Adaptations and mitigations to climate change by stakeholders in the vegetable production systems in the Mount Kenya region

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THE NETHERLANDS

SEPTEMBER 13th 2023

A Research Project submitted to Van Hall Larenstein University of Applied Sciences as a partial fulfilment of the requirements for the degree of master in APCM Course-specialisation in horticulture chains management

ACKNOWLEDGEMENTS

First, I would like to thank God for his grace and blessings.

Secondly, I am grateful to the Dutch Government for awarding me this fully paid International Scholarship to enable me to pursue this course.

My humble appreciation to my Supervisor Albertien Kijne for thorough guidance from the start of this project until the end. Thank you for your quick response and availability.

To my assessor Arno de Snoo, I can't thank you enough, you have been helpful, and I appreciate your input. To the course coordinator Marco Verschuur, thank you so much for your guidance and motivation throughout the course period. To all the lecturers and VHL fraternity who were involved in one way or the other to make this accomplishment possible.

I am thankful to my sister Esther for being a shoulder to lean on whenever I needed a hand. You are the true definition of family. To the entire APCM and MOD crew, you became my new family, thank you for making my life at Van Hall University easy and enjoyable.

Am also grateful to my course mentor Geert Houwers for the study support throughout the course.

I am hugely indebted to my family, especially my mother Janice and dad Jacob, for the encouragement and prayers and my two daughters Sheridan and June for understanding my absence.

DEDICATION

I dedicate this research to my three beautiful ladies and my two bouncing baby boys. My Mum Janice and my two daughters Sheridan and June. You are the reason why I smile every day. Thank you for understanding me always! My Nephews Stijn Bakker and Lars Bakker thank you for holding up my spirit, seeing you occasionally gave me the strength to hold on and satisfy the purpose. Thank you!

ABSTRACT

Agricultural food crop output around the Mount Kenya region has been continuously decreasing in the last couple of decades. This has led to increasing food insecurity and reduced incomes. This study was commissioned by Mt. Kenya Sprout Company to get data and insights on how farmers are affected by climate change and how they are adapting and mitigating to climate change impacts and to propose recommendations for intervention. The study used a qualitative research approach to collect data from the field. Interviews and focus group discussions were used. Data was transcribed and categorized according to the research questions. The findings of the study indicated that the farmers were negatively affected by climate change. The farmers mainly suffered reduced crop yield, increase in farming costs, competition for water resources, decreased soil fertility and negative impacts on family dynamics. Some of the key adaptations and mitigating strategies the farmers engaged in include, (re)afforestation, diversification of food crops and livelihoods options, borrowing, and sourcing for alternative water sources. While some of the strategies are common in other parts of the world, the sustainability of some of the strategies applied by farmers was questionable. The study concluded that these strategies are at an infancy stage. There is a need to educate farmers about the sustainability of mitigating and adaptation strategies is important and so is financial and technical support on this matter.

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CHAPTER ONE: INTRODUCTION

Agriculture accounts for up to 55% of the African continent's GDP (AGRA, 2017a, AGRA, 2017b). The sector serves as both the foundation for food security and the primary source of income (Shah et al. 2008). In Sub-Saharan Africa, agriculture 85% of the population depends on rain-fed farming. It is therefore not surprising that climate change has had negative impact on the agricultural industry resulting into a steady decline in productivity over the last 50 years (Derbile et al., 2022)

Like in other countries in Sub-Saharan Africa, agriculture is the backbone of the Kenyan economy. It contributes 24% directly to the national GDP and 27% indirectly. Horticulture accounts for 36% of the Agricultural GDP contribution. This percentage continues to grow between 15% and 20% per year (Ministerie van LandBouw, 2015).

The horticulture sector is a major exchange earner in the country. The industry employs over six million Kenyans directly or indirectly, which is an enormous contribution to food security and household income. About 95% of horticultural products produced are consumed locally while the remaining 5% is exported (Christopher Kipsang 2022)

Kenya is a primarily arid and semi-arid country (Musalia, 2016). Only 20% of Kenya's total geographical area has sufficient fertility and rainfall for farming. Despite this, agriculture is the country's largest industry. The Mount Kenya region (referred to as Mt. Kenya) is located along the equator and at the centre of the country (longitudes 36°45'E to 38°10'E and 0°S0'N to latitudes 1°07'). The region is considered the breadbasket of the country and accounts for 40% of the total crop output for the county (Eckert et al., 2017). Key crops are maize, broad beans, bananas, vegetables, and fruits grown predominantly. However, vegetables and fruits account for 34% of the total crop output in the region (Zaehringer et al., 2018).

The rich volcanic soils are well suited for the intensive production of these crops and have attracted commercial farmers who grow these crops mostly for export. The locals are mostly engaged in subsistence farming using family labour and hand tools on small pieces of land averaging 5 acres (Rapsomanikis 2015). An analysis based on household data from nine countries he Mt. Kenya region has witnessed its share of unrelenting variations in climate attributed to climate change. The climate in the region Is described as an equatorial mountain climate, characterized by two seasons that allow the cultivation of crops up to 2,000 meters up the mountain. However, the rainy seasons have increasingly become shorter, and the amount of rainfall per season has also decreased (Chepkoech et al., 2020), With the corresponding decrease in crop yields hence famines have become more frequent (Gates, 2018). Commercial farmers have resorted to supplementing the inadequate rainfall with irrigation that draws underground water. This has had a destabilizing effect on the agro-ecosystem further aggravating the reduction in productivity (Giller, 2021). These challenges call for adaptation by farmers if they are to continue to operate profitably, hence the need for this study.

1.1 The aim of the study

The aim of the study is to explore the adaptation methods being applied by vegetable farmers in the Mt. Kenya region in the face of severe impacts of climate change. The study also has identified strategies that farmers can use to mitigate the negative impacts of climate change so that they can continue to operate sustainably. In addition, the study explores how the existing conditions under which farmers are operating and how they make them vulnerable to a greater decline in productivity if not addressed.

1.2 Problem owner

The project is commissioned by a horticultural company known as Mt. Kenya Sprouts, located on the slopes of Mt Kenya. Mt. Kenya Sprouts Limited is a small-scale horticulture company specializing in broccoli, french beans, leaks, lettuce, and brussels sprouts. Mt. Kenya Sprouts supports the local community in many ways including free water for the villagers and animals during droughts, paying school fees for needy children, employing local people, and preservation of environment in a sustainable manner. One of Mount Kenya Sprouts Limited's goals is to differentiate itself from foreign-owned farms in the region, by focusing on corporate social responsibility and the profit, people, and planet in its mission and company strategies.

1.3 Problem Statement and justification

There has been a decrease in crop output around the Mount Kenya region in the last decades. This leads to food insecurity and reduced incomes which has negatively affected the livelihoods of the local people. One of the main reasons for decreasing crop output is prevailing (continued) climate variation and change, meaning changes in weather conditions such as temperatures and precipitations due to changes in the circulation of air and ocean among other factors. This has significantly affected the livelihoods of the local people and the economy at the local level and at the national level.

In this regard, a call for a solution has been made to combat further deterioration of food availability in the region. This study has investigated how farmers in the Mount Kenya region are adapting to the current changes in climate (crop output/changes caused by varying climate-crop output, income, farm management practices, longer/extended maturity/yield period), and come up with insights on how the farmers can mitigate these changes.

1.4 Significance of the study

The project will explicitly offer advice measures to the Mt. Kenya Sprouts company on important knowledge about the impacts of vulnerabilities, and coping capacity of local farmers to climate variations both long term and short term[1]. This advice and knowledge will impact Mount Kenya Sprouts Ltd in decision making about their corporate social responsibilities. The company will better understand the extent of the problem facing local Mt. Kenya farmers by identifying the vulnerabilities such as crop failure, water scarcity, pests, and disease infestation on the most.

critical areas and thus align their resources with the needs of the local farmers. Moreover, farmers' current adaptation strategies will also give the company a better idea as to what is already accomplished in the community. This will avoid duplication and improve the impacts and effectiveness of their interventions.

Courtesy of Mt. Kenya Sprouts through the results of the study, the local government will also benefit by having focused results about the status of local farmers considering climate variation in the area. Local agricultural extension officers will specifically benefit by acquiring a better view of the impacts and challenges farmers are facing. The results of the study can be used by

[1] Continued climate variability one that occurs over a couple of decades translates to climate change. In this study the term variability and change were used interchangeably. This is because climate variability to be considered climate change, the variations need to be sustained for at least 30 years. In this study some changes maybe existing for longer than 30 years while others are not.

them to allocate agricultural support and training. All research done in Kenya must be registered at the ministry of agriculture. Stakeholders, both local and international looking for specific research on Mount Kenya on this topic can use the results.

This project is important for addressing food securities, understanding the vulnerabilities of rural communities, and achieving sustainable development goals to the locals which in turn will position the Mt. Kenya Sprouts company at a better bargaining power within the international market to penetrate a wider market.

1.5 Objectives

Investigate food production systems adaptations and mitigations to climate variation in the Mount Kenya region.

Specific objectives

a) To identify the drivers of accelerating climate variation in the Mt. Kenya region.
b) To analyze the impacts of climate variation on the food production system in Mt. Kenya region.
c) To investigate the vulnerability to climate variation among food production system stakeholders in the Mt. Kenya region.
d) To explore mitigation and adaptation strategies by farmers in the Mt. Kenya region.

1.6 Main research question

What are the adaptations and mitigation strategies of food production systems in the Mount Kenya region to climate variation and how can these vulnerabilities be mitigated?

Research sub-questions

a) What are the drivers of accelerating climate variation in the Mount Kenya region?
b) In what ways do climate-related factors impact food production systems and its stakeholders in the Mt. Kenya region?
c) What mitigation and adaptation strategies are applied by food production system stakeholders to cope with climate variations and change.

CHAPTER TWO: LITERATURE REVIEW

The impact of climate variability on crop productivity and food security is a major subject of concern globally (Mwangi et al., 2016).

2.1 Climate change and variability causes and drivers

Climate variability refers to the natural variations of climate conditions or a fundamental aspect of climate (Wheeler and Von Braun, 2013). Wind patterns, temperatures, and precipitation are among climate indicators that contribute to variability in patterns, trends, and fluctuations in climate parameters (Ochieng, 2016). Climate variability focuses on how climate changes through time and between different geographical areas. Finding trends, cycles, and anomalies in climatic parameters requires examining past climate-related data. Variability is a natural part of changes in temperature usually arranged within an acceptable and expected range (Muralikrishna, 2017). The expected pattern of variation is formed over time. In the last couple of decades, these prevailing patterns have been changing and are expected to keep changing

(La Sorte and Fink, 2017). This means that weather conditions and seasons have been outside the expected range.

2.2 Factors contributing to climate variability and change in Kenya

In addition to the natural causes of climate variability, human activity acts to amplify variability at the local climatic system (Mwangi, 2016). Unsustainable land use (Kairis, 2015), encroachment into natural resources areas (Kariuki, 2013), over-exploitation of groundwater levels and deforestation are some of the factors that researchers found to be accelerating climate variability specifically in the Mt. Kenya region (Carpenter et al.,2011). Karienye and Macharia, (2021) found out that deforestation in the region was increasing at an alarming rate. The region has lost about five hundred hectares of forest in the past decades (Ochieng, 2016).

