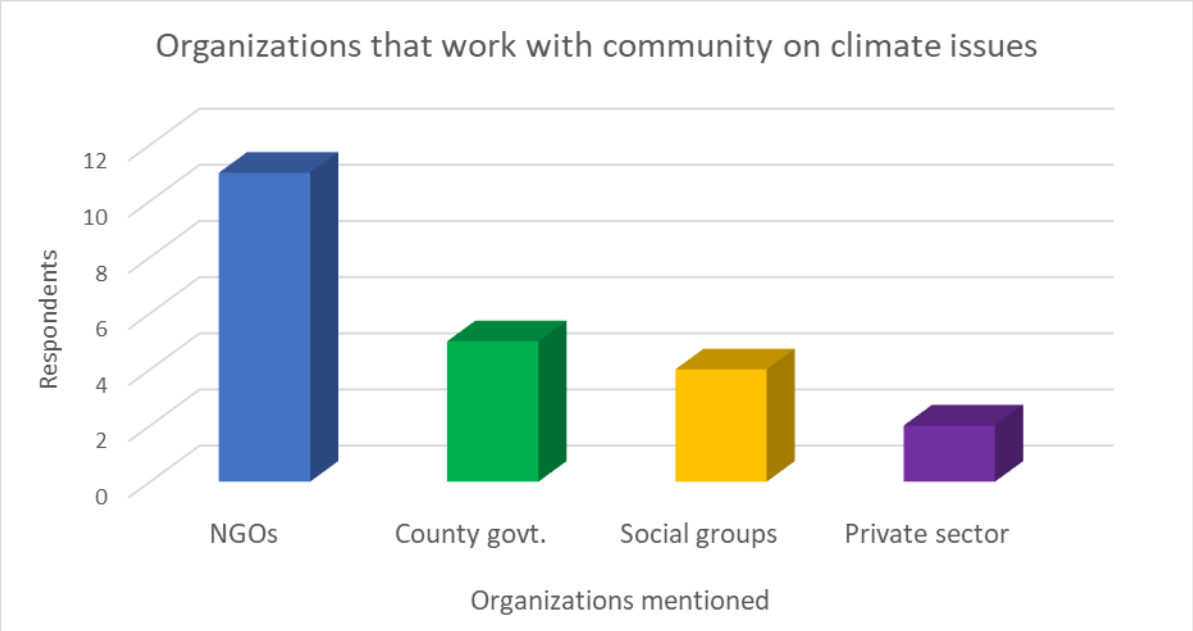

Figure 4.15: Organizations that work with Kyawango residents on climate issues

Source: Field data 2020

The above organizations have technical staff who advise the farmers to plant drought resistant crops, change crop varieties and use fertilizers to boost their yield, modify planting methods, plant a variety of crops so that if one crop fails, the other crops can be harvested for food, keep livestock to diversify livelihoods, build water storage schemes to help store water for use during dry season, irrigate crops during dry season and to construct terraces to help conserve soil.

The guidance from the above organizations have helped reduce drying of crops before maturity, it has helped improve crop yield and availability of food to sustain the community during the dry seasons.

4.7 The Role of Social Groups - Kithito Women Group (KWG)

During the study it came out evident that Women in Kyawango Location are highly vulnerable to Climate Variability than men. They walk long distances to search for clean water for dometic use and firewood for cooking fuel. This affects the girls and women more than men because of the existing culture.

