ASSESSING THE EFFECTS OF CLIMATE VARIABILITY AND CHANGE ON CROP FARMERS: SMALL SCALE FARMERS IN RONGAI SUB-COUNTY, NAKURU COUNTY IN THE REPUBLIC OF KENYA

BY

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Declaration

I declare this research presented as being entirely of my own creation. To the best of my knowledge and understanding, it has not been submitted previously, in any form, for academic recognition to this or any other educational institution.

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Signature .....

Date: 15/11/2023

Approval by the supervisor

I have reviewed this project and found it worth for examination.

DR. KENNETH KIVISI MBALI

Signature: ....

Date: 15.11.2023

Dedication

I dedicate this work to my parents, siblings, and friends.

Acknowledgement

I thank God for the good health, and energy. I also want to thank my supervisor for his invaluable support during the process of writing this project. Additionally, I'm thankful to my friends for their encouragement and motivation.

Abstract

The study was carried out in the Rongai Sub-County of Nakuru County, with a focus on assessing how crop farmers are affected by the changes and variations in climate, specifically investigating their socio-economic repercussions. To accomplish this, the researcher outlined four distinct objectives: Firstly, to delve into how the changes in climate influence small-scale farmers and gauge its socio-economic effects on their livelihoods. Secondly, to identify the factors influencing the choices small-scale farmers make when selecting climate adaptation strategies. Lastly, to analyze the factors influencing farmers' perceptions concerning the changes and variability in climate

The research targeted a diverse group comprising small-scale crop farmers, Sub-County officials, administrators, and local leaders. A sample of 255 respondents was thoughtfully selected to participate. Structured questionnaires, focus group discussions, as well as interviews were used to collect data. The study employed stratification to identify various locations, systematic sampling to pinpoint households, simple random techniques for selection of respondents, and purposive sampling to identify informants.

To analyze the collected data, the research employed the Statistical Package for Social Sciences (SPSS) Version 20 software, with the findings being presented in a comprehensible manner through graphs, pie-charts, and tables for descriptive data, while inferential statistics were explored using the chi-square test.

From the results, the farmers were aware of the changes in climate and variability. Moreover, factors such as age, education, farming experience, household size, land size, and capital played pivotal roles in shaping farmers' perceptions and the options they considered for adapting to the changes. Notably, prolonged droughts, declining yields, and increased pest and disease prevalence, were seen as the most significant impacts of the changes ($p=0.0000$). Most farmers reported annual earnings ranging from 21,000 to 40,000 Kenyan shillings from their farming activities. Observable signs such as rising temperatures, less rainfall, and frequent floods, were consistently recognized ($p=0.0000$).

Farmers adapted to these challenges by employing various measures, including mixed cropping, the use of improved crop varieties, and irrigation practices ($p=0.0000$). Insufficient finances (Mean=4.76, S.D=0.43) were commonly cited as the primary hindrance to effective climate change adaptation. The study also highlighted that indigenous knowledge ($p=0.0000$) played a crucial role in disseminating information about the changes and variability in climate among farmers.

In light of these findings, it is imperative for both the National and County Governments to prioritize investment in extension services. These services can provide farmers with accurate and reliable information on changes and variability in climate, enabling them to better navigate the challenges and adapt more effectively.

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Abbreviations and Acronyms

ASALs	Arid and Semi-Arid Lands
CO2	Carbon dioxide
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GCMs	Global Climate Models
GHGs	Green House Gases
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
K Shs	Kenya Shillings
LDCs	Least Developed Countries
NGO	Non-Governmental Organization
SPSS	Statistical Package for Social Sciences
SSA	Sub-Saharan Africa
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development

CHAPTER ONE

1.0 Introduction

The chapter contains critical information on the background, statement of the problem, objectives, research questions, justification and importance of the study. Information on the scope and limitation of the study, assumptions made as well as the definition of important terms are also contained in this chapter.

1.1 Background to the Study

Globally 85 % of farmers representing about 475 million all over the world are small scale farmers operating on a land which is less than 2 hectares[1]. Climate change encompasses several environmental components which include extreme patterns of variations in climate. The United Nations Framework Convention on Climate Change (UNFCCC) in 2018 defines climate change as the alterations in the Earth's climate system, both directly and indirectly linked to human activities. These changes affect global atmospheric patterns and contribute to shifts in climate, in addition to the variations experienced over some time[2]. Furthermore, Mafongoya *et al.* (2015) emphasized that the changes represent a critical global challenge, particularly concerning agricultural practices. They underscored the adverse impacts of increasing temperatures and unpredictable weather patterns on farming activities. The most affected people as a consequence of the climatic changes remain rural farmers through its adverse impacts[3]. Ubisi *et al.* (2017) found that climatic change over the years caused low crop yields by way of lengthy droughts,

[1] Rapsomanikis G. "The economic lives of Small holder farmers. An analysis based on household data from nine countries 2015 p.1. "
[2] "United Nations Framework Convention on Climate Change 1992."
[3]Mafongoya P & Chivenge P. "Small Holder Farmer Perceptions on Climate Change and Variability: A Predisposition for their Subsequent Adaptation Strategies, 2015."

high temperature and reduced precipitation which also affected the global socio-economic, biophysical and ecological systems. Agriculture is the single largest economic activity for rural farmers who are considered to be the most affected by the changes in climate[4], due to significant changes in rainfall and temperature which serve as vital direct inputs to crop regions. Karanja *et al.* (2007) concluded that fluctuations in temperature as well as rainfall are likely to have undesirable impacts on overall crop earnings.[5].

These changes in rainfall and temperature have higher impacts for farmers that practice rain-fed agriculture as well as for those with restricted access to loans and those that cannot access markets. This in essence affects sources of revenue for millions of people who currently are underprivileged and under threat of climate change which has altered the natural resources they are contingent on for agronomics. To curb chronic dependency on rain-fed agriculture, it is imperative to adopt new farming strategies so as to diminish the adversarial effects on their crops. According to the Intergovernmental Panel on Climate Change (IPCC) (2012), adaptation is "the alteration in natural or human systems in response to genuine or anticipated climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities"[6]. Numerous Governmental and Non-Governmental Organizations (NGOs) in agricultural regions can aid formulation of policies that can easily be utilized by farmers.

[4]Ubisi N, Mafongoya P, Kolanisi U & Jiri O. "Smallholder farmer's perceived effects of climate change on crop production and household livelihoods in rural Limpopo province, South Africa. p.9.''
[5]Kabubo-Mariara J & Karanja F (2007) "The economic impact of climate change on Kenyan crop agriculture: A Ricardian approach"
[6]"IPCC, 2012: Glossary of terms. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J Dokken, K.L Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (Eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 555-564.''

Among regions that experience the changes and variability in climate, Sub-Saharan Africa (SSA) is regarded as the greatest susceptible expanse to the changes in climatic situations. This is mainly due to farmer dependence on precipitation for agriculture to feed a population that is currently expanding. It is clear that the African climate is experiencing variations in the average precipitation and temperature patterns coupled with prevalence of weather extremes. The harvests in areas that have long been appropriate for cultivation are also projected to decline. Kotir *et al.* (2011), state that doubts exist regarding the magnitude to which the climate has changed. The changes will most definitely affect all aspects of food productivity, accessibility, availability, stability and utilization and thus bring about increased starvation in the region[7].

The agronomic sector contributes 33% of the country's Gross Domestic Product (GDP)[8]. In employment terms, 40% of Kenyans are employed through agriculture with 70% of them being in the rural parts of the country[9]. Kenya has various climatic conditions that tend to vary from one region to another due to differences in agro-ecological zones, with low temperatures at mountain level and high temperatures at sea level (Maeda *et al.*, 2014). Kenyan climatic conditions vary across the country with annual average precipitation ranging from 250 mm-2000mm in semi-arid and tropical areas respectively (Omondi, 2019). Craparo *et al.* (2015) indicate that Kenya's climatic patterns have changed with the increase in temperature from the1960s at an average mean temperature of 0.21^0C translating to warming of the atmosphere. This in essence has affected crop productivity especially by farmers across the country, especially Rongai Sub-County.

[7]Kotir J. "Climate change and variability in Sub Saharan Africa: a review of current and future trends and impacts on agriculture and food security. 2011.''
[8]"https://www.usaid.gov/kenya/agriculture-and-food-security ''
[9]"http://www.fao.org/kenya/fao-in-kenya/kenya-at-a-glance/en/''

1.2 Statement of the Research Problem

The changes in climate causes global challenges affecting the agricultural sector and production at large. Jose Graziano da Silva projects that by 2050, there will be a need to increase the production in agriculture by 50% to be able to sustain the high food demand by a population that is ever increasing[10].

The majority of farmers who face harsh realities of climate change are small scale farmers who are majorly poor, lack knowledge on the changes in climate, and also have no insurance which makes it difficult for them to diversify their crops or access modern technologies of farming. Literature indicates there has been a drop of crop yields with many scholars attributing it to the variations in climate. In essence it affects farmers' income which further pushes them into poverty making them unable effectively adapt to the changes and variations in climate. Furthermore, adaptation is normally shaped by farmers' perceptions especially through skills after practicing agriculture for extended periods of time. Perceptions vary across different households and are influenced by socio-economics, age, education level, geographical location, and gender.

Most literature has focused on the future changes in climate. The social aspects receive less scholarly literature and if they do research on it; most scholars tend to tackle one issue like perception, adaptation or socio-economics. The researcher is interested in understanding the interconnection between the stated variables of socio-economics, perceptions, adaptation and crop yields.

This has necessitated the investigator to carry out this research on how the changing climate affects small scale crop agronomists.

[10] Graziano da Silva J. (Director General FAO). The future of food and agriculture. Trends and challenges 2017.''

1.3 Objectives

1.3.1 General Objective

Assessing effects of climate change on crop farmers: Cases of farmers practicing agriculture in smaller scales in Rongai Sub-County, Nakuru County in the Republic of Kenya.

1.3.2Specific Objectives

1. To investigate how changes in climate impact the productivity of small-scale crop farmers in the area.
2. To evaluate socio-economic implications of changes in climate on the farmers in Rongai Sub-County.
3. To identify factors that shape choices of adaptation strategies among small-scale farmers residing in Rongai Sub-County.
4. To examine the elements that influence how the farmers view the changes in climate in Rongai Sub-County, Nakuru County, within the Republic of Kenya.

1.4 Research Questions

1. How do changes in climate and variability affect productivity of crops?
2. What socio-economic consequences have been experienced by the farmers due to these changes?
3. What factors are considered while choosing suitable adaptation strategies to help the farmers cope with the changes?
4. What influences farmers' perception on climate change?

1.5 Justification of the Study

The findings from the research will aid various stakeholders in the agricultural sector, as well as policy makers at all levels of government, local farmers, extension officers, public institutions like universities, research institutions and NGOs in that they will help them identify and adjust to climatic change realities which is imperative in developing pro-climate adaptive measures that are suitable for small scale farmers.

1.6 Significance of the Study

Non-Governmental Organizations

The conclusions provided will help improve local farmers' understanding on climate due to NGOs' grassroots connections as well as resources.

Policy Makers

Both national as well as county governments will use the findings to assist small scale farmers cope with changing climatic patterns by formulating proper policies and adaptation mechanisms.

Researchers

The study has provided more information on already known knowledge on climate change and variability thus academicians have additional data to elicit further research in this field. It will form part of literature for future researchers interested in climate change while acting as both reading and secondary source material in the said field.

1.7 Scope and Limitations of the Study

Rongai Sub-county, Nakuru County in the Republic of Kenya was the area of investigation which focused on evaluating how changes in climate impact crop farmers within the area. The

research was based on crop production, socio-economics, adaptive measures and farmer perceptions towards changes in climate.

The research was limited towards maize, wheat and beans. The researcher anticipated reluctance by respondents in providing information on the notion that the information may not be treated with confidentiality which could cost them their work especially those working in the Sub-County and local administrators. The researcher countered this by reassuring everyone involved in the study that their identities as well as the information they provide shall be treated with utmost discretion. The researcher also assured them that the information will only be used for educational purposes.

1.8 Assumption of the Study

It was presumed all respondents understood the changes as well as variations associated with climate. A major assumption was entirely that the population was represented by the targeted respondents. The other supposition of the research was that the respondents targeted obliged enough to provided precise and accurate information.

1.9 Definition of Operational Terms

Climate Variability: Climate variability is fluctuations in average conditions and other statistical measures (like standard deviations, occurrences of extreme events, etc.) of the climate over various scales, distinct from specific weather events. This variability can either be internal or external[11]. Essentially, it represents the changing climate conditions of a region around its long-term average.