Natural resource sites in Kenya have been destroyed by citizens over the past ten years. Mount Kenya, as a significant conservation and protection area in the nation, was among the locations that was impacted by this catastrophe. Diverse approaches such as forests registration have been put up for managing these natural regions in a sustainable way. Corruption and bad governance contributed to people encroaching on the mountain. Fuel wood demands, people living in the mountain forest, cutting down trees to burn charcoal and cattle ranching are becoming common practices. In the past decade, there has been a search for sustainable alternatives for local communities collaborating with international agencies and forest actors to protect the forest (Karuri, 2020). A bill was to ensure that the forest community or landowners residing within a 5km radius of a local forest register as a forest user to protect its biodiversity and protect the landscape (Kariuki, 2013).

According to Mburu (2016), the understanding of climate variability in semi-arid areas by locals is that people are familiar with the term climate change where they associate it with environmental degradation. However, there are gaps and misconceptions in understanding the causes of climate variabilities. The level of understanding the causes of variability differs between individuals when it comes to perception of factors like the onset of the rain, planting period, and harvesting period. To improve climate variations knowledge, there is a need for climate variation education by scientific institutions to provide information on local climatic conditions, regional drivers of climate variations, and global understanding of climate variations (Nyang'au et al., 2021).

2.3 Effects of climate variability on food production systems

Agriculture, wild animals, and fish all play a significant role in the world economy. Agriculture and fisheries are the main reliant on climate conditions. As a result, increased temperatures and carbon dioxide levels can significantly affect the availability of water, and the moisture content of the soil hence disrupting the ecosystem (Gomez-Zavaglia, 2020). Changes in the weather patterns, i.e., the intensity of droughts and floods can be extremely difficult for farmers, hence risk food safety.

2.4 Vulnerability and adaptive capacity of farmers to climate variation

The degree to which a system, like a socio-ecological system, is susceptible to damage, harm, or stress in the natural or social environment is known as its vulnerability (Ochieng, 2016). The

degree of sensitivity, effects, and resilience in the face of those variations all work together to create vulnerability. Vulnerability is also thought to be a trait shared by all individuals, ecosystems, and geographic areas dealing with socioeconomic or environmental challenges (Adger, 2016). Although levels of vulnerability, (the state in which coping capacity becomes compromised) vary, they are typically higher in the poorest classes (Gomez-Zavaglia, 2020). Food production systems often encounter additional pressures along with climate change, making it extremely difficult to detect these changes and link them to climate variations.

Serdeczny et al. (2017) argued that it is necessary to evaluate the local food system's exposure to broader multiple social and environmental conditions and processes, as well as the system's capacity to cope, adjust, and adapt to the changes. Vulnerability also necessitates considering how local social and power inequalities have led to differential exposure, adaptive capacity, and differential food insecurity outcomes.

According to Nyang'au et al. (2021) small-scale farmers believe that access to land, household income, and the planting of trees and shrubs on farms (agroforestry) are the key variables influencing their capacity to adapt to climate change.

2.5 Impacts of climate variation on food availability

Variability in climate can have a significant impact on ecosystems, changing biodiversity, shifting species distributions, and changing how ecosystems work. Effective conservation and management efforts require an understanding of these effects. Studying how impacts affect human systems including agriculture, water resources, and public health also aids in identifying vulnerabilities while developing productive methods of coping (Rodgers et al., 2021).

The supply side of food security is addressed as food availability (Affoh et al., 2022). Climate variability directly affects food availability by reducing or increasing crop yields. The yield of crops can be impacted by temperature variations. For instance, greater temperatures may hasten carboxylation in plants and increase transpiration, respiration, and photosynthesis. While low temperatures can enhance sugar storage and minimize the consumption of energy, higher temperatures can partially promote flowering. Farmers are challenged by the development of new diseases in grain crops because of rising temperatures, such as wheat blasts, which puts their food supply in jeopardy Affoh et al. (2022). An in-depth review of agricultural output in South Asia and Africa revealed a potential 8% drop in crop yields by 2050. Additionally, crop yields were projected to decrease in Africa due to climate change by 17% wheat, 5% maize, 15% sorghum, and 10% millet (Affoh et al., 2022).

Climate variability affects grain quality. A significant correlation between weather and child stunting was found in a study on climate change and its effects on child malnutrition among subsistence farmers in low-income countries (Mburu, 2016).

2.6 Food crop systems stakeholders’ adaptive strategies

Adaptation refers to the level of reduction of vulnerability to the harmful effects of climate variation (Karuri, 2021). The goal is to empower communities, practitioners, and policymakers with the knowledge and information they need to create and put into practice efficient adaptation and mitigation approaches. Understanding climate change variability makes it easier to identify strategies, evaluate risks, and develop appropriate solutions to improve resilience and minimize the adverse impacts of climate change.

Kenya recognizes the importance of climate change action and has policies and plans to enact adaptation and mitigation measures. These plans include the National Climate Change

Response Strategy (NCCRS) of 2010, the National Policy in Climate Finance (2015). The Climate Change Act of 2016, the National Climate Change Action Plan (NCCAP)2018-2022, and the National Environmental Management Authority (NEMA).

The NCCR prioritizes agriculture as one of the most vulnerable sectors of the economy. It set institutions to help govern climate change affairs, policies and related legislation be put in place. The focus is to ensure that adaptation and mitigation measures are integrated in development objectives and government planning.

NCCAP represents the direction in which national mechanisms through which climate change can be addressed. Which includes clean energy solutions, agroforestry, climate-smart agriculture, improved water resource management, and sustainable forest management.

Common adaptive strategies currently used by farmers include crop rotation, using drought resistant crops, water harvesting techniques and mulching. Factors determining if adaptation strategies will succeed include knowledge gaps, finances, and institutional support (Abid et al., 2015).

2.7 Mitigating strategies of food crop systems stakeholders

Unexpected weather patterns have increasingly affected various geographical areas. The earth is warming, and natural climate variability alone cannot explain this trend. Green gas emissions are produced by human activities and the impacts of warming are experienced in every place, from changing weather patterns, drought, rising sea levels, and melting of snow (Nicholson, 2019). Most farmers within the Mt Kenya region have realized cutting down of trees is only disadvantaging them, they have adopted the method now known as cut one plant two as the only way to mitigate unexpected weather patterns in the region.

Vegetable planting is done through different methods of planting. Through sowing of seeds directly or transplanting of a tree plant. Maturation of different vegetables takes different times in maturing. For many species adaptation to climate variation can therefore be carried out through adjusting planting dates. Adjusting measures can however be undertaken through the availability of water, enough rainfall as well as through crop husbandry activities such as mulching, irrigation period, and fertilizer application to climate variation (Karuri, 2021).

Nicholson (2019) focuses on mitigation measures for carbon sequestration and how a clean environment can improve livelihoods. Mitigation of greenhouse emissions was found to positively impact agriculture. A comprehensive analysis incorporating geographic and ecologic done by (Pandey et al., (2015) suggested that agroforestry systems are a preferable option for mitigating climate change because they provide additional environmental advantages including improved farm revenue, increased food security, biodiversity restoration, and stable land tenure.

2.8 Conceptual framework

The framework provides interconnectedness between variations in the agricultural systems and environment. The research conceptual frame for this study was created by mixing and adapting two models. Food System model and the climate variation model. The food system is a system that embraces all elements (environment, people, inputs, processes, infrastructure, institutions, etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food and the outputs of these activities, including socioeconomic and environmental outcomes.

The second model was developed by the author of this paper on impacts, adaptation, and vulnerability. This model explains how different factors/vulnerabilities influence climate variations. The model seeks to identify the positive results and impacts brought by the implementation of new adaptive measures as well as mitigation measures put in place.

Food systems and climate variability conceptual framework

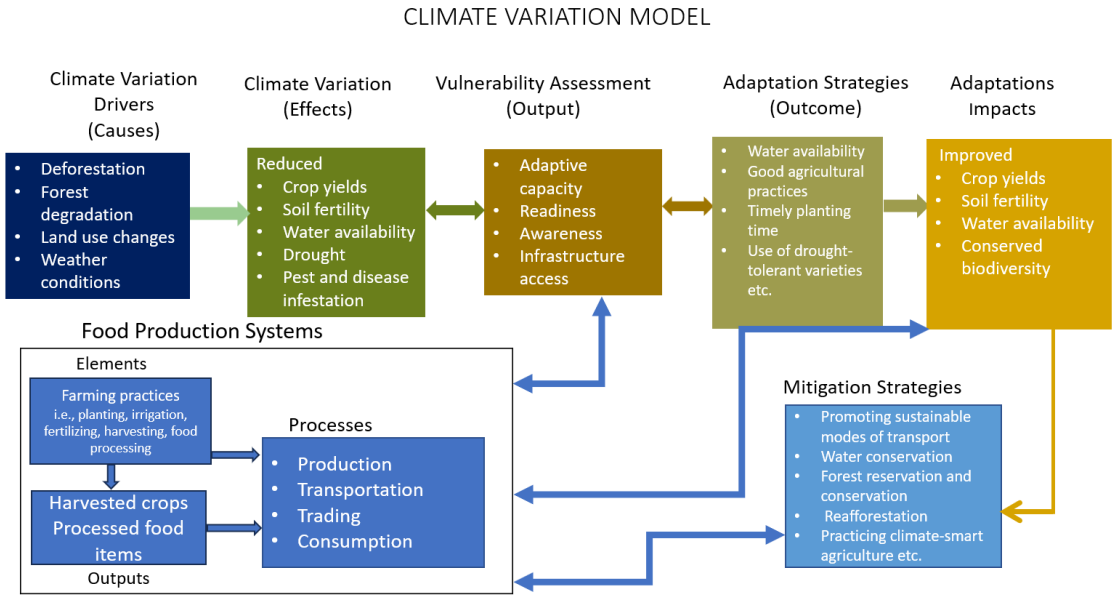


Figure 1 Food systems and climate variability conceptual framework

The adaptation and mitigating strategies are determined by the climatic causes and effects. The food system processes affect and are affected by vulnerability factors. For instance, as adaptive capacity improves, the food system improves, while a lower adaptive capacity, negatively affects the food production system. The adaptation and mitigating strategies have an impact on the food production systems and vice versa. For this study climatic drivers that will be included are deforestation, forest degradation and land use changes, reduced crop yields, soil fertility, water availability, and livestock production will be the indicators for impacts. Adaptive capacity and stake-holders awareness will be used to indicate vulnerability.

Under food production system the research considered; horticulture, agroforestry, livestock, under transportation it was considered access to market. While trading and consumption were investigated regarding food supply and bargaining power.

Promoting sustainable mode of transport can reduce greenhouse gas emissions to positively impact agriculture.