The researcher managed to interview a Social Women Group in form of a focus group discussion. Kithito Women Group in Kyawango Location was started in 1992 to empower and support women with an aim to overcome the challenges faced by rural women farmers, and more specifically curb climate variability effects on livelihoods. It is a group of 25 women who came together with the goal of supporting one another to achieve more. They have done several projects the main one being water harvesting, whereby each member has benefited by getting a water jar (SIDA assisted project), and a self-sponsored 10,000 litre capacity water tank. This has helped each one of them to reduce the problem of scarcity of clean drinking water and has reduced water borne diseases. This group has also invested in a Posho Mill project which is built on their own land. This project helps them get alternative source of income apart from farming. "Every member participates as we have a duty roster and gets an average of Kes. 4,500 semi-annually thus improving our living standards" said their leader. "The group has a joint savings bank account where we manage to pool savings together. This has enabled us to practice farming projects whereby we rent farmlands, fence around and do largescale farming. Some of the crops that we have grown include cotton, sorghum, maize, cowpeas, pigeon peas and green grams". However, they confessed that due to water shortage, they have not been able to grow vegetables as these require a lot of rain or irrigation. "Due to the climate variability experienced in the area, we have opted to grow drought resistant crops only" explained one of the members. A number of organizations more specifically NGOs and CBOs (e.g SIDA) have sponsored their farming project by giving free farm inputs. These inputs include fertilizers and a variety of drought resistant crops which do very well in the area resulting in increased crop production as compared to the normal crops. They sell the produce and sub-divide the money amongst themselves. This has improved their living standards a great deal. Other projects practiced by the group include basket weaving and chicken rearing.

Plate 6: Kithito Women Group Water Jar project – SIDA

Plate 7: KWG Posho Mill Project

Plate 8: KWG self-sponsored water harvesting project – cement water tanks

Source: Field data 2020

4.8 Challenges faced by households in adapting to climate variability

Farmers of Kyawango experience various challenges in taking steps to adjust to climate variability and change. As observed by Mburu (2013), Climate change adaptation requires capital because a large proportion of the interventions are not natural in the area. The residents of Kyawango cited shortage of capital, shortage of labour, lack of information, insufficient land size, lack of access to water and poor health as key factors that hinder their capacity to adapt to climate variability. The most experienced challenge was shortage of capital. These findings are similar to the findings of Mburu (2013) in his study of the effects of climate variability and change on dryland agriculture and small-scale farmers adaptation strategies in Yatta district. Mburu (2013) found that farmers are faced by financial constraints, lack of information, lack of relevant skills, lack of infrastructure and inputs lack of scientific and technical knowledge.