[11] IPCC Glossary of terms p.557

At specific time periods every year, the rainfall at a given location the climate is different. Some years the location gets below average rainfall signaling a drought and above average signaling a flood.

Small scale farmer: Farmers practicing subsistence production. The most widely used definition refers to small farms that are less than 2 hectares.

Climate Change: Climate Change shows transformations in the Earth's climatic system observed through scientific measurements. This transformation endures for years or even longer. It includes changes in climate patterns over time.

Changes in climate as defined by the IPCC is the shifts in the measurements in fluctuations in its average characteristics and variability, often spanning decades or more. The changes may arise from internal natural processes, external influences, or alterations caused by human activity.[12].

Adaptation: Adaptation involves the responding to the present or future climate conditions and their consequences to minimize potential harm. In natural ecosystems, adaptation indicates the ability to acclimatize to the existing climate and its repercussions. Human intervention can play a role in aiding adjustment to anticipated climatic changes. Its primary objective is to mitigate harm and capitalize on favorable opportunities.

Indigenous Traditional Knowledge (Experience): This is the information, practices and innovations of native communities. It develops through understandings obtained over centuries

[12] IPCC- Glossary of terms p.557

and adapted to indigenous cultures and environments. The awareness is handed down verbally and through practice from generation to generation[13].

[13] "Inter-agency support group on indigenous peoples' issues report 2014.''

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Previous studies regarding changes and variability in climate, theoretical frame work, empirical framework, existing gaps of knowledge as well as the conceptual framework are contained in this chapter.

2.2 Climate Change and Variability

Rahmstorf *et al.* (2012) explains that surface temperature globally has been on the increase and that has resulted in climate associated changes such as precipitation, soil moisture and rising sea levels[1]. Predictions suggest that we can expect greater fluctuations in the intensity, predictability, and speed of precipitation as the climate continues to evolve. These shifts in climate patterns are contributing to an overall rise in climate variability. Malla (2008) states that erratic changes in climate variability and weather patterns are as a result of human activities[2]. Due to this, the variation in climatic conditions has negatively affected agricultural production[3]. Behera *et al.* (2010) indicate that underprivileged communities as well as countries are expected to undergo adverse effects due to geographic locations, low institutional capacity and low income coupled with over dependence on the agricultural sector which is climate sensitive[4]. Rain-fed farming

[1]Coumou D & Rahmstorf S. (2012) "A Decade of Weather Extremes". Nature climate change 2(7) 491-496
[2]Malla G. "Climate change and its impact on Nepalese agriculture". "*Journal of agriculture and environment* 9 (2008): 62-71.''
[3]"Gregory P, Johnson S, Newton A, and Ingram J." "Integrating pests and pathogens into the climate change/food security debate." "*Journal of experimental botany* 60, no. 10 (2009): 2827-2838.''
[4]Nath P. & Behera B. (2011) "A Critical Review of Impact & Adaptation to Climate Change in Developed and developing Economies".

dependency, low levels of technologies and limited funds contribute to the effects of the changes in climate.

2.3 Theoretical Review

2.3.1 Anthropogenic Global Warming Theory

This theory aims to clarify the ongoing, prolonged rise in the Earth's atmospheric temperature by attributing it to human activities in commerce and agriculture. The rise in gas emissions from greenhouses is directly associated with increased atmospheric temperatures. The emissions consists mixtures of gases that comprise of methane and carbon dioxide (CO_2). Apart from emissions caused by natural sources such as volcanoes, emissions from human industries, transport and livestock are considered as the most significant cause of global warming over the recent centuries. The additional heat retained from increases in CO_2 and other greenhouse gases (GHGs) causes a temperature rise known as enhanced greenhouse effect[5]. Johnson *et al.* (2019), state that since the 1800s, human activity has resulted in the increase in the atmospheric greenhouse gases[6]. Most of the changes in our climate arise from human industry, particularly the combustion of fossil fuels like oil and coal (idib)[7]. To grasp this concept, it's essential to delve into our understanding of the solar system. The delicate balance between the energy we receive from the sun and the energy we emit back into space has been significantly disrupted, leading to alterations in regional and global weather patterns and climate. This disruption is commonly referred to as global warming[8]. Supporters of this theory argue that more than 0.7 degrees Celsius of global warming in the past century and over 0.5 degrees Celsius in the last 30

[5]Khan Z. (2017). "Causes and consequences of greenhouse effects and its catastrophic problems for earth. *International journal of sustainability management and information technologies 3(4) 34-39*.
[6]Johnson C, Mathew D. Affolter, Inkenbrandt P and C. Mosher C. "An Introduction to Geology (2019)".
[7] "idib"
[8] https://www.epa.gov/report-environment/greenhouse-gases.

years is as a result of gases from greenhouses (GHGs). They challenge claims put forth by other scholars who attribute the rise in global warming to natural recovery from the Ice Age.

2.3.2Theory of Solar Variability

The argument by Nashon (2019) is that global solar variability makes up much of global warming despite the presence of man-made GHG emissions[9]. This is mainly due to Solar flares that emanate from the sun's surface which burst to form charged particles also identified as solar winds[10]. Solar winds extend to the earth's surface and in turn affect galactic rays which affect cloud materialization. Fluctuations in cloud materialization result from variations in surface temperatures and wind patterns[11]. The changes affect temperatures, rainfall and also affect weather patterns in areas where small scale farmers depend on rainfall for agriculture which affect crops yield. This study seeks to understand how such variations affect farmers' crop production in Rongai Sub-county in Nakuru in the Republic of Kenya.

2.4 Empirical Review

Limantol *et al.* (2016) state that the farmers' capability of adaptation especially using seasons suggests that adaptation is influenced by the farmers' demographic factors, accessibility to land and their access to services like loans[12].

Nkwusi *et al.* (2015) examined what farmers in urban Lagos, Nigeria thought about climate change. From the survey, younger farmers with higher education levels had enhanced

[9]Omondi N. (2019) "Effect of climate change on agricultural productivity in Kenya".
[10]Nwankwo V, Jibiri N & Kio M. (2020). "The impact of space radiation environment on satellites operation in near-Earth space. *Satellites Missions and Technologies for Geosciences*".
[11]Omondi N. (2019). "Effect of climate change on agricultural productivity in Kenya".
[12]Limantol A, Keith B, Azabre B. A and Lennartz B. (2016) "Farmers' perception and adaptation practice to climate variability and change: a case study of the Vea catchment area in Ghana".

appreciations for climatic change. Older farmers did not fully comprehend what climate change is but had been able to develop some adaptation measures based on experience[13].

Adams *et al.* (2016) investigated how changes in climate affected agriculture. Their research was centered on livestock and crop production across the African continent. Great amounts of CO_2 absorption in the atmosphere and climatic factors such as, precipitation change and temperature have had larger effects on crop production. The research has revealed rising temperatures tend to decrease crop yields and degrade the quality of grains.

Bowen *et al.* (2012) explored the impact that changes in climate brings on economic growth, specifically on agronomics as well as the adaptation steps in several countries with the results indicating more negative effects than the positive ones.[14].

Gregory *et al.* (2012) found that variations in climatic settings significantly influenced food productivity in a negative way. The research findings showed that addressing issues related to food security, mitigating climate-related challenges, and building resilience against future climatic changes require a delicate balance between capital-intensive and consumption-oriented food production systems. This poses a challenge in a world where people rely on agronomy as a source of revenue. The study also stated that agriculture contributes 30% of the anthropogenic GHG productions that negatively influence climate change[15]. Galicia *et al.* (2017) state that two

[13].Nkwusi G, Adeaga S, Ayejuyo A & Annuk A. (2015). "Climate Change; Farmers Awareness, Perception and Response in Lagos state (2015)".
[14] Bowen A, Sarah C & Samuel F. "Climate change, adaptation & economic growth (2012)".
[15]Smith P and Gregory J. (2012). "Climate change and sustainable food production".

of the greatest challenges to humanity is achieving food security globally by decreasing environmental impacts on food productivity and providing healthy diets for people[16].

Karanja *et al.* (2007) explains that there is significant potential for mitigating the impacts that changes in climate has on farmers, through various steps such as responses from the markets, advancements in technology as well as reforms in various institutions. Their study underscores the importance of closely monitoring climate changes and consistently sharing data with farmers to encourage adaptive actions in response to these shifts.

Furthermore, the scholars emphasize the need for enhanced management and conservation of water, as well as its recycling and harvesting. These measures could effectively create irrigation possibilities especially in regions experiencing low rainfalls, thereby bolstering agricultural resilience across the country.[17].

Kasimba (2012) avers that production of crops had been affected due to unstable rainfall levels, as well as high temperatures, leading to pests diseases affecting crops. This resulted in massive crop failure in Guruve[18].

2.5 Crop Production

The changes in climate has affected food production all over the world. In their 2010 article titled "Implications of Climate Change for Agricultural Productivity in the Early 21st Century," Gornall et al. highlight how the variations in climate has affected production of food across the

[16]Ibarrola-Rivas M and Galicia L. (2017). "Rethinking food Security in Mexico: Discussing the need for Sustainable Transversal Policies linking food production and food Consumption". *Investigaciones Geográficas, Boletín de Instituto de Geografía, 2017(94), 106-121*.

[17]Kabubo-Mariara J and Karanja F. (2007). "The economic Impact of Climate Change on Kenyan Crop Agriculture: A Ricardian approach".

[18]Kasimba R. (2012). "Impacts of climate Change on crop Production practices among small scale farmers in Guruve District, Zambia (2012)".

globe. Farmers have historically demonstrated adaptability in response to weather fluctuations and year-to-year variability. Their ability to adapt is rooted in established infrastructure, individual experiences, and farming practices tailored to local climates.

Climate change is poised to affect agriculture by posing threats to farming systems and practices. However, it also presents opportunities for improvement through the adoption of innovative adaptation measures to safeguard food security. Hoffmann et al., in their 2017 research titled "Analysis of Climate Signals in the Crop Yield Record of Sub-Saharan Africa (SSA)," establish strong connections between crop yields and temperature variations. They note that the length of heat or cold waves and variations in plant maturity stages play a significant role in crop yield outcomes during extreme weather events.

In SSA migratory insects like locusts have adapted to the changes in climate with their survival being in concert with the environmental constraints such as wind direction and rainfall. According to Tratalos *et al.* (2007), the environmental constraints will alter the migratory behavior of the locusts. The changes caused in the migratory behavior may bring greater fears regarding food productivity in areas where increased rainfall is expected[19]. Findings by Kiarie *et al.* (2016) indicate that small scale farmers who rely on rainfall for agriculture suffered frequent crop failures due to shortages in rainfall. Predictions by climate scientists indicate that much of Africa has experienced increases in dry conditions as a product of variability in climate. Changes in climate mainly affects developing as well as the Least Developed Countries (LDCs), where farmers have insufficient resources to help them face such changes[20]. Kiarie (2016) found that in Africa, climate variability is causing stress to farmers, though most rural farmers have been adapting to these

[19]Cheke Rand Tratalos J. "Migration, Patchiness and Population processes illustrated by two Migrant Pests (2007)".
[20]Kiarie S. (2016). "Effects of Trends of Climate Change variability and Small scale farmer's perception and adaptation strategies in Kajiado location, Kiambu County, Kenya".

situations for decades depending on ecological zones with their adaptation and coping strategies. Reenberg *et al.* (2011) stated that farmers attributed the decrease in productivity and revenue from rain-fed agriculture to insufficient rainfall both in quality and distribution[21]. The farmers managed to increase revenue by diversifying into livestock.

Studies by Lobell *et al.* (2008) and Kiarie (2016) found major crops in East Africa will suffer significant crop losses by 2030 with the exception of cowpea. Scientists using various models such as global climate models (GCMs) project small changes food production worldwide due to climatic changes. Scientists and researchers agree that variability of climate may bring a substantial decline in agronomics as a result of limited resources.

The IPCC Fifth Assessment report titled "Impact, adaptation and vulnerability (2014) indicates that climate change currently being experienced is due to increased climate variability[22]. Further, Antle (2009) states that the least developed countries will experience much of climate variability as a consequence of over dependence on rainfall for agriculture[23].