Practicing climate smart agriculture, reafforestation, forest conservation is directly linked to improved adaptation outcomes which are quality water availability, improved farming practices and improved adaptation impacts which are related to improved soil fertility, ample crop yields and enough water availability.

CHAPTER THREE: RESEARCH METHODOLOGIES

3.0 Methodology

The study, being primarily qualitative research, utilized various methods for data collection including the use of focus group discussion and interview schedules as well as key informant interviews from the field. The study adopted the participatory vulnerability profiles (PVP) approach from Miriam Alfie-Cohen & Flor Yunuen Garcia-Becerra. The PVP approach focuses on responses to improve resiliency on future risks and reduce present vulnerability (GarciaBecerra 2022). This approach places the stakeholders at the centre of the research study which is vital because people in the region have developed indigenous knowledge systems that have enabled them to cope so far with the change phenomenon and climate variability. This chapter discusses the procedures and research techniques used during data collection including the study area's population in figure 2.2, research location, research design, examples of research and data investigation tools, ethical concerns, and study limits.

3.1 Scope of study

The research took place in Nanyuki, Kenya, MT. Kenya region which is in the eastern part of Mt. Kenya, see figure 2.2. Nanyuki is a town in Laikipia County which is located west of Mt. Kenya bordering Meru County, rendering it to be highly inhabited. It is characterized by extensive forested regions and agricultural areas. Agriculture plays a significant role in the region, with both intensive arable and livestock farming. Currently, the local county governments are promoting the transition towards sustainable and nature-inclusive agricultural systems aiming to preserve biodiversity, soil, and water, and reduce greenhouse gas emissions (D'Alessandro et al., 2015).

figure 2 Mount Kenya region. Source, Google maps

3.2 Data collection and methods

The present study also used a rapid approach method approach to develop an in depth understanding of climate variation drivers toward mitigation and adaptive strategies in the Mt. Kenya region. A semi-structured interview protocol was applied to carry out this study with stakeholders from different stages of the food value chains.

The target population of this research constituted of stakeholders that can contribute to the mitigation and adaptation strategies to combat climate variances. To answer all sub-questions, the research strategy was based on qualitative primary data which was collected from 30 respondents within the county. 16 farmers among 2 lead farmers (farmer associations representatives), 2 suppliers, 2 middlemen, 2 traders, 2 local forest officers, 2 climate network coordinators (CNC), 2 meteorological officers and 2 agricultural officers. Focus group discussions were also carried out and the numbers of each category were decided based on the total population per category. For instance, Farmers represent the largest group and focus group discussions were the main primary method that was used on farmers to derive information. The researcher also looked at what was feasible within the time, access, and resources available. Table 1 below shows data sources for each research question.

To reach the target population, purposive sampling was applied, using the existing network of the area chief, to recruit input suppliers, farmers, traders, consultants, farmer associations, coordinators of climate networks, and climate institutions.

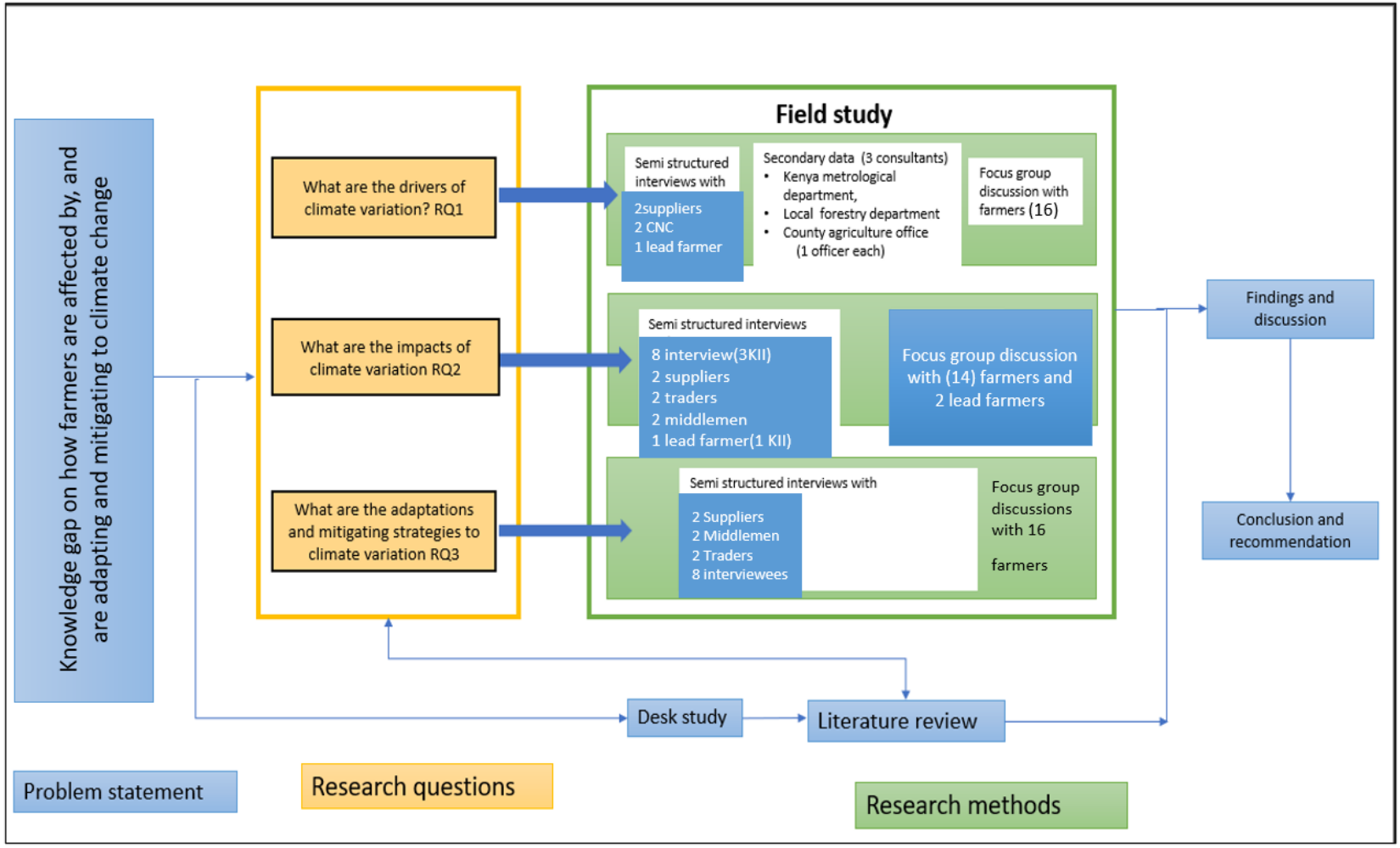
Initially climatic data was to be obtained from the Kenya Meteorological Department but due to the unavailability of the data a secondary data source (Meteoblue) was used. This is a climate database that offers past (from 1979) and present (2023) climatic data for various parts of the world. Data can be accessed free of charge.

Crop production data was obtained from farmers, local forest officers, and local agricultural officers. For confidentiality purposes, codes were used instead of their real names when quoting them directly.

Table 1. Data sources for each research question.

Main information was collected with the corresponding research question	(Sample size 30)
RQ1: Drivers of accelerating climate variations e.g. • Land use changes • Weather patterns • Deforestation • Forest degradation	• 2 Suppliers of seedlings, fertilizers • 8 respondents from Kenya metrological department, Local forestry department, County agriculture office, CNC (2 each) • 4 key informant interviews with 1 lead farmer, 1 local forestry officer, 1 meteorologist officer and 1 agricultural officer.
RQ2: Impact of climate variation food production systems and its stakeholders e.g. • Increase in crop yields • Better soil fertility • Quality water availability • Diversifying of crop grown • Use of drought-tolerant crops	• 1 lead farmer (1KII) • 2 Traders (SSI) • 2middlemen (SSI) • Focus group discussions with 16 farmers
RQ3 mitigation and adaptation strategies are applied by food production system stakeholders to cope with climate variations. Protect and conserve the forests. E.g. • Planting trees where there is none and replacing trees that have been cut. • Use of solar, wind and hydropower • Use of vehicles and machines that do not use fossil fuel. • Practicing climate-smart agriculture	• 4 respondents (3 KII) • 14 Farmers (FGD) • 2 Middlemen (SSI) • 1 lead farmer (1KII)

Food systems and climate variability research framework, source:Author 2023.



3.3 Data processing

The collected data was transferred to a computer, transcribed using Temi record and transcribe App. This being an AI, powered App, transcribed data was edited to make coherent quotes and to increase comprehension. Data was then grouped into themes based on the research sub-questions. Due to the qualitative nature of the data, narrative analysis and thematic analysis was used instead of statistical software such as NVIVO or SPSS.

3.3.1 Focus group discussion

The researcher conducted Focus group discussions with farmers to get a better understanding of their thoughts on the causes, vulnerability, and impacts of climate variability. In this case, interviewing was done with a group of farmers with similar backgrounds, like planting the same type of crops, being in the same self-help group and farmers who share experience in relation to the subject under discussion. Farmer's views are significant to understand the system and its future opportunities or threats. The formation of village self-help groups helped the researcher to execute 2 focus group discussions which consisted of 16 members split into 2 sessions. To further triangulate data gathered from semi-structured interviews, the researcher conducted 2 focus group discussions with 16 farmers, 8 from each group which included both males and females, who were randomly selected and provided valuable qualitative information on perceptions of climate variations and longtime observation impacts on environment and livelihoods. Below is a photo taken with farmers after FGD session.

Photo 1. Focus group discussion with farmers

Source: Author field data 2023

3.3.2 Semi-structured interviews

Data collection and compilation through conducting of semi-structured interviews was the method used to gain insight into the first sub-research question which was to analyze the drivers that accelerate climate variation in Mt. Kenya region and was derived from the respondents interviewed through interview guide which was categorized per sub question of categories to help draw out the information gathered from the fieldwork, this includes, two lead farmers, 2 local forest officers, two officers from the weather department, 2 local agricultural officers and 2 from the climate network department.

The semi-structured interview was used to interview 4 key informants, 2 middlemen and 2 traders, to seek expert views and information per sub-questions. Data collected on deforestation rates and agricultural practices have negatively impacted climate.

3.3.3 Key Informant Interviews (KII)

Four key informants—a local forestry officer, head of the farmers' organisation, who is a lead farmer, an extension agricultural officer and a meteorologist from the weather department—were interviewed by means of key informant interviews. The KII sessions lasted 35 to 45 minutes, and the researcher was able to acquire their opinions on the research topic during this interview. The researcher was significantly helped by the KII's firsthand information when carrying out field study. A notebook with data from KII and a recording device were present. The first and third research questions were addressed using KII data. Also, information was gathered from 1 lead farmer in addition to FGD to cover research question.