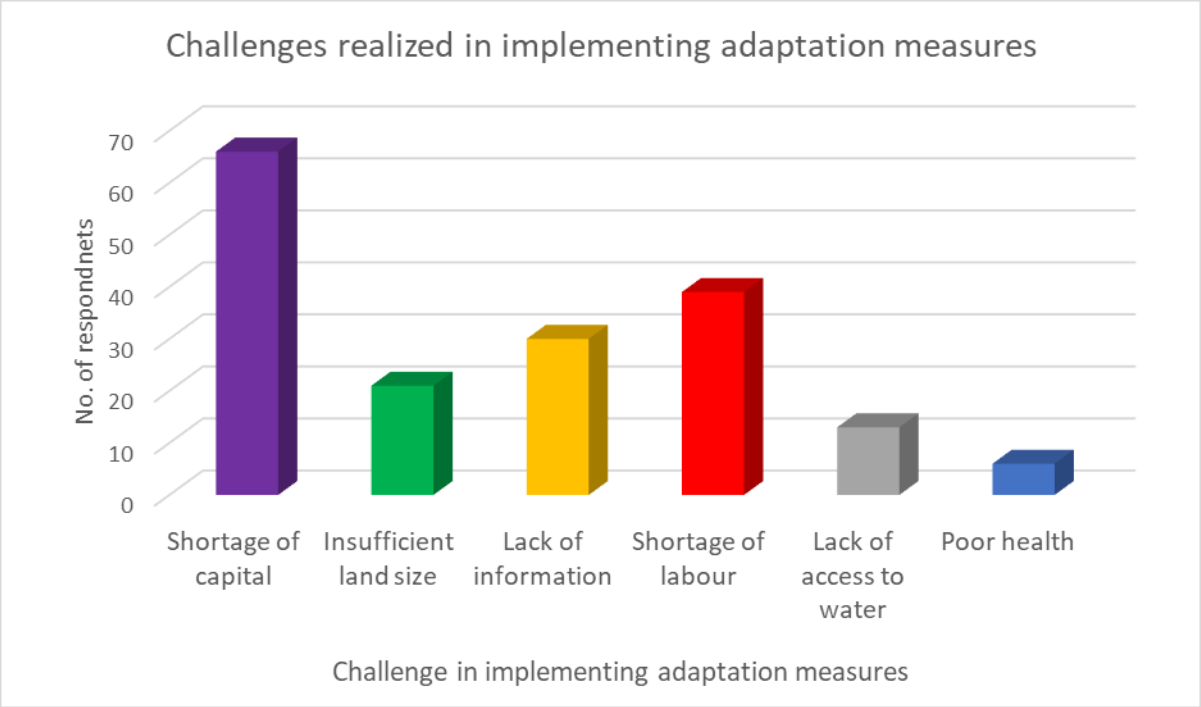

Figure 4.16: Challenges in implementing adaptation measures

Source: Field data 2020

Hypothesis Testing

3. H_0: There is no significant difference between the challenges faced by the rural farmers and adaptation to climate variability and change

   H_1: The alternative.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	75.792[a]	37	.000
Likelihood Ratio	83.238	37	.000
N of Valid Cases	101		

The chi square value is 75.792 and has a corresponding p-value of 0.00 which is less than the p-value of 0.005. This shows that there exist significant differences between strategies used by the rural communities to adapt to climate change and the challenges faced in adapting to climate variability and change. We therefore reject the null hypothesis and adopt the

alternative hypothesis, because there is enough evidence from the sample to do so. There is an effect on the challenges like lack of capital, insufficient size of land, lack of sufficient labour, poor health and lack of sufficient information on CV to the adaptation. These challenges do hinder the adaptation process negatively.

4.9 Environmental effects from actions taken to adapt to climate variability

The researcher felt that it was important to the environmental challenges arising from the adjustments made. However, not all the adaptation strategies resulted in negative effects to the environment. The adaptation strategies undertaken by the farmers in Kyawango location were assessed for their effects on the environment. The respondents observed that dryland irrigation of crops leads to depletion of water sources, pollutes water and soil, results into salinization of the soil and results into air pollution due to the toxic gases emitted by the water pumps. Also, if the water used to irrigate is polluted e.g with heavy metals it may get into the food chain and harm human health.

Plate 7: Highly polluted water from River Athi used to irrigate crops

Source: Field data 2020

Migration of people to other places causes land degradation, transfer of pests and diseases from one place to another, degrades the soil and reduces soil cover due to soil erosion. Changing the size of land meant for cultivation leads to deforestation due to clearing of land,

soil erosion and land degradation. Further, engaging in other livelihoods such as charcoal burning, the illegal sand harvesting (which is still happening) and brick making leads to deforestation, soil degradation and land degradation.

Interestingly, implementation of soil conservation schemes has its advantages such as improvement of the environment. However, it has such negative effects such as infertility of the soil over a period of time due to continuous cultivation and soil infertility due to excessive use of fertilizers.

Use of pesticides to improve agricultural production pollutes water sources and soil and is also harmful to human health.

A brick-kiln and bricks ready for sale and Cutting down of trees for firewood/charcoal burning resulting in deforestation

Plate 8: Alternative Livelihoods adjustment

Source: field data 2020

4. SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of findings and Conclusions

This chapter outlines summary of findings as per the study objectives, hypothesis testing results, conclusions and recommendations of the study. The study recommendations were drawn from the findings and conclusions.

This research analyses the adaptation strategies as a result of climate variability in kyawango location - Machakos County. The study sought to assess the rural households' knowledge of climate variability in the study area, determine the effects of climate variability on the livelihoods of local farmers in the study area, assess the various strategies used by households to adapt to effects of climate variability in the study area and examine the challenges faced by households in adapting to climate variability in the study area.