2.6 Socio-economic

In a study conducted by Awinda in 2018, researchers explored the influential role of various socio-economic factors driving adaptation of smallholder irrigation practices within the Gem Rae irrigation scheme. This initiative aimed to bolster food security among farmers. The study employed a cross-sectional survey approach, involving in-depth interviews with 120 farmers. The findings illuminated the significance of aspects such as land tenure and size, educational

[21]Nielsen J and Reenberg, A *et al* (2011). "Adaptation strategies and Climate Vulnerability in the Sudano-Sahelian region of west Africa".
[22]IPCC Fifth Assessment report "Impact, Adaptation and Vulnerability (2014)": Reflection on the working group II report of the Intergovernmental Panel on Climate Change.
[23] Antle J. (2009). "Agriculture and food Systems: Adaptations to Climate Change RFF report".

attainment, and access to credit as primary drivers behind the adoption of irrigation methods. These choices were particularly prompted by the challenges posed by climate change and its unpredictable variations.[24].

It's important to recognize that agriculture constitutes a substantial portion of developing economies, and even minor increases in temperature can exert severe pressures on food prices. As underscored by Kiarie in a 2016 projection, the far-reaching impacts of climate change and variability are expected to disproportionately affect incomes of impoverished farmers, especially in developing countries such as Kenya who find it challenging to meet food requirements forcing more people to poverty and hunger[25].

A study by Majule (2008) conducted in the districts of Igunga and Kishapu in Tanzania showed that variability of temperature in the said districts was connected with changes in the weather variables. High temperature increased transpiration which in turn affected the moisture content of the crops that affected pasture productivity for livestock, ultimately proceeding to scarcity of water for both crops and livestock.

Climate change models predict that Africa will be one of the regions that will suffer adversely from climatic variability due the fact that it is already suffering from food insecurity caused by climatic variability[26] as stated by Devereux & Edwards (2009).

[24]Awinda D. "The Socio-Economic Impacts of Irrigated Smallholder Agriculture sustainable household Food security in Kenya (2018)".
[25]Kiarie, S. (2016). "Effects of Trends of Climate Change variability and Small scale farmer's perception and adaptation strategies in Kajiado location, Kiambu County, Kenya (2016)".
[26]Devereux S and Edward, J. (2009). "Climate Change and food Security".

2.7 Perception of Climate Change

Capstick *et al.* (2018) aver that understanding public perception on climatic change is critical when developing effective communication strategies, socially robust technologies as well as democratic policies[27]. The above mentioned scholars aver that the perceptions on climate change are linked to beliefs, attitude, knowledge and apprehensions about if and how the climate is changing.

Teweldemedhin *et al.* (2014) state that education, farm size, family size, family revenue, preparation and farming know-how were considerably influential and interrelated to perceptions relating to climatic change. Governments and Non-Governmental Organisations (NGOs) were said to be pushing forward interventions focused on acknowledged factors that are imperative in aiding farmers build capacity in the battle against climate change effects[28].

Mkuna *et al.* (2016) assessed the farmers' perception on climatic change influences in diverse rice production structures in Morogoro, Tanzania. Outcomes showed socio-economic influences comprising of age, size of the household, education and main undertakings of households affect the adaptation and coping strategy perceptions of rice farmers[29]. The scholars suggested that there needed to be an up scaling in awareness, education and capability building with regard to good agricultural practices that help farmers deal with climatic change.

Perception is the distinctiveness of individuals, their familiarity, the data they obtain, and the geographic cultural conditions they live (van der Linden, 2015; Whitmarsh & Capstick, 2018). Sabrina (2020) shows that life experiences influence perception in that an individual who has

[27]Capstick S and Whitmarsh L. (2018). "Psychology and Climate Change" "Perception of Climate Change p13-33
[28]Teweldemedhin M and Montle B. (2014) "Assessment of Farmers Perception and the Economic Impact of Climate in Namibia: Case study on Small-Scale Irrigation Farmers (SSIFs) of Ndonga Linena Irrigation Project". *Journal of Development and Agricultural economics, 6, No 11 (2014): 443-454,.*
[29].Mugula J and Mkuna E "Farmers perception on Climate Change impacts in different production systems in Morogoro Tanzania (2016)".

directly been affected by extreme climatic actions tends to report that the chances of such events occurring again is reasonably high. Moreover, the opinion a farmer has on climate change can be influenced by the data that she/he obtains. The article put forward the understanding of factors that drive farmers to adopt adaptive measures to cope with the changing environments[30].

2.8 Adaptation

Moser *et al.,* (2010) sought to introduce a pilot methodology that was cost effective and quickly capable of introduction into the planning processes, the appreciation and implication of the impacts of climate change on people in informal urban settlements. The research made visible the effects climate change had on various kinds of vulnerable people, it illustrated what small traders and underprivileged societies are doing to manage impacts caused by climate change, and it also identified how policy and institutional organizations can adapt to the realities of climate change in order to cultivate pro-poor urban climate change strategies regarding resilience. Climate change influences can be mitigated at indigenous community levels though it depends on the severity of extreme weather events[31]. Adaptation strategies are commonly classified into two primary categories, as defined by Moser et al. in their 2010 work. Autonomous adaptation consist of the actions taken by individuals and households facing vulnerability, enabling them to address the challenges posed by climate change and its consequences. These actions do not rely on external technical or financial assistance but instead empower individuals to adapt on their own terms. Planned adaptation measures on the other hand involve deliberate strategies and

[30]de Matos S. "Understanding farmers' perception and adaptation to Climate Change: the case of Rio dos Cantos basin, Brazil (2020)".
[31]Moser C, Norton A, Stein A and Georgieva A (2010). "Pro-poor adaptation to climate change in urban centers: Case studies of vulnerability and resilience in Kenya and Nicaragua".

decisions formulated by government institutions. These initiatives aim to mitigate the impact of climate change on vulnerable farming communities by implementing proactive measures.

The European Commission offers a comprehensive definition of adaptation to climate change, emphasizing the importance of taking action to prepare for and adjust to both the existing and anticipated effects of climate change."[32]. Aaron *et al.* (2017) state that adaptation is understood to mean the adjustment in human structures to mitigate effects, or exploit advantageous opportunities connected to definite or expected climate impacts[33]. Adaptation should be easy and simple for implementation by small scale farmers or by government through appropriate programs targeted at stimulating effective adaptive strategies (planned adaptation). Several researchers assert that to effectively manage the changes, exposed societies will have to put in place various adaptive strategies.

Researchers at the International Fund for Agricultural Development (IFAD 2014) and (UNFCCC 2011) assert that management of impacts of the changes in climate is done effectively through implementing appropriate adaptation measures. Other scholars such as Apata *et al.* (2011) have opined that adaptive strategies should be done in two ways. Farmers should first recognize shifts in temperature and precipitation patterns, and then respond by taking adaptive measures in light of these changes.

Ngigi (2009) has examined that susceptibilities of climate change that occur at numerous scales and effective adaptations are subject to the strategies implemented at national and farm levels.

[32] "https://ec.europa.eu/clima/eu-action/adaptation-climate-change_en.''
[33]Aaron R, Llewellyn H, Konisky D and Kaylor C (2017). "Extreme weather exposure and support for climate Change adaptation".

Adaptations in this sector are more to be expected as reflections of these extreme weather events rather than accumulative impacts attributed to climatic change[34].

According to Lopez-Feldman *et al.* (2021) adaptation requires one to recognize change is happening or anticipate future transformation, thus attributing enough weight to such perception by preparing to implement effective measures. Moreover, the perception by farmers concerning the changes in climate is seen as a precursor to the adoption of agricultural adaptation. In a world with comprehensive economies, sufficient inducements and perfect information, the resolution to implement and or adopt a particular strategy would matters of simply valuing the strategies net benefits. Unavailability of finance, insurance, and inadequate information on adaptation are obstacles to farmers in relation to technological adaptations[35].

Nielsen *et al.* (2011) assert that implementation of adaptive approaches by the farmers is greatly affected by lack of finances, further suggest that crop farmers should be given enough data on the variations in climate. The scholars argue that in SSA, lack of technological advances pose serious challenges to climate adaptation.

Muchapondwa *et al.* (2021) suggest that adaptation strategies can be implemented through various methods such as planting short season crops. In areas where there is decrease in rainfall, farmers are urged to plant drought resilient crops such as sorghum. Irrigation, agro-forestry, soil preservation and changing planting dates are vital adaptive strategies used by small scale farmers[36].

[34]Ngigi, S. "Climate change adaptation strategies: water resources management options for smallholder farming systems in sub-Saharan Africa (2009)".
[35]Feldman A and Gonzalez I (2021) "Farmers' Perception to Climate Change: A Review of the Literature for Latin America".
[36]Komba C and Muchapondwa E (2021) "adaptation to Climate Change by small-scale farmers in Tanzania"

Adaptive measures can be practiced at different levels involving recognizing climatic change and then deciding whether or not to implement. Simane *et al* (2018) further elaborate on the issue of perception; they state that farmers who have an existing view on variations in climate may not chose the adaptive measures due to the interaction between social, economic, environmental, and institutional factors[37].

Anthropogenic climate changes require future allocation of financial resources and planning responses that are more futuristic beyond temporary responses in order to tackle the existing climate variability. Though through anticipation, future scenarios may provide evidence to validate building some adaptation responses. Research by Ngigi (2009) shows that embracing and assimilation of these adaptation measures has been slow by farmers.

The human dimension in regard to agricultural adaptation has identified farmers as core to the success as they are regarded as planners, performers, and innovators based on various factors such as cultural and socio-economic. Moreover, Singh *et al* (2020) state that human dimensions on adaptive measures concentrate on farmers' perception as well as past experiences with regard to climatic change[38].

Some scholars have stated that perceptions by farmers do not necessarily equal adaptation as a number of elements may affect their adaptive capacity. The ability for adaptation is based on farmers' mental capability.[39]

[37]Asrat P and Simane B (2018). "Farmers' perception of climate change and adaptation strategies in the Dabus watershed, North-West Ethiopia." "*Ecological processes* 7(1) 1-13.''

[38]Singh S *et al* (2020). "Farmers' perception of climate change and adaptation decisions: A micro-level evidence from Bundelkhand Region, India." "*Ecological Indicators* 116, 106475".

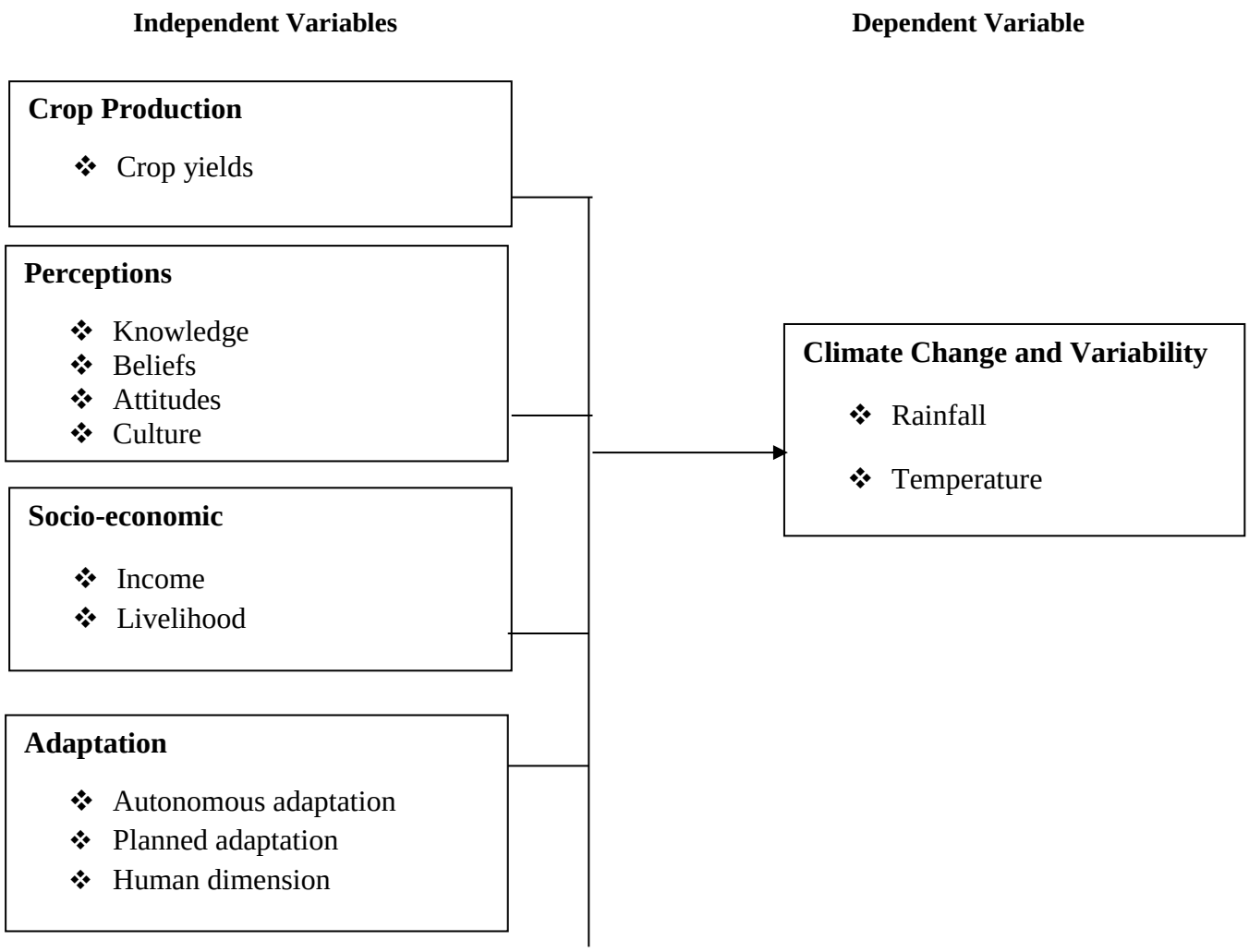
[39]Omerkhil N *et al* (2020) "Climate change vulnerability and adaptation strategies for smallholder farmers in Yangi Qala District, Takhar, Afghanistan." "*Ecological Indicators* 110 (2020): 105863".