3.4 Research Data validity and reliability

The researcher used multiple data sources to increase data reliability. While using multiple methods (semi- structured interviews, focus group discussion, key informants) ensured validity. The FGDs took place in a farm during the exercise carried out by the farmers of loading soil in plastic bags for planting trees on the mitigation of climate variation. In total 2 FGDs were carried out. This was to increase the reliability of data. In addition, the interviewer used different prompt questions for the same concept in different parts of the interview. This was done to probe through questions to get more clarification or a deeper understanding of the interview questions.

3.5 Ethical consideration

The researcher ensured there was a full guarantee of confidentiality. The identity of the respondents was kept anonymous, and interviews were administered with full consent and approval. More so, the researcher took time and explained to the respondents the objectives of the research and how their contributions would be helpful to the region. The respondents were not bribed, compensated or forced to participate in the study.

3.6 Study limitation

The study was conducted in Mt. Kenya region in Timau division, Meru County in Kenya, which is a rural area with approximately 200 small-scale farmers engaged in mixed vegetable farming. The major limitation was commitment by respondents. It was difficult for some respondents to show up after confirming their attendance.

The ongoing roads extension within the locality. This provided an emotional environment where farmers were disappointed in the actions of the government.

Time and finance were also other factors that contributed to the smooth collection of data. Though the appointments took 60 to 90 minutes for the whole interview process, the respondents expect to be compensated for their time, claiming they should be doing something else for income.

Gathering focus group discussions for farmers was not easy as most farmers have to work to on their farms.

CHAPTER 4: FINDINGS

This section presents the findings of the study. First, a review of the data collection procedure is presented in combination with the respondent's profile. Thereafter the findings are presented based on the research sub-questions.

4.1 Respondents' profile

To answer the main research question, the participants were selected purposively. The researcher identified certain groups of people who would provide the relevant information to help answer the research question. Semi-structured interviews were done with 16 participants, Including 12 males and 4 females. Females were more reluctant to participate in a one-on-one interview and often referred to their husbands to participate. However, they were more willing to participate in a Focus group discussion (FGD). FGD discussion was done at the home of one of the female farmers. Small incentives were offered in exchange for participation.

The table below provides the particulars of the people who participated in Focus Group Discussions and Semi-structured Interviews.

- 32 people (36% females, 64% males) participated in the study.
- 16 of them (47%) were involved in Semi-Structured Interviews while 53% participated in Focus Group Discussions.

Key Informants Interviews were tarried along the 53% percent of participants involved in SSI

- There was a near parity of the number of participants in the sessions even though the total number of males was more than the females (14 females versus 18 males)

Table 2. Respondents gender

Type	Respondents gender		Total
	Male	Female	
Semi-structured interviews	12	4	16
Focus-Group Discussions	6	10	16
Key-informant's interviews	2(among SSI and FGD sample)	2(derived from SSI and FGD sample)	4(respondents included in the total targeted group)
Grand total	18	14	32

The total number of respondents was 30. The table above indicates 32 since 2 of the participants (2 lead farmers) participated both in semi-structured interviews and focus group discussions.

The KII participants are among the total number of 30 respondents interviewed.

Table 3 Age of respondents

Age structure	Number of respondents in FGDs	Number of respondents in SSI	Total
36-50 years of age	6	11	17
51- 65 years of age	10	3	13
Total	16	14	30

From the table above:

- The respondents aged 50 years and below dominated the Semi-structured Interviews (68%) whereas they constituted only 33% of respondents in FGD.
- FGDs were dominated by the elderly (51 years and above) who constituted 67% of the respondents.

4.2 Climate changes in the Mount Kenya region

The researcher initially planned to collect climate data from the local meteorological office. The officer, however, indicate that the local office had scanty data and referred the researcher to the Swiss owned and managed database Meteoblue.

A study of the data on this database shows that rainfall and temperature (two of the main commonly used factors to measure climate change) have been erratic in the past couple of decades. The figure below shows the overall anomalies in temperature and precipitation for the two traditional starts of the rain months.; short rains starting in January/February and long rains starting in July/ August data is also highlighted.

*(Image sources Meteoblue)