5.2 Knowledge of climate variability

The study found out that residents of Kyawango location have knowledge of climate change which they mostly learn through personal experience and observation (88%) and through the media such as Radio and television (68%). After testing the first hypothesis, (H_0: There is no significant difference between households' knowledge on climate variability and adaptation to climate variability), it was evident that significant differences exist between households' knowledge on climate variability in Kyawango Location, Machakos County and adaptation to climate variability. Therefore, the alternative hypothesis was adopted. A change in the level of knowledge has an impact on the adaptation to CV e.g a farmer has extensive knowledge is likely to choose effective techniques or adjustments to adapt to the negative effect of CV as compared to those with minimal knowledge.

5.3 Effects of climate variability on livelihoods of farmers

The study established that the consequences of climate fluctuations have been encountered in the study area. In summary the common effects of CV experienced by farmers of Kyawango Location are water scarcity due to drying up of water sources, reduced crop yields as a result of crop failure, increased crop and animal pests and diseases, inadequate pasture for livestock, unpredictable income and high cost of farm production due to climate variability. The second hypothesis was tested (There is no significant difference between effects of climate variability on livelihoods and adaptation to climate variability) and the results of the

Chi Square suggested that "there is insignificant differences between the effects of CV and adaptation to climate variability". The null hypothesis was adopted. This means that the effects of CV in Kyawango has no impact on the adaptation process and the two are independent of each other.

5.4 Adaptation to effects of Climate Variability

The farmers of Kyawango Location adapt to climate variability by practicing crop diversification, soil conservation practices such as terracing, constructing water harvesting schemes, crop irrigation, crop rotation, changing planting dates and use of fertilizers and manure to improve produce. Knowledge and perception of climate change ensured that the community adapted appropriately to climate variability and its effects. This response is, however, still low with most measures being practiced by less than 50% of Kyawango farmers.

5.5 Challenges in adapting to Climate Variability effects

Challenges experienced in Kyawango in having to adapt to the variations in climate are; shortage of capital for buying inputs, shortage of labour, lack of information, insufficient land size, lack of access to water and poor health. Chi square testing of the last hypothesis (H_0: There is no significant difference between the challenges faced by the rural farmers and adaptation to climate variability) revealed that there exists significant difference between adapting to CV and the challenges faced in adapting to climate variability and change. This resulted in the adoption of the alternative hypothesis. Therefore, it is evident that challenges faced by farmers do affect the outcopme of adaptation to the negative effects of CV in Kyawango.

5.6 Conclusion

This study concludes that farmers in the study area have knowledge on climate variability although more awareness can be created as the level of knowledge is wanting, mostly minimal and average knowledge. Common effects of CV are water scarcity due to drying up of water sources, reduced crop yields as a result of crop failure, increased crop and animal pests and diseases, inadequate pasture for livestock, unpredictable income and high cost of farm production due to climate variability. Farmers of Kyawango have made some adjustments in effort of coping with the effects of CV. These include practicing crop diversification, soil conservation practices such as terracing, constructing water harvesting

schemes, crop irrigation, crop rotation, changing planting dates and use of fertilizers and manure to improve produce. The most experienced challenge was shortage of capital, followed by shortage of labour and lack of information. Other challenges recorded were lack of access to water, poor health and insufficient size of land.

5.7 Recommendations

To policy makers - The County government should come up with policies and programs that can empower farmers to adapt to climate variability. NGOs and private organizations should come up with programs that can empower the farmers adapt to climate variability in Kyawango location as well. Funding projects by the county government and other institutions should be extended to the farmers so that they can access farm inputs and the capital required. More awareness of SACCOs that can support the farmers should also be created in the study area.

The percentage of awareness and knowledge of climate variability can be increased through increased education and community activities related to climate change. More awareness of the effects of CV can also be disseminated to the local farmers through seminars organized by CBOs and the County Government Ministry of Agriculture in collaboration with the Ministry of Environment. This will ensure that farmers understand the climatic effects facing them well and thus use relevant adaptation measures or adjustments in order to improve their livelihoods. More activities, education and information is needed to enable households gain knowledge on various adaptation methods like planting drought resistant trees like *Gravellia* (Agroforestry). The area lacks this strategy in the farmers' practices.