2.9 Knowledge Gap

Several studies in the past have focused on how the changes in climate have affected production of crop and, as seen in studies like FAO (2007), Mendelsohn (2000), and Dinar et al. (2008). However, there is insufficient information available concerning the adaptive measures, socio-economics and perception which are the pillars of the research. This necessitated this academic to carry out this investigation to fill the gap.

2.10 Conceptual Framework

The framework, shown in Figure 2.1 below, explains how various variables of the study relate. The independent ones under consideration are Crop Production, Perception, Socio-economic factors, and Adaptation practices. Climate change and variability is dependent.



Source: Researcher, 2022

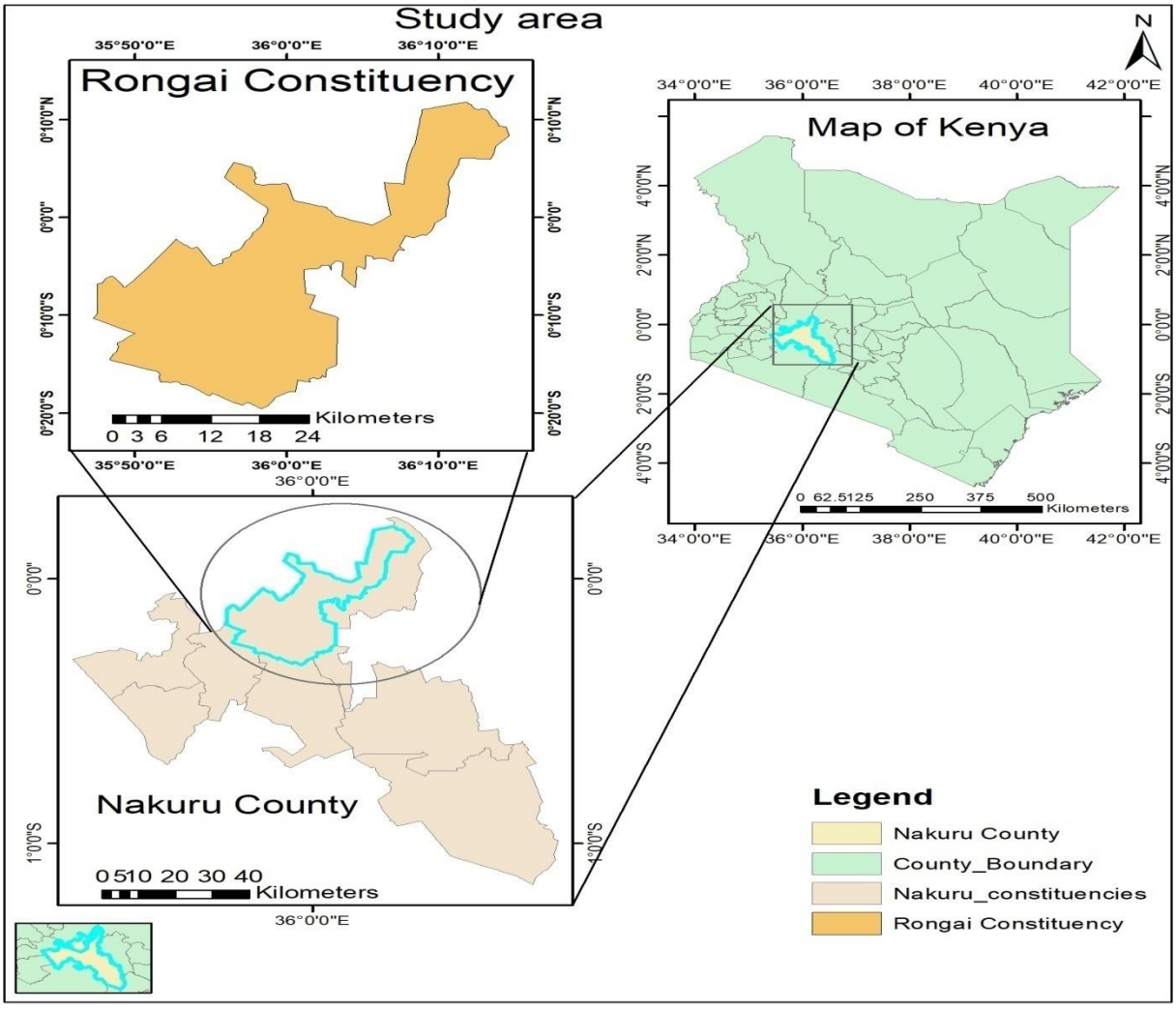
Figure 2:1 Conceptual framework for the study

CHAPTER THREE
RESEARCH METHODOLOGY

3.0 Introduction

Methods deployed by this study are represented in this chapter, including the design, targeted population, sampling size and process, instruments used for the research, their reliability and validity , techniques used for collection and analysis of data, as well as measurable variables. Ethical considerations are also outlined.

3.1 Study Area



Source: Researcher, 2022 Figure 3.1: Map of study area

The study was done in Rongai Sub-county of Nakuru County in the Republic of Kenya, which covers an area of about 1,049.10 square kilometers (km^2) and is made up of five wards. It has an estimated population of 130,132[1].The area has maximum temperatures of 20°c and minimum temperatures of 13°c[2]. Rongai receives an average amount of rainfall of between 760mm- 1270 mm. The area depends on agriculture for food, employment, income, as well as raw materials for industries pursuing processing[3].

3.2 Study Design

The study used a descriptive design which elaborates emerging opinions, processes as well as developments[4]. The said survey design was essential in describing the variations in climate factors influencing production of crops by small scale farmers.

3.3 Data Collection Methods

The data used was both primary and secondary data. Qualitative data was attained by administering questionnaires. Secondary data is what had previously been compiled by others researchers and scholars, and can found in published or unpublished form, online and in libraries. Qualitative data sources like related journals, articles and Kenyan government reports and documents.

3.4 Target Population

The population targeted by this research refers to the component which the conclusions after the study period are generalized (Patton, 2002). In this case, a targeted population is the assembly of individuals the academic aims to conduct a study on and thereafter draw a conclusion. For this

[1] Kenyacradle.com
[2] Weatherspark.com
[3] Kenya Climate Risk Profile: Climate Risk Profile Nakuru County
[4] Mohajan H. (2021). "*Journal of Economic Development, Environment and People: A Successful Investigation in Natural and social Sciences".*

study, the target population included small scale farmers, Ward representatives and community representatives such as Chiefs, Youth Leaders, Women Leaders, and Sub-county Agricultural officers.

3.5 Sampling Procedures and Sample Size

The population sample was carefully chosen using Stratification, Systematic, Purposive and Simple random sampling methods, while the size of the sample was selected using the formula given below by Andrew Fischer. The size of two hundred and fifty five (255) respondents was chosen as suitable. Respondents numbering two hundred (200) were selected from small scale farmers; informants were fifteen (15) made up of Ward Representatives, Chiefs and Village Elders, Sub-county, and NGO officers were carefully chosen and interrogated to offer detailed information for the study.

Forty respondents (40) were selected in groups of four (4) for deliberations, with each group having 10 members of different age, gender and education. The research used the central limit theorem to identify the 255 respondents[5]. Below is the formula administered to determine the sample.

$$n = \frac{Z^2 p(1-p)}{D^2}$$

$$n = \frac{1.96^2 \times 0.21 \times 0.79}{0.05^2}$$

$$= 254.928576$$

$$= 255$$

[5]Hartmann D and Olivarez M. "Asymptotically distribution-free (ADF) interval estimation of coefficient alpha".

Where ***n*** represents the Sample Size, **Z** is the Confidence Interval value (1.96 for 95% Confidence Interval), **p** represents the estimated Proportion of the Population, and **D** represents the Margin of Error.

3.6 Sampling Procedures

The methods used comprised; simple random, stratification, purposive and systematic sampling. The location was stratified with the ward and selected the few needed that took part in the study. The researcher strolled along traditional roads navigating localities to identify every 5th household and select them to take part in the study. The respondents in the selected households who were 18 years were selected using random sampling. The systematic sampling method enabled the researcher to canvass a wide area hence restraining biasness in the data derived from the respondents. Vital informants were selected using purposive sampling method.

3.7 Data Processing

The data from the questionnaires were compiled, coded, verified, reorganized and summarized for computer analysis. After processing, the information was scrutinized using Statistical Package for Social Sciences Software (SPSS) version 20

3.8 Data Analysis

Data was examined using both the descriptive and inferential statistics. Pie charts, bar graphs, percentages and distribution tables were used for descriptive analysis. Standard deviation means and Chi-square test aided in checking the relationship between different variables.

3.9 Validity

Validity is how accurate an instrument gives measurements[6]. In guaranteeing validity, objective questions were encompassed in the questionnaires and pre-testing of the instrument was

[6] Li Y (2016) "How to determine the validity and Reliability of an Instrument".

conducted[7]. For proper internal legitimacy of the research results, expert judgment (by supervisor) was done to ensure that the questions were well apprehended. Questionnaires and interview schedule assembled in close discussion with the University supervisor. Suitable models were carefully chosen to ensure external validity.

3.10 Reliability

Reliability has been defined as the degree a research apparatus yields constant and reliable results. It helps in ensuring dependability and consistency of a test under study. The reliability of the questionnaire used was tested to ascertain its dependability in testing what it was envisioned to measure using the test re-test system[8]. The procedure involved administering the test to the respondents for the first time, then five days later the researcher administered the test a second time before correlating and tallying the results from both testing stages.

3.11 Measurement of Variables

The Likert scale was applied by the study to gather opinion. It is a scale that is used in research to measure respondents' attitudes towards a certain subject. Dr. S. McLeod states that a Likert scale involves a scale which consists of five or seven points that permits a person to express how much they approve or disapprove with a specific statement[9].

3.12 Ethical Considerations

Ethics govern human conduct and has a significant impact on human welfare[10]. The National Commission for Science, Technology and Innovation approved the research. Written consents in

[7] "Eremenco S, Cella D and Arnold B (2005). "A Comprehensive method for the Translation & Cross-Cultural Validation of Health Status Questionnaires".
[8] Li Y (2016) "How to determine the validity and Reliability of an Instrument''.
[9] McLeod S. "Likert Scale Definition, Examples & Analysis.''
[10]Minja D (2009). "Ethical Practices for Effective Leadership: Fact or Fallacy-The Kenyan Experience".

English or Kiswahili, were received from all the respondents before collection of data began. The study required a high degree of confidentiality as the information obtained was of strategic importance. The identities of the respondents were not divulged and all who contributed to this exercise were not coerced.

CHAPTER FOUR

RESULTS

4.1 Introduction

Analysis, interpretation, as well as presentation of the study's data are contained in this chapter. The findings of the study are presented as percentages and chi-square values.

4.2 Questionnaire return rate

Totally, 200 inquiry forms were administered. The completed forms were edited for completeness and consistency. All the 200 forms were returned. This symbolized a 100% reply rate. This concurred with Mugenda *et al* (2003) who state that in simplification terms, a 50% answer rate is adequate for analysis and exposure, 60% good, and 70% and above is considered exceptional[1].