Figure 4 general climate change data Mount Kenya 1979-2023

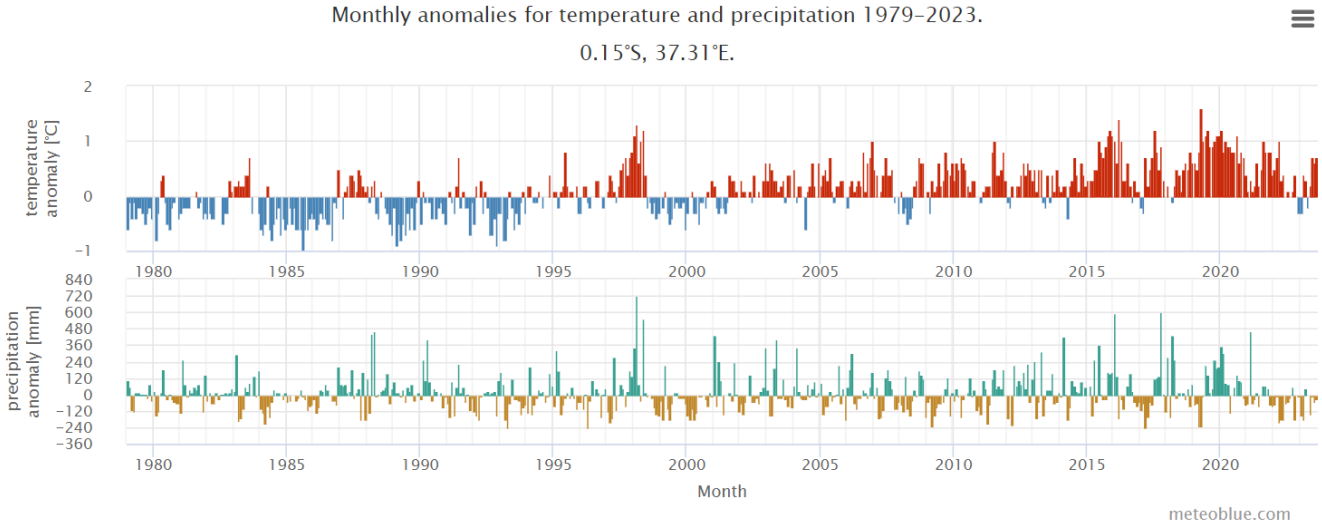


Figure 5 climate data Mount Kenya 1979-2023 January

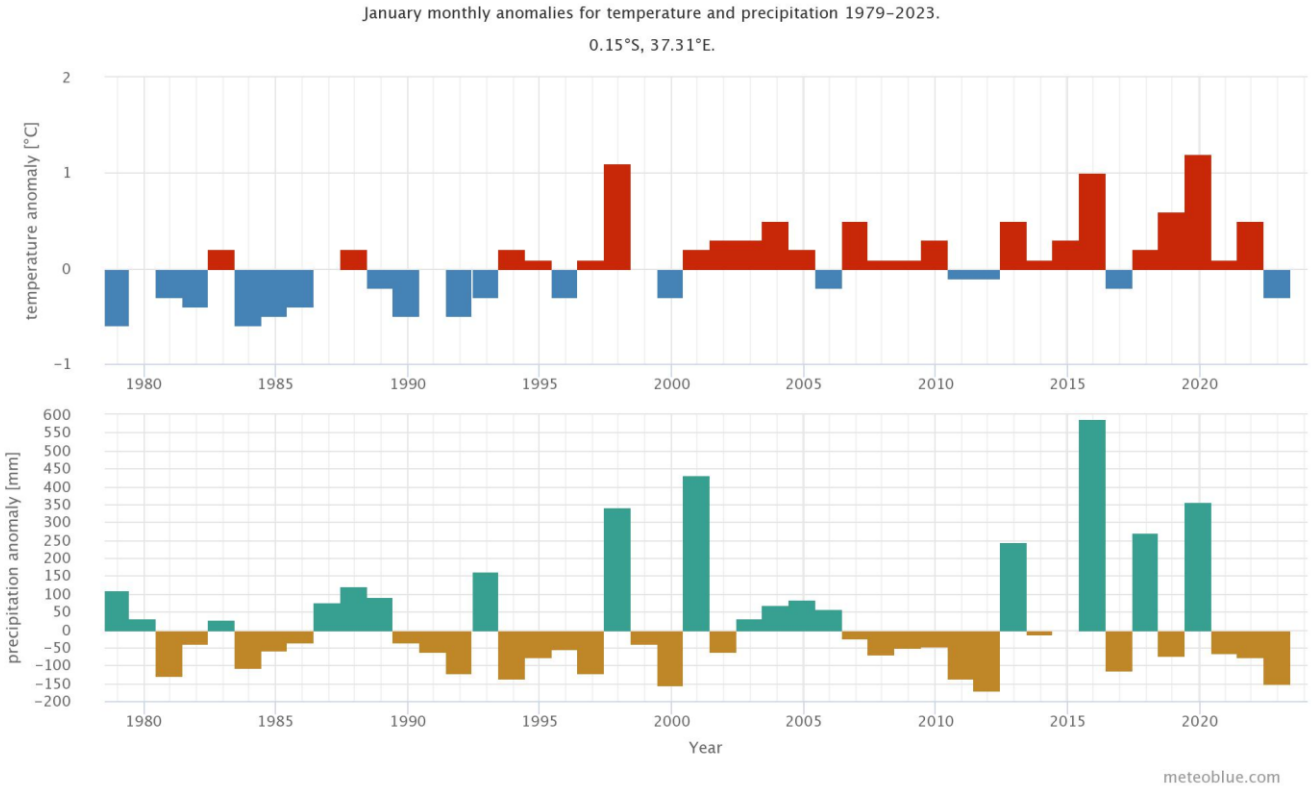


Figure 6 climate data Mount Kenya 1979-2023 February

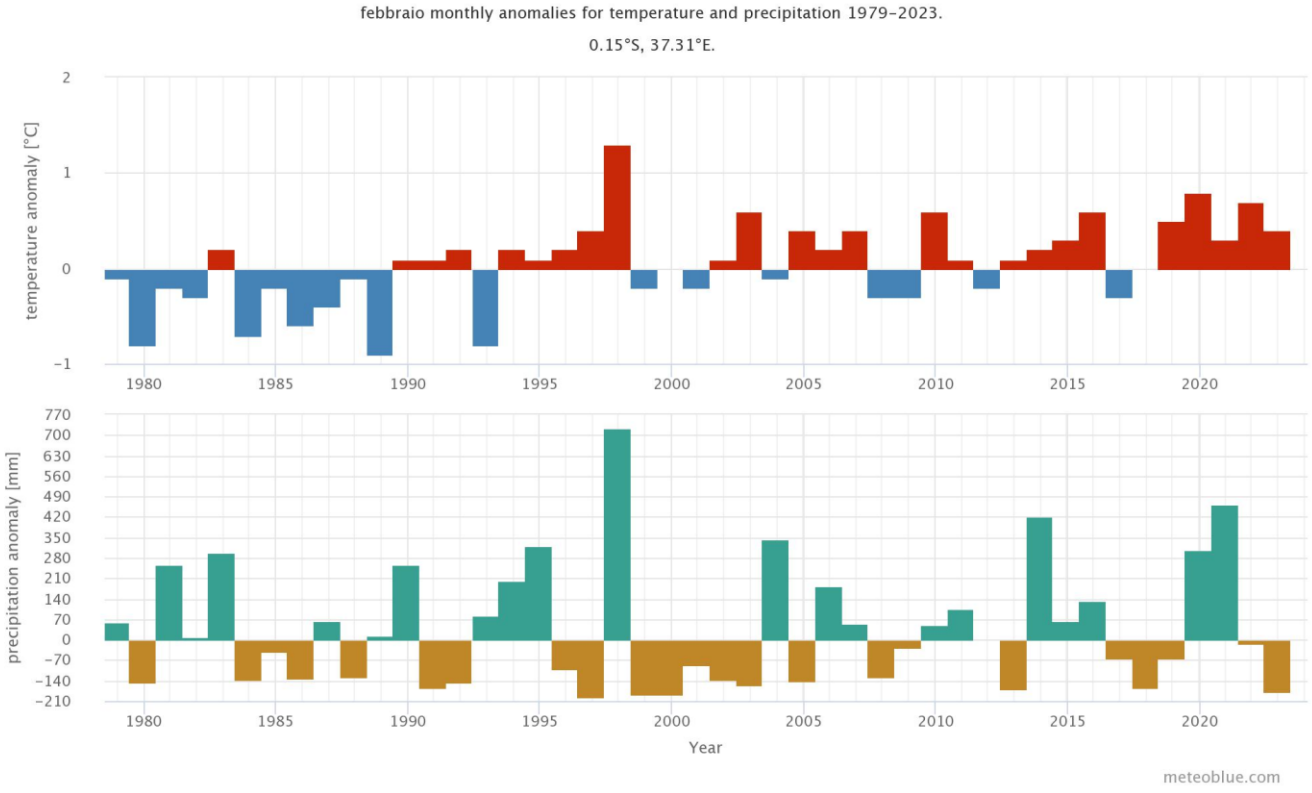


Figure 7 climate data Mount Kenya 1979-2023 July

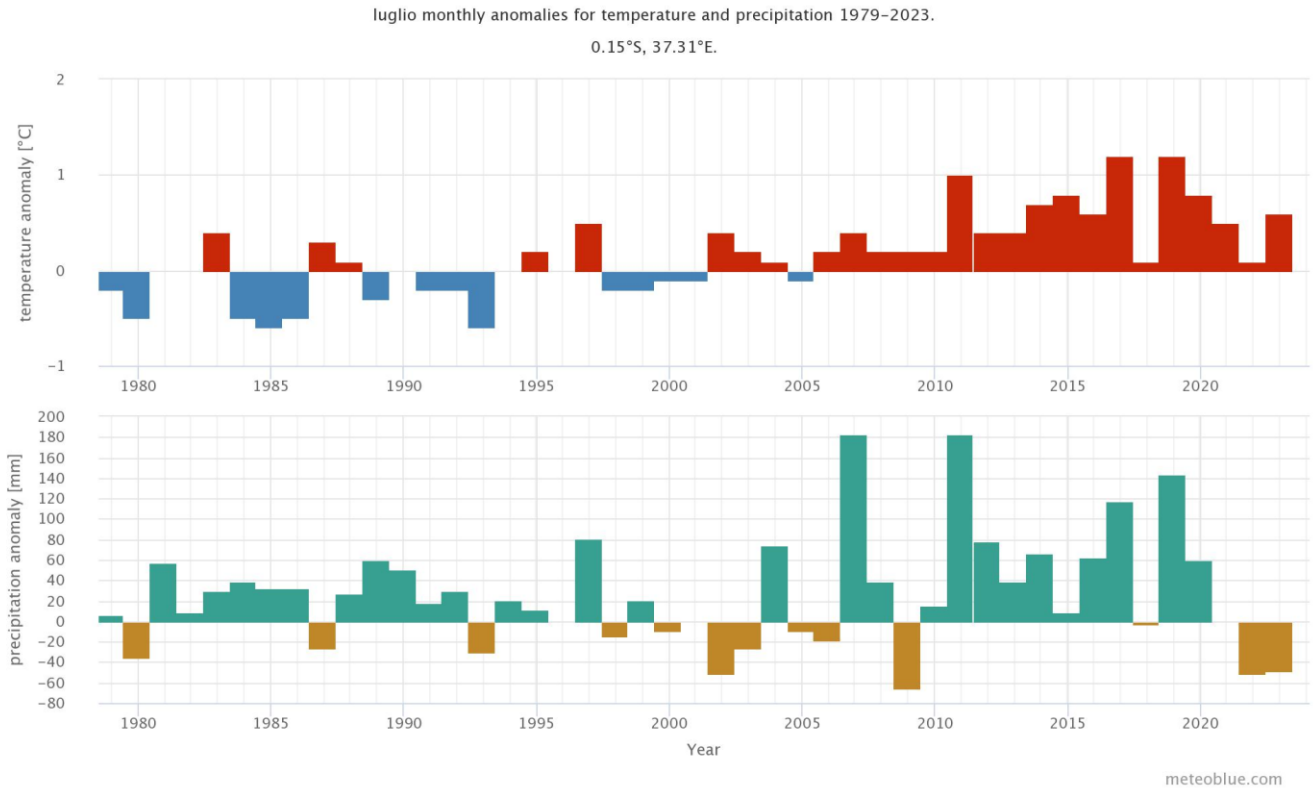
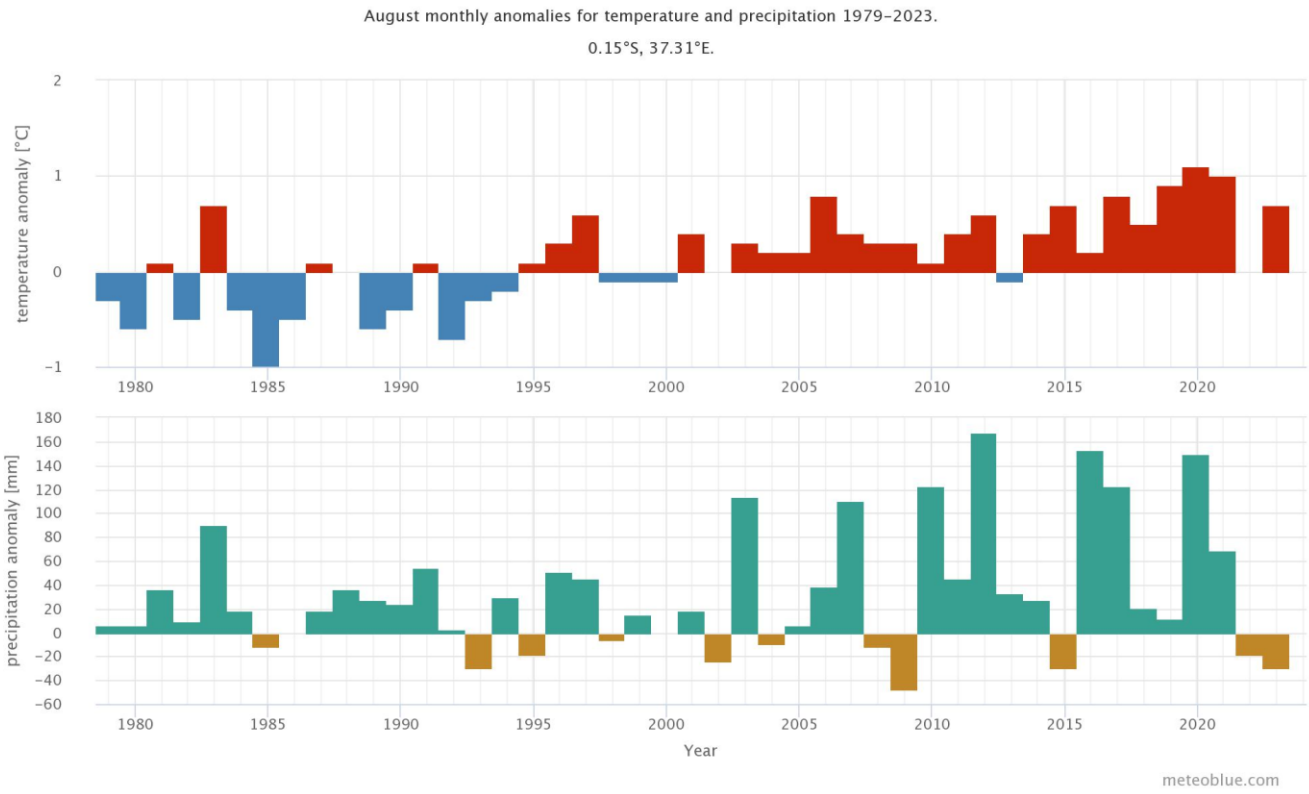


Figure 8 climate data Mount Kenya 1979-2023 August



From the data above, it is clear to see that for the long rain's temperatures have been increasing and rainfall has also been increasing in the last two decades. In 2015 and 2018 extreme events of drought can be observed. Extreme drought (too little to not rain) is observed regularly form 2009 and more frequently from 2015.

For the short rains an increase in temperature is observed. Simultaneously rainfall for this period is more erratic.

4.3 Causes of climate variation and change

During the SSIs (participants who were in this category, (farmers, experts) the respondents were asked to enumerate and explain what they think are the causes of the climate variations and change in an open question. Most respondents had an idea about the causes of climate change. From the received answers and by grouping similar responses the researcher deduced 4 main responses. These are presented below:

Changes in weather factors

Several interviewees mentioned changes in weather elements as indicators of climate change. Some mentioned an increase in the amount of sun, heat, too warm, too dry, a decrease in the amount of rainfall, unreliable rainy season, dwindling rain, and too little water were common answers. Some uncommon responses included too much wind and a curse from God.

Deforestation and forest degradation

Deforestation and Forest degradation were the other significant factors of climate variations mentioned by the respondents. Under this category, cutting down trees, damage to vegetation, overgrazing, and burning trees for charcoal were mentioned. Interviewees also mentioned forest fires as a cause of climate change. It was mentioned that the original natural forest vegetation has over time given way to crop farming. The rich volcanic soils and the ample rainfall are suitable for crops that thrive best in fertile soils. This has contributed to the highest attraction of large-scale commercial farmers including Mount Kenya Sprouts Limited, the commissioner of this study.

Local climate experts mentioned that efforts to control tree cutting or to replenish those that have been cut, are not yielding much fruit. This was attributed to population growth and corruption.

"…. The public roads and paths in the villages are being widened, and the trees around the farms have been cut without any notice or compensation. People no longer trust the government..."

The current situation on the ground.

The following pictures show the cut down of trees and other damage including demolishing of houses, gates, toilets etc., along farmer's farms so to expand the roads. The initial road measurements normally is supposed to be 20 feet wide but the new law requires the roads to be 30 feet wide. To facilitate this increase in width, everything that falls within 10 feet must be demolished or uprooted. This is done without prior notice and without thinking about the consequences for the ecosystem. For instance, green fences which act as nesting grounds for birds are cut.