To Farmers - it is also recommended that farmers of Kyawango adopt integrated approach that includes adaptation measures, sustainable farm management and increased investment in agriculture in order to overcome the challenges they are facing as a result of CV. In adopting these measures their well being will be enhanced.

5.8 Suggestions for further study

It is suggested that further research is necessary to show the role of policies and the institutional position in fighting climate variability effects in Kyawango location. This is because the researcher noticed that there is a big potential in involving institutions to help the local community to adapt to effects of Climate Variability.

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Appendix 2: Questionnaire

Introduction

My name is Monicah Mwanzia a student at the University of Nairobi, pursuing a Master of Arts degree in Environmental Planning and Management. I am currently conducting a study aiming at analysing adaptation strategies as a result of Climate Variability in Kyawango Location - Machakos County. You are one among many other farmers who have been selected for this study and I am kindly requesting for your time in answering the questions below. All information provided shall be held with due confidentiality and shall only be used for the purposes of this research, while adhering to all regulations governing research.

PART A: Demographic Information

1 Name of Respondent (optional)……..

2 Gender

Male [ ]

Female [ ]

3 Age:

Less than 30 Years [ ]

31-40 Years [ ]

41-50 years [ ]

More than 50 Years [ ]

4 Marital Status

Married [ ]

Single [ ]

Divorced [ ]

Widowed [ ]

5 Highest level of education

No formal education [ ]

Primary level [ ]

Secondary level [ ]

College level [ ]

University level [ ]

Post graduate level [ ]

6 How many people are in your household? [ ]

7 Who makes decisions regarding when and what to plant, as well as farm inputs to use?

Head of the family [ ] Wife/Mother [ ] Other (Please specify) [……..]

8 What is the main source of income for the household? Only one answer is possible

i. None
ii. Crop farming
iii. Business
iv. Livestock Rearing
v. Salary
vi. Wages
vii. Remittance
viii. Other (Specify)……

9 What is the size of your land under cultivation and livestock rearing?.....

10 Have you employed someone to work on your farm? Yes [ ] No [ ]

11 If yes, what is the monthly income that you pay? Kes. ……

12 Do you have any other job apart from farming? Yes [ ] No [ ]

13 If yes, what is your monthly income from the employment? Kes……. per month.

Part B: Knowledge of Climate Variability

14 Do you perceive climate variability and change? (Tick appropriately) Yes [ ] No [ ]

15 Circle the statements below from 1 to 5 that you feel best represents your knowledge on climate variability

i. I don't know [ ]
ii. I have minimal knowledge [ ]
iii. I have average knowledge [ ]
iv. I have extensive knowledge [ ]

16 If yes, how did you get to know about Climate Variability? (Tick appropriately)

i. Radio/Television [ ]
ii. From observation
iii. NGOs [ ]
iv. County government Ministry [ ]
v. Private sector
vi. An individual
vii. Social Groups
viii. Don't know
ix. Others (specify) ……..

17 What significant changes in weather have you observed in your community over the last 20 years?

i. Unpredictable rains [ ]
ii. Prolonged dry season [ ]
iii. Increased temperatures [ ]
iv. Increased rainfall [ ]
v. Don't know [ ]
vi. Others (specify).....

Part C: Effects of Climate variability on livelihoods

State of livelihoods

18 Which of the below livelihoods does your household farm practice:

i. Crop farming [ ]
ii. Livestock rearing [ ]
iii. Fruit Farming [ ]
iv. Fishing [ ]
v. Basket Weaving
vi. Others ……..