4.3 Socio-demographic Characteristics of Households

Majority 63.5% of respondents were male while 36.5% were female. Respondents aged between 40-50 years were the majority forming 39%, respondents between the ages of 29-39 years formed 22.5% and 10.5% were over 62 years of age. Majority (46.5%) of interviewed respondents had attained secondary level education, 33% primary level and 5.5% had never attended school. The respondents that had 22-32 years farming experience were 48% , 23% had 11-21 years of farming experience and only 12% had between 0-10 years of farming experience. Crop farmers who were the majority formed 48.5%, agro-pastoralists formed 21% and only 4% were salaried. Majority (54%) of the respondents operated 3 acres, 35.5 % had a farm size of between 4-7 acres and 10.5% had a land size over 8 acres. Most of the land was owned by the respondents at 78%, leased at 11.5% and communal at 10.5%. Majority of the household size was 4-7 members at 47%, 3

[1]Mugenda O and Mugenda A. (2003). "Research methods: Qualitative and Quantitative Approaches. Nairobi: African Centre for Technology Studies''.

members at 26% and above 11 members at 8.5%. Access to information by respondent was through indigenous knowledge at 44.5%, through media at 35.5% and extension officers at 3.5%. Majority (51%) of the respondents grew maize, 37.5% grew beans and 11.5% had wheat.

Table 4.1: Demographic characteristics of respondents

Farmers Attributes	Description	Frequencies	Percentage Frequency
Gender			
	Male	127	63.5
	Female	73	36.5
		200	100
Age			
	18-28 years	23	11.5
	29-39 years	45	22.5
	40-50 years	78	39
	51-61 years	33	16.5
	62 years and above	21	10.5
		200	100
Education Level			
	Never attended school	11	5.5
	Primary	66	33
	Secondary	93	46.5
	Tertiary	30	15
		200	100
Occupation			

	Crop Farmer	97	48.5
	Pastoralist	12	6
	Agro-pastoralist	42	21
	Salaried employment	8	4
	Unemployed	22	11
	Business	19	9.5
		200	100
Land Size			
	0-3 Acres	108	54
	4-7 Acres	71	35.5
	Above 8 Acres	21	10.5
		200	100
Land Ownership			
	Communal	21	10.5
	Owner	156	78
	Lease	23	11.5
		200	100
Household Size			
	0-3	52	26
	4-7	94	47
	8-11	37	18.5
	Above 11	17	8.5
		200	100

Farmer Experience			
	0-10	24	12
	11-21	46	23
	22-32	96	48
	Above 33	34	17
		200	100
Access to Information			
	Extension Officers	7	3.5
	Media	71	35.5
	Indigenous Knowledge	89	44.5
	Internet	23	11.5
	Farmers Association	10	5
		200	100
Type of crop grown			
	Maize	102	51
	Bean	75	37.5
	Wheat	23	11.5
		200	100

4.4 Crop Production

Respondents that reported climate variability and change had affected productivity of crop formed a majority at 89% while 11% had different views, suggesting that they had not been affected.

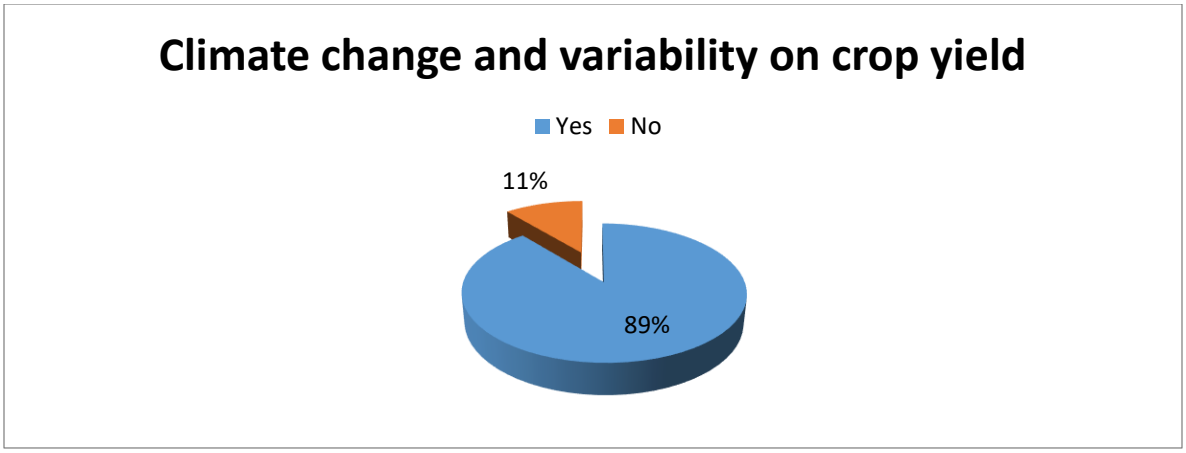


Figure 4.1 Climate change and variability on crop production.

4.4.1 Main effect of climate change and variability on crop production

Table 4.2: Effect of climate change and variability on crop production

Response	**SD**	**D**	**N**	**A**	**SA**	
Presence of pests and diseases	21 10.5%	61 30.5%	33 16.5%	50 25%	25 12.5%	χ^2 = 30.42 d.f=4 P= 0.0000
Prolonged drought	-	-	3 1.5%	56 28%	141 70.5%	χ^2=145.39 d.f=2 P= 0.0000

Interruptions of planting seasons	9 9.5%	18 9%	32 16%	83 41.5%	58 29%	χ^2= 92.05 d.f=4 P= 0. 0000
Reduction of yields	-	13 6.5%	9 4.5%	55 27.5%	123 61.5%	χ^2 = 168.08 d.f=3 P= 0.0000
Increased risks and uncertainties	14 7%	19 9.5%	41 20.5%	93 46.5%	33 16.5%	χ^2= 99.4 d.f=4 P= 0.0000
Poor germination	51 25.5%	36 18%	45 22.5%	45 22.5%	23 11.5%	χ^2= 11.9 d.f=4 P= 0.0018
Withering	15 7.5%	31 15.5%	7 3.5%	84 42%	64 32%	χ^2 = 107.13 d.f=4 P= 0.0000
Unpredictable yields	18 9%	28 14%	11 5.5%	47 23.5%	96 48%	χ^2 = 116.35 d.f=4 P= 0.0000
Stunted growth	70 35%	62 31%	36 18%	20 10%	12 6%	χ^2=64.6 d.f=4 P= 0.0000

Key: Strongly Disagree (SD), Degree (D), Neutral (N), Agree (A), Strongly Agree (SA)

From the above table, there were differences in the presence of pests and diseases p<0.00000, prolonged drought p<0.0000, interruptions of planting seasons p<0.0000, Reduction of yields p<0.0006, increased risks and uncertainties p<0.0000, Poor germination p<0.0018, Withering plants p<0.0000, Unpredictable yields p<0.0000 and Stunted growth p<0.0000. Findings indicate that changes in climate has had serious influences on crops especially during germination, growth and final yields.

4.4.2 Increase of temperature on crop production

Table 4.3: Increase of temperature on crop production

Response	**SD**	**D**	**N**	**A**	**SA**	**Mean**	**Standard Deviation**
Stunted growth	80	37	56	19	8	2.19	1.18
Reduced yields	7	13	21	59	100	4.16	1.08
Poor germination	21	25	34	73	47	3.49	1.27
Increase of pests and diseases	15	20	16	67	82	3.90	1.25
Fast growth of crops	18	27	72	51	32	3.26	1.16
Normal germination	76	50	24	30	20		
Wilting of crops	11	26	13	61	89	3.96	1.24

Majority of the respondents stated that increased temperatures had impacted their crop yield; with the main lamentation on reduced yields (Mean=4.16, S.D=1.08), increase of pests and diseases (Mean=3.90, S.D=1.25), Wilting of crops (Mean=3.96, S.D=1.24) though there were mixed responses on stunted growth (Mean=2.19, S.D=1.18).

4.4.3 Increase of rainfall on crop production

Table 4.4: below provides various responses on increased rainfall on crop production

Response	**SD**	**D**	**N**	**A**	**SA**	
Soil erosion	-	-	-	62 31%	138 69%	χ^2 =28.88 d.f=1 P= 0.0000
Causes diseases	4 2%	12 6%	19 9.5%	104 52%	61 30.5%	χ^2=176.45 d.f=4 P= 0.0000
Loss of nutrients	-	-	-	79 39.5%	121 60.5%	χ^2= 8.82 d.f=1 P= 0. 0030
Rotting of crops	-	-	5 2.5%	56 28%	139 69.5%	χ^2 = 137.23 d.f=2 P= 0.0000
Reduced yields	17 8.5%	23 11.5%	14 7%	88 44%	58 29%	χ^2= 103.05 d.f=4 P= 0.0000
Increase crop production	31 15.5%	52 26%	39 19.5%	33 16.5%	45 22.5%	χ^2= 7.5 d.f=4 P= 0.1117

As shown in Table 4.4: above there was a substantial change on soil erosion $p<0.00000$, causes of diseases $p<0.0000$, loss of nutrients $p<0.0030$, rotting of crops $p<0.0000$ and reduced yields $p<0.0000$. However, the researcher found responses on the increase in crop production $p>0.1117$ to be of no significance to farmers. This is due to the increase in rainfall which caused leaching of minerals, especially fertilizer. The increase in rainfall usually causes soil erosion which also tends to affect production of crops negatively. Most crops require rainfall for germination as well as flowering although too much rain during harvesting may lead to rotting of the crops in fields.

4.5 Socio-economic

4.5.1 Climate change and variability effect on income

78% of the respondents stated that the changes had affected their income while only 22% had not been affected.

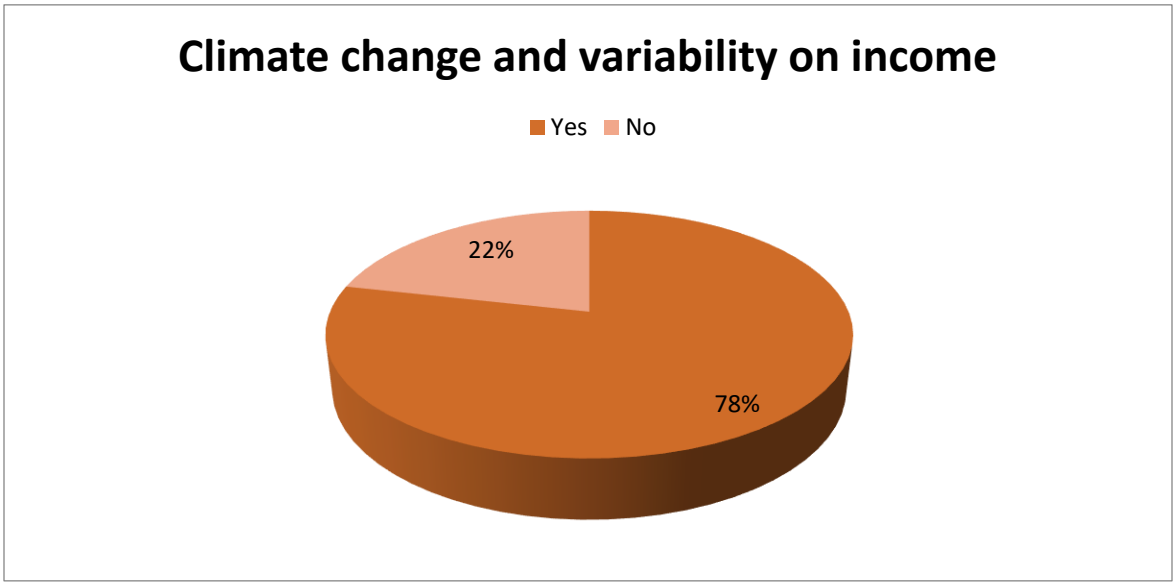


Figure 4.2 Change of climate and variability effect on income

4.5.2 Annual household income

Table 4.5: Climate change and variability effect on income

Income	Number of respondents	Percentage
Below 20,000	33	16.5
21,000-40,000	71	35.5
41,000-60,000	44	22
61,000-80,000	21	10.5
81,000-100,000	17	8.5
Above 101,000	14	7
	200	100

Majority of the respondents' annual income was between sh 21,000- K Sh 40,000 at 35.5%, K Sh 41000- K Sh 60,000 at 22% and least was those earning above K Sh 101, 000 annually at 7%.