As much as people are trying to solve climate variation challenges, activities such as these keep occurring without notice and without compensation.

Photo 2: A beautiful view of a village path before the cutting down of trees.
Source: Author field data 2023

After

Photo 3 the same path after the trees have been cut down
Source: Author field data 2023

In the aftermath, the farmers must refinance this damage. This is an extra additional and unexpected cost for an already struggling region.

Pressure on land

Answers in this category included overcrowding, too many people, too little land for everyone, government internally displacing people. Among the experts the answers were similar but included scientific terminologies such as encroachment on forest areas, increasing population density of farmers, land use changes, and precipitation.

In the FGD, the same question was asked, and similar answers were received. When asked the follow-up question to justify their respondents' answers, participants cited personal observations and experiences from the previous years.

The participants were quite knowledgeable about the drivers of climate variation. During FGDs, the elders were able to highlight historical perspectives and trends that spanned over five decades. They could therefore state authoritatively that indeed irreversible change has occurred and predicted that the worst was still to come.

As one respondent said" In my 48 years of life, it has never gotten this bad. Usually, the rain would start in March, and rain for 3 days. This was a natural notice to start planting. After two or three weeks the rain would start and keep coming for 6 months. However, these days the pattern is broken".

Another respondent stated "50 years ago, we would plant some crops at the beginning of March even when there is yet no sign of rain, and surely rain would not rain later than mid-March. Today, even when the meteorologist says, 'it will rain throughout next week', wait till it really rains before you jubilate because it may not rain at all, or the amount of rain may be insufficient". Participant FGD6

Corruption

It was mentioned that systems are in place for dealing with deforestation. The fidelity of this system, however, was questionable. It was stated "…. Unfortunately, some of the people in charge of enforcing the control measures are the very ones who, because of corruption, allow the control systems to be compromised. For instance, there are powerful people who can be given concessions to cut trees from certain parts of the forests and the local enforcers are powerless to restrain them...." Participant FGD9

Participant FGD12 stated"… Commercial farmers are utilizing underground water to irrigate their farms, a practice which destabilizes the agroecosystem, but nobody can restrain them. Emissions from vehicles and factories are beyond the capacity of locals to do anything about, yet they suffer the consequences of the resultant global warming."

There was a notable misconception about greenhouse gases as drivers of climate variation.

Six out of 16 respondents did not consider greenhouse gases as prime causes of climate variations. They did not see the direct connection as one of the dissenting respondents said,

"We do not see the effects of these gases directly here unlike the effects of weather. It has become hotter over the years and the ice over Mt Kenya is disappearing causing our streams to dry. We have cut down trees and the result are less rain. But with these gases, I do not see any effect. Is it because we have few vehicles in this place that we do not see the effects of the gases?".

Other participants responded that the availability of too many commercial farms with greenhouses is the cause of too much sun.

4.4 Effects of climate variability on food systems

During Focus group discussions, respondents explored the effects/impact climate variations have had on their farming activities and livelihoods in general.

Reduced crop yields

A particular concern was the effect of increasingly inadequate and erratic rainfall that affects crop yields. All respondents mentioned that they have suffered significant crop yield losses. This was attributed to the reduction in harvest due to reduced rainfall. They also mentioned inadequate water to irrigate their crops by drying the rivers. An increase in the number of large commercial farms in the region was mentioned as one of the reasons for reduced water availability.

Farmers mentioned that reduced yield results in less food for the household, leaving hardly anything to sell for the much-needed cash required to meet non-food household needs. In case there is a critical need that cannot wait, such as medical expenses or school fees, the family borrows money or sells convertible assets to meet the costs.

Farmers indicated that agriculture in this region is not mechanized. Less food affects the physical health and mental health of the farmers as they have less energy to work on the farms. This decreases the agricultural productivity potential of the family. One of the participants said" ... I do not want to go to the farm anymore. It is hurtful to see the dry crops and to see my efforts yield nothing season after season. If this continues the kids cannot go to a highly competitive school."

Another one said "My debt list keeps growing. Last season I gave the shopkeeper my calf. No one has money to give me anymore. The government should help us...."

Increased farming cost

Increased costs of farming were another indirect impact of climate change found in the Mount Kenya region. Farmers stated that erratic rainfall makes planning for the season difficult. They mentioned it also increases the risk of crop failure. While farmers depended on a predictable pattern of sowing and harvesting, this is not the case anymore. Farmers often must repeat sowing after the initial rainfall, which was originally seen as the go-ahead for sowing. In most cases, farmers end up borrowing from expensive sources or converting coveted assets which further impoverishes the family. This is a costly undertaking for farmers who already struggle to make ends meet.

Competition for alternative water sources for irrigation

Due to decreasing rainfall, farmers said they have turned to irrigation to bridge the rainfall gap or as a main water source. Common alternative water sources mentioned include rivers and water harvesting

options such as tanks. Those who can afford to cover the costs have drilled boreholes. Local experts mentioned that to avoid over-exploitation of ground water borehole permits are issued by the local government and are not permitted per individual, several people must form a group to be given the permit. However, due to corruption and lack of transparency in the process, this is not the case.

"…. Those with enough money can get permits to drill private boreholes w. While the rest of us must form groups and scramble for leftover water. And when the rivers dry, they will not let us in their fenced compounds to even fetch drinking water..."

Over-exploitation of groundwater has contributed to local rivers drying up faster.

Decreased soil fertility

The local agricultural officer said that extended dry seasons, abnormally violent floods, and extreme temperatures all have deleterious effects on soil structure and microorganisms. Therefore, soils have become increasingly degraded, and fertility drastically reduced. He continued to say, under such circumstances, farmers encroach into areas that would normally not be used for farming, for instance very steep hillsides, that still have natural fertility. In the process, natural vegetation is cleared to make way for crops with the resultant deforestation and loss of biodiversity. In addition, since vegetation removes carbon dioxide from the atmosphere, a greenhouse gas, removal of vegetation leads to global warming, he concluded.

Impacts on family dynamics.

An interesting finding was the impacts of changes on climate change on the well-being of family relationships. Respondents intimated that their normal pattern of life in the household is disrupted by the reduced income from agriculture. Families tend not to agree on alternative sources of income and on resource allocation. It is difficult for members of the household to agree on which coping strategies to implement. Women tend to have strategies that are influenced by their gender roles and responsibilities. Quite often the strategies are not always agreeable to the men hence the disharmony.

Disruption of value chains and other planned activities

The respondents intimated that the value chain of all crops grown in the study area is affected by climate change.

"...because the roads are impassable during the rainy seasons, we cannot get the French beans from the farmers in Kiguru (place). If the beans are not delivered to Nairobi on the same day, they cannot be exported. They spoil and won't be accepted..."

Emergence of new pests and diseases

The respondents attributed some of the new pests and diseases to changes in climate. One such pest mentioned is the Fall Army Worm. The elders intimated that such pests were not heard of in the past.

"…. These days there are a lot of worms and insects. A few years back I lost my whole potato farm to locusts. They eat everything."

4.5 Adaptations and Mitigation Strategies

All respondents were asked to mention adaptation and mitigation strategies they are currently using to tackle the effects of climate change and their responses have been summarized below.

Table 4. Adaptations and mitigations strategies summary

Adaptation strategies

Construct dams and drill boreholes to provide additional water to farmers	• FGD -Farmers • Extension agricultural officer • Head of the farmers' organisation
Planting of trees	• FGD -Farmers • Extension agricultural officer • Head of the farmers' organisation
Use of drought-tolerant crop varieties	• FGD -Farmers • Extension agricultural officer • Head of the farmers' organisation Climate officer
Water for domestic use should be recycled and used for crops.	• • Extension agricultural officer Head of the farmers' organisation
Diversification of crops grown	• FGD -Farmers • Extension agricultural officer • Head of the farmers' organisation
Growing early maturing crops	• FGD -Farmers • Extension agricultural officer • Head of the farmers' organisation • climate officer
Diversifying sources of household income	• FGD -Farmers • Extension agricultural officer • Head of the farmers' organisation
Promoting sustainable agroforestry Mixed farming	• Local forestry officer • FGD- farmers • Climate officer • Head of the farmer's organisation
Increase in charcoal burning	• FGD -Farmers
Practice soil conservation techniques	• FGD -Farmers
Implementing irrigation techniques	• FGD -Farmers
Praying and not giving up hope	• FGD -Farmers
Keeping fish(catfish) as an alternative	• FGD -Farmers

Borrowing from able neighbors'	• FGD -Farmers

Mitigating strategies

Protect and conserve the forests.	• Local forestry officer
Increase fines of up to 1 million KES (10,000 Euros) should be levied on people caught cutting rare species of trees such as Cedar.	• Local forestry officer
Planting trees where there is none. Replacing trees that have been cut.	• Climate officer
Use of solar energy instead of diesel generators to provide power in homes.	• Climate officer
Use of vehicles and machines that do not use fossil fuel. Promote sustainable modes of transport	• Climate officer
Practicing climate-smart agriculture such as reducing the use of synthetic fertilizers.	• Agricultural officer

The main highlights on adaptations and mitigation strategies employed and suggested from the field are further elaborated below.

During the interview process, a farmer group leader explained that there is a knowledge gap among the farmers hence it is difficult for the farmers to know exactly when the rains will start, he mentioned that since there are many international exports large farms with the right weather gadgets, they rely on copying the activities that happen within the farms.

For example, if the international farms start tilling their land the farmers also start. This method is not reliable because sometimes they till and leave the tilled land lying idle for some time. He continued that, with the right varieties to use for cultivation that are drought, pest, and disease resistant, and knowledge on when to spray and carry out farm practices the small holder farmers can benefit. In addition, most of the farmers interviewed are above 40 years of age. He continued to say that more sensitizations are needed to encourage youth to participate in agricultural activities.

The researcher raised a question on the issue of using irrigation water instead of relying on rainfall. The objective was to determine how many respondents could survive prolonged rainfall failure without relying on rainfall. The farmers explained that through the help of a self-help group, they have been able to buy rainwater harvesting tanks and drill community boreholes that benefit the farmers when there is less rainfall. The lead farmer appealed to the government or well-wishers to help by drilling water dams and more boreholes in the community to combat the irrigation water issues. Many interviewees related the availability of quality water to the availability of finance. According to them, the availability of finances will ensure the availability of quality irrigation water to water vegetables, ensuring lumpsum harvest, more income, higher living standards and better health.

Modernizing current water harvesting and irrigation systems to include a dam, a combination of personal and large communal water harvesting systems, boreholes and perforated irrigation pipes was repeatedly mentioned. Even for those that are connected to a borehole, water is available in shifts and rationing is common during droughts.

It was mentioned that tree-planting initiatives are currently underway in the community. Farmers have formed self-help groups to enable them to access support from international donors. The farmers have adopted the new way of planting trees on their farms whereby they are paid for the number of trees present on their farms. Trees that are older than 2 years are accounted. Each tree goes at around 150 Euros. The hope is that other farmers, NGO organizations, private organizations will level up and put more effort into planting more trees.