19 Name the types of crops that you grow in your farm

20 Name the types of livestock that you keep in your farm

21 For crop production, how many times in a year do you plant [SPECIFY WHICH CROPS?]

Crop ……

22 Which of these statements best describes the current performance of crop production and livestock rearing in your household farm in the last 12 months?

i. Excellent [ ]
ii. Very good [ ]
iii. Good [ ]
iv. Fair [ ]
v. Poor [ ]
vi. Very poor [ ]

Effects of Climate variability on livelihoods

23 What is the main effect of climate variability on your household farm?

i. Drying and yellowing of crops before maturity [ ]
ii. Low crop/livestock yields [ ]
iii. Drying up of water sources [ ]
iv. Pests and Diseases [ ]
v. Stunted growth of crops
vi. Wind erosion
vii. Rural Urban Migration

viii. Insufficient pasture [ ]

ix. Don't know [ ]

x. Others (specify).....

24 How have changes experienced in the above factors impacted your livelihood?.....

25 What changes would you associate with climate variability on each of the following:

i. Crop Production ……

……

ii. Livestock Production ……..

……

iii. Income Generation ……

……

iv. Human Health ……

……

v. Water Sources ……

……

vi. Other (Specify)……

26 Which is the most common effect that your household experiences? …….

Part D: Adaptation strategies to effects of climate variability

27 Have you made any adjustment in your farming practices to climate variability?

Yes [ ] No [ ]

28 What adjustments have you made in your livelihood and farming practices to these long-term shifts in weather? Tick the adjustments made. (Multiple responses allowed)

i. Plant varieties of drought resistant crops [ ]

ii. Build water harvesting schemes [ ]

iii. Implement soil conservation schemes [ ]

iv. Migration of livestock to other areas during drought

v. Changing planting dates [ ]

vi. Increase size of land under cultivation [ ]

vii. Irrigation of crops [ ]

viii. Increase number of livestock [ ]

ix. Reduce number of livestock

x. Diversify from farming to non-farming activity [ ]

xi. Others (Specify)…….

29 Are there institutions/organisations your community has worked with to address the effects of Climate Variability on livelihood or to offer advisory?

Yes [ ] No [ ]

30 If, yes please indicate what type of institutions/organisations they were

i. NGOs

ii. County Government ministry

iii. Private sector

iv. An individual

v. Social Groups

vi. Don't know

vii. Others (specify) ……..

31 If yes, what was that advice?.....

32 How did the advice improve the state of your livelihood (livestock and crop farming) currently regarding the effects of climate variability?……

Part E: Challenges experienced in adapting to climate variability/change impacts

33 What challenges do you realize in implementing your adaptation measures?

i. Lack or shortage of capital [ ]

ii. Insufficient size of land [ ]

iii. Lack of information [ ]

iv. Shortage of labour [ ]

v. Lack of access to water [ ]

vi. Poor health [ ]

vii. Others (specify).....

Awareness of effects of the adaptation measures

34 In your opinion, what environmental effects do the following coping mechanisms cause in Kyawango area?

i. Planting a varieties of drought resistant crops……
ii. Dry land Irrigation of crops ……
iii. Migration of livestock to other areas……
iv. Engaging in other livelihoods, e.g Charcoal burning……
v. Implementation of soil conservation schemes ……..
vi. Diversify livestock types and varieties……..
vii. Change of planting dates/seasons……
viii. Change of size of land under cultivation…….
ix. Reduce/increase number of livestock ……
x. Others (Specify)…….

THANK YOU FOR PARTICIPATING

Appendix 3: Key informant interview guide

1. Has there been any major changes in rainfall and temperature patterns in Kyawango over the last two decades?
2. What effects of climate variability have you observed in Kyawango on crop and livestock rearing?
3. In what ways has climate variability affected the plant and animal species in Kyawango?
4. What copying mechanisms does the Kyawango farmers employ to counteract the effects of climate variability?
5. What environmental impacts has the copying mechanisms brought to the environment?

6. Which institutions or organizations are involved in advising farmers on climate variability and coping mechanisms?
7. In your opinion, which policies and strategies should be put in place to reduce or mitigate the negative effects of climate variability and help farmers to ensure that their livelihoods are secure?