4.5.3 Source of income for previous years

Below are some sources of revenue as pointed out by respondents in the previous year. Majority, 42%, were involved in crop farming, 20.5% dairy farming and the least was livestock at 3.5% with a significant difference of (χ^2 = 113.68, d.f=5. P-Value = 0.0000).

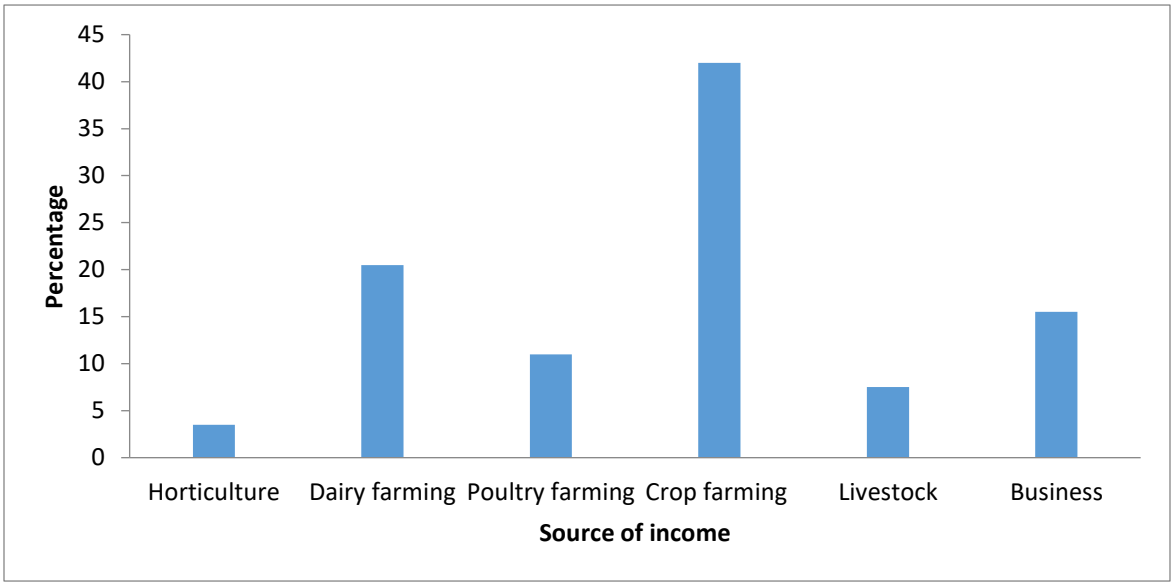


Figure 4.3 Source of income for previous years.

4.5.4 Impact of climate change and variability on farmers' socio-economic status

Table 4.6: Climate change and variability on farmers' socio-economic status

Response	**SD**	**D**	**N**	**A**	**SA**	**Mean**	**Standard Deviation**
My income has not been affected	93 46.5%	71 35.5%	7 3.5%	21 10.5%	8 4%	1.90	1.13
I have earned more income from the crops despite the change in climate and variability	77 38.5%	62 31%	16 8%	28 14%	17 8.5%	2.23	1.32
Climate change and variability has affected my income from crops	12 6%	26 13%	20 10%	59 29.5%	83 41.5%	3.87	1.25
Lack of income has affected adaptation mechanisms	2 1%	8 4%	11 5.5%	64 32%	115 57.5%	4.41	0.84
Farmers cannot diversify to mitigate on climate shock	42 21%	67 33.5%	21 10.5%	30 15%	40 20%	2.79	1.45
Affected the farmers' access to loans due to risks and uncertainties involved	12 6%	23 11.5%	9 4.5%	68 34%	88 44%	3.98	1.22

Majority of the respondents stated lack of income had affected adaptation mechanisms (Mean=4.41, S.D=0.84), the change had affected their income from crop farming (Mean=3.87, S.D=1.25), loan access to farmers was affected by the changes due to the uncertainties involved (Mean=3.98, S.D=1.22) though there were mixed responses in the case where some respondents stated that they had earned more income from the crops despite change of climate and variability (Mean=2.23, S.D=1.32).

4.6 Farmers' perception on climate change and variability

Table 4.7: Perception of farmers on changes in climate and variability compared to past years.

Response	**SD**	**D**	**N**	**A**	**SA**	
Increased rainfall	47 23.5%	21 10.5%	29 14.5%	54 27%	49 24.5%	χ^2=19.70 d.f=4 P= 0.0006
Decreased rainfall	20 10%	28 14%	27 13.5%	55 27.5%	70 5%	χ^2 = 45.95 d.f=4 P= 0.0000
Increased number of hot days	15 7.5%	18 9%	12 6%	69 34.5%	86 43%	χ^2=121.25 d.f=4 P= 0.0000
Increased temperature	4 2%	12 6%	31 15.5%	101 50.5%	52 26%	χ^2= 150.65 d.f=4 P= 0. 0000
Decreased temperature	76	50	36	19	19	χ^2 = 57.35

	38%	25%	18%	9.5%	9.5%	d.f=4 P= 0.0000
Prolonged drought	-	-	-	89 44.5%	111 55.5%	χ^2= 2.42 d.f=1 P= 0.1198
Frequent floods	-	-	-	132 66%	68 34%	χ^2= 20.48 d.f=1 P= 0.0000
Increased pests and diseases	-	-	7 3.5%	66 33%	127 63.5%	χ^2=108.01 d.f=2 P= 0.0000
Decrease in yield	-	-	14 7%	113 56.5%	87 43.5%	χ^2 = 73.85 d.f=2 P= 0.0000
Dryness of rivers	-	-	-	99 49.5%	101 50.5%	χ^2=0.02 d.f=1 P= 0.8875
Increased land degradation	63 31.5%	58 29%	34 17%	42 21%	3 1.5%	χ^2=56.55 d.f=4 P= 0.0000

Table 4.7 above shows there were significant differences where farmers felt there was an increasing number of hot days $p<0.00000$, increased rainfall $p<0.0006$, increased temperatures

p<0.0000, frequent floods p<0.0000, decrease in yields p<0.0000,increased pests and diseases p<0.0018 and increased land degradation p<0.0000. However, the researcher found responses on prolonged drought p>0.1198 and dryness of rivers p> 0.8875 to be of no significance. Dryness of the rivers may be more of human anthropogenic activities than climate change and variability. Drainage of wetlands which are some of the sources of rivers may lead to dryness. Planting of eucalyptus trees along river banks may affect the flow of rivers and the same may apply to over-utilization of river water for irrigation purposes. Deforestation may affect rainfall leading to prolonged drought in different areas especially those depending on rain-fed agriculture.

4.6.1 Perception of farmers on changes in rainfall

Figure below provides information farmers perception on changes in precipitation. Farmers who perceived light density rainfall in recent years formed a majority of 26.5%, 20.5% felt there was high density rainfall that also affected the planting season and 3% planted earlier due to the early onset in rainfall with a significant difference of (χ^2 = 61.94, d.f=6. P-Value = 0.0000.

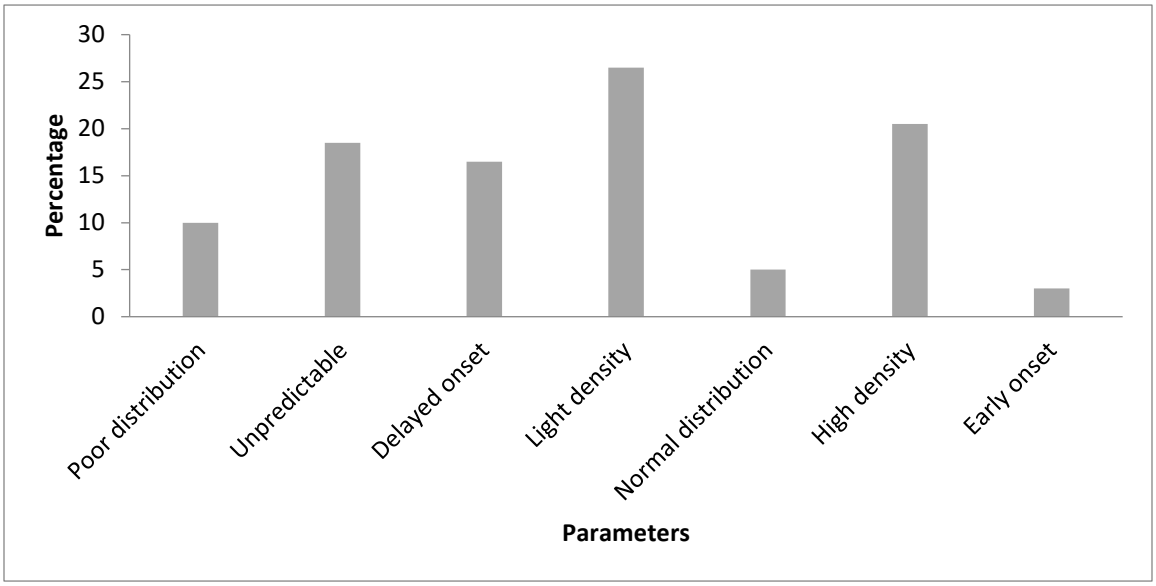


Figure 4.4 Perception of farmers on changes in levels of rainfall.

4.6.2 Perception of farmers on temperature trends in Rongai Sub-County

Majority of the respondents, at 58.5 % felt there was an increase in temperatures, while others felt that temperatures were normal (29%), and the least stated that temperatures had become unpredictable with a significant difference of (χ^2 = 147.56, d.f=3. P-Value = 0.0000).

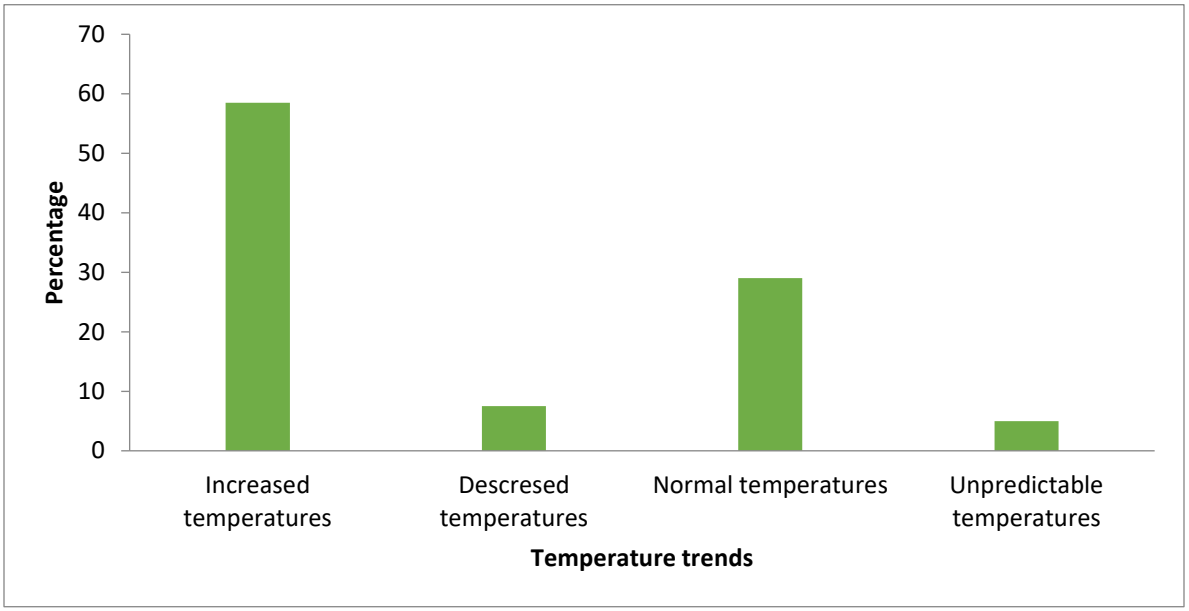


Figure 4.5 Perception of farmers on temperature trends.

4.7 Adaptation Strategies

Table 4.8: Adaptation strategies to changes in climate and variability.