CHAPTER 5: DISCUSSION

In this chapter, the findings of the previous chapter are discussed.

5.1 Drivers accelerating climate variation

The results of this study indicate that changes in climate around the Mount Kenya region have been increasing in the past decade. These are like those experienced by other agricultural regions in Africa (Zaehringer 2018). Human impact and activities are notably to blame. Specifically, increased damage to vegetation and land use changes are happening at an alarming rate, echoing the findings of the desktop research/literature review. The carbon sequestration role that trees play is in jeopardy and this contributes to global warming. One of the mentions was the increasing inadequacy and unreliability of rainfall. This was not surprising because being engaged in rain-fed agriculture, variations will always have a serious impact (Kalungu 2023) (citation). Among farmers, the role of fungicides and artificial fertilizers in climate change, as well as Greenhouse gases appeared to be low. There is still more work to be done to create awareness among locals on this matter.

5.2 Impacts of climate variability on crop production

The findings in this study provide evidence of how agricultural income, local communities and climate change are connected. In countries where alternative funding and sources of food are not available, recurring crop loss could lead to long-term health problems and further deteriorate the livelihoods of the families (Nzuma 2017). This creates a cycle of scarcity with a reduced probability of economic recovery.

Over-exploitation of groundwater

The role of good governance of public water resources cannot be overemphasized. Over-exploitation of groundwater has contributed to local rivers drying up faster. It also affects the water table leading to higher soil temperatures and a negative impact on the soil ecosystem and ultimately productivity of crops. Considering the overarching importance of maintaining groundwater levels, good governance practices can help to avoid the over-exploitation of groundwater (Kurukulasuriya 2013). A system where farmers are not excluded and disadvantaged by their socioeconomic status will ensure that the set national guidelines on drilling boreholes are adhered to. In times of uncertainty a sense of transparency, good citizenship and belonging is important (Kurukulasuriya 2013). This can create a more reliable social support system in a region where traditional social support systems such as government welfare programs, and insurance are non-existent (Paul 2018). Since the long rain season seems to be experiencing significantly higher rainfall than in the past, this presents an opportunity for rainwater harvesting. A well-managed water harvesting approach could reduce the demand for exploiting ground water. This would in turn have a positive impact on the ecosystem (Esteban, Calvo et al. 2021) .

Disruption of value chains

Crop failure means that marketing commitments cannot be met, loans may have to be renegotiated, and inputs obtained on credit cannot be paid for. All these lead to stress and loss of trust. Agricultural extension services that utilize practical demonstration methodologies are also disrupted given that the demonstrations must, as a matter of necessity, be done at the right time. For instance, training on pest and disease control must be done when crops are in the field. Therefore, if crops are not planted because of lack of rain, then the demonstration cannot take place. Seedlings supplier services that provide raw materials cannot meet expectations.

Family dynamics

Discussion on the livelihood alternatives and choices to make caused by reduced agricultural income has accelerated a great impact on family dynamics. When choices are to be made on pertinent issues such as which children to stay home and who to go to school, buying food versus paying school fees can cause a strain in family situations. These findings are consistent with general literature on family dynamics (White 2012), though not specifically linked to climate change impacts. Especially in families with limited alternative livelihood options. This may cause long-term damage to family relationships.

This shows that critical information gaps still exist. More specifically, farm-level activities such as using fertilizers and fungicides were not mentioned as causes or contributors to climate change both by farmers and experts. This could indicate that awareness of this subject matter is low. Literature (Biswas 2015) asserts that the use of fertilizers, livestock farming, machine-intensive farming methods, and tillage are practices that cause loss of organic matter emitting carbon dioxide into the atmosphere in the process. Besides these practices make soil more vulnerable to future climate factors exposure and erosion.

5.3. Adaptive and mitigating strategies for climate variations

The key adaptation strategies employed by farmers in this region can be said to be short-term, simple, and inconsistent. Due to a lack of reliable weather forecasting tools farmers lack timely and quality information that is vital for decision making in uncertain times. For instance, copying what their neighbours are doing means that the farmers are operating on old news. Considering the size, scale and focus of big multinational export farms, a simple one-on-one replication of activities is ill-suited for application in the small-scale type of subsistent farming in the region. A more structured knowledge and information sharing could be implemented.

According to a study carried out by Nicholson (2019) Carbon sequestration and a clean environment can improve livelihoods. Mitigation of greenhouse emissions was found to positively impact agriculture. A comprehensive analysis incorporating geographic and ecological done by (Pandey et al., (2015) suggested that agroforestry systems are a preferable option for mitigating climate change because they provide additional environmental advantages including improved farm revenue, increased food security, biodiversity restoration, and stable land tenure.

Mitigating strategies appear to be in their early stages. Deforestation and afforestation are a sustainable approach to improve local microclimate. Trees encourage broader biodiversity which increases soil quality, have a cooling effect and capture greenhouse gases. The challenge appears to be how to reconcile these benefits with the demand for land in an increasingly corrupt environment.

Adaptation strategies were similar among farmers and the experts. However, a notable difference is in the long-term aspect and sustainability aspects of the strategies. For instance, farmers mentioned burning charcoal as a strategy to diversify their livelihoods. Others mentioned grazing in the forest reserves. These are activities that provide farmers with alternative income in the present but have unforeseeable repercussions for the greater ecosystem.

Also for concern is the decreasing livelihood and its associated health impacts and its effects on the coping capacity and the mitigating capacity of the farmers. Given the demand for trees for firewood and timber, how can farmers be discouraged from felling trees or from planting fast growing but unsustainable tree species, such as eucalyptus as an alternative source of income? This is going to be difficult unless a well-structured system is put in place to stimulate, train and most importantly support farmers to transit to more sustainable livelihoods alternatives.

CHAPTER 6: CONCLUSIONS

This research concludes that climate change is impacting farmers in the Mount Kenyan region in similar ways to the impacts experienced by other farmers in Africa. The Conclusions for each research question are as follows:

a. What are the drivers of accelerating climate variation in the Mount Kenya region?

Climate variability focuses on how climate changes through time. From the analysis of the study, we conclude that the Mt Kenya region has been experiencing significant variations in climatic factors. We also conclude that besides natural variability, human factors such as encroachment on forested areas and population growth have contributed to climate variability in the region. This conclusion is in line with the literature review that claims that besides climate variability being a natural part of changes in temperature and weather patterns, human factors also contribute to climate change (La Sorte and Fink, 2017). It was noted that human impact and activities are notably to blame. Specifically, increased damage to vegetation and land use changes are happening at an alarming rate, echoing the findings of the desktop research.

The study further revealed that actors have a clear understanding of drivers that accelerate climate variation such as deforestation, land use changes, and weather conditions. Actors also recognize that reafforestation on farmlands contributes to a healthier biodiversity.

b. In what ways do climate-related factors impact food production systems and their stakeholders in the Mt. Kenya region?

The study concludes that the local food production system was negatively affected by climate change. Extreme weather seasons Floods, droughts, heat waves, and changes in weather temperature and precipitation patterns have been witnessed as disruptive events, and as some of the causes of low productivity of agricultural systems in the region. Additionally, pest and disease infestation has been seen as another indirect climate-related factor that poses a challenge to food production.

The study concludes that water shortage has the most negative impact on food production systems. Erratic rainfall, drying of seasonal rivers and low groundwater levels coupled with unfair distribution of water resources have caused a significant decline in crop yield in the region. The absence of a reliable alternative water supply to sustain crops when rainfall fails aggravates the problem. Livelihood options continue to decrease and as a result, the farmers' capacity to cope is significantly stretched.

c. What mitigation and adaptation strategies applied by food production system stakeholders to cope with climate variations?

The study concludes that actors in the region are aware of their agency (that they can do something about) in dealing with climate change. As seen by a variety of the actions i.e., preparation of nursery seedlings for tree planting, conservation, and preservation of forests etc. to adapt and mitigate climate change, we conclude that the farmers are concerned and are actively involved in attempts to reduce the impacts of climate change in a variety of ways. We conclude that farmers use simple and unsophisticated approaches that are more short-term than long-term orientated.

We conclude that while these actions have the potential, they require a more organized and communal approach, especially regarding shared natural resources such as water and forests. By partnering with each other and with external stakeholders the farmers can be provided with information, training, and support to enable them to adopt more long-term adaptation and mitigation approaches and to successfully transition to more sustainable practices and diversify their livelihood options.

Information gaps and areas for further research

It would be important to find out the perception of farmers' contribution to climate change. More specifically how their farming practices such as using artificial fertilizers and adapting traditional methods of farming or precision agriculture could affect crop yield considering climate change. In additionally it would be insightful to study the knowledge level of farmers regarding the type, quality and choice of the mitigating strategies they apply.

RECOMMENDATIONS

From the conclusions of this study, the following two recommendations are proposed.

From the discussions and conclusions presented in the study, the researcher chose two challenges that if addressed will have a long-term impact on the farmer's capacity to cope with the negative impacts of climate change.

Recommendation 1: Strengthen farmers' coping capacity by constructing water harvesting reservoirs

Firstly, inadequate resources to mitigate climate change impact the local farmers. Due to poverty, farmers' capacity to cope continues to decline.

While Mount Kenya Sprouts cannot solve the poverty issue for all farmers in the region, it can contribute by providing technical support to the farmers. Mt. Kenya Sprouts has since its inception, set up a series of water harvesting reservoirs such as dams, tanks, and ponds among other water management approaches. It can help local farmers by constructing several water harvest reservoirs. The company has the technical know-how and the equipment to make this happen. In the long term, this will be a low hanging fruit for the company.

Table 5 proposed advice 1

Construct five community water harvesting reservoirs	
What	5 Water harvesting tanks
	Mt Kenya Sprouts should set up a project to build water harvesting *reservoirs* that can be used by the community as backups in case of failed or inadequate rains. A committee of representatives from the local community can be set up to decide the size and location of the communal water harvesting reservoirs. Mt. Kenya Sprouts and its network can advise on the technical aspects of these decisions. The local county environmental officer and arid and semi-arid lands office based in Nanyuki can advise on the type of reservoirs (a tank, a pond, or a dam) that are appropriate for what location.
Where	Several appropriate locations to be agreed on by the farmers.
When: Timeline	Polishing the proposal -1 month Setting up committee members – 1 month Recruiting partners and extra fundraising – 3-6 months Groundwater scouting – 1 month Acquiring lands and permits 3-9 months. Drilling and construction of dams – 2.5 years (2 every 6 months)
Who: Staffing	Farmer's climate mitigation and adaptations support program manager employed by Mt. Kenya Sprouts 2 interns (program officers) employed by Mt. Kenay Sprouts The project is implemented by contractors so internal staffing is only for control, fundraising and project management activities.