Appendix 4: List of Plates

Rain Water Harvesting and evidence of water scarcity in the area – water carts for transporting water

Adjustments: Irrigation of crops and use of trenches and terraces

A key informant during the study *Focus Group Discussin - KWG*

Indegenous Chicken rearing by different farmers

Improving the soil fertility and use of pesticides (pump for spraying crops)

Adjustments - Maize stalks and nappier grass to serve as extra pasture for livestock

Land degradation as a result of sand harvesting

Appendix 5: NACOSTI License

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Appendix 6: Data Matrix

Study variable	Categorization	Frequency	Percentage (%)
Dependent variable			
1. Adaptation to climate Variability	1 = Yes (adjusted) 2 = No (did not adjust)	76 25	75.2 24.8
Interdependent variables			
Socioeconomic variables			
2. Source of income	1 = None® 2 = Pastoralism 3 = Remittance 4= Salary and Wages 5 = Crop farming 6 = Business	2 7 9 12 63 8	2.0 6.9 8.9 12 62.4 7.9
3. Education level	1 = No formal education® 2 = Primary 3 = Secondary 4 = College & above	12 24 52 13	11.9 23.8 51.5 12.9
4. Size of farmland	1= 1-3 acres 2= 4-6 acres 3 = 7 and above	63 27 10	63 27 10
5. Gender	1 = Male 2 = Female	50 51	49.5 50.5
6. Age	1 = Less than 30 Years 2 = 31-40 Years 3 = 41-50 years 4 = More than 51 Years	7 28 39 26	6.9 27.7 38.6 25.7
7. Number of household members	1 = 1-3 2 = 4-6 3 = 7 and above	29 62 10	29 61 10
8. Marital Status	1 = Married 2 = Single 3 = Divorced 4 = Widowed	68 11 2 20	67.3 10.9 2 19.8
9. Farming Decision	1 = Husband 2 = Wife 3 = Others	79 17 5	78.2 5.0 16.8
10. Source of Labour	1 = Employed Someone 2 = Own Labour	32 69	32 68
Knowledge of Climate Variability			
11. Awareness	1 = Yes 2 = No	99 2	98 2
12. Level of knowledge	1 = None 2 = Minimal 3 = Average 4 = Extensive	2 43 52 4	2.0 42.6 51.5 4
13. Source of Information	1 = Radio/Television 2 = Observation/experience 3 = NGOs 4=County Government Ministry 5 = Private Sector 6 = Social Groups/CBOs	69 89 2 5 1 35	68.3 88.1 2.0 5.0 1 34.7

	7 = Others	10	9.9
14. Changes in weather observed	1 = Unpredictable rains 2 = Prolonged dry season 3 = Increased temperatures 4 = Increased rainfall 5 = High wind speed	71 61 56 0 2	70 60 55 0 1.9
Effects of Climate variability on livelihoods			
State of livelihoods **15. Livelihoods practiced**	1 = Crop farming 2 = Livestock rearing 3 = Fruit Farming 4 = Basket Weaving 5 = Others	92 93 43 4 4	91 92 42.5 3.9 3.9
16. Main Crops grown	1 = cow peas 2 = beans 3 = maize 4 = green grams 5 = mangoes 6 = pumpkins 7 = kales 8 = bananas 9 = millet 10 = sweet potatoes 11 = sorghum 12 = oranges 13 = pigeon peas	78 94 98 21 24 15 16 6 6 6 7 20 89	77.7 93.1 97 20.8 23.8 14.9 15.8 5.9 5.9 5.9 6.9 19.9 88.2
17. Livestock kept	1 = Cattle 2 = goats 3 = sheep 4 = donkey 6 = chicken/poultry	87 80 32 12 24	86.13 79.2 31.7 11.9 23.8
18. **Production performance**	1 = Good 2 = Fair 3 = Poor 4 = Very poor	15 62 15 10	15 61 15 10
19. Effects of Climate Variability	1 = Low yields 2 = Drying up of water sources 3 = Pests and Diseases 4 = Stunted growth of crop	62 13 7 5 8	61.4 12.9 6.9 5.0 7.9