Response	**SD**	**D**	**N**	**A**	**SA**	
Mixed cropping	-	-	-	48 24%	152 76%	χ^2 = 54.08 d.f=1 P= 0.0000
Improved crop varieties	-	-	-	71 35.5%	129 64.5%	χ^2=16.82 d.f=1

						P= 0.0000
Agro-forestry practices	6 3%	11 5.5%	12 6%	109 54.5%	62 31%	χ^2= 200.65 d.f=4 P= 0. 0000
Soil conservation practices	11 5.5%	31 15.5%	44 22%	63 31.5%	51 25.5%	χ^2 = 39.7 d.f=4 P= 0.0000
Irrigation practices	16 8%	21 10.5%	15 7.5%	61 30.5%	87 43.5%	χ^2= 105.3 d.f=4 P= 0.0000
Adjusting planting dates	9 4.5%	13 6.5%	30 15%	82 41%	66 33%	χ^2= 105.75 d.f=4 P= 0.0000
Relocating from dry to wet, river banks and wetlands	20 10%	41 20.5%	32 16%	55 27.5%	52 26%	χ^2 = 20.85 d.f=4 P= 0.0003
Grow crops that mature faster	9 4.5%	24 12%	7 3.5%	91 45.5%	69 34.5%	χ^2 = 143.7 d.f=4 P= 0.0000
Planting drought resistant crops	16 8%	11 5.5%	26 63%	63 31.5%	84 42%	χ^2=101.95 d.f=4 P= 0.0000

Increased use of inorganic fertilizers	71 35.5%	65 32.5%	37 18.5%	15 7.5%	12 6%	χ^2 = 75.1 d.f=4 P= 0.0000
Diversity of crops	7 3.5%	16 8%	25 12.5%	67 33.5%	85 42.5%	χ^2=116.1 d.f=4 P= 0.0000
Diversification to other enterprises	20 10%	25 12.5%	20 10%	74 37%	61 30.5%	χ^2== 65.55 d.f=4 P= 0.0000

As shown in the above table, there were significant adaptive measures put in place to mitigate the effects of change in climate: mixed cropping $p<0.00000$, improved crop varieties $p<0.0000$, agro-forestry practices $p<0.0000$, soil conservation practices $p<0.0000$, irrigation practices $p<0.0000$,adjusting planting dates $p<0.0000$, relocating from dry to wet, river banks and wetlands $p<0.0003$, grow crops fast maturing crops $p<0.0000$, Planting drought resistant crops $p<0.0000$, diversify of more crops $p<0.0000$ and diversification to other enterprises $p<0.0000$.

4.7.1 Challenges to changes in climate strategies of adaptation among the small scale farmers

Table 4.9: Climate adaptations strategies.

Response	SD	D	N	A	SA	Mean	Standard Deviation
Lack of capital	0 0%	0 0%	0 0%	49 24.5%	151 75.5%	4.76	0.43
Lack of information about proper adaptation mechanisms	3 1.5%	7 3.5%	13 6.5%	120 60%	57 28.5%	4.10	0.79
Lack of ready market for farm produce	63 31.5%	88 44%	26 13%	20 10%	3 1.5%	2.06	0.99
Lack of opportune forecasting data on the anticipated changes in climate	6 3%	10 5%	30 15%	68 34%	86 34%	4.09	1.02
Lack of information about proper adaptation mechanisms	2 1%	10 5%	21 10.5%	67 33.5%	100 50%	4.27	0.91
Shortage of water for irrigation	13 6.5%	43 21.5%	28 14%	80 40%	36 18%	3.42	1.19
Poverty	0 0%	8 4%	18 9%	81 40.5%	93 46.5%	4.30	0.79

Several respondents stated that lacking capital impacted their adaptation abilities (Mean=4.76, S.D=0.43), lack of information about proper adaptation mechanisms (Mean=4.10, S.D=0.79), lack

of ready market for farm produce (Mean=2.06, S.D=0.99) lack of information about proper adaptation mechanisms (Mean=4.27, S.D=0.91), poverty (Mean=4.30, S.D=0.79).

4.7.2 Awareness about changes in climate and variability

Majority, 51.5%, stated that information they issued had been obtained through indigenous knowledge, 15.5 % stated they had extensive knowledge about the topic obtained through education, media, Non- Governmental Organizations (NGOs) and Sub-county officers. Majority of them stated that they had been observing changes for long periods of time while others, at 6.5% were not informed about the changes with a significant difference of (χ^2 = 181.48, d.f=5. P-Value = 0.0000).

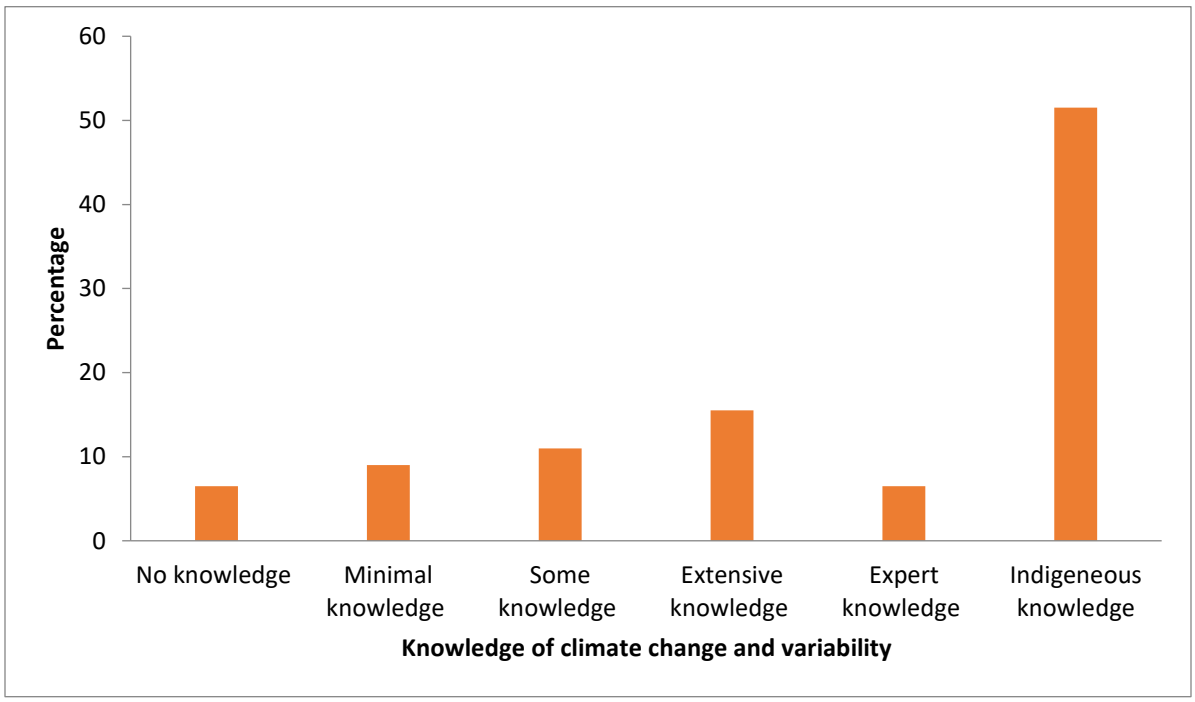


Figure 4.6 Awareness about changes in climate and variability

CHAPTER FIVE

DISCUSSION

5.0 Demographics characteristics

Rongai forms part of the arid and semi-arid lands (ASALs). The farmers remain aware of the changes in climate, as seen from adaptation measures already in place. Ndambiri *et al.* (2012) aver that in ASALs, 94% of farmers had recognized variations in the climate. Education is an imperative feature which influences the farmers' adaptive strategies. The dissemination of knowledge and improved education are essential policy measures for motivating indigenous population's implementing numerous development and natural resource conservation initiatives[1]as stated by Anley, Bogalen & Haile-Gabriel (2007).

Secondary school level of education was attained by 46.5%, thus suitable for farming and capable of using modern technology in farming while adapting mitigation measures as consequences of the changes and variability in climate. Enhanced education lead to tougher positive observations by the farmers on the changes. The outcomes concur with the study by Deressa *et al.* (2009) which explained that levels of education impact crop variety, soil and water management as adaptive methods[2]. The same is supported by a study by Makuvaro *et al.* (2018). Higher levels of education leads to enhanced farming experiences and awareness. It also encourages the enthusiasm to acquire new knowledge by undergoing training on the changes in climate.

[1]Anley Y, Bogalen A & Haile-Gabriel A. (2007)."Adoption decision and use intensity of soil and water conservation measures by smallholder subsistence farmers in Dedo district, Western Ethiopia.''
[2]Deressa T *et al* (2009) "Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia".

There were more male respondents than females in the study; numerous research has revealed that at farm level gender is a significant element affecting the adoption decisions. Dolisca *et al*. (2006) observed that female farmers preferred adaptive practices more than males[3]. However, Drake *et al.* (2003) found that gender did not influence the farmers' resolutions to implement adaptive measures[4]. 39% of the respondents were aged 40-50, while those between 29 and 39 years were 22.5%. According to Mwaniki (2016), the Kenyan rural population is 63% and 47% of that population is reasonably youthful falling under 15 years of age[5]. The conclusion concur with Onyango *et al.* (2019) who suggest that practiced farmers are more informed about the changes in climate than younger farmers[6]. Findings showed that 48% of farmers had between 22 and 32 years farming experience. Extended periods of farming usually years of farming experience have a substantial affiliation with the perception and the adaptive strategies implemented by farmers[7]. This is according to Ayanlade *et al.* (2017). Therefore, it is safe to say that farming experience usually over long periods of time influences perceived knowledge.

Family size is vital in rural settings especially in provision of labor; from the findings, majority consisted of between 4 and 7 members at 47%. Zizinga *et al.* (2017) concluded that the size of the household determined the decision to choose a particular adaptive techniques[8]. This account also aligns with the study by Balew et *al.* (2014).

[3]"Dolisca F, Carter D, McDaniel, J, Shannon D, & Jolly C. (2006). "Factors influencing farmers' participation in forestry management programs: A case study from Haiti".
[4]Lars D and Wagayehu B (2003). "Soil and water conservation decision behavior of subsistence farmers in the Eastern Highlands of Ethiopia: a case study of the Hunde-Lafto area.
[5]Mwaniki F. (2016). "Kenyan Farmers' perception of and adaptation to Climate Change before and after a radio program Intervention". (Doctoral dissertation, James cook University).
[6] Onyango C and Agesa B. (219) "Climate Change effects on Crop Productivity in Yatta Sub-County Kenya: Farmers' perception and adaptation Strategies".
[7] Ayanlade A, Radeny M and Morton J. (2017) "Comparing smallholder farmers' perception of climate change with meteorological data: A case study from southwestern Nigeria".
[8]Zizinga A, Kangalawe R, Ainslie A, Tenywa M, Majaliwa J, Saronga N & Amoako E. (2017). "Analysis of farmer's choices for climate change adaptation practices in South-Western Uganda 1980-2009".

Accessing information is critical in determining farmers' adaptive measures and perception issues. Positive relationships exist between farmers' access to information which they require to make adaptive decisions. Chances of farmers adjusting to climate change practices and advances increase when they have access to any information they require[9]as stated by Kimaru-Muchai *et al.* (2020).

Gifford *et al.* (2011) state that people who have an idea or are cognisant of the occurrence of the changes in climate are not aware of the particular engagements that can be undertake in order to deal with its effects[10]. Access to information by respondents was through indigenous knowledge at 44.5% and through media at 35.5%. The findings showed extension services were the last option by farmers. Bryan *et al.* (2013) showed that extension services, credit as well as information on climate increased resilience to the changes[11]. Farming family units are likely to perceive climate change wrongly or not perceive it at all if they did not get beneficial information from extension agents' visits. The results contradict the averments by Kimaru-Muchai *et al.* (2013) in that the use extension officers from government as well as non-governmental organizations is for farmers to source material on the usage of animal manure for farming.

Majority (54%) of the respondents operated on land sizes of 3 acres, 35.5 % had farm a size of between 4 and 7 acres and 10.5% had land size of over 8 acres. The probability of implementing the required measures is regulated by farm size[12]as stated by Belay *et al.* (2017).Crop

[9]Kimaru-Muchai S, Mucheru-Muna M and Mugwe J, (2020) "Accessibility and Reliability of Information Sources in Dissemination of Soil Fertility Management in Eastern Kenya".
[10]Gifford R. (2011). "The dragons of inaction: Psychological Barriers that limit Climate Change Mitigation and Adaptation".
[11]Bryan E, Ringler C, Okoba B, Roncoli C, Silvestri S and Herrero M (2013). "Adapting Agriculture to Climate Change in Kenya: Household strategies and Determinants".
[12]Belay A, Recha J. Woldeamanuel T and Morton J. (2017) "Smallholder farmers' adaptation to Climate Change and Determinants of their Adaptation decisions in the central Rift valley of Ethiopia".

diversification in large farms afford the distribution of risks associated with irregular weather changes. Most of the respondents in this study are small scale farmers who should be supported through the required technological and institutional interventions to enable them adopt the necessary measures.

5.1 Crop Production

The verdicts indicate that the changes in climate change affected the production of crops as a result of pests and diseases p=0.00000, prolonged drought p=0.0000, interruptions of planting seasons p=0.0000, reduction of yields p=0.0006, increased risks and uncertainties p=0.0000. Similarly, East African increases in temperature, low or unpredictable rainfall and land degradation resulting from climate change had decreased crop production as stated by Thornton *et al.* (2009). Pests and disease escalations have been as a consequence of temperature increase (Mean=3.90, S.D=1.25). USAID (2019) discovered that increases in temperature has a direct connection with the advent of pests, diseases, drought and dryness of water bodies.

5.2 Socio-economic

Majority of the annual income earned by the respondents was between 21,000 and 40,000 shillings at 35.5%; majority, 42%, were involved in crop farming and 20.5% of the respondents stated that lack of income had affected adaptation mechanisms (Mean=4.41, S.D=0.84). Sarker *et al*. (2013) aver that increases in farm revenue improves potentials of complementary irrigation, agro-forestry and different variations of crop as adaptation measures among farmers affected by climatic change[13]. Farmers' per-capita income is a stimulus to their decisions in applying adaptive measures. Maponya *et al.* (2013) stated that agriculture was the most important sector in African

[13] Sarker R, Rashid A, Khorshed A and Gow J (2013) "Assessing the Determinants of Rice farmers' adaptation strategies to Climate Change in Bangladesh".

countries where its Gross domestic Product (GDP) is approximately 30% with 70% of the populace depending on agriculture[14].

5.3 Perception

The findings on perception indicate farmers felt there were increases in the number of hot days p=0.00000, increased rainfall p=0.0006, increased temperature p=0.0000, frequent floods p=0.0000, decrease in yields p=0.0000, increased pests and diseases p=0.0018 and increased land degradation p=0.0000. A majority of 26.5 % of the respondents stated that there was light intensity rainfall in recent years while 20.5% felt there was high intensity rainfall. Most of the respondents experienced a rise in temperature p=0.0000. Risks and opportunities are perceived to affect farmers' source of revenue and adaptive measures[15], as stated by Brown *et al.* (2003). Jianjun *et al*. (2015) state that perception based research at grass root levels is important in developing strategies to respond to climate change[16]. These conclusions are similar to results from Kitinya *et al.* (2012) where farmers reported the increase in temperature and drought were more frequent. Krosnick *et al.* (2006) stated that a population that had experienced higher temperature locally due to experience registered a better awareness about climate change as opposed to those that had not[17]. Donner *et al.* (2013) investigated how public outlook about the changes in climate in the United States was influenced by temperature fluctuations. The study led them to conclude that since 1990, climate variability was a major factor that influenced the public's opinion on climate change. It

[14] Maponya P & Mpandeli S. (2013) "The role of extension services in Climate Change adaptation in Limpopo province, South Africa"
[15] Adger W, Huq S, Brown K and Conway D. (2003) "Adaptation to Climate Change in the Developing world".
[16]Jianjun J, Yiwei G., Xiaomin W, & Pham N. (2015) "Farmers' risk preference and their Climate Adaptation Strategies in Yongqaio District, China".
[17]Krosnick J, Holbrook A and Visser P (2006) "The Origins and Consequences of a Democratic Citizens' Policy Agendas: a study of Popular Concern about Global Warming".

was found out that change in temperature influenced people's opinions, their willingness to adjust their attitude and or support climate policy[18].

Macharia *et al.* (2012) indicate that temperature increases and premature precipitation shadowed aridness, unpredictable precipitation patterns, long dry seasons and drying of water bodies were signs of climate change[19].

Signs of climate variability in dry lands are temperature and long-term rainfall. They manipulate rainfall efficiency and water accessibility for farming. Overwhelmingly, a significant number of Kenyan farmers were mindful that climate change presented itself as higher temperature and lower precipitation amounts. Precipitation was inconsistent and drought occurrences increased.

5.4 Adaptation

Most of the respondents adopted mixed cropping p=0.00000, improved crop varieties p=0.0000, agro-forestry practices p=0.0000, soil conservation practices p=0.0000 and irrigation p=0.0000. These result signify that altering crop variety is an achievable adaptive measure. Ogalleh *et al.* (2012) concur stating that smallholder farmers were informed on how to respond to climate variability by diversifying varieties of crops, migrating and the selling of livestock[20]. The farmers experience greater flexibility in adaption measures to climate change due to diversifying crop varieties. The opinions of or consciousness, as well as employing adaptive measures were swayed by social, economic, and environmental elements which include absence of data, finance, scarcity

[18]Donner S and McDaniels J. (2013). "The Influence of National temperature in the U.S since 1990".
[19]Macharia P, Thuranira G, Nganga L, Lugadiru J & Wakori S (2012) "Perceptions and Adaptations to Climate Change and Variability by immigrant farmers in semi-arid regions of Kenya".

[20]Ogalleh S, Vogl C, Eitzinger J and Houser M (2012) "Local Perceptions and Responses to Climate Change and Variability: The case of Laikipia District, Kenya".

of land and labor, irrigation inefficiencies, climate variability, weather extremes and unstable markets.

When it comes adoption of the most effective approaches, most respondents had challenges implementing such measures due to lack of capital (Mean=4.76, S.D=0.43), lack of information about proper adaptation mechanisms (Mean=4.10, S.D=0.79) and lack of ready market for farm produce (Mean=2.06, S.D=0.99).A profound obstacle to adaptive measures by farmers in developing nations is deficiency of financial resources. This is supported by Tambo *et al.* (2013) where farmers faced challenges in adapting due to nonexistence of information on climate change, suitable adaptive measures and unavailability of credit[21]. Significantly, farmers in this study stated credit was a barricade to adaptive measures. In this regard, National and County governments should make all efforts to increase farmers' access to financial resources. In developing economies lack of funds or inadequate funding have prevented the farmers from adopting farm management practices. Adaptation costs as well as deficiency in finance were cited as the greatest challenge faced by farmers in this research who employed adaptive measures.

Majority, 51.5%, stated that the knowledge they had about climate change and variability was gained through indigenous knowledge. Indigenous awareness increases adaptive aptitudes and capabilities in societies, and their ability to adapt effectively to the changes. Ghorbani *et al.* (2021) also explained that farmers had adopted several effective practices despite low climate science literacy.

[21]"Tambo A and Abdoulaye T. "Smallholder farmers' perception of and adaptation to Climate Change in The Nigerian savanna (2013)"

Conclusion

The research on the effects of climate variability and change on small scale farmers provides information on perception, socio-economic as well as adaptation by farmers. Descriptive statistics were employed to deliver respondents' insights. Conclusions indicate majority respondents observed changes in climate and variability through increased levels of temperature and erratic rainfall over the years. Age, education levels, experience in farming and information accessibility swayed the perception of the farmers on changes of climate.

Deficiency in finance was allude to as a key restraint to adaptive strategies adopted by farmers. Though there has been recent technological advancement in weather forecasting, most of farmers still rely on indigenous knowledge in determining weather changes and adaptation options.

Recommendations

1) National and County governments need to invest in extension studies so that farmers access accurate and reliable facts.
2) Limited funding was cited a key hindrance affecting the adaptation towards the changes in climate; farmers should therefore be provided with affordable loan services to enable them adapt good approaches towards the changes in climate.
3) Meteorological Departments together with the Agricultural Ministry in the republic of Kenya should warrant reliable, precise and customized weather data are chronicled and advisories regarding weather are developed timely and availed to the farmers.
4) Areas for further research include; researching on lack of financial support and the impact of adaptive strategies needed to decrease effects associated with the changes in climate.

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APPENDICES

I: Questionnaire for small scale farmers

INTRODUCTION

I, Paul Sitieney, a student at the University of Nairobi, and I am doing a research on "*Assessing the effects of climate variability and change on crop farmers: The case of small scale farmers in Rongai Sub-County, Nakuru County in the Republic Kenya".* Any information contained in this research is considered confidential, and will only be used for academic purposes.

SECTION A: Socio-demographic characteristics of the respondents

Gender

[1] Male [2] Female

Age group

[1] 18-28 years [2] 29-39 years [3] 40-50years [4] 51-61 years [5] 62 years and above

Education level.

[1] Never attended school [2] Primary [3] Secondary level [4] Tertiary level

Occupation

[1] Crop Farmer [2] Pastoralist [3] Agro-pastoralist [4] Salaried employment [5] Unemployed

Land size

[1] 0-2acres [2] 4-6 acres [3] Above7acres……

Land Ownership

[1] Communal [2] Owner [3] Lease

Types of crops planted by farmers……..

SECTION B: Crop Production

Has climate change affected your crops yield?

Yes ( ) No ( )

What is the main effect of climate change and variability on production of crops?

Tick the level of agreement with the statement

Response	**SD**	**D**	**N**	**A**	**SA**
Presence of pests and diseases					
Prolonged drought					
Interruptions of planting seasons					
Reduction of yields					
Increased risks and uncertainties					
Access to loans					

Key: Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree

SECTION C: Socio-economic

1. Has climate change and variability affected your income?

   Yes ( ) No ( )

2. How much were you earning from your crops (in Kenya Shillings)?

Crops	Initial Earnings	Current earnings
Maize		
Beans		
Wheat		

3. How has climate change affected the socio-economics of farmers?

   Tick the level of agreement.

Response	**SD**	**D**	**N**	**A**	**SA**
My income has not been affected					
I have earned more income from the crops despite change of climate and variability					
Climate change and variability has affected my income from crops					
Lack of income has affected adaptation mechanisms					
Farmers cannot diversify to mitigate on climate shock					
Affected the farmers' access to loans due to risks and uncertainties involved					

SECTION D: Farmers' Perception on Climate Change and Variability

13. Do you believe there are changes and variability in climate?

Tick the level of agreement.

Response	**SD**	**D**	**N**	**A**	**SA**
Increased rainfall					
Decreased rainfall					
Increased number of hot days					
Increased temperatures					
Decreased temperatures					
Prolonged drought					
Frequent floods					
Pest and diseases					

14. Do these perceptions affect farming activities?

……
……

15. Issues experienced as result of climatic change and variability.

……
……

SECTION E: Adaptation

16. Which of the following strategies of adapting to the changes in climate has been adopted by your household?

    Tick the level of agreement.

Response	**SD**	**D**	**N**	**A**	**SA**
Mixed cropping					
Improved crop varieties					
Agro-forestry practices					
Soil conservation practices					
Irrigation practices					
Adjusting planting dates					
Migrating from dry to wet river banks and wetlands					
Grow crops that mature faster					
Planting drought resistant crops					
Increase use of inorganic fertilizers					

17. What are the key challenges towards strategies of adapting to the changes in climate among the small scale farmers?

Response	**SD**	**D**	**N**	**A**	**SA**
Lack of capital					
Poor infrastructure					
Lack of information about proper adaptation mechanisms					
Lack of ready market for farm produce					
Lack of timely climate forecasting information on the expected climate changes					

Lack of information about proper adaptation mechanisms					
Shortage of water for irrigation					
Poverty					

18. How knowledgeable are you about the changes in climate and variability?

No knowledge [ ]

Minimal knowledge [ ]

Some knowledge [ ]

Extensive knowledge [ ]

Expert knowledge [ ]

Appendix II: Interview schedule guide

1. Gender ----------Position held in government and/or community----------
2. Have you ever heard of changes in climate and variability?
3. Has changes in climate affected small scale crop farmers? If yes, name some of the ways.
4. In your own opinion, do you think that changes in climate has led to a reduction in the production of crops? If so, in what ways?
5. In your own opinion, do you view the changes in climate as a threat in the production of crops?
6. As a leader, do you think that the changes in climate affect the economic wellbeing of small scale farmers?
7. What are some of the measures taken by farmers to adapt effectively to the changes and variability in climate?
8. Do local farmers understand the changes and variability in climate? Do they have access to information on the same?

Appendix III: Focused group discussion guide questions

1. What is climate change and variability?
2. Do you believe that the changes and variability in climate exist? If yes, state the reasons.
3. How does the changes and variability in climate affect crop yields?
4. Has the changes and variability in climate affected your earnings?
5. Is there a difference between initial and current earnings due to the changes and variability in climate?
6. Does existing perception affect adaptation measures undertaken by farmers?
7. State some of the adaptive measures undertaken by farmers to effectively cope with the changes and variability in climate?
8. What information do farmers have relating to the changes and variability in climate?
9. What are the challenges associated with adaptation measures?