Funding	Estimated budget 50,000 Euros from Mt Kenya sprouts and well-wishers
Added value	The approach tackles the heart of the problem: inadequate water supply. Increased water supply means that crop failure is reduced. Farmers can be assured of some harvest, if not enough for commercial services at least for their own subsistent use. The project can be scaled down to individual water harvesting initiatives.
Future potential	Mt. Kenya Sprouts can expand the program to provide services to enable the setting up of water harvesting strategies in their private farms. It could also provide farmers with more effective water usage equipment such as perforated irrigation pipes either for a small fee, as a grant or for free. The program can be extended to include other support projects such as support with seedlings in case of extreme events.

Recommendation 2: Improve knowledge and information for agricultural decision-making.

Secondly Mt, Kenya Sprouts company is advised to create a Farmer's climate mitigation and adaptations support program. This program will have the following objectives.

1. Develop a weather mobile application for the farmers within the next six months.
2. Set up a local farmer's information and training program where local experts and farmers can share information and experiences in the next 1 year.

The results from the study indicate that despite having the will to “do something” to survive climate change impacts, most of their actions are not well-informed. Mt. Kenya Sprouts is in a unique position to have the trust of the various stakeholders in the region. Its close relationship with the local government can be leveraged through the county environmental program, the agricultural office, and the Arid and semi-arid lands office to provide the training required to employ more sustainable practices.

Table 6 proposed advice 2

Create a farmer's information and awareness program (Jamii initiative)	
	Farmer's Information and Awareness program (Jamii initiative
What	This is a service that Mt Kenya Sprout can offer to the farmers. It can partner with the local meteorological department and other big farms to share weather forecast information with the farmers in a single database. Farmers can have access to the information in this database either online or offline. Farmers who cannot use the internet will be registered to receive SMS (push notifications) updates about important weather forecasts in the local language directly to their mobile phones. Farmers who are conversant with the internet will be guided to download and use the Jamii initiative app on their mobile phones.
Who: Staffing	Mt Kenya Sprout is advised to create a call for tenders from a local app creator. Creating an app in Kenya costs no more than 800 Euros. Liaise with local colleges and farmers to employ two interns (6 months minimum) who under the supervision of someone from Mt. Kenya Sprouts will manage the information sharing. They will ensure that partners have shared up-to-date information, the information is translated using translation software, information is sent out on time, any questions are answered, and any issues are reported to the Mt. Kenya Sprout representative. These interns will also be involved in the water harvesting project program.
When: Timeline	Further developing the concept- 1 month Recruiting partners – 1 month Creating a database, and an app (including testing) – 4 months Training end users – 1 month
Added value	Farmers will have the information that is crucial for important decisions in the agricultural food value chain. They will know when to wait before planting or harvesting. Meaning they will not lose their seedlings and will not waste their harvest. There will be a uniform way of receiving messages for each farmer, the information will be disseminated simultaneously to relay the same information to the farmers.
Future potential	The services provided can be extended to include other important information such as new crop varieties in the market, an outbreak of pests and diseases, training opportunities, funding opportunities, community farmers' events etc.

MY ROLE AS A RESEARCHER REFLECTION PAPER

To graduate from Vanhall University of Applied Sciences, every student is required to carry out a three-month program which is a mandatory requirement to graduate from Van Hall University of Applied Sciences as part of the APCM course. The research started with proposal preparation, choosing a research topic, and formulating a proposal, with literature review information. Afterwards, pitch the proposal and get validation for a go or no go to the field.

Formulating a proposal was not an easy task. First, the biggest hurdle was coming up with a researchable topic. I had anticipated working with a different commissioner on an avocado project. But then my sponsor Mt. Kenya Sprouts changed his mind about that. As a result, I had to work on a topic that was useful for their social Corporate Responsibility. Together with my boss, we settled on a climate-related topic, and I ended up with my current topic. My commissioner tasked me to carry out research on how climate change is affecting the farmers in the region and how to think about how the company can help. Still fine-tuning the topic to reflect both impact, adaptations and mitigation while remaining feasible required many hours of writing and rewriting. While I knew what the problem was, I had to follow the principles of research, to make sure that the title, the research question, and the problems were formulated accordingly. With the help of my supervisor, the topic “Adaptations and mitigation strategies of food production systems in the Mount Kenya region to climate variation and how can these vulnerabilities be mitigated” was adopted. I had to write and formulate a conceptual framework to facilitate the data collection. The previous mini/action research we did as a group during the third block helped me in this process as well when I was formulating and carrying out interview questions.

I left for the field research on the 10th of July 2023 back to Kenya. I had a feeling it was going to be tough, but my confidence was brought by the fact that we had several lectures in class about research development and analysis. The mini-research provided me with fundamental knowledge of data collection, processing, and interpretation.

Throughout my three-month research process, I had the opportunity to explore the key drivers of climate variations in the Mt. Kenya region in Kenya. Having worked with vegetable farmers from the region, and having ground experience in the region, coupled with my training at VHL I was well-suited to explore this topic.

The Mt. Kenya region has not experienced enough rain for the last two decades. When it has rained, it’s been either too little too late or too much and all at once. This has led to continuous poor harvests and flooding among other issues. A master's program in agricultural production chain management inspired me to seek further knowledge on the topic and helped me understand the impacts of climate variations on the environment. I explored farmers' coping capacities as well as vulnerabilities. It was inspiring to learn about adaptive measures that farmers have taken to combat climate change challenges.

After the first week of arrival, I started by making appointments for the interviews, focus group discussions and key interview informants. Getting their contacts was not easy because I had to look for relevant forces to get information from. Fortunately, my dad is the area chief, so he helped to get the necessary respondents, which facilitated my interview process. Although it became easy to get the right respondents, the main challenge was time management from the respondents as some of them just did not show up. I learnt to be patient, to ask again and to follow up. I think I should have planned to meet the respondents on their farms and interview them as they go about their farm business to save them the time to travel.

On Tuesday 18th of August, I officially started fieldwork. I saw the reality of how climate variabilities have impacted local farmers negatively, only farmers who have irrigation water have something to show for their efforts. The farmers were sceptical about what I was carrying out, some thought I was a government official, so they were afraid to give out information. I assured them it was purely academic

with a possibility of help from the government, well-wishers, donors, or policymakers. That is when they agreed to give me the relevant information that I needed for my research. The information gathered after each day's interview, I could try and transcribe data at the end or start of every day.

Most of the data collection was conducted in one of the national languages (Swahili) so I had to translate the two focus group discussions into English. I must admit that since my research was purely qualitative it was time-consuming to analyse the data since I had to code them into themes, scan and analyse the relevant information.

The process was useful because I was able to put my analytical skills into practice as well as develop critical skills while analysing. Working with local farmers was quite an experience. I had a chance to understand the coping mechanisms and adaptation capabilities of the farmers. Nobody has faith like farmers, they grow their crops with the faith that it will rain, and despite the outcome, they don't give up, they do it again expecting different results.

Compiling the whole report was a challenge, my supervisor was very helpful in every step. I managed to present my findings, discussions, conclusions, and recommendations. Details for further research were mentioned.

In conclusion, I must admit it was an educative but challenging experience. I was able to relate theoretical versus real experiences. I grew as a novice researcher. When I started, I did not know much about doing research. My skills have grown at every step. Specifically, I feel that I have grown in managing my own learning. I know better how to receive and process feedback, ask for help, and manage the communications and relationship with my supervisors. I still have a lot to learn but I can confidently say that I have mastered the most important foundations to identify a problem in society, gathering information on the problem, evaluating the quality of that information, analysing the information, interpreting the results, and coming up with relevant conclusions and recommendations.

The interactions I had with my respondents were valuable moments of learning for me. Through these interactions I could see the power of bringing people together to discuss an issue that is of common interest. During the FGD, often the participants would talk among themselves, ask each other questions and exchange ideas. Sometimes they also disagreed but mostly it was peaceful. I am proud to have been responsible for bringing them together and hope that the inputs they got form these interactions will be inspiring and helpful in their futures. In addition, the advice I am giving to Mt. Kenya sprout will contribute significantly towards softening the impacts of climate change on farmers. I hope that my report will not be gathering dust on a shelf. That the commissioner will go ahead and further develop my advice even downscaled or a modified version. This will be a star on my role contribution to my region and a change maker.

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Appendices

Appendix 1. INTERVIEW QUESTIONS

Research question	Possible prompt questions	Stakeholders to be asked the question's					
		Farmers	Middlemen	Traders	Processors	Suppliers	Climate stakeholders (others)
	What are the key factors affecting the region's crop production?	X	X	X	X	X	X
	How are the agriculture sector and farmers' vulnerability affected by the effects of climate variation?	X	X	X	X	X	X
	How is the food production system impacted by severe weather conditions including droughts, floods, and heat waves?		X	X			X

	What do you believe are the causes of climate variation and change? (Explain what you mean by climate	X	X	X	X	X	X
	change and give examples of drought, and other extreme events if needed)						
	What specific challenges does the climate pose in relation to agricultural crops	X	X	X	X	X	X
	What changes have you noticed regarding the availability of quality water sources for irrigation in agriculture in the area	X	X	X	X		X
	How does the changing climate affect when and how crops are planted and harvested?						X
	How does climate change affect stakeholders' vulnerability over a long period of time?	X					X
	What kind of assistance do you think farmers would need to deal with the effects of climate variability and change?	X					

Adaptation/mitigating options	What do you think should be done by stakeholders to: • Increase water availability. • Manage crop yield. • Protect and conserve the forests. • Combat deforestation.	X	X	X	X	X	X
Access to the market	How has access to the market changed in the last couple of years? • Can you connect these changes to climate change and variation? • What can be done to improve which stakeholders to increase market access?	X	X	X	X	X	X
Coping capacity	What do you personally do to cope with climate variation? • How successful do you think your efforts to deal with changes in climate have been? • Do you feel that you are well equipped to deal with these changes? • What are you lacking, or missing to be able to deal with these changes? • What support would you require to enable you to sufficiently deal with these changes?	X	X	X	X	X	X

Access to information	What is your knowledge level about climate change? • Do you think you could benefit from more information on this topic? • Who, where and when would you be the best person, time, or place for you to receive this information? • What do you think would be the best way to share information about climate variation?	X	X	X	X	X	X
Climatic factors: Climate variation impacts	How is crop production affected by the effects of climate variation?	X	X	X	X	X	X
	How do climate changes impact the biodiversity and ecosystem services that support food production systems?						X
	How do climate changes impact ecosystem services and biodiversity that underpin food production systems?						X
Stakeholders support /mitigating strategies	Which actions can stakeholders take to reduce climate variation?						
	What specific mitigation measures may stakeholders in the transportation sector take to prevent the negative effects of climate on food transportation??						
	How can stakeholders in various sectors						

	be supported to: • Be aware of their coping capabilities. • Measure and know how their actions contribute to climate change. • Evaluate their current capability for adaptation and identify areas that require development?						
	How can stakeholders build resilience and adapt to climate variation?	X	X	X	X	X	X
	What actions can stakeholders take to reduce their vulnerability to climate change?	X	X	X	X	X	X
Enabling environment	Who do you think should be responsible for dealing with the impacts of climate change on the food production system and why?	X	X	X	X	X	X