	5 = Migration to other places 6 = Insufficient pasture	4	4.0
20. Most common Effects	1 = Reduced income 2 = Unpredictable Income 3 = Reduced living standard 4 = shortage of water 5 = High cost of production 6 = Migration due to pasture	9 9 4 15 3 2	8.9 8.9 4 14.9 3 2
Adaptation strategies to effects of climate variability			
21. Have you made any adjustments?	1 = Yes 2 = No	76 25	75.2 24.8
22. Adjustments Made	1 = Change crop variety 2 = Water harvesting schemes 3=Implement soil conservation schemes 4= Changing planting date 5 = Increase cultivation land 6 = Irrigation of crops 7 = Reduce number of livestock 8 = Diversify to non-farming activity 9 = Use fertilizer or manure	25 25 62 4 1 12 9 7 1	24.7 24.7 61.4 3.9 0.9 11.8 8.9 6.9 0.9
23. Involved Institutions to adapt to effects of C.V.?	1 = Yes 2 = No	23 78	22.8 77.2
24. Institutions/Organizations involved	1 = NGOs 2 = County Government Ministry 3 = Private sector 6. = Social Groups	11 5 2 4	10.9 5 2 3.9
Challenges faced by households in adapting to climate variability			
25. Challenges faced	1 = Shortage of capital 2 = Insufficient size of land 3 = Lack of information 4 = Shortage of labour 5 = Lack of access to water 6 = Poor health	66 21 30 39 13 6	65.3 20.8 29.7 38.6 12.9 5.9
Environmental effects from measures taken to adapt to CV			
26. Environmental Effects from adjustments	1 = Environmental pollution 2 = Depletion of water sources 3 = Salinization of soil 4 = Environmental degradation	9 16 5 3	8.9 15.8 5 3

Temperature and Rainfall data from KMD

Year	RAI
1980	-1.3
1981	-0.1
1982	0.3
1983	-1.1
1984	0.5
1985	0.5
1986	0.1
1987	-2.1
1988	0.5
1989	0.4
1990	1.1
1991	-0.7
1992	-0.3
1993	0.1
1994	1.1
1995	-0.5
1996	-1.0
1997	0.5
1998	1.5
1999	0.0
2000	-1.2
2001	0.1
2002	0.4
2003	0.0
2004	-0.1
2005	0.1
2006	-0.1
2007	-0.6
2008	-0.8
2009	-1.1
2010	0.5
2011	-0.4
2012	0.0
2013	0.0
2014	-0.8
2015	-1.0
2016	-2.0
2017	-0.5
2018	0.77

Years	Rainfall
1980	457.1
1981	648.3
1982	750.9
1983	490.5
1984	815.7
1985	813
1986	700.5
1987	334
1988	807.1
1989	770.1
1990	975.7
1991	564
1992	615
1993	691.4
1994	977.6
1995	595.2
1996	505.4
1997	816.3
1998	1110.2
1999	661.4
2000	483.8
2001	693
2002	791.2
2003	675.8
2004	657.5
2005	682.7
2007	579.9
2008	534
2009	488
2010	799.8
2011	598.1
2012	669
2013	674.9
2014	545.1
2015	516
2016	357
2017	582
2018	893

Year	MAX TEMP
1980	25.0
1981	24.6
1982	24.8
1983	25.6
1984	25.1
1985	24.2
1986	24.6
1987	25.9
1988	24.8
1989	24.1
1990	24.3
1991	25.2
1992	24.9
1993	24.8
1994	25.2
1995	25.1
1996	25.4
1997	25.4
1998	24.5
1999	25.3
2000	25.6
2001	25.0
2002	25.1
2003	25.3
2004	25.2
2005	25.7
2006	25.2
2007	25.1
2008	25.3
2009	25.9
2010	25.0
2011	26.1
2012	25.9
2013	25.6
2014	25